Structural and Stratigraphic Significance of the *Buchia* Zones in the Colyear Springs-Paskenta Area California

GEOLOGICAL SURVEY PROFESSIONAL PAPER 647-A

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By DAVID L. JONES, EDGAR H. BAILEY, *and* RALPH W. IMLAY

JURASSIC (TITHONIAN) AND CRETACEOUS *BUCHIA* ZONES IN NORTHWESTERN CALIFORNIA AND SOUTHWESTERN OREGON

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Recognition of Buchia *zones aids in understanding and interpreting major structural and stratigraphic features in northwestern California*

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STRUCTURAL AND STRATIGRAPHIC SIGNIFICANCE OF THE *BUCHIA* ZONES IN THE COLYEAR SPRINGS-PASKENTA AREA, CALIFORNIA

By David L. Jones, Edgar H. Bailey, and Ralph W. Imlay

ABSTRACT

The highest Jurassic (Tithonian) and lowest Cretaceous (Berriasian-Valanginian) beds exposed in the Colyear Springs-Paskenta area of northwestern California consist of 12,000-25,000 feet, or more, of interbedded and intertonguing mudstone, sandstone, and conglomerate that are characterized faunally by an abundance of the pelecypod *Buchia*. These beds are difficult to correlate lithologically for more than a few miles because of the presence of three major faults and the lack of persistent marker beds. Correlation can be achieved, however, on the basis of the stratigraphic distribution of certain species of *Buchia* of which six form mappable assemblage zones.

The distribution of these *Buchia* zones, as mapped herein, shows clearly that movement along the three major faults amounts to many miles; that the Cretaceous *Buchia* zones are many times thicker and contain coarser detritus on the north side of each fault zone than on the south side; that nearly 4 miles of sedimentary rocks end abruptly on the north at a major fault near the North Fork of Elder Creek; that only the highest two *Buchia* zones continue north of the Elder Creek fault; and that all *Buchia* zones are absent north of the fault near the Cold Fork of Cottonwood Creek. The evidence indicates probable movements along faults when the beds were more nearly horizontal than now and a left lateral displacement of at least tens of miles.

The six *Buchia* zones include two of Tithonian age, one of Berriasian age, and three of Valanginian age as determined by the associated ammonites. The oldest zone is characterized by *Buchia piochii* (Gabb). It is divisible into a lower subzone of *B. elderensis* (Anderson) and an upper subzone of *B. fischeriana* (d'Orbigny). The next higher zone marks the top of the Jurassic, and is characterized by *B.* aff. *B. okensis* (Pavlow). It also contains *B. terebratuloides* (Lahusen), *B. trigonoides* (Lahusen), and rare *B. piochii* (Gabb). The lowermost *Buchia* zone in the Cretaceous is characterized by *B. uncitoides* (Pavlow) and rare specimens of *B. okensis* (Pavlow). Above follows the zone of *B. pacifica* Jeletzky (equals *B. crassicollis* of common usage) which is associated with a few specimens of *B. inflata* (Toula) and *B. keyserlingi* (Lahusen). Next follows a zone characterized solely by an abundance of *B. keyserlingi*. At the top and only north of the Elder Creek fault occurs a zone characterized by *Buchia crassicollis solida* (Lahusen), a subspecies that is common farther north in Oregon, Canada, and Alaska.

INTRODUCTION

Upper Jurassic (Tithonian) and Lower Cretaceous (Berriasian through Valanginian) sedimentary rocks containing the pelecypod *Buchia* are well exposed in California along the west side of the Great Valley, especially in the northern or Sacramento Valley half. They crop out also in smaller areas throughout the Coast Ranges and in the Klamath Mountains. These beds are particularly fossiliferous and enormously thick in the northwestern part of the Sacramento Valley, where they have received sporadic attention from geologists and paleontologists since before 1900. Such studies yielded descriptions of many molluscan species, but few systematic detailed geologic and stratigraphic studies were made until after 1950 when topographic base maps of good quality first became available. Unfortunately, many of the older investigations based on inadequate maps are imprecise in regard to exact localities and to relationships of rocks and fossils. The information presented in this report is based on several field seasons of geologic mapping and much new collecting, as well as a reexamination of all previously collected fossils available for study.

Jones and Bailey began mapping and biostratigraphic studies in 1963 in the Colyear Springs quadrangle west of Red Bluff, and later extended their studies southward through the Paskenta quadrangle in order to further delineate the *Buchia* zones recognized by Jones. In 1965 they were joined by Imlay, who collaborated on biostratigraphic studies with emphasis on the ammonite faunas.

This report discusses the characteristics of the *Buchia* zones and the significance of these zones relative to major structures of western California. Delineation of the fossil zones based on the stratigraphic occurrence of species of *Buchia*, but supported by ammonites, indicates major structural features in the Colyear Springs-Paskenta area which were not anticipated from the lithologic data alone. The *Buchia* zonation presented herein also aids our understanding of the different but coeval Franciscan rocks lying farther west in the California Coast Range, and should be especially useful in the much needed further study of the *Buchia*-bearing rocks of southwestern Oregon which are similar to those we have studied in the Great Valley of California.

During the course of this study we have benefited from the generous assistance of Dr. J. A. Jeletzky of the Geological Survey of Canada, who freely made available to us his extensive knowledge of Canadian *Buchia* faunas. He also supplied us with plaster casts of many of his figured specimens which facilitated our identification of California material. Jeletzky conferred with us in the field, edited the comparative *Buchia* charts included with this report, and made other numerous helpful suggestions for which we are grateful. His excellent series of published reports on Canadian Late Jurassic and Early Cretaceous faunas have been extremely useful, and have stimulated us to examine more closely the *Buchia*-bearing beds of California and Oregon.

We also wish to thank Dr. Leo Hertlein of the California Academy of Sciences for furnishing plaster casts of fossils described by F. M. Anderson; and Mr. Joseph Peck, Department of Paleontology, University of California, Berkeley, for supplying a cast of the type of *B. piochii.*

William Cobban of the U.S. Geological Survey and N. J. Silberling of Stanford University read the manuscript and offered helpful advice.

Abbreviations appearing in plate descriptions in the text include CAS for the California Academy of Sciences, UC for the University of California at Berkeley, USGS Mesozoic loc. for U.S. Geological Survey Mesozoic locality, and USNM for U.S. National Museum.

HISTORY OF INVESTIGATION

Buchia-bearing beds of the Sacramento Valley were first studied by geologists of the Whitney Survey and included in the Shasta Group of Gabb (1869, p. 12–14) which embraced all beds of supposed Early Cretaceous age exposed along the west side of the valley. The Shasta Group was further subdivided by White (1885, p. 11–15) and Becker (1888, p. 213–218) into a lower sequence called the "Knoxville beds" and an upper sequence called the "Horsetown beds." The Knoxville beds were described by Becker (1888, p. 180), as "especially characterized by the presence of *Aucella*," [equals *Buchia*], but he did not publish a detailed lithologic description or designate an exact type section. Stanton (1895, p. 12) later extended the name Knoxville to include all the *Aucella*-bearing Cretaceous beds on the Pacific coast of the United States.

Diller (1890, p. 476) and Diller and Stanton (1894, p. 439–441) studied in detail the exposures along Elder Creek in the Colyear Springs quadrangle in the northern part of the Sacramento Valley, and concluded that the exposures comprised an unbroken sequence of Cretaceous strata nearly 30,000 feet thick. The lower 19,900 feet contained the pelecypod *Buchia* and was assigned to the Knoxville. These workers noted that at several places along their apparently continuous section the shale beds were twisted and veined and locally much folded. They also noted that thick units of conglomerate present to the north and south did not appear on Elder Creek.

Diller and Stanton (1894, p. 447) also recognized two distinctive zones of *Buchia*-bearing beds within the Knoxville; a lower "horizon" of *B. piochii* (Gabb) and an upper "horizon" of *B. crassicollis* (Keyserling). According to them, in the lower parts of the Knoxville, *B. piochii* occurs alone, but higher in the section it is associated with a broader form designated *B. piochii ovata* (Stanton) which becomes the prevailing species near the top of the range of *B. piochii.* The first representative of the *B. crassicollis* horizon was said to occur with *B. piochii ovata* about 2,000 feet below the top of the *Buchia* beds, and the upper 1,500 feet of beds was characterized solely by this species and its many varieties (including varieties *solida*, *gracilis*, *bulloides*, *keyserlingi*, *piriformis*, *majuscula*, and *inflata*). Because they felt that all of these forms could not be separated into distinct species, they referred them all to *B. crassicollis*, as this was the earliest name applied to the group.

Anderson (1902, p. 43) observed that most of the Knoxville fauna obtained from near Paskenta came from the upper 4,000 feet of *Buchia*-bearing strata; the beds below this level he observed to be much less fossiliferous. Because of this difference, Anderson (1902, p. 46, 48) designated the more fossiliferous beds as the "Knoxville (Paskenta) horizon" and the less fossiliferous beds below as the "sub-Knoxville horizon." No lithologic differences were described nor were definite stratigraphic limits placed on these subdivisions.

The first statement that the Knoxville contained beds older than Cretaceous was made by Pavlow (1907, p. 83) who suggested that the lower part is Jurassic in age. Smith (1909, p. 347–348), Knowlton (1910), and Burckhardt (1912, p. 32) also arrived at similar conclusions. This change in age assignment led Anderson (1932, p. 315; 1933, p. 1239) to propose a change in definition of the Knoxville on the basis that Whitney (in Gabb, 1869, p. 12–14) had not intended to include in Gabb's Shasta Group (which originally included the Knoxville) any strata older than Neocomian (earliest Cretaceous). This interpretation by Anderson was certainly erroneous, because as originally defined, the Shasta Group included all beds in the Great Valley below the Chico Group (Upper Cretaceous). These beds were in part of uncertain age but seemingly ranged from Neocomian to Albian. Nonetheless, Anderson (1933, p. 1239) split the original Knoxville into two parts. He designated the Jurassic part as the Knoxville Series, and left the Cretaceous part in the Shasta.

In order to justify this splitting of a unit, originally conceived to be lithologically and faunally continuous, Anderson (1938, p. 39–40) stated that the basal Shasta in some places contains thick conglomerates that are set off from the Knoxville by a quite well marked unconformity and which provide distinct evidence of diastrophism and erosion of the underlying Knoxville and older formations. Despite these supposed unequivocal evidences of unconformity, Anderson admitted that "in a few exceptional places, as in the McCarthy Creek-Elder Creek district this unconformity is less evident and the successions from upper Knoxville to Lower Cretaceous has been believed to be continuous."

The restriction of the Knoxville to only the Jurassic, left unnamed the Cretaceous *Buchia*-bearing part of the original Knoxville. This Cretaceous part was first referred to the "Knoxville (Paskenta) horizon" by Anderson (1902, p. 43–45), later referred to the Paskenta beds (Anderson, 1932, p. 321–323), and finally named the "Paskenta Group" (Anderson, 1938, p. 41–46) with the type district designated as "Elder Creek to Thomes Creek and southward." The top of the Paskenta was based mainly on faunal grounds, but was said to be marked in places by conglomerates at the base of the Horsetown.

The restricted Knoxville Series of Anderson was later (1945, p. 924–932) subdivided by him from top to bottom into the Newville, Grindstone, and Elder Creek Groups, each of which was characterized mainly by faunal criteria. The Elder Creek Group was recognized as extending southward from the South Fork of Cottonwood Creek to Elk Creek Village, where it was thought to be overlapped by the Grindstone Group which formed the basal beds from that point southward. The Newville Group contained the largest fauna and consisted mainly of dark argillaceous shales. Long lists of fossils from each group were provided by Anderson (1938, p. 940–942). These groups, as well as the Paskenta Group, in our opinion are strictly biostratigraphical, are not based on lithology, are not mappable, and serve no useful purpose.

The supposed unconformity between the "Knoxville" and the "Paskenta," as stated by Anderson (1938, p. 42), has received wide credence (Irwin, 1960, p. 33; Lachenbruch, 1962, p. 59; Popenoe and others, 1960, p. 1504), because of a failure to find ammonites or species of *Buchia* of Berriasian age. Nonetheless, because of the similar distribution and attitude of the Jurassic and Cretaceous strata and because of the lack of definitive field evidence, Bailey, Irwin, and Jones (1964, p. 131, 132) expressed doubt that an unconformity actually existed, but they recognized the need for additional careful searching for fossils.

The presence of beds of Berriasian age in California was first suggested by Jeletzky (1965, fig. 2) based on his identification of *Buchia okensis* (Pavlow) sensu lato and *B. uncitoides* (Pavlow) sensu lato. He also questionably postulated the existence of a regional unconformity separating these two species, but provided no supporting data. In November 1966, at the meeting of the Geological Society of America, Jeletzky (196?, p. 102) revised these determinations, and stated that both *B. uncitoides* and *B. okensis* were missing in California. At the same meeting, Jones, Bailey, and Imlay (1968, p. 104) stated that the first conclusions made by Jeletzky in 1965 were valid. As a result of a field conference of Jeletzky, Jones, and Imlay and further study of associated ammonites, it became apparent that the species identified by us as *B. okensis* and assigned a Cretaceous age was misidentified. It belongs instead to an unnamed late Jurassic species, which Jeletzky (oral commun., 1966) plans to describe and is herein referred to as *B.* aff. *B. okensis* (Pavlow).

We now recognize that our zone of *Buchia okensis* is equivalent to Jeletzky's latest Jurassic zone of *B. subinflata* and *B. occidentalis*. Our zone of *Buchia uncitoides* is valid and, along with ammonites, is evidence for a Berriasian age. Other differences from our preliminary zonation include the substitution herein of the name *B. keyserlingi* for *B. inflata* (based on an oral commun. from Jeletzky, 1966) and *B. elderensis* Anderson for *B.* cf. *B. blanfordiana*. Despite the change in age assignment of *B.* aff. *B. okensis* from earliest Cretaceous (Berriasian) to latest Jurassic (Tithonian), we believe that the *Buchia*-bearing sequence is complete and continuous from mid-Tithonian through the Valanginian and even into younger beds, and that there is neither stratigraphic nor paleontologic data to support the hypothesis of a regional unconformity at the base of the Cretaceous, at least in the northern part of the Sacramento Valley.

GEOLOGIC SETTING

The Colyear Springs-Paskenta area was initially selected for study because it lies at a triple junction of three vastly different suites of rock, each of which is so widespread as to provide the ultimate basis for three of the geologic provinces of California—the Great Valley, Coast Ranges, and Klamath Mountains (fig. 1). In the Great Valley the oldest rocks consist of Upper Jurassic and Cretaceous shelf and slope deposits known as the Great Valley sequence (Bailey and others, 1964, p. 123), the lowest part of which provides the principle topic for this report. In the Coast Ranges to the west, and generally separated from the Great Valley sequence by a fault containing a "sill" of serpentine, are the eugeosynclinal Franciscan rocks, which are equivalent in age to the rocks of the Great Valley sequence (fig. 2). In the Klamath Mountains to the northwest are Paleozoic and Triassic rocks that are partly metamorphosed and intruded by both ultramafic and granitic masses.

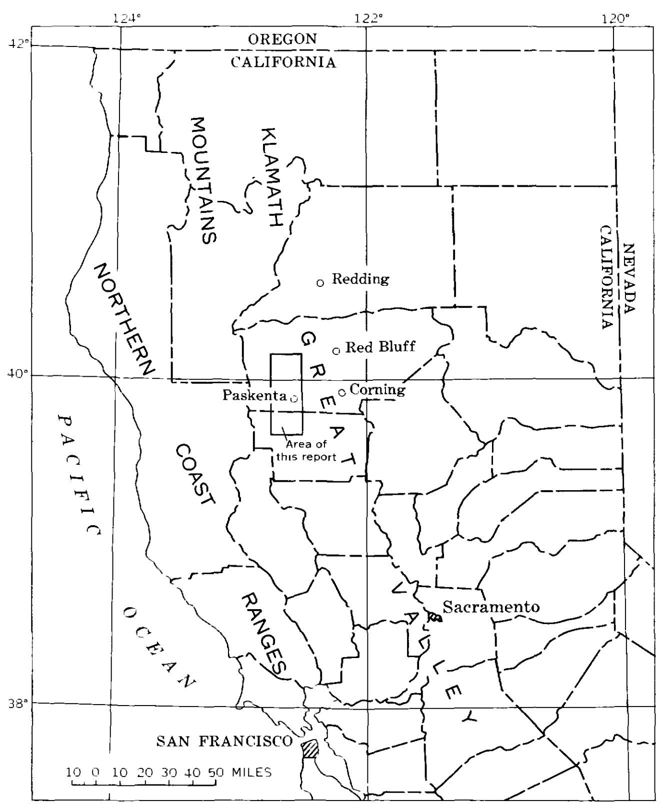

FIGURE 1.—Index map of northern California showing position of the Colyear Springs-Paskenta area.

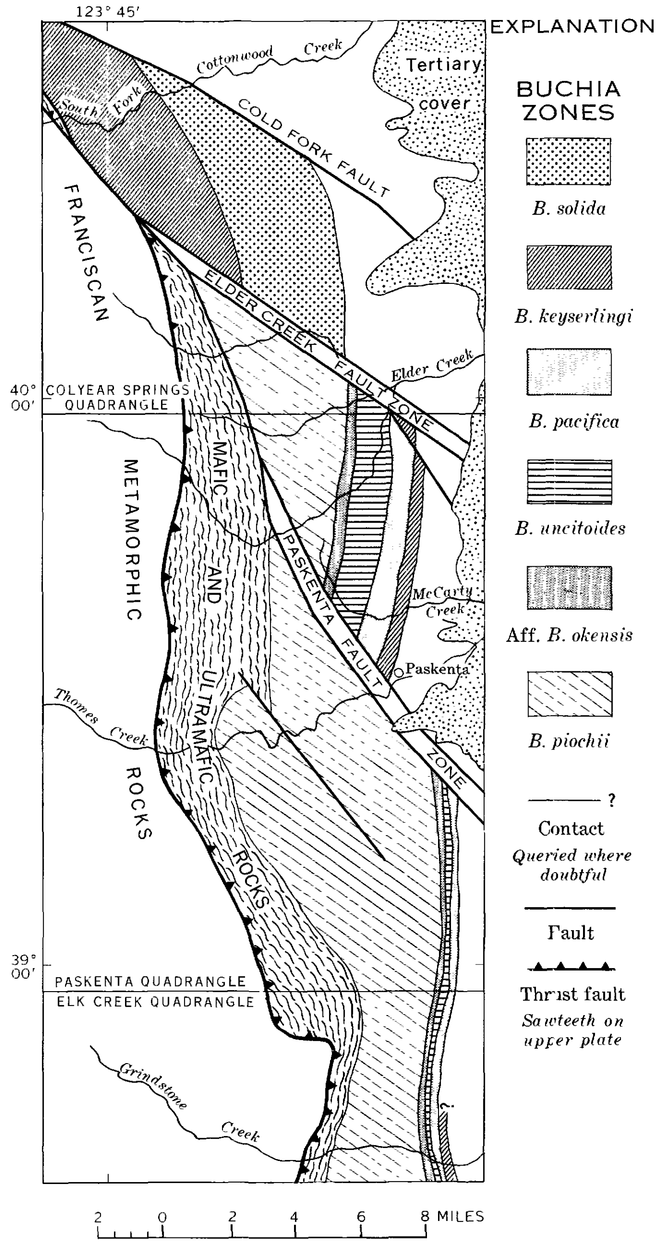

FIGURE 2.—Areal distribution of *Buchia* zones and major faults in the Colyear Springs-Paskenta area.

These rocks are overlapped by post-Valanginian Cretaceous sedimentary rocks of the Great Valley sequence, but are separated from the Franciscan rocks by a major fault.

STRATIGRAPHIC AND STRUCTURAL RELATIONS

The *Buchia*-bearing beds in the Colyear Springs-Paskenta area form the basal part of the Great Valley sequence which comprises interbedded mudstone, sandstone, and conglomerate ranging in age from Late Jurassic (Tithonian) to Late Cretaceous (Maestrichtian).

This sequence has a total thickness of at least 40,000 and perhaps as much as 60,000 feet, and the lower *Buchia*-bearing part attains a thickness in excess of 25,000 feet. This entire thick sequence is well exposed along the west side of the Sacramento Valley where it forms a northward-trending homocline which has steep eastward dips and is crossed by incised eastward-flowing streams.

Traversing diagonally the homocline of *Buchia*-bearing rocks are three steep northwest-trending major faults that are named, from north to south, the Cold Fork, Elder Creek, and Paskenta faults (fig. 2). These faults not only offset the stratigraphic units but they also have offsets so large that the time equivalent sequences on opposite sides of the faults do not match in either thickness or lithology. The faults are complex, and their exact limits have not been fully determined, but their positions are marked by broad shear zones, as much as half a mile in width, in which mudstones are sheared and distorted and against which the more resistant conglomerate and sandstone beds terminate. They yield a fault pattern of apparent left lateral horizontal displacement of several miles along each, but, as is discussed later, this is not the true amount of offset.

The Cold Fork fault, trending through the central part of the Colyear Springs quadrangle, marks a major lithologic and faunal change in the lower part of the Great Valley sequence, and probably also marks a difference in the basement rocks on which this sequence is deposited. North of the fault in Tehama and Shasta counties the basal beds lack *Buchia*, contain Hauterivian ammonites (Imlay, 1960, p. 178–181), and rest on deformed Paleozoic and early Mesozoic rocks of the Klamath Mountains. In contrast, the lower part of the sequence south of the fault lies in fault contact with serpentine, contains many thousands of feet of *Buchia*-bearing beds, contains ammonites of Tithonian to Valanginian ages, and is not underlain anywhere along the western edge of the Great Valley by basement rocks like those of the Klamath Mountains.

The Elder Creek and subparallel Paskenta faults farther south likewise coincide with abrupt faunal and stratigraphic changes, though there appears to be no change in the underlying serpentine and basement rocks. The *Buchia*-bearing beds between these two faults have an exposed thickness of about 22,000 feet, of which about 12,000 feet is Upper Jurassic and 10,000 feet is Lower Cretaceous. In contrast, south of the Paskenta fault the exposed section, although nearly as thick, contains only a little more than 1,100 feet of Lower Cretaceous beds which represent the same time interval as the 10,000 feet of Lower Cretaceous beds north of the fault.

These three faults thereby divide the Great Valley sequence in the Colyear Springs-Paskenta area into four distinct fault-bounded blocks in which the rocks are broadly similar lithologically but distinct in stratigraphic details. The northern block does not contain *Buchia*-bearing beds within the Colyear Springs-Paskenta area and is not further considered in this report. Each of the other three blocks contains units of mudstone, sandstone, and conglomerate similar in appearance to units in other blocks but differing greatly in thickness and stratigraphic position. We have not succeeded in tracing units across the major faults on the basis of lithology alone, and the successions of species of *Buchia* in each block show clearly that no direct ties of individual units can be established from one area to another. Therefore the relationship of the rocks in the three fault-bounded blocks has been established by the detailed mapping of the *Buchia* zones, though we are, of course, also mapping the lithology in as great a detail as possible on a 1:24,000 base. The total lack of key beds, or distinctive lithologic sequences, continuing from one block to another has forced this reliance on biostratigraphic methods, which are made possible through the abundance of specimens of *Buchia*.

The next section of this report presents the biostratigraphy of each of the fault-bounded blocks beginning with the southern block. Following details of the biostratigraphy, the significance and possible explanation for the vast changes across the faults are discussed.

BIOSTRATIGRAPHY

GENERAL STATEMENT

The fossil zones established in the Colyear Springs-Paskenta area on the basis of the distribution of the *Buchia* species are given in table 1.

TABLE 1.—Buchia *zones in the Colyear Springs-Paskenta area*

Zone	Stage	Epoch
Buchia crassicollis solida *keyserlingi* *pacifica*	Valanginian	Early Cretaceous (in part)
Buchia uncitoides	Berriasian	
Buchia aff. *B. okensis*	Tithonian	Late Jurassic (in part)
Buchia piochii (sensu lato) *Buchia fischeriana* subzone *elderensis* subzone		

To illustrate the distribution, lithology, and thickness of these zones in the three fault-bounded blocks, partial composite sequences are shown in figure 3. The sequence on the left is based on the strata exposed

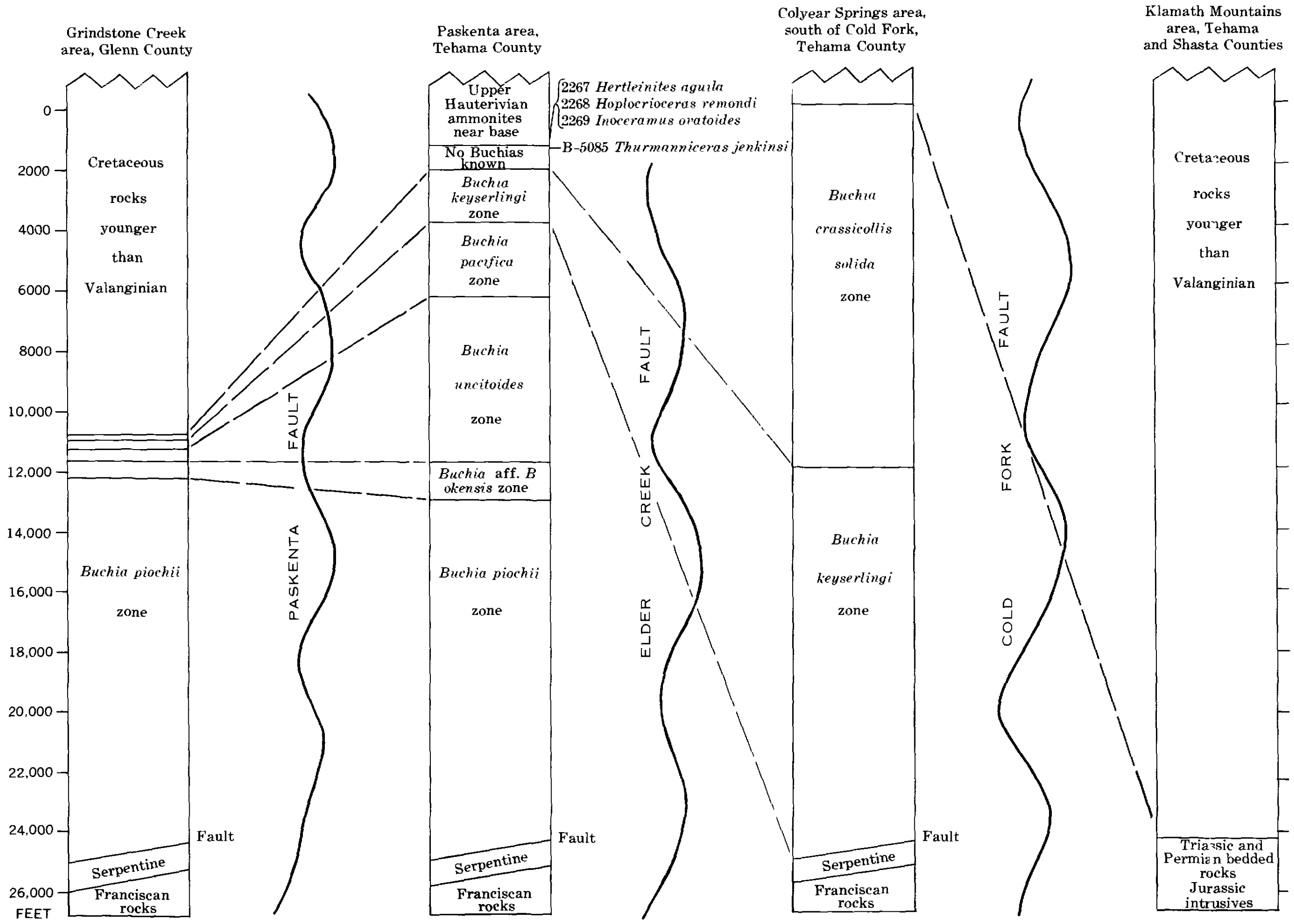

FIGURE 3.—Relationships of *Buchia* zones across three major fault zones.

along Grindstone and Watson Creeks in an area south of the Paskenta fault. The middle sequence represents the area farther north between the Paskenta and Elder Creek faults, and it includes the much-studied McCarty Creek section. The third sequence portrays the area farther north between the Elder Creek and Cold Fork faults, which is the poorest known geologically. The biostratigraphy of each of these areas is described in detail in the following sections.

AREA SOUTH OF THE PASKENTA FAULT

In the Grindstone Creek area, 15 miles south of the Paskenta fault, the *Buchia*-bearing beds are nearly 14,000 feet thick and consist dominantly of mudstone, but their lower part includes several thick lenses of sandstone, conglomerate, and pebbly mudstone. The *Buchia piochii* zone forms most of this thickness. The overlying *Buchia* zones of *B.* aff. *B. okensis* (Pavlow), *B. uncitoides* (Pavlow), and *B. pacifica* Jeletzky are faunally very well developed along Grindstone Creek (fig. 4) but comprise only 1,100–1,200 feet of the 14,000 feet.

The lower to middle parts of the *Buchia piochii* zone contain few specimens of typical *B. piochii* and many specimens that appear to be the same as *B. elderensis* (Anderson) (Anderson, 1945, p. 967, pl. 4, figs. 1–4). *B. elderensis* is replaced stratigraphically in the upper part of the *B. piochii* zone by *B. fischeriana* (d'Orbigny) in association with abundant *B. piochii* (Gabb). Establishment of the exact stratigraphic and biologic relationships of these species must await detailed mapping and collecting.

The overlying *Buchia* aff. *B. okensis* zone on Grindstone Creek and on nearby Watson Creek comprises nearly 500 feet of dark gray mudstone that contains abundant fossiliferous limestone concretions. Besides *B.* aff. *B. okensis*, which differs from *B. okensis* (Pavlow) mainly by having a more oblique outline, the zone

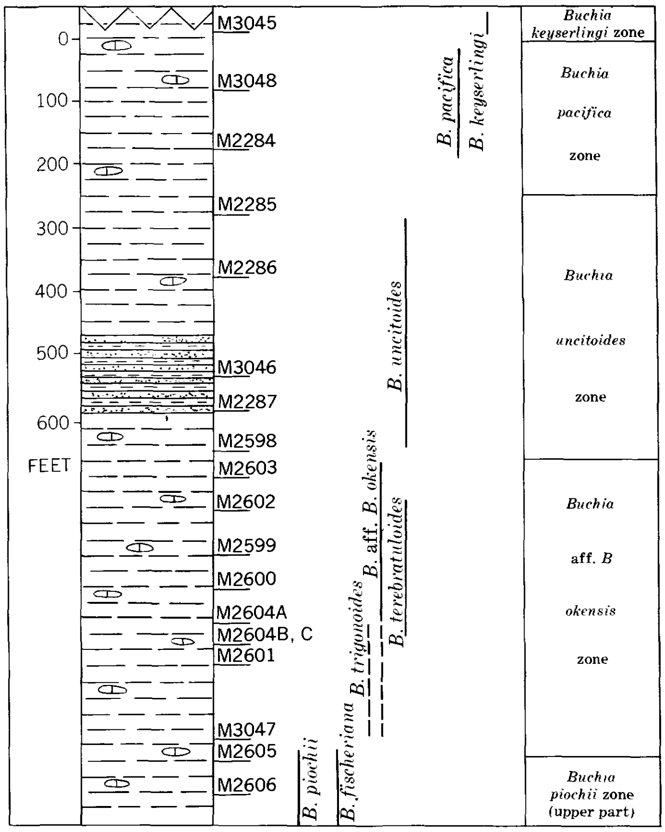

FIGURE 4.—Upper part of *Buchia* succession along Grindstone Creek. Fossil collections indicated on right side of columnar section were obtained on south side or in bed of Grindstone Creek. Stratigraphic distribution of species based on fossil collections are shown by vertical lines.

contains *B. terebratuloides* (Lahusen) as well as the ammonites *Phylloceras*, *Spiticeras*, *Proniceras*, *Substeueroceras*, *Parodontoceras*, *Blanfordiceras*, and possibly *Aulacosphinctes*. In addition, *Buchia trigonoides* (Lahusen) occurs in the lower part of the zone as well as in the underlying beds.

The overlying zone of *B. uncitoides* along Grindstone Creek is about 400 feet thick and consists mostly of dark-gray mudstone, but beginning about 50 feet above the base of the zone it includes a 100-foot-thick unit of interbedded sandstone and siltstone. The middle to upper part of the zone is here poorly fossiliferous and disturbed by minor faults, but it has furnished *B. uncitoides* within 40 feet of the lowest occurrence of *B. pacifica*. About 2 miles north of Watson Creek, in the NE. cor. of sec. 4, T. 21 N., R. 6 W., where the zone is unfaulted and approximately 1,000 feet thick, *B. uncitoides* occurs in fair abundance to within about 25 feet of the lowest occurrence of *B. pacifica*. In both places, *B. uncitoides* is associated at the top of its range with a more inflated variety which appears to be transitional to *B. tolmatschowi* (Sokolov). In neither place, however, are there any beds characterized solely by that species, such as Jeletzky (1965, p. 35–43) has found in Canada. In California there does not appear to be an intervening *Buchia* zone between the *B. uncitoides* and *B. pacifica* zones.

The *B. pacifica* zone on Grindstone Creek comprises 200–300 feet of dark-gray highly fossiliferous mudstone containing a few calcareous concretions. Its lower part is characterized by having only coarsely ribbed specimens of *B. pacifica*, whereas its middle and upper parts may also contain fairly smooth, greatly inflated specimens of *B. inflata* (Toula).

The next higher zone of *B. keyserlingi* has been identified on Grindstone Creek only tentatively on the basis of several poorly preserved specimens that show the even, fine, closely spaced ribs characteristic of *B. keyserlingi*. This zone is much better developed farther north near Paskenta.

AREA BETWEEN PASKENTA AND ELDER CREEK FAULTS

The *Buchia*-bearing beds near Paskenta have been studied by Diller (1890, p. 476), Stanton (1895, p. 13–18), Anderson (1933; 1938, p. 41–46; 1945, p. 924–943), and by several graduate students from the University of California at Berkeley whose theses are unpublished. None of these workers, however, recognized the presence of the Paskenta or Elder Creek faults, and, consequently, lithologic and faunal relations discussed by them may be erroneous.

In this area, the *B. piochii* zone is about 12,000 feet thick and consists of thick units of silty and sandy mudstone alternating with massive lenticular beds of sandstone and conglomerate. In the lower part of the zone, thick mafic volcanic breccias are interbedded with dark-gray mudstone, and fossils are very rare. The lower *B. elderensis* subzone is 6,000–7,000 feet thick, and the upper *B. fischeriana* subzone is 5,000–6,000 feet thick.

The overlying *B.* aff. *B. okensis* zone is particularly well developed along the Middle Fork of Elder Creek where it comprises 1,200 feet of silty and sandy mudstone containing abundant fossiliferous calcareous nodules and lentils (fig. 5). This zone can be traced to the south past Oakes ranchhouse (abandoned) to just beyond McCarty Creek, where it is truncated by the Paskenta fault. Faunally, the *B.* aff. *B. okensis* zone near Paskenta is nearly identical with the zone on Grindstone and Watson Creeks, but it differs in being somewhat thicker.

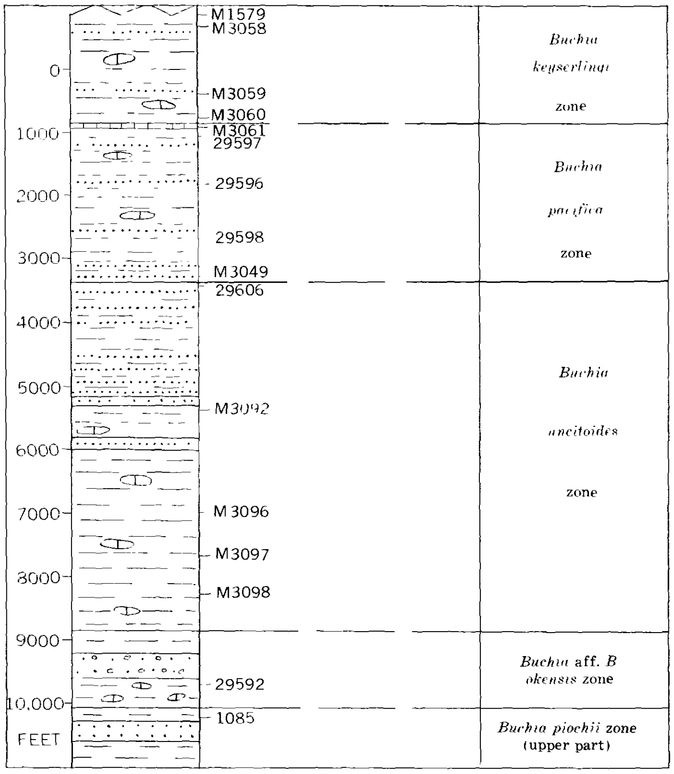

FIGURE 5.—Upper part of *Buchia* succession in the Paskenta area. Fossil collections indicated on right side of columnar section were obtained on south side of Mill Creek and near the South Fork of Elder Creek. Many other collections were obtained at other stratigraphic positions along other lines of traverse.

The *B. uncitoides* zone north of Paskenta comprises about 5,500 feet of mudstone that in places includes many interbeds of sandstone. It is well exposed along McCarty Creek and along the South Fork of Elder Creek. Along the Middle Fork of Elder Creek, the zone is poorly fossiliferous and is disrupted by the Elder Creek fault.

The overlying *B. pacifica* zone is about 2,500 feet thick. It consists mainly of gray mudstone, but includes some interbedded sandstone and mudstone units, and it is very fossiliferous, particularly in its upper part. This zone is very well exposed on McCarty Creek, and can be traced northward to the SE¼ sec. 28, T. 25 N., R. 6 W., where it is terminated by the southernmost strand of the Elder Creek fault. In California, no specimens of *B. pacifica* have been found north of the Elder Creek fault, although in southwestern Oregon the species is abundantly represented.

The overlying *B. keyserlingi* zone consists of at least 1,700 feet of gray mudstone that contains many limestone nodules and lentils. It is not as fossiliferous as the underlying zone, and to find well-preserved specimens requires considerable searching. This zone is best developed and most fossiliferous in the eastern half of secs. 4 and 9, T. 24 N., R. 6 W., and from 4½ to 6½ miles north of Paskenta. It can be traced northward to the northern part of sec. 33, T. 25 N., R. 6 W., where it is truncated by the Elder Creek fault. North of this fault, the *B. keyserlingi* zone reappears, but it is offset many miles to the west, is much thicker, and has totally different lithology.

AREA BETWEEN ELDER CREEK AND COLD FORK FAULTS

Between the Elder Creek and Cold Fork faults in the Colyear Springs quadrangle, the *Buchia*-bearing beds are nearly 25,000 feet thick and are divisible into two zones, a lower zone of *B. keyserlingi* and an upper zone of *B. crassicollis solida* (fig. 3). The lower half of these beds, corresponding approximately to the *B. keyserlingi* zone, consists of rhythmically interbedded, fine- to coarse-grained sandstone, grit, siltstone, and pebbly mudstone. Abundant graded bedding, groove casts, and slump structures indicate deposition by turbidity currents. Fossils are rare and generally leached; much searching is required to find shells sufficiently well preserved to be worth collecting. Limestone nodules and lentils are nearly absent, in marked contrast to equivalent rocks south of the Elder Creek fault where nodules and lentils are abundant and commonly fossiliferous.

The upper half of the *Buchia*-bearing beds north of the Elder Creek fault differs from the lower half by containing less coarse sandstone and much more dark-gray mudstone and siltstone interbedded with thin beds of sandstone. Limestone nodules and lentils here are also scarce, except in the uppermost beds. Fossils have been found in abundance at a few places but appear to be lacking throughout thousands of feet of section. Wood fragments are especially common in the upper beds.

The stratigraphic and structural relationships within the *Buchia*-bearing beds north of the Elder Creek fault are not well known because much of the terrane is covered by dense brush, the small stream valleys are choked with impenetrable vegetation, trails are sparse, and outcrops are generally few. Nearly continuous exposures occur only in the gorge of the South Fork of Cottonwood Creek. The *Buchia*-bearing beds might be cut by undetected faults that duplicate parts of the section and increase its apparent thickness.

Correlation of these *Buchia*-bearing beds with coeval beds south of Elder Creek has been difficult because of the conditions just described, because of great lithologic and thickness differences between the two areas, because *Buchias* are much scarcer north of Elder Creek, and because the zone of *B. crassicollis solida* is not known south of Elder Creek. Fortunately, however, an initial correlation based on a few specimens of *B. keyserlingi* has been sustained by the discovery of ammonites in the lower part of the section exposed in the gorge of the South Fork of Cottonwood Creek. These include specimens of *Neocomites*, *Olcostephanus*, and *Polyptychites*, which together are excellent evidence for a Valanginian age (Imlay, 1960, p. 172, 174). Their presence in association with finely ribbed *Buchia keyserlingi* shows that the lower part of the *Buchia*-bearing beds north of the Elder Creek fault is virtually the equivalent of the highest *Buchia*-bearing beds south of the fault.

STRUCTURAL SIGNIFICANCE OF THE OFFSET *BUCHIA* ZONES

The present distribution of *Buchia* zones firmly establishes that movements on the Paskenta, Elder Creek, and Cold Fork faults are much larger than heretofore supposed, even though a complete analysis of the time, duration, and exact amount of movement cannot yet be made. The faults have juxtaposed unlike sequences in such a manner that most *Buchia* zones above the zone of *Buchia* aff. *B. okensis* are many times thicker and contain more coarse-grained detritus on the north side of each fault than on the south side. Furthermore, north of the Elder Creek fault all zones below the *Buchia keyserlingi* zone are missing, and north of the Cold Fork fault all *Buchia* zones are absent. In spite of this, we have found no evidence of change of facies or thickness that is directly related to the fault zones, and thus see no reason to believe that faulting and deposition of the *Buchia*-bearing beds were contemporaneous. On the contrary, because strata as young as Turonian are cut by the Elder Creek fault, part, if not all, of the movement is post-Turonian.

The large differences in thickness and lithology across the faults and the absence of correlative lithologic units from one fault-bound sequence to another indicate that many miles of stratigraphic separation were achieved through movements along the faults, and that the apparent surface offset of beds of similar age does not provide a true measure of the real displacement along the fault. Movement probably occurred when the beds were in a more nearly horizontal position than now. Without more knowledge of directions and rates of facies changes, it is not possible to fix the exact direction or amount of displacement. However, the approximate direction of displacement is clear and a total cumulative left lateral displacement of 30 miles or more seems to be required.

One critical, unsolved, problem is the dynamic relationship of the northwest-trending faults to the major, serpentine-filled fault zone that separates the Great Valley sequence to the east from the coeval Franciscan rocks to the west. Bailey, Irwin, and Jones (1964, p. 163–165) suggested that the Great Valley rocks have been thrust over the Franciscan, and Irwin (1964, p. C6, C7) and Blake, Irwin, and Coleman (1967, p. C6, C7) postulated that the western margin of the Klamath Mountains rocks farther north is also in thrust relation on the Franciscan. The blueschist facies metamorphic rocks in the Franciscan beneath the serpentine (Blake and others, 1967, p. C7) seems to support the idea of Klamath Mountains and Great Valley rocks overriding the Franciscan. Differential movement within the sheet above the thrust, with the northern Klamath Mountains block moving relatively farther west than the Great Valley sequence south of the Cold Fork fault, would produce a zone of left-lateral tear faults at their juncture. At the present time this seems to be the most reasonable hypothesis to explain the persistent apparent left-lateral separation and the great stratigraphic differences observed in the *Buchia*-bearing beds within the Colyear Springs-Paskenta area.

FAUNAL CHARACTERISTICS AND AGES OF THE *BUCHIA* ZONES

BUCHIA PIOCHII ZONE (SENSU LATO)

Current studies suggest that the *Buchia piochii* zone is divisible into two subzones based on different species, or association of species, of *Buchia*. The upper subzone is characterized by the typical variant of *B. piochii* (Gabb) (table 2, pl. 2, fig. 16, pl. 3, figs. 20–29) in association with *B. fischeriana* (d'Orbigny) (table 2, pl. 1, figs. 3, 7–9). The lower subzone is characterized by Buchias that have been described as *B. sollasi* (Pavlow) of Anderson (1945, p. 965, pl. 2, figs. 9, 10; pl. 3, figs. 8–11), *B.* sp. A (Anderson, 1945, p. 973, pl. 3, figs. 15, 16), *B.* aff. *B. mosquensis* (von Buch) of Anderson (1945, p. 966, pl. 4, figs. 12a, b), and *B. elderensis* (Anderson) (1945, p. 967, pl. 4, figs. 1–4).

TABLE 2.—*Characteristic Late Jurassic (Tithonian)*

Buchia species	Relative size	Shape of valve			Beaks
		Cross section	Left valve	Right valve	Left valve
Buchia aff. *B. okensis* (*Pavlow*).	Medium to fairly large.	Moderately convex, fairly thick, inequivalved.	Broad, trigonal, higher than wide. Posterior ear small and angular.	Gently convex, much smaller than left valve.	Straight, stout, gently incurved, slightly overhangs right valve.
Buchia terebratuloides (Lahusen).	Small----	Moderately convex, inequivalved to nearly equivalved.	Subtriangular, higher than wide, generally not extended posteriorly.	Subtriangular, gently to moderately convex. Anterior margin below beak is straight or concave.	Fairly long and narrow, curves moderately downward and to left, overhangs right valve slightly or not at all.
Buchia trigonoides (Lahusen).	Medium to fairly large.	Fairly convex, inequivalved.	Subtriangular, higher than wide, elongate posteriorly.	Subtriangular, moderately convex.	Moderate in length and stoutness, curves to left, overhangs right valve slightly or not at all.
Buchia fischeriana (d'Orbigny).	Medium----	Gently convex, becomes less convex during growth, thickest near hinge margin, inequivalved.	Broad, pear shaped to trigonal, elongated posteriorly. Becomes broader and flatter toward postero-ventral margin. Posterior ear small and rounded.	Round to triangular, weakly convex to weakly flat, generally much less convex than left valve.	Short, fairly narrow, straight or curved feebly to right. Gently incurved or coiled, but rarely overhangs right valve.
Buchia piochii (Gabb).	Small----	Moderately convex in adult, highly convex in young, thicker than wide.	Narrow, elongate posteriorly. Much longer than wide. Maximum thickness at about two-thirds of height of valve.	Gently convex, much smaller than left valve.	Long, slender, strongly incurved or coiled, generally straight, overhangs beak of right valve.
Buchia elderensis (Anderson).	Small to medium.	Moderately convex in adult, highly convex in young, wider than thick, inequivalved.	Stout, obliquely elongate posteriorly, much longer than wide. Maximum thickness slightly dorsal to middle of valve.	Irregularly rounded, gently convex.	Fairly long, becomes fairly stout, moderately incurved or coiled, curves to left, overhangs beak of right valve.

Stratigraphically the last four species were considered by Anderson (1945, p. 939, 940) to range from 1,200 feet to about 4,000 feet above the lower fault contact of the Jurassic *Buchia*-bearing beds with serpentine. *Buchia* aff. *B. mosquensis* (von Buch) of Anderson was obtained 1.5 miles southwest of Chrome, Elk Creek quadrangle, within a few hundred feet of the contact with serpentine, and has been recollected recently (USGS Mesozoic loc. 29494). *B.* sp. A was obtained 1.2 miles southeast of the Kleinsorg mine on the Middle Fork of Elder Creek, about 4,000 feet above the fault contact, and near the type locality of *Kossmatia kleinsorgensis* Anderson (1945, p. 982, 1001). The holotype of *B. elderensis* (Anderson) was found (Anderson, 1945, p. 939, 967) in association with an ammonite assigned to *Durangites* by Anderson (1945, p. 983, pl. 2, fig. 4) 600 feet north of the gate at Hull Place. This is about half a mile south of the occurrence of *K. kleinsorgensis* Anderson but at a slightly lower stratigraphic position. *B. sollasi* (Pavlow) of Anderson was obtained (Anderson, 1945, p. 939) near Pellow Place, a half mile west of Hull Place, and about 1,000 feet stratigraphically lower than the occurrence of *B. elderensis* (Anderson). In addition, the Geological Survey collections contain *B. elderensis* (Anderson) from near, or a little above, the middle of the *B. piochii* zone (USGS Mesozoic locs. 666, M4053, 29492), or about 5,000–6,000 feet below the top of that zone.

All these four *Buchia* species of Anderson are herein included in *B. elderensis* (Anderson) (table 2; pl. 2, figs. 17–34, 36–45). The smaller specimens of that species greatly resemble *B. piochii* (Gabb) but differ by being a little stouter, more elongate posteriorly, and by the beak on the left valve curving to the left. The larger specimens of *B. elderensis* are identical with *B.* cf. *B. blanfordiana* (Stoliczka) of Jeletzky (1965, p. 17, pl. 2, figs. 3, 4, 6, pl. 3, figs. 5, 6, 8) from western British Columbia and are much stouter than *B. piochii*.

Other fossils than Buchias that are definitely from the lower 5,000 feet of the *Buchia piochii* zone include *species of* Buchia *in the Pacific Coast States*

Beaks—Continued	Concentric markings		Distinguishing features
Right valve	Ribs	Constrictions	
Small, low, sharp	Sharp, fairly low, regular, widely to fairly widely spaced.	None	Intermediate between *B. okensis subokensis* (Pavlow) and *B. fischeriana* (d'Orbigny). Differs from *B. fischeriana* by being much larger and stouter and by having coarser sparser ribbing. *B. subokensis* has a larger posterior ear and is more elongate posteriorly.
Small to moderately prominent, pointed.	Nearly smooth to fine and sharp, variably spaced, but may be dense near ventral margin.	Undulations or weak constrictions common.	Differs from *B. keyserlingi* by having a longer beak, a less convex right valve, constrictions, and weaker less regular ribbing. Differs from *B. uncitoides* by having a less elongate left valve, a less convex right valve, weaker ribbing, and a more downcurved left beak.
Small, pointed	Weak to moderately strong, dense to moderately spaced, may be replaced by concentric striae.	None	Intermediate between *B. fischeriana* and *B.* aff. *B. okensis*. *B. fischeriana* is more elongate posteriorly, generally less convex, and typically has lower weaker and sparser concentric ribs. *B.* aff. *B. okensis* has much sharper and sparser ribs, particularly on its umbones.
Small, low, sharp	Generally sharp, low, moderately to widely spaced, but may be fine and closely spaced or irregularly spaced.	None	Small forms resemble *B. piochii*, but adults are much less convex and have sharper, more regular ribs. Its most coarsely ribbed variant resembles *B. subokensis* (Pavlow), but is generally smaller, less convex, less coarsely ribbed and its beak is narrow instead of stout.
Small, pointed, much shorter and smaller than on left valve.	Low, variable in strength, irregularly spaced.	Fairly common, as irregular weak undulations.	Small forms resemble *B. uncitoides*. Adult forms are less equivalved, more elongate posteriorly, have less sharp concentric ribbing and the beaks on left valves are nearly straight and much incurved or incoiled.
Small, pointed, low, much smaller then on left valve.	Weak to sharp, low, variable in strength and spacing.	Weak and irregular.	*B. piochii* is more slender and less elongate posteriorly. *B. mosquensis* (von Buch) has stronger constrictions and commonly has radial markings. *B. blanfordiana* (Stoliczka) is much more elongate posteriorly, bears less distinct concentric ribbing, and has a flatter right valve.

some belemnites (Anderson, 1945, p. 940, 990), *Pecten? risti* Anderson (1945, p. 962, pl. 4, fig. 7), and the ammonites *Kossmatia* (Anderson, 1945, p. 981, 982, pl. 2, figs. 1a–c, 3, pl. 10, figs. 5a, b), and *Durangites?* (Anderson, 1945, pl. 2, figs. 4a, b). Other fossils definitely from the upper 5,000 feet of the zone include the ammonites *Parodontoceras storrsi* (Stanton) (1895, p. 79, pl. 17, figs. 1, 2, pl. 18, figs. 3, 4), *Phylloceras knoxvillense* Stanton (1895, p. 72, pl. 14, figs. 1–3), *Phylloceras?* n. sp., *Lytoceras* sp., *Aulacosphinctes?* sp., *Groebericeras?* n. sp., *Spiticeras* sp. (USGS Mesozoic loc. 1085), and fragments of pelecypods (Mesozoic loc. 1084). The middle part of the *B. piochii* zone, comprising thousands of feet of beds, has not furnished any ammonites except *Kossmatia dilleri* (Stanton) (1895, p. 16, 82, pl. 18, figs. 6, 7).

The age of the *Buchia piochii* beds is Tithonian on the basis of the presence of *Kossmatia* in its lower and middle parts and of *Parodontoceras*, *Groebericeras?*, and *Spiticeras* in its upper part. Of these, *Kossmatia* has been found in New Zealand in beds of middle (?) and late Kimmeridgian age (Fleming, 1960, p. 264–268; Fleming and Kear, 1960, p. 17–45; Stevens, 1965, p. 22–32, 132–135), in southern Europe in beds of Tithonian age (Mazenot, 1939, p. 129, 130), and in Mexico in beds of middle to early late Tithonian age (Burckhardt, 1912, p. 220–222; Imlay, 1939, p. 22, 23). *Parodontoceras* is common in many regions in beds of late middle to late Tithonian age (Arkell and others, 1957, p. L354) and possibly ranges into the Berriasian. *Spiticeras* has not been found in beds older than late Tithonian (Arkell and others, 1957, p. L345). *Groebericeras* in Argentina has been found in beds of Berriasian age.

The lower part of the *Buchia piochii* beds is probably not older than middle Tithonian as indicated by an absence of *Buchia rugosa* (Fischer) and *B. mosquensis* (von Buch), which are common in North America and the Boreal region in beds of middle Kimmeridgian to early middle Tithonian ages (Imlay, 1955, p. 74, 75, 85).

BUCHIA AFF. B. OKENSIS ZONE

The uppermost Jurassic *Buchia* zone in northwestern California is characterized by a species that is possibly a variant of *Buchia okensis* (Pavlow) (table 2) and is herein referred to *B.* aff. *B. okensis* (Pavlow) (pl. 1, figs. 18–22, 25–35). Associated fossils include abundant *B. terebratuloides* (Lahusen) (pl. 2, figs. 1–15), rare *B. piochii* (Gabb), *B. trigonoides* (Lahusen) (pl. 1, figs. 1, 2, 4–6, 10–17, 23, 24; pl. 2, fig. 35), *Inoceramus ovatus* Stanton, *Cylindroteuthis tehamaensis* Stanton, *Phylloceras knoxvillense* Stanton, *P. glennense* Anderson, *P.* n. sp., *Lytoceras* sp., *Proniceras* n. sp., *Spiticeras* cf. *S. obliquenodosum* Retowski, *Substeueroceras stantoni* Anderson, *S.* cf. *S. kellumi* Imlay, *Blanfordiceras* n. sp., *Parodontoceras reedi* (Anderson), *Aulacosphinctes*? *jenkinsi* Anderson, and possibly *Bochianites*? *glennensis* Anderson.

Buchia aff. *B. okensis* (Pavlow) from California has been illustrated under the name *Aucella fischeriana* (d'Orbigny) by Anderson (1945, pl. 12, figs. 1a, b) and Imlay (1959, pl. 17, figs. 6, 11). It differs from that species, however, by being more convex and much more coarsely and sparsely ribbed. It may be within the range of variation of *B. okensis* (Pavlow) (1907, p. 40, pl. 1, figs. 10a–c, 11a–c) as recently described from British Columbia by Jeletzky (1965, p. 23–25, pls. 4–7 in part).

Buchia aff. *B. okensis* (Pavlow) (table 2) from California is trigonal in shape, has moderate to coarse ribbing, and shows considerable variation in the strength and spacing of its concentric ribbing. Most specimens have fairly high, moderately coarse, and moderately spaced ribs comparable with those on *B. subokensis* (Pavlow) (1907, pl. 1, figs. 17a–c; Jeletzky, 1965, pl. 4, figs. 23a–d, 24a–d, pl. 6, figs. 3a, b) which Jeletzky (1965, p. 24, 25) considers to be a variety of *B. okensis* (Pavlow). A few specimens have low, sharp, moderately spaced ribs similar to those on *B. fischeriana* (d'Orbigny) in Pavlow (1907, p. 58, pl. 4, figs. 15–19; Lahusen, 1888, pl. 2, figs. 14–20) and *B. trigonoides* Lahusen (1888, pl. 2, figs. 21–24). A few have very coarse and widely spaced ribs as on one of the type specimens of *B. okensis* figured by Pavlow (1907, pl. 1, figs. 10a–c) and obtained from an unknown locality in California. None of the specimens, however, attains the large size, the oblong shape, and the extremely coarse, sparse ribbing of the most coarsely ribbed form of *B. okensis* (Pavlow) that occurs in the basal Cretaceous of Alaska (Imlay, 1961, pl. 7, figs. 5, 9, 17–20) and British Columbia (Jeletzky, 1965, pl. 4, figs. 1a–d). Overall, the species from the highest Jurassic of California appears to be transitional morphologically as well as stratigraphically between *B. fischeriana* (d'Orbigny) from Upper Jurassic beds and the most coarsely ribbed variant of *B. okensis* (Pavlow) from basal Cretaceous beds. The succession from oldest to youngest appears to be *B. fischeriana* (d'Orbigny), *B. trigonoides* (Lahusen), *B.* aff. *B. okensis* (Pavlow), and *B. okensis* (Pavlow).

The age of the *Buchia* aff. *B. okensis* beds is late Tithonian because those beds contain an association of the ammonites *Substeueroceras*, *Parodontoceras*, *Blanfordiceras*, *Proniceras*, and *Spiticeras* (Arkell and others, 1957, p. L345, L352, L354) and directly underlie beds characterized by the Berriasian ammonite *Spiticeras* (*Negreliceras*) (Djanelidze, 1922, p. 48, 49, 51; Arkell and others, 1957, p. L346). The species *Buchia* aff. *B. okensis* (Pavlow) itself is not evidence of a latest Jurassic age because of its close resemblance to *B. okensis* (Pavlow) (1907, p. 40, pl. 1, figs. 11a–c) which is of early Berriasian age (Jeletzky, 1965, fig. 1 opposite p. 2, p. 20; Sachs and others, 1963, table 7). Nonetheless the derivation of *B. okensis* (Pavlow) from *B. fischeriana* (d'Orbigny) during latest Jurassic time has been suggested by Jeletzky (1965, p. 25, fig. 3, opposite p. 58) and he notes that variants of *B. okensis* (Pavlow) occur occasionally in latest Jurassic beds (Jeletzky, 1967, p. 33, 34).

BUCHIA UNCITOIDES ZONE

This zone is characterized by an abundance of *Buchia uncitoides* (Pavlow) (1907, p. 61, pl. 5, figs. 14, 15a, b; Sokolov, 1908, p. 11, pl. 1, figs. 10–13; Jeletzky, 1965, p. 28–33, pl. 4, figs. 2, 13, pl. 5, figs. 1, pl. 6, fig. 7, pl. 7, figs. 12–14, pl. 8, figs. 10–12, pl. 9, figs. 1–6, 9–23, pl. 10, figs. 3, 8, 10–14, pl. 11, fig. 8), which species was recognized by Imlay in 1953 (written commun., to F. G. Wells dated Sept. 17, 1953) but later included by him in the synonymy of the Jurassic species *B. piochii* (Gabb) (Imlay, 1959, p. 158). *B. uncitoides* has recently been studied in detail by Jeletzky (1965, p. 28–33) and distinguished from the similar appearing *B. piochii* (Gabb), although he notes that "small to medium-sized representatives of *B. uncitoides* may be confused with the older *B. piochii*."

The characteristics of *Buchia uncitoides* (Pavlow), as defined by Jeletzky (1965, p. 28–30), are shown in table 3. Immature specimens closely resemble *B. piochii* (Gabb) and may be difficult to differentiate. Adult forms, however, are distinguishable by being more equivalved and less elongate posteriorly, by having somewhat sharper concentric ribbing, and by the beaks on the left valves curving left instead of being nearly straight and by curving downward only moderately instead of being much incurved or coiled. Some typical specimens from California are illustrated herein (pl. 3, figs. 1–19).

Other mollusks found with *Buchia uncitoides* (Pavlow) in California belong mostly to the ammonite genus *Spiticeras*, including many specimens of the subgenus *Spiticeras* (*Negreliceras*) (USGS Mesozoic locs. 2286, 29505, M2025, M3096, and M4066) and a few specimens of the subgenus S. (*Spiticeras*) (USGS Mesozoic locs. M2598, and M3092). In addition, a few specimens of *B. okensis* (Pavlow) were found at one locality (USGS Mesozoic loc. M4066).

In California the subgenera *S.* (*Negreliceras*) and *S.* (*Spiticeras*) have been collected at various levels throughout the lower two-thirds of the *Buchia uncitoides* zone. They been found near the base of the zone at USGS Mesozoic locality M2598, near the top of the lower fourth at Mesozoic locality M4066, near the middle at Mesozoic locality M2025, and near the top of the middle third at Mesozoic localities M3092, M3096, and 29505.

The age of the lower two-thirds of the *Buchia unictoides* zone in California is Berriasian on the basis of the presence of the subgenus *Spiticeras* (*Negreliceras*) at many localities and the stratigraphic position of the zone directly above beds containing characteristic latest Jurassic (late Tithonian) ammonites. The upper third of the zone has not furnished ammonites and could be as young as Valanginian.

BUCHIA TOLMATSCHOWI ZONE

The presence of a distinct zone characterized by *Buchia tolmatschowi* (Sokolov) (table 3) as in western British Columbia (Jeletzky, 1965, p. 35–43, pl. 13, figs. 1, 3, 4, pl. 15, fig. 1, pl. 15, figs. 7, 10, 11) has not been established in California or Oregon. In northwestern California, however, two collections (USGS Mesozoic locs. M3057 and M3064) obtained immediately below the base of the *B. pacifica* zone contain some elongate specimens of *Buchia* that have been identified by J. A. Jeletzky (oral commun., November 1966) as *B. tolmatschowi* (Sokolov) (1908, p. 13, pl. 2, figs. 1, 2). These are not as inflated, however, as are the specimens of *B. tolmatschowi* figured by Jeletzky and cannot be unequivocally assigned to that species. They are herein interpreted as large specimens of *B. uncitoides* that are transitional toward *B. tolmatschowi.* In this regard, Jeletzky (1965, p. 35, 37, 44) notes that *B. tolmatschowi* (Sokolov) on the west coast of Vancouver Island ranges throughout about 119 feet of beds, intergrades basally with *B. uncitoides*, and intergrades in the upper 50–60 feet of its range with *B. pacifica.* Nonetheless, most specimens of *B. tolmatschowi* (Sokolov), according to Jeletzky (1965, p. 32, 37), have certain features that permit differentiation from other species of *Buchia.*

Fieldwork in California shows that the specimens resembling *B. tolmatschowi* (Sokolov) occur in a thin sequence of beds, are much too rare to use as guide fossils, and in practice have been regarded as in the upper part of the *B. uncitoides* zone. This conclusion has no bearing on the validity of the *B. tolmatschowi* zone in British Columbia.

BUCHIA PACIFICA ZONE

This zone in the Pacific coast region is characterized by an abundance of *Buchia pacifica* Jeletzky (1965, p. 43–49, pl. 15, figs. 12a, b, pl. 16, figs. 1–4, 7–10, pl. 18, figs. 2, 3, pl. 19, figs. 3, 4, 6, 8, pl. 21, figs. 3a–d). With these (Pl. 4) are a few specimens that belong to *Buchia inflata* (Toula) (pl. 3, figs. 30–33), as defined by Jeletzky (1965, p. 46, 47, pl. 17, figs. 2–4, 6) and to *Buchia keyserlingi* (Lahusen) (pl. 5, figs. 12–15, 18–33). The only ammonites obtained near the base of the zone in California is a *Thurmanniceras* (USGS Mesozoic loc. 29593) that resembles *T. stippi* (Anderson). Ammonites from the middle third of the zone in California include *Thurmanniceras californicum* (Stanton) (Mesozoic locs. 1001 and 1095) and *Kilianella crassiplicata* (Stanton) (Mesozoic locs. 1001, 5339), and *Lytoceras saturnale* Anderson (Mesozoic locs. 1001, 5339). Ammonites from the top of the zone in California include *Tollia mutabilis* (Stanton), *Sarasinella angulata* (Stanton), and *Bochianites paskentaensis* Anderson (Mesozoic locs. 1010, 1093). Other associated mollusks from the top of the zone include the pelecypods *Avicula* (*Oxytoma*) *whiteavesi* Stanton, *Pinna* sp., *Arca tehamaensis* Stanton, *Leda glabra* Stanton, and *Astarte corrugata* Stanton, the scaphopod *Dentalium californicum* Stanton, the gastropods *Hysipleura gregaria* Stanton and *Cerithium strigosum* Stanton, and the belemite *Acroteuthis.*

The specimens now assigned to *Buchia pacifica* Jeletzky have been included previously in *Aucella crassicollis* Keyserling (Stanton, 1895, pl. 5, figs. 10, 11, pl. 6, figs. 1–5; Pavlow, 1907, p. 62, 83; Anderson, 1938, pl. 8, figs. 1, 2; Jelezky, 1950, p. 41, 42; Imlay, 1959, p. 161, 162, pl. 19, figs. 3–7, 9–11, 13–24), in *Aucella crassa* Pavlow (Stewart, 1930, p. 112; Jelezky, 1950, p. 24), and in *A. solida* Lahusen in Pavlow (1907, pl. 5, figs. 25, 26).

The characteristics of *B. pacifica* Jeletzky and its differences from other species of *Buchia* with which it may be associated have been discussed in detail by Jeletzky (1965, p. 44–47) and are shown herein in table 3. The close relationships of some of these species in the Pacific coast region is shown by the vertical intergradation of *B. uncitoides* (Pavlow) through *B.*

TABLE 3.—*Characteristic Early Cretaceous (Berriasian and*

Buchia species	Relative size	Shape of valve			Beaks
		Cross section	Left valve	Right valve	Left valve
B. crassicollis solida (Lahusen).	Small to medium.	Strongly arched. Thickest near middle of shell.	Short, plump. Resembles shape of *B. pacifica.* Ventral margin tapers gradually.	Subrectangular, much less convex and much smaller than left valve. Ventral margin tapers gradually.	Long, hooklike. More or less strongly coiled. Overhangs beak of right valve. Straight or curved feebly left or right.
B. inflata (Toula).	Small to medium.	Very convex, nearly equivalved.	Short, plump. Ventral margin tapers. Hardly any ear.	Slightly smaller than left valve. Hardly any ear.	Blunt, short, curved to left. Does not overhang right valve.
B. keyserlingi (Lahusen).	Medium to giant.	Moderately convex. Nearly equivalved.	Subovate, rounded, a little longer than wide. Hardly any ear.	Nearly as convex as left valve. Hardly any ear.	Short, blunt, nearly straight or curved slightly to left. Does not overhang right valve.
B. pacifica (Jeletzky).	Large to medium.	Highly convex. Thick__	Short, swollen. Always larger, thicker, and longer than right valve. Ventral margin truncated.	Generally swollen. Slightly to considerably smaller than left valve. Ventral margin truncated.	Sharp, fairly long, strongly incurved. Generally overhangs beak of right valve. Pronounced left-handed curvature.
B. tolmatschowi (Sokolov).	Large to medium.	Thick, rounded, trapezoidal to quadrangular. Generally thickest in dorsal third or uncommonly near middle.	Narrow, long to very long, subtriangular. Always higher than wide. Tapers ventrally.	Similar to left valve. Varies from nearly as convex to much less convex. Tapers ventrally.	Short to long. Strongly bent downward. Pronounced left-handed curvature. Long beaks overhang right valve and may be tightly coiled.
B. uncitoides (Pavlow).	Medium__	Generally highly convex with flat top and steep flanks. Thickness slightly less than or equal to width.	Obliquely elongate. Generally much longer than wide.	Almost as large and thick as left valve.	Long, sharp, not coiled, moderately downcurved. Normally does not overhang beak on right valve. Generally curves left.
B. okensis (Pavlow).	Large to giant.	Moderately convex. Thick. Inequivalved.	Shape varies from quadrate to pear shaped. Generally wider than high. Ear large and angular.	Ear large and angular. Gently convex to almost flat.	Curves downward regularly. Does not overhang right valve or have hooklike bend. Straight or curved feebly left or right.

tolmatschowi (Sokolov) into *B. pacifica* Jeletzky (1965, p. 37) and by an apparent intergradation of *B. pacifica* through *B. inflata* (Toula) var. *crassa* (Pavlow) into *B. inflata* (Toula) (Jeletzky, 1965, p. 47, pl. 17, figs. 2, 4).

The age of the *Buchia pacifica* zone in the Pacific coast region, judging by the ranges of the pelecypods *Buchia inflata* (Toula), *B. crassa* (Pavlow), and *B. keyserlingi* (Lahusen) in northern Eurasia, could be late Berriasian (*Tollia tolli* zone) to middle Valanginian *Polyptychites michalskii* zone). However, ammonites indicate the age of the *Buchia pacifica* zone is probably early to middle Valanginian. This is shown by the presence of *Thurmanniceras* near its base, of *Thurmanniceras* and *Kilianella* throughout its middle third, and of *Sarasinella*, *Kilianella*, and *Tollia* at its top. The presence of *Thurmanniceras* near its base suggests an age not older than Valanginian (Busnardo, and others, 1965, p. 27, 32). The presence of *Tollia* at its top indicates an age not younger than middle Valanginian (Sachs and others, 1963, p. 68, table 7). Such an age is supported by the stratigraphic position of the *B. pacifica* beds below beds containing ammonites of late Valanginian age.

BUCHIA KEYSERLINGI ZONE

In northwestern California, *Buchia keyserlingi* (Lahusen) (1888, p. 40, 41, pl. 4, figs. 18–23; Pavlow, 1907, p. 62, 63, pl. 4, figs. 17–19) is the dominant species in beds directly overlying the *Buchia pacifica* zone, although the species occurs also in the *Buchia pacifica* zone. In Canada, *B. keyserlingi* has a longer strati-

Valanginian) species of Buchia *in the Pacific Coast States*

Beaks—Continued	Concentric markings		Distinguishing features
Right valve	Ribs	Constrictions	
Short, small, moderately sharp, feebly incurved to left.	Finely and densely ribbed and (or) striated. Nearly smooth on internal mold.	A few broad constrictions and welts present.	Differs from *B. pacifica* by being finely ribbed or striated instead of coarsely ribbed, its right valve is much less convex, its ventral margin tapers gradually, and the beak on its left valve is straight or curved feebly.
Short, pointed, slightly smaller than on left valve.	Fine, regular, mostly dense.	----------------	Differs from *B. pacifica* in its generally smaller size, thinner and less swollen shell, tapered ventral margin, and lesser left-handed curvature of beaks. Grades through *B. inflata crassa* (Pavlow) into *B. pacifica* Jeletzky.
Small, pointed------	Sharp, high, regular, fairly dense.	None----------	Differs from *B. uncitoides* by being shorter, broader, thinner, almost equivalved, and by having a shorter, blunter beak. Differs from *B. inflata* by having a straighter beak and higher and sharper ribs and by being less convex.
Sharp and incurved but relatively short. Has pronounced left-handed curvature.	Generally sharp and high on shell and mold. Dense to widely spaced. Some specimens are nearly smooth. Others are coarsely ribbed.	Prominent on both valves.	Characterized by large size, strongly swollen valves, ventral truncation, left-handed curvature of beaks, and prominent ribs and constrictions. Differs from *B. uncitoides* by being much shorter, thicker, and truncated ventrally, and by its beaks being more incurved and curve more to left.
Short to long, in some specimens as long as on left valve.	Bears fine concentric striae, or weak to strong ribs that are irregularly spaced.	Constrictions present or absent.	Differs from *B. pacifica* in being longer, by its shell tapering gradually ventrally instead of being truncated abruptly, and by absence of regularly spaced concentric ribs on shell or on internal mold. Grades into *B. pacifica* and into *B. uncitoides.*
Sharp, incurved, shorter and smaller than on left valve.	Generally fine, closely spaced, and sharp. Some variants are coarsely-ribbed and some bear mostly fine concentric striae.	None----------	Differs from *B. tolmatschowi* by having a thinner and wider shell; much less pronounced left-handed curvature of beaks; and commonly much sharper, more closely-spaced ribs; and by its right valve being less convex and wider. Small forms resemble *B. piochii.*
--------------------	Very coarse and widely spaced.	None----------	Differs from *B. pacifica* by having a wider and lower shell, a large angular ear, a posteriorly oblique shell, flatter right valves, uniquely coarse and widely spaced ribs, and mostly straight instead of strongly left-handed beaks. Grades into *B. fischeriana* and *B. uncitoides.*

graphic span and ranges from the upper part of the *Buchia uncitoides* zone to the very top of the *Buchia*-bearing beds (Jeletzky, 1965, p. 31, 33, 49, 62, text figs. 1, 3). The species (pl. 5, figs. 12–15, 18–33) is characterized by moderately convex, nearly equal valves and by sharp, high, regular, closely spaced concentric ribs. Its characteristics and differences from other species have been discussed in detail by Jeletzky (1965, p. 31, pl. 10, fig. 1, pl. 11, fig. 1, pl. 12, figs. 1, 2, pl. 19, figs. 1, 2, 5, 7) and are summarized herein in table 3. Some typical specimens from California have been illustrated by Imlay (1959, pl. 19, figs. 1, 2, 7, 8, 15).

In the Elk Creek quadrangle, the *Buchia keyserlingi* zone has been identified faunally on Grindstone Creek by its characteristic species and on nearby Watson Creek by *Thurmanniceras jenkinsi* Anderson (Mesozoic loc. M1575).

Mollusks other than *Buchia* in the *Buchia keyserlingi* zone of the Paskenta quadrangle include the following:

Anomia senescens Stanton (USGS Mesozoic loc. 1087)
Nucula gabbi Stanton (USGS Mesozoic loc. 1088)
Astarte trapezoidalis Stanton (USGS Mesozoic loc. 1088)
Turbo? trilineatus Stanton (USGS Mesozoic loc. 1088)
?humerosus Stanton (USGS Mesozoic loc. 1088)
Belemnites impressus Gabb (USGS Mesozoic loc. 1088)
Lytoceras saturnale Anderson (USGS Mesozoic loc. 1087)
Crioceratites sp. (USGS Mesozoic loc. 1009, equals 1087)
Thurmanniceras jenkinsi (Anderson) (USGS Mesozoic locs. 1088, 1091, M1575, M1578, M1579, M3058, M3083, UC B–5085)
stippi (Anderson) (USGS Mesozoic locs. 1091, M1580, M3059, M3084)

cf. *T. stippi* (Anderson) (USGS Mesozoic loc. M3082)
Polyptychites trichotomus (Stanton) (USGS Mesozoic loc. 1087)
sp. (USGS Mesozoic loc. M1577)
Neocraspedites giganteus Imlay (USGS Mesozoic locs. 1009, 1087, 1088(?), 1091).
Sarasinella cf. *S. subspinosa* Uhlig (USGS Mesozoic loc. M3060)
cf. *S. uhligi* (Spath) (UC 2605)

Mollusks other than rare specimens of *Buchia* in the *Buchia keyserlingi* zone of the Colyear Springs quadrangle include the following:

Olcostephanus cf. *O. atherstoni* Baumberger [not Sharpe] (USGS Mesozoic locs. M2680, 29555, and 29485)
Polyptychites sp. (USGS Mesozoic loc. 29555)
Neocomites cf. *N. neocomiensis* (d'Orbigny) (USGS Mesozoic loc. M2680)
cf. *N. neocomiensis* (d'Orbigny) var. *premolica* Sayn (USGS Mesozoic loc. M2680)
cf. *N. wichmanni* Leanza (USGS Mesozoic locs. M2679 and M2680)
Thurmanniceras cf. *T. jenkinsi* (Anderson) (USGS Mesozoic loc. M2040)

The stratigraphic positions of the mollusks within the *Buchia keyserlingi* zone in the Paskenta quadrangle are fairly well known. *Thurmanniceras jenkinsi* (Anderson) ranges from near the base (Mesozoic loc. 1088) to about 2,450 feet above the base (Mesozoic locs. 1091, M1579, M3058, UC B–5085). *T. stippi* (Anderson) ranges from 450 feet (Mesozoic loc. M3059) to 1,700 feet above the base (Mesozoic loc. 1091). *Polyptychites* sp. was found only about 1,250 feet above the base and *Sarasinella* cf. *S. subspinosa* Uhlig within 100 feet of the base. The holotype of *Neocraspedites giganteus* Imlay as well as all species listed from USGS Mesozoic localities 1009, 1087, M3082, M3083 and M3084 and U.C. locality 2605 are from a faulted area and consequently their exact stratigraphic positions cannot be determined. The illustrated paratypes of *N. giganteus* Imlay are from near the base (Mesozoic loc. 1088) and near the top (Mesozoic loc. 1091) of the *B. keyserlingi* zone. Among these ammonites, *Thurmanniceras jenkinsi* is the only mollusk other than the pelecypod *Buchia keyserlingi* that occurs in sufficient abundance to be useful as a guide fossil.

The stratigraphic positions of the mollusks within the *Buchia keyserlingi* zone in the Colyear Springs quadrangle are definitely low in the zone. Most of the ammonites listed were collected near each other within a stratigraphic interval of several hundred feet and about at the top of the lower fourth or fifth of the zone. The specimen of *Thurmanniceras*, however, was collected at a different place, nearer the faulted lower contact of the *Buchia*-bearing beds, and presumably at a lower stratigraphic position than the other ammonites.

The age of the *Buchia keyserlingi* zone in the Paskenta quadrangle, California, is definitely Valanginian as shown by the presence of such genera as *Sarasinella*, *Polyptychites*, and by an abundance of *Thurmanniceras*. The association of *Neocraspedites*, *Crioceratites*, and *Polyptychites* at one place (Mesozoic locs. 1009 and 1087) is good evidence for a late Valanginian age (Imlay, 1960, p. 172, 174). An age not older than middle Valanginian for the *B. keyserlingi* zone is indicated by its superposition on the *B. pacifica* zone whose upper part is probably of middle Valanginian age.

The age of the *Buchia keyserlingi* zone in the Colyear Springs quadrangle, California, is likewise definitely Valanginian as shown by the association of such genera as *Olcostephanus*, *Polyptychites*, and *Neocomites*. An age not older than middle Valanginian is suggested by the presence of a coarsely ribbed species of *Olcostephanus*. The zone cannot represent the latest Valanginian because it is overlain by the *Buchia crassicollis solida* zone of latest Valanginian age.

BUCHIA CRASSICOLLIS SOLIDA ZONE

The highest *Buchia*-bearing beds in northwestern California, found only north of the Elder Creek fault in Colyear Springs quadrangle, are characterized by a plump, nearly smooth, constricted species of *Buchia* (pl. 5, figs. 1–11, 16, 17) that is assigned herein to *B. crassicollis* (Keyserling) subspecies *solida* (Lahusen) as defined by Jeletzky (1965, p. 50–52, pl. 20, figs. 1, 8–12, pl. 21, figs. 2, 5–7, pl. 22, fig. 1). The characteristics of this subspecies are shown on table 3. Jeletzky (1965, p. 51) states frankly, however, that he is unable to interpret the original descriptions and illustrations of *B. crassicollis* published by Keyserling (1846, p. 300, pl. 16, figs. 9–12), but does follow the specific definition published by Lahusen (1888, p. 24, 25, pl. 5, figs. 8–16) and Sokolov (1908, p. 24, pl. 3, figs. 6–12). Jeletzky states, furthermore, that if the species as defined by Lahusen and Sokolov should prove to be specifically distinct from the original specimens described by Keyserling, then "it would be necessary to use the name *B. solida* (Lahusen, 1888) for the species here referred to as *B. crassicollis* (Keyserling, 1846) s. str."

The possibility that *B. crassicollis* (Keyserling) is specifically distinct from the specimens that Jeletzky refers to that species is indicated by the pronounced left curvature of the beak on the left valve of one of the cotypes of *B. crassicollis* (Keyserling) (1846, pl. 16, fig. 10). This curvature contrasts markedly with the straight or feebly curved beak on the left valves of *B. crassicollis* as defined by Jeletzky (1965, p. 50, pl. 20, figs. 8a and 10d, pl. 21, figs. 2c, 5c, 7c).

The *Buchia crassicollis solida* zone in northwestern California has not furnished ammonites other than fragmentary *Lytoceras* which are of no value for a close age determination. Its age is considered to be Valanginian, however, because it contains the highest Buchias found in the Pacific coast region, because its characteristic species of *Buchia* is common in northern Eurasia in the upper part of the Valanginian (Jeletzky, 1965, p. 54), and because in Oregon, *B. crassicollis solida* is associated with the ammonites *Olcostephanus* and *Homolsomites* beneath beds containing early Hauterivian ammonites (Imlay and others, 1959, p. 2775; Imlay, 1960, p. 175, 201–203).

DESCRIPTIONS OF MENTIONED U.S. GEOLOGICAL SURVEY MESOZOIC FOSSIL LOCALITIES

Locality

666. On ridge about 3 miles directly west of the Lowrey Ranchhouse. Probably NW¼ sec. 24, T. 25 N., R. 7 W., Tehama County, Calif. Probably near middle of *Buchia piochii* zone. J. S. Diller, 1889.

1001. One-half mile east of Henderson's house, NW¼ sec. 29, T. 24 N., R. 6 W., Tehama County, Calif. Near middle of *Buchia pacifica* zone. J. S. Diller and James Storrs, 1893.

1009. On hill, 500 ft east of road in south-central part sec. 28, T. 27 N., R. 6 W., Tehama County, Calif. *Buchia keyserlingi* zone. J. S. Diller and James Storrs, 1893.

1010. About half a mile northwest of Shelton's Ranchhouses (abandoned), NW¼ sec. 9, T. 24 N., R. 6 W., Tehama County, Calif. At top of *Buchia pacifica* zone. J. S. Diller and James Storrs, 1893.

1084. One mile northwest of Cooper's Ranchhouse. Probably NE¼ sec. 1, T. 24 N., R. 7 W., Tehama County, Calif. Probably 2,000–3,000 ft below top of *Buchia piochii* zone. James Storrs and T. W. Stanton, 1893.

1085. Near South Fork of Elder Creek just west of Cooper's house, NE. cor. SW¼SW¼ sec. 6, T. 24 N., R. 6 W., Tehama County, Calif. Near top of *Buchia piochii* zone. James Storrs and T. W. Stanton, 1893.

1087. Same as loc. 1009.

1088. About half a mile east of road and three-fourths mile north of the Wilcox Ranchhouse, north-central part of sec. 33, T. 25 N., R. 6 W., Tehama County, Calif. Probably near base of *Buchia keyserlingi* zone. J. S. Diller, T. W. Stanton, and James Storrs, 1893.

1091. About half a mile east of Wilcox Ranchhouse. NE¼ NW¼ NE¼ sec. 4, T. 24 N., R. 6 W., Tehama County, Calif. About 1,550 ft above base of *Buchia keyserlingi* zone. T. W. Stanton, J. S. Diller, and James Storrs, 1893.

1093. Same as loc. 1010.

1095. Same as loc. 1001.

2267. About half a mile north of loc. 1091 and 400–500 ft higher stratigraphically, SE. cor. sec. 33, T. 25 N., R. 6 W., Tehama County, Calif. T. W. Stanton, 1900.

Locality

2268. About three-fourths of a mile southeast of Wilcox Ranchhouse, east-central part of sec. 4, T. 24 N., R. 6 W., Tehama County, Calif. T. W. Stanton, 1900.

2269. Same as loc. 2268 except 8 ft lower stratigraphically. T. W. Stanton, 1900.

2275. Five miles west of Lowrey's Ranchhouse in gulch south of North Fork of Elder Creek, Tehama County, Calif. In lower part of *Buchia piochii* zone. T. W. Stanton, 1900.

2286. On Stony Creek about half a mile northeast of town of Elk Creek. SW. cor. sec. 3, T. 20 N., R. 6 W., Glenn County, Calif. From 425 ft of greenish-gray sandstone in *Buchia uncitoides* zone. T. W. Stanton, 1900.

5339. One-third mile west of Wilcox Ranchhouse, NW¼ sec. 4, T. 24 N., R. 6 W., Tehama County, Calif. James Storrs, 1908.

26789. On South Umpqua River near Days Creek in NW¼ sec. 15, T. 30 N., R. 4 W., Douglas County, Oreg. From 175 ft above base of type section of Days Creek Formation. R. W. Imlay and Norman Peterson, 1957.

29485. South side of South Fork of Cottonwood Creek, 1,350 ft east and 670 ft south of NW. cor. sec. 12, T. 26 N., R. 8 W., Tehama County, Calif. *Buchia keyserlingi* zone D. L. Jones and R. W. Imlay, 1966.

29489. Creek bed 300 ft southwest of Oakes Ranchhouse, 2,500 ft west of SE. cor. and just north of south line of sec. 30, T. 25 N., R. 6 W., Tehama County, Calif. Lower third of *Buchia* aff. *B. okensis* zone. D. L. Jones and R. W. Imlay, 1966.

29492. From a small tributary of Heifer Camp Creek, 1,250 ft east and 1,800 ft north of SW. cor. sec. 9, T. 22 N., R. 6 W., Glenn County, Calif. About 5,000 ft below top of *Buchia piochii* zone. D. L. Jones and R. W. Imlay, 1966.

29493. From an unnamed eastern tributary of Heifer Camp Creek, one-fourth mile above junction with North Fork of Stony Creek, 250 ft east and 1,400 ft north of SW. cor. sec. 3, T. 22 N., R. 6 W., Glenn County, Calif. *Buchia piochii* zone, within 1,000 ft of top. D. L. Jones and R. W. Imlay, 1966.

29494. At sharp bend in road about 700 ft east-southeast of center of sec. 6, T. 21 N., R. 6 W., Glenn County, Calif. About 10,000 ft below top of *Buchia piochii* zone. D. L. Jones and R. W. Imlay, 1966.

29498. From 400 ft west of NE. cor. and near north line of sec. 4, T. 21 N., R. 6 W., Glenn County, Calif. About 400 ft below top of *Buchia uncitoides* zone. D. L. Jones and R. W. Imlay, 1966.

29499. Same as loc. 29498 except 100 ft higher stratigraphically.

29504. About 450 ft east of NW. cor. sec. 3, T. 21 N., R. 6 W., Glenn County, Calif. Upper part of *Buchia pacifica* zone. D. L. Jones and R. W. Imlay, 1966.

29505. On McCarty Creek, 1,600 ft west and 550 ft south of NE. cor. sec. 30, T. 24 N., R. 6 W., Tehama County, Calif. About base of upper third of *Buchia uncitoides* zone. John Warren, 1965.

Locality

29555. North side of South Fork of Cottonwood Creek, 1,000 ft east and 1,350 ft south of NW. cor. sec. 12, T. 26 N., R. 8 W., Tehama County, Calif. *Buchia keyserlingi* zone. D. L. Jones, 1967.

29566. Middle Fork of Elder Creek, 100 ft upstream from bridge, east-central part of sec. 20, T. 25 N., R. 6 W., Tehama County, Calif. *Buchia crassicollis solida* zone. D. L. Jones, 1967.

29592. North side of South Fork of Elder Creek, one-fourth of a mile northeast of Cooper's Ranchhouse (now Ray Borello's), north-central part NE¼SW¼ sec. 6, T. 24 N., R. 6 W., Tehama County, Calif. Probably near middle of *Buchia* aff. *B. okensis* zone. R. W. Imlay, 1967.

29593. In gully 400 ft north and 1,400 ft west of SE. cor. sec. 8, T. 24 N., R. 6 W., Tehama County, Calif. From lower 150 ft of *Buchia pacifica* zone. W. O. Ross and R. W. Imlay, 1967.

29596. About 750 ft east and 1,650 ft south of NW. cor. sec. 9, T. 24 N., R. 6 W., Tehama County, Calif. Near base of upper third of *Buchia pacifica* zone. W. O. Ross, 1967.

29597. About 1,250 ft east and 1,050 ft south of NW. cor. sec. 9, T. 24 N., R. 6 W., Tehama County, Calif. About 200 ft below top of *Buchia pacifica* zone. R. W. Imlay, 1967.

29598. About 500 ft west and 1,700 ft north of SE. cor. sec. 8, T. 24 N., R. 6 W., Tehama County, Calif. About top of lower third of *Buchia pacifica* beds. W. O. Ross, 1967.

29604. South bank of South Fork of Elder Creek SE¼SE¼NW¼ sec. 32, T. 25 N., R. 6 W., Tehama County, Calif. About same spot as M3092. Near base of upper third of *Buchia uncitoides* zone. R. W. Imlay, 1967.

29606. One-third mile east of South Fork of Elder Creek, SE¼NE¼NE¼ sec. 32, T. 25 N., R. 6 W., Tehama County, Calif. At top of *Buchia uncitoides* zone, 60 ft stratigraphically below lowest *Buchia pacifica*. W. O. Ross and R. W. Imlay, 1967.

M703. On Stony Creek, 2,050 ft east and 500 ft south of NW. cor. sec. 3, T. 20 N., R. 6 W., Glenn County, Calif. *Buchia pacifica* zone. Stewart Chuber, 1957 or 1958.

M745. Little Indian Creek, 200 ft east and 2,000 ft north of SW. cor. sec. 36, T. 17 N., R. 6 W., Glenn County, Calif. *Buchia pacifica* zone. R. D. Brown, Jr., 1959.

M880. Grindstone Creek, 650 ft west and 2,300 ft north of SE. cor. sec. 16, T. 21 N., R. 6 W., Glenn County, Calif. *Buchia* aff. *B. okensis* zone. Stewart Chuber, 1958 or 1959.

M888. About 3 miles south of Elk Creek village, 1,100 ft east and 400 ft south of NW. cor. sec. 28, T. 20 N., R. 6 W., Glenn County, Calif. *Buchia piochii* zone. Stewart Chuber, 1958 or 1959.

M1004. In tributary to Water Canyon, 750 ft west and 1,875 ft north of SE. cor. sec. 11, T. 18 N., R. 6 W., Glenn County, Calif. *Buchia uncitoides* zone. R. D. Brown, Jr. and E. I. Rich, about 1959.

Locality

M1012. East side of Green Valley, about 200 ft north of Stonyford quadrangle and 100 ft below basaltic sandstone, sec. 17, T. 19 N., R. 6 W., Glenn County, Calif. *Buchia piochii* zone. R. D. Brown, Jr. and E. I. Rich, about 1959.

M1575. Just north of junction of Watson Creek and Grindstone Creek, 900 ft east and 1,400 ft south of NW. cor. sec. 15, T. 21 N., R. 6 W., Glenn County, Calif. Probably *Buchia keyserlingi* zone. D. L. Jones and R. W. Imlay, 1962.

M1577. South of northern tributary to Mill Creek, 1,600 ft west and 1,900 ft south of NE. cor. sec. 4, T. 24 N., R. 6 W., Tehama County, Calif. About 1,250 ft above base of *Buchia keyserlingi* zone. D. L. Jones and R. W. Imlay, 1962.

M1578. About 200 ft west of loc. M1577 and about 1,075 ft above base of *Buchia keyserlingi* zone. D. L. Jones and R. W. Imlay, 1962.

M1579. North of northern tributary to Mill Creek, 1,200 ft west and 500 ft south of NE. cor. sec. 4, T. 24 N., R. 6 W., Tehama County, Calif. About 1,550 ft above base of *Buchia keyserlingi* zone. D. L. Jones and R. W. Imlay, 1962.

M1580. McCarty Creek, 300 ft west and 1,800 ft south of NE. cor. sec. 29, T. 24 N., R. 6 W., Tehama County, Calif. About 1,000 ft above base of *Buchia keyserlingi* zone. D. L. Jones and R. W. Imlay, 1962.

M2010. On south side of North Fork of Elder Creek, 2,500 ft west and 1,700 ft north of SE. cor. sec. 12, T. 25 N., R. 7 W., Tehama County, Calif. *Buchia crassicollis solida* zone. E. H. Bailey, 1963.

M2018. On south side of De Haven Gulch, 500 ft west and 2,150 ft north of SE. cor. sec. 14, T. 25 N., R. 7 W., Tehama County, Calif. *Buchia piochii* zone. E. H. Bailey, 1963.

M2025. North side of Middle Fork of Elder Creek at spillway from pond, 1,052 ft east and 1,900 ft north of SW. cor sec. 20, T. 25 N., R. 6 W., Tehama County, Calif. About 2,000 ft above base of *Buchia uncitoides* beds. E. H. Bailey, 1963, and R. W. Imlay, 1965.

M2030. On South Fork of Cottonwood Creek, 1,500 ft west and 1,000 ft south of NE. cor. sec. 7, T. 26 N., R. 7 W., Tehama County, Calif. *Buchia keyserlingi* zone. E. H. Bailey, 1963.

M2040. Sunflower Trail on north bank of Red Bank Creek, 1,200 ft west and 600 ft south of NE. cor. sec. 20, T. 26 N., R. 7 W., Tehama County, Calif. *Buchia keyserlingi* zone. E. H. Bailey, 1963.

M2253. On Watson Creek 500 ft northwest of cemetery, 600 ft west and 700 ft south of NE. cor. sec. 16, T. 21 N., R. 6 W., Glenn County, Calif. *Buchia* aff. *B. okensis* zone. D. L. Jones, 1964.

M2281. Southeast of Hensley Springs, 1,800 ft west and 1,500 ft north of SE. cor. sec. 13, T. 26 N., R. 8 W. Tehama County, Calif. *Buchia keyserlingi* zone, D. L. Jones, 1964.

M2284. South bank of Grindstone Creek, 230 ft east of west line of sec. 15, T. 21 N., R. 6 W., Glenn County Calif. *Buchia pacifica* zone. D. L. Jones, 1964.

Locality

M2285. South bank of Grindstone Creek, 120 ft east of west line of sec. 15, T. 21 N., R. 6 W., Glenn County, Calif. *Buchia uncitoides* zone. D. L. Jones, 1964.

M2286. South bank of Grindstone Creek, 10 ft east of west line of sec. 15, T. 21 N., R. 6 W., Glenn County, Calif. *Buchia uncitoides* zone. D. L. Jones, 1964.

M2287. South bank of Grindstone Creek, 225 ft west of east line of sec. 16, T. 21 N., R. 6 W., Glenn County, Calif. Near base of *Buchia uncitoides* zone. D. L. Jones, 1964.

M2598. South bank of Grindstone Creek, 300 ft west of east line of sec. 16, T. 21 N., R. 6 W., Glenn County, Calif. A few feet above base of *Buchia uncitoides* zone. D. L. Jones, 1964.

M2599. South bank of Grindstone Creek, 450 ft west of east line of sec. 16, T. 21 N., R. 6 W., Glenn County, Calif. About base of upper third of *Buchia* aff. *B. okensis* zone. D. L. Jones, 1964.

M2600. South bank of Grindstone Creek, 500 ft west of east line of sec. 16, T. 21 N., R. 6 W., Glenn County, Calif. Near middle of *Buchia* aff. *B. okensis* zone. D. L. Jones, 1964.

M2601. South bank of Grindstone Creek, 600 ft west of east line of sec. 16, T. 21 N., R. 6 W., Glenn County, Calif. Near top of lower third of *Buchia* aff. *B. okensis* zone. D. L. Jones, 1964.

M2602. South bank of Grindstone Creek, 400 ft west of east line of sec. 16, T. 21 N., R. 6 W., Glenn County, Calif. About 85 ft below top of *Buchia* aff. *B. okensis* zone. D. L. Jones, 1964.

M2603. South bank of Grindstone Creek, 340 ft west of east line of sec. 16, T. 21 N., R. 6 W., Glenn County, Calif. About 35 ft below top of *Buchia* aff. *B. okensis* zone. D. L. Jones, 1964.

M2604A. South bank of Grindstone Creek, 560 ft west of east line of sec. 16, T. 21 N., R. 6 W., Glenn County, Calif. A little below middle of *Buchia* aff. *B. okensis* zone. D. L. Jones, 1964.

M2604B. Same as loc. M2604A except 15 ft farther west.

M2604C. Same as loc. M2604A except 20 ft farther west.

M2605. South bank of Grindstone Creek, 775 ft west of east line of sec. 16, T. 21 N., R. 6 W., Glenn County, Calif. A few feet below top of *Buchia piochii* zone. D. L. Jones, 1964.

M2606. South bank of Grindstone Creek, 830 ft west of east line of sec. 16, T. 21 N., R. 6 W., Glenn County, Calif. About 65 ft below top of *Buchia piochii* zone. D. L. Jones, 1964.

M2679. West bank of South Fork of Cottonwood Creek at boundary line between secs. 2 and 11, 500 ft west of SE. cor. sec. 2, T. 26 N., R. 8 W., Tehama County, Calif. *Buchia keyserlingi* zone. D. L. Jones, 1964.

M2680. East bank of Cottonwood Creek, 300 ft west and 650 ft south of NE. cor. sec. 11, T. 26 N., R. 8 W., Tehama County, Calif. *Buchia keyserlingi* zone. D. L. Jones, 1964.

M2734. On Sunflower Gulch Creek, 975 ft north and 2,550 ft west of SE. cor. sec. 30, T. 26 N., R. 6 W., Tehama County, Calif. *Buchia crassicollis solida* zone. D. L. Jones, 1965.

Locality

M3029. Watson Creek, 216 ft southeast of bridge which is 1,100 ft west and 800 ft south of NE. cor. sec. 16, T. 21 N., R. 6 W., Glenn County, Calif. *Buchia* aff. *B. okensis* zone. D. L. Jones, 1965.

M3037. At center of easterly curve in road, 2,350 ft west and 2,150 ft north of SE. cor. sec. 6, T. 21 N., R. 6 W., Glenn County, Calif. About same spot as loc. 29494. About 10,000 ft below top of *Buchia piochii* zone. D. L. Jones, 1965.

M3044. On road to Maupin Flat about 200 ft north of McCarty Creek, 300 ft west and 600 ft south of NE. cor. sec. 29, T. 24 N., R. 6 W., Tehama County, Calif. *Buchia uncitoides* zone, about 1,200 ft below top. D. L. Jones, 1965.

M3045. South bank of Grindstone Creek, 200 ft east of dam and 425 ft east of west line and 1,980 ft north of SW. cor. sec. 15, T. 21 N., R. 6 W., Glenn County, Calif. *Buchia keyserlingi* zone. D. L. Jones and R. W. Imlay, 1965.

M3046. South bank of Grindstone Creek, 342 ft west of dam and 242 feet west of east line of sec. 16, T. 21 N., R. 6 W., Glenn County, Calif. About top of lower third of *Buchia uncitoides* zone. D. L. Jones and R. W. Imlay, 1965.

M3047. South bank of Grindstone Creek, 940 ft west of dam and 750 ft west of east line of sec. 16, T. 21 N., R. 6 W., Glenn County, Calif. base of *Buchia* aff. *B. okensis* zone. D. L. Jones and R. W. Imlay, 1965.

M3048. South bank of Grindstone Creek, 100 ft east of dam and 325 ft east of west line of sec. 15, T. 21 N., R. 6 W., Glenn County, Calif. Near middle of *Buchia pacifica* zone. D. L. Jones and R. W. Imlay, 1965.

M3049. On ridge between South Fork of Elder Creek and road to Red Bluff, 200 ft west and 750 ft south of NE. cor. sec. 32, T. 25 N., R. 6 W., Tehama County, Calif. About 80 ft above base of *Buchia pacifica* zone. R. W. Imlay, 1965.

M3057. On ridge between the South Fork of Elder Creek and road to Red Bluff, 400 ft west and 650 ft south of NE. cor. sec. 32, T. 25 N., R. 6 W., Tehama County, Calif. Near top of *Buchia uncitoides* zone and about 100 ft below loc. 29606. R. W. Imlay, 1965.

M3058. On hill half a mile south of Mill Creek, 1,900 ft west and 2,000 ft south of NE. cor. sec. 9, T. 24 N., R. 6 W., Tehama County, Calif. About 1,530 ft above base of *Buchia keyserlingi* zone. R. W. Imlay, 1965.

M3059. On hill south of Mill Creek, 2,200 ft east and 2,000 ft south of NW. cor. sec. 9, T. 24 N., R. 6 W., Tehama County, Calif. About 450 ft above base of *Buchia keyserlingi* zone. R. W. Imlay, 1965.

M3060. About half a mile south of Mill Creek at base of northeast end of prominent knoll, 1,750 ft east and 2,000 ft south of NW. cor. sec. 9, T. 24 N., R. 6 W., Tehama County, Calif. In lower 200 ft of *Buchia keyserlingi* zone. R. W. Imlay, 1965.

Locality

M3061. At top of prominent knoll about half a mile south of Mill Creek, 1,500 ft east and 2,400 ft south of NW. cor. sec. 9, T. 24 N., R. 6 W., Tehama County. Calif. At top of *Buchia pacifica* zone. Same as locs. 1010 and 1093. R. W. Imlay, 1965.

M3064. About half a mile south of Mill Creek on east side of prominent sandstone ridge, 1,400 ft west and 2,800 ft south of NE. cor. sec. 8, T. 24 N., R. 6 W., Tehama County, Calif. Near top of *Buchia uncitoides* zone. R. W. Imlay, 1965.

M3082. South side of road from Paskenta to Red Bluff, 800 ft southeast of bench mark 870 near South Fork of Elder Creek, 400 ft east and 2,000 ft south of NW. cor. sec. 28, T. 25 N., R. 6 W., Tehama County, Calif. *Buchia keyserlingi* zone. D. L. Jones, 1965.

M3083. South side of road from Paskenta to Red Bluff, 1,100 ft east and 1,750 ft north of SW. cor. sec. 28, T. 25 N., R. 6 W., Tehama County, Calif. *Buchia keyserlingi* zone. D. L. Jones, 1965.

M3084. On top of small knoll 600 ft north of road and 800 ft northeast of loc. M3083, Tehama County, Calif. *Buchia keyserlingi* zone. D. L. Jones, 1965.

M3085. On small hill east of road from Paskenta to Red Bluff, 800 ft north and 2,300 ft east of SW. cor. sec. 28, T. 25 N., R. 6 W., Tehama County, Calif. Probably same spot as locs. 1009 and 1087. *Buchia keyserlingi* zone. D. L. Jones, 1965.

Locality

M3092. South Fork of Elder Creek, 2,400 ft east and 2,500 ft south of NW. cor. sec. 32, T. 25 N., R. 6 W., Tehama County, Calif. Near base of upper third of *Buchia uncitoides* zone. D. L. Jones, 1965.

M3096. East bank of South Fork of Elder Creek, 300 ft east and 2,000 ft south of NW. cor. sec. 5, T. 24 N., R. 6 W., Tehama County, Calif. A little below middle of *Buchia uncitoides* zone. D. L. Jones, 1965.

M3097. South bank of South Fork of Elder Creek, 750 ft west and 1,750 ft north of SE. cor. sec. 6, T. 24 N., R. 6 W., Tehama County, Calif. Near top of lower fifth of the *Buchia uncitoides* zone. D. L. Jones, 1965.

M3098. East bank of South Fork of Elder Creek, 1,500 ft west and 1,350 ft north of SE. cor. sec. 6, T. 24 N., R. 6 W., Tehama County, Calif. Near top of lower tenth of *Buchia uncitoides* zone. D. L. Jones, 1967.

M4053. Heifer Camp Creek, 850 ft east and 1,150 ft north of SW. cor. sec. 9, T. 22 N., R. 6 W., Tehama County, Calif. About 5,000 ft below top of *Buchia piochii* zone. D. L. Jones and E. H. Bailey, 1966.

M4066. West of road to Maupin Flat, 2,500 ft east and 1,700 ft south of NW. cor. sec. 19, T. 24 N., R. 6 W., Tehama County, Calif. About 1,300 ft above base of *Buchia uncitoides* zone. D. L. Jones and E. H. Bailey, 1966.

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PLATES 1–5

PLATE 1

[All figures are natural size]

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4–6, 10. Right valve, left valve, and anterior and apical views of hypotype, USNM 161444 from USGS Mesozoic loc. M3047.

11–13. Anterior view, left valve, and right valve of hypotype, USNM 161442 from USGS Mesozoic loc. M3047.

14–17. Right valve, left valve, and anterior and apical views of hypotype, USNM 161443 from USGS Mesozoic loc. M3047.

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32. Left valve of specimen, USNM 161440 from USGS Mesozoic loc. 29489.

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BUCHIA TRIGONOIDES (LAHUSEN), *B.* AFF. *B. OKENSIS* (PAVLOW), AND *B. FISCHERIANA* (D'ORBIGNY)

PLATE 2

[All figures are natural size]

FIGURES 1–15. *Buchia terebratuloides* (Lahusen) (p. A10).

1–3. Left valve, right valve, and apical view of hypotype, USNM 161453 from USGS Mesozoic loc. M2604A.

4–6, 9. Left valve, anterior view, and right valve and apical view of hypotype, USNM 161451 from USGS Mesozoic loc. M2600.

7. Left valve of hypotype, USNM 161452 from USGS Mesozoic loc. M2604A.

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Left valve of hypotype, USNM 161423 from USGS Mesozoic loc. M2018. Note that umbo is longer and more slender than on *B. elderensis* (Anderson).

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25–27. Anterior view, left valve, and right valve of hypotype, USNM 161432 from USGS Mesozoic loc. M3037.

28–30. Posterior view, right valve, and left valve of hypotype, USNM 161429 from USGS Mesozoic loc. 29494.

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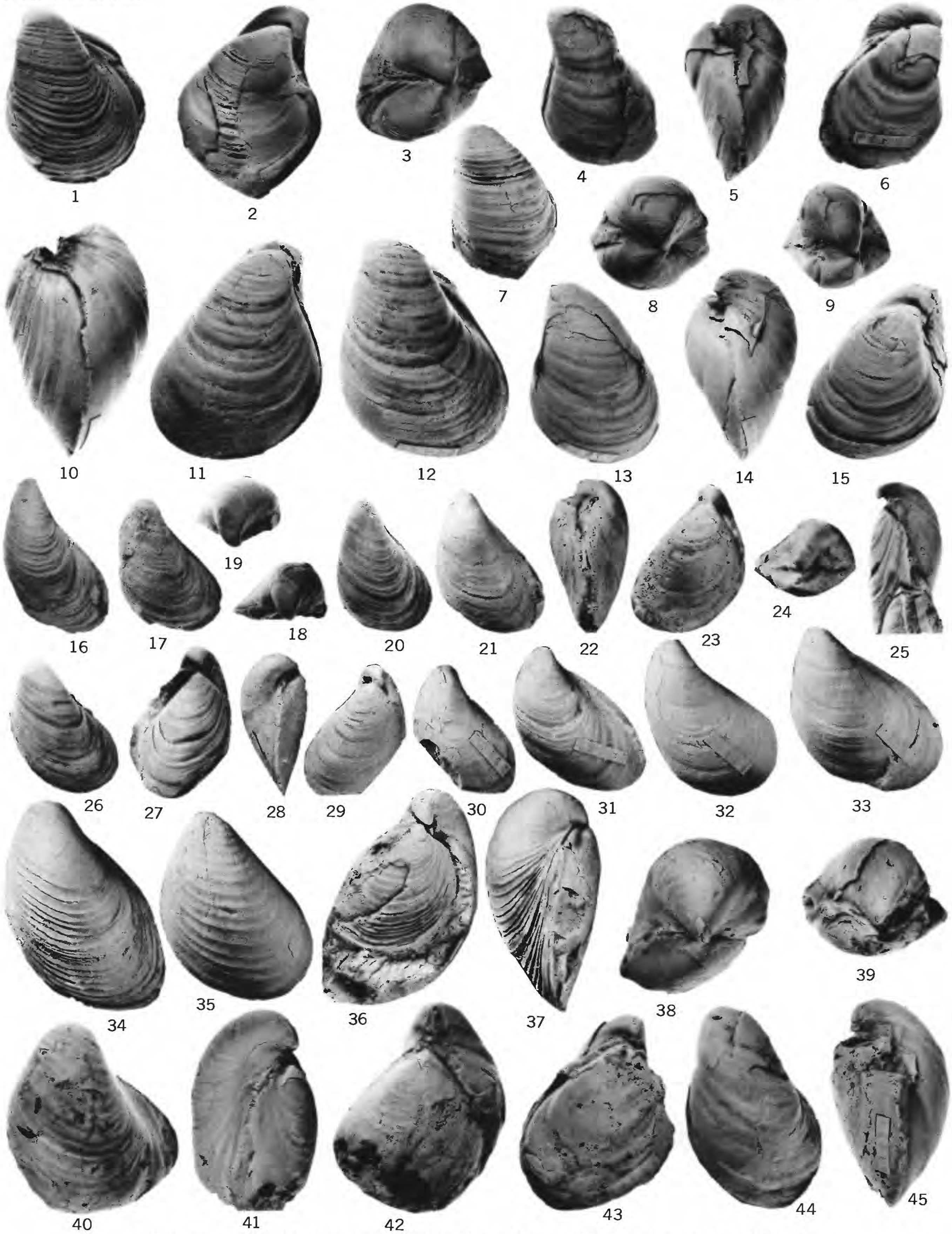
Left valve of hypotype, USNM 161446 from USGS Mesozoic loc. 29489.



BUCHIA TEREBRATULOIDES (LAHUSEN), *B. PIOCHII* (GABB), *B. ELDERENSIS* (ANDERSON), AND *B. TRIGONOIDES* (LAHUSEN)

PLATE 3

[All figures are natural size]

FIGURES 1–19. *Buchia uncitoides* (Pavlow) (p. A14).

1–4. Anterior view, left valve, apical view and right valve of hypotype, USNM 161456 from USGS Mesozoic loc. M1004.

5–7. Left valve, posterior view, and right valve of hypotype, USNM 161454 from USGS Mesozoic loc. 29499.

8–10. Left valve, posterior view, and right valve of hypotype, USNM 161460 from USGS Mesozoic loc. 29604.

11–13. Left valve, posterior view, and right valve of hypotype, USNM 161455 from USGS Mesozoic loc. 29499.

14–17. Apical view, left valve, anterior view and right valve of hypotype, USNM 161458 from USGS Mesozoic loc. M3046.

18. Left valve of hypotype, USNM 161457 from USGS Mesozoic loc. M3044.

19. Left valve of hypotype, USNM 161459 from USGS Mesozoic loc. 29498.

20–29. *Buchia piochii* (Gabb) (p. A10).

20–23. Hypotypes USNM 129053a–d from USGS Mesozoic loc. 2275. Shows typical elongate slender left valves.

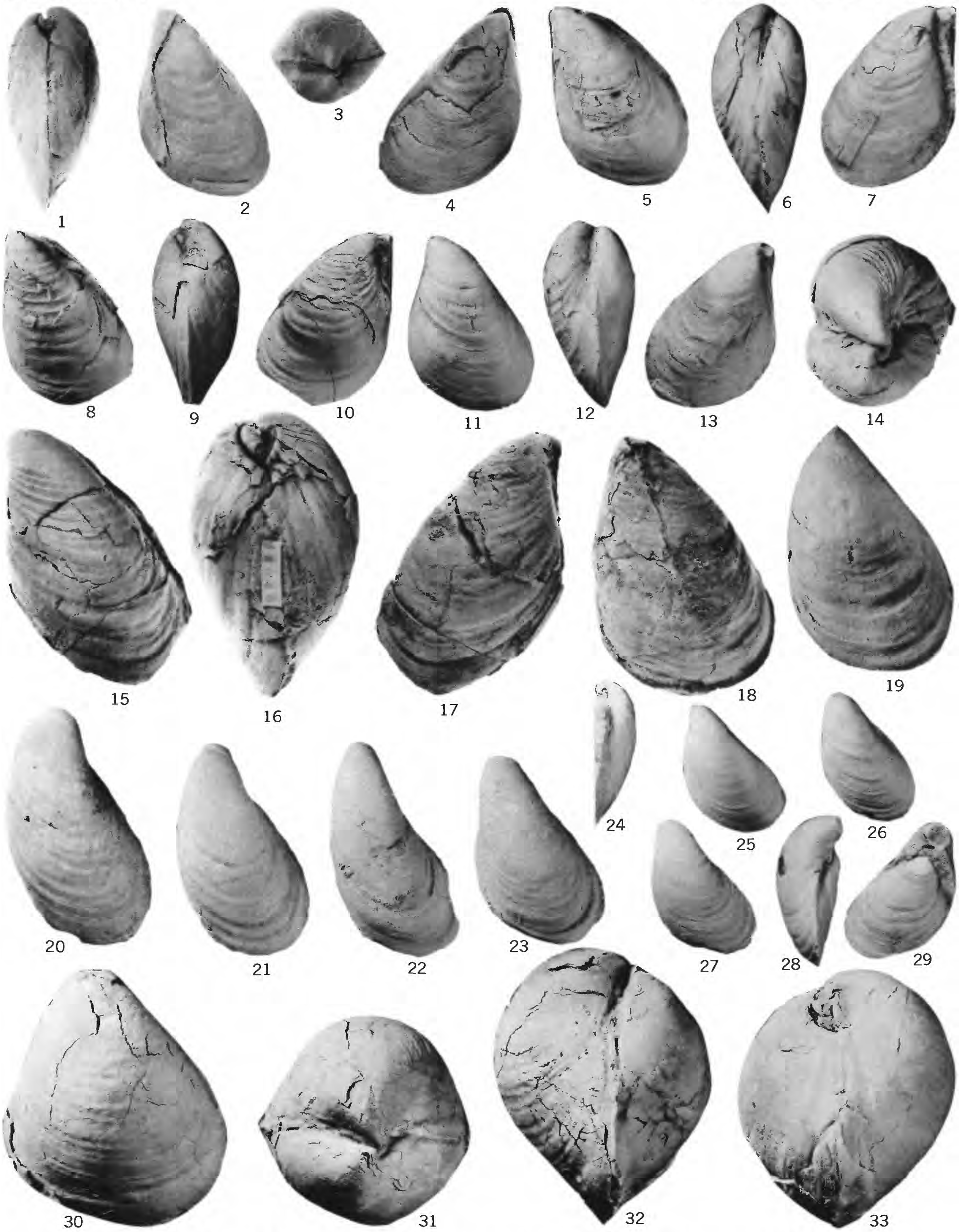
24, 25. Anterior view and left valve of hypotype, USNM 161425 from USGS Mesozoic loc. 29493.

26. Left valve of hypotype, USNM 161424 from USGS Mesozoic loc. 29493.

27–29. Left valve, posterior view, and right valve of hypotype, USNM 129053e from USGS Mesozoic loc. 2275.

30–33. *Buchia inflata* (Toula) (p. A14).

Left valve, apical, posterior, and anterior views of hypotype, USNM 161466 from USGS Mesozoic loc. 29504.



BUCHIA UNCITOIDES (PAVLOW), *B. PIOCHII* (GABB), AND *B. INFLATA* (TOULA)

PLATE 4

[All figures are natural size]

FIGURES 1–19. *Buchia pacifica* Jeletzky (p. A14).

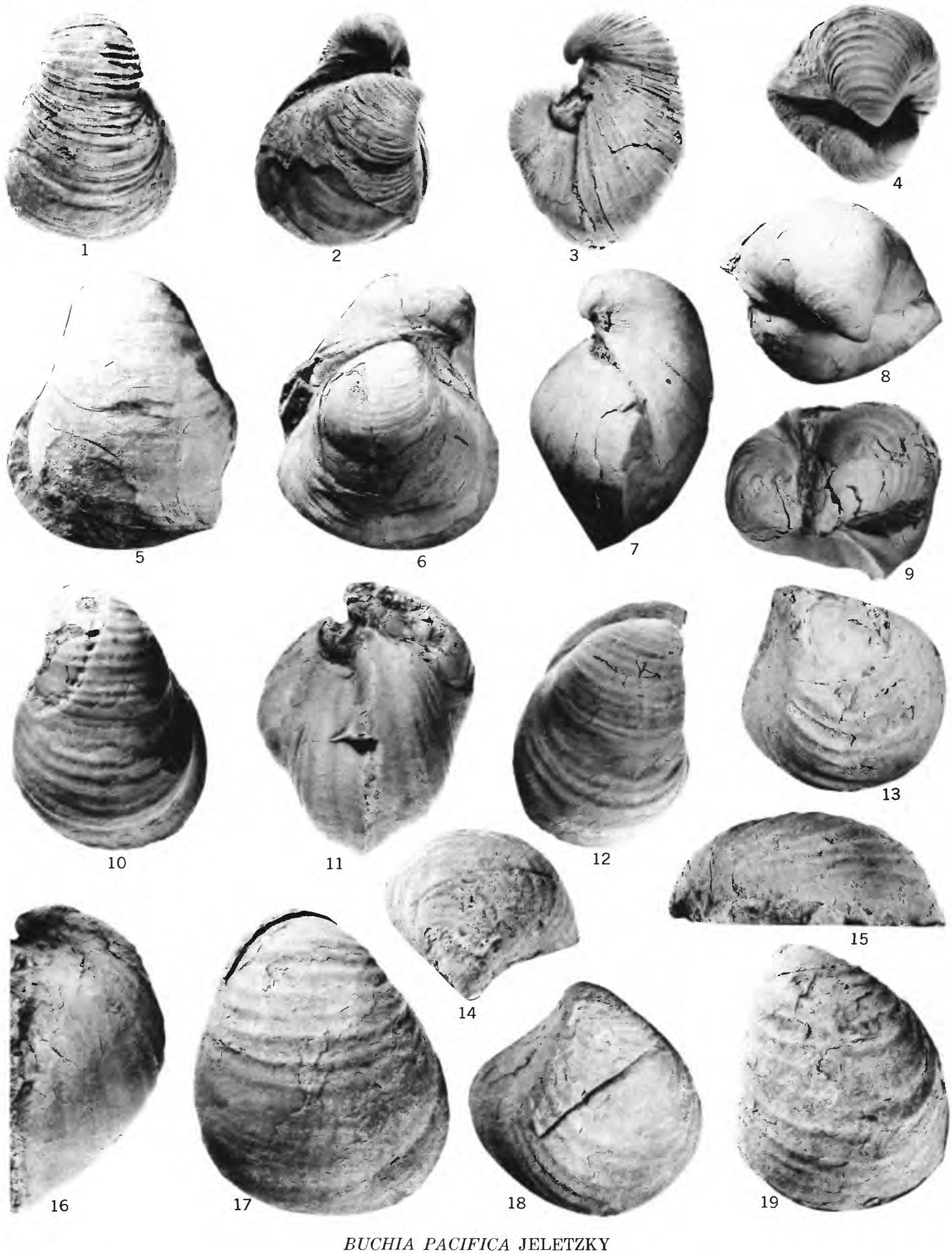
1–4. Left valve, right valve, and anterior and apical views of hypotype, USNM 161464 from USGS Mesozoic loc. M3048.

5–8. Left valve, right valve, and anterior and apical views of hypotype, USNM 161465 from USGS Mesozoic loc. 29504.

9–12. Apical view, left valve, anterior view and right valve of hypotype, USNM 161463 from USGS Mesozoic loc. M703.

13, 15, 19. Apical and anterior views and left valve of hypotype, USNM 161462 from USGS Mesozoic loc. M745.

14, 16–18. Apical and anterior views and full view of left valve of hypotype, USNM 161461 from USGS Mesozoic loc. M745.



BUCHIA PACIFICA JELETZKY

PLATE 5

[All figures are natural size]

FIGURES 1–11, 16, 17. *Buchia crassicollis solida* (Lahusen) (p. A14).

1–4. Anterior view, left valve, right valve and apical view of hypotype, USNM 161447 from USGS Mesozoic loc. 26789.

5–8. Apical view, left valve, right valve and anterior view of hypotype, USNM 161474 from USGS Mesozoic loc. M2734.

9, 10. Apical view and left valve of hypotype, USNM 161475 from USGS Mesozoic loc. 29566.

11, 16, 17. Apical view, left valve, and posterior view of hypotype, USNM 161473 from USGS Mesozoic loc. M2010.

12–15, 18–33. *Buchia keyserlingi* (Lahusen) (p. A14).

12–14, 25. Left valve, right valve, and anterior and apical views of hypotype USNM 23038 from USGS Mesozoic loc. 1091. Note presence of fine, sharp ribbing wherever shell is preserved.

15. Right valve of hypotype, USNM 161471 from USGS Mesozoic loc. M3083.

18, 19. Left valve and anterior view of hypotype, USNM 129057 from USGS Mesozoic loc. 1091.

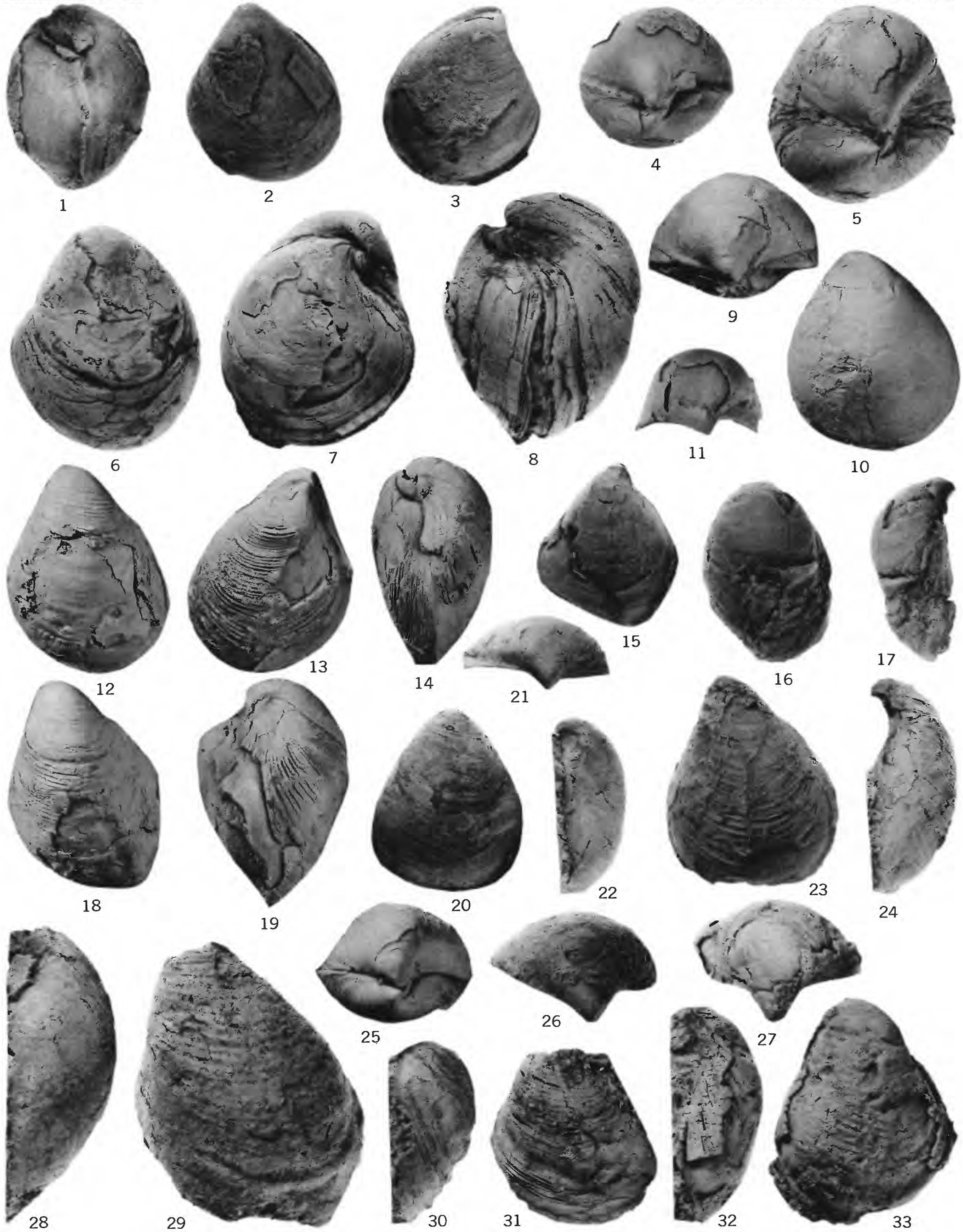
20–22. Left valve, apical and anterior views of hypotype, USNM 161470 from USGS Mesozoic loc. M3083.

23, 24, 26. Left valve, anterior and apical views of hypotype, USNM 161472 from USGS Mesozoic loc. M3058.

27, 32, 33. Apical and anterior views and left valve of hypotype, USNM 161469 from USGS Mesozoic loc. M2281.

28, 29. Anterior view and left valve of hypotype, USNM 161467 from USGS Mesozoic loc. M2030.

30, 31. Anterior view and left valve of hypotype, USNM 161468 from USGS Mesozoic loc. M2281.



BUCHIA CRASSICOLLIS SOLIDA (LAHUSEN) AND *B. KEYSERLINGI* (LAHUSEN)