University of Nevada

Reno

New Upper Jurassic Foraminifera from the Knoxville Formation, Elk Creek, California

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of the Requirements for the Degree of

Master of Science in Geology

by

Sandra Kay Cutler

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The thesis of Sandra Kay Cutler is approved:

Thesis Advisor

Department Chairman

Dean, Graduate School

University of Nevada

Reno

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ABSTRACT

Approximately 10,000 feet of Upper Jurassic (Tithonian) Knoxville Formation are exposed on the west side of the Sacramento Valley, near Elk Creek, California. Consisting of thin-bedded shales, interbedded graywackes, limestone lenses, and Buchia piochii coquina, the strata also contain a very large foraminifera fauna. Four new species are described from this fauna: Saracenaria berryi, Neobulimina knoxvillensis, Bolivina lankfordi, and Berrya larsoni. Significant morphologic features differentiate Berrya larsoni from other Upper Jurassic foraminifera and require the proposal of a new genus, subfamily, and family. Because Berrya larsoni is a very distinct and relatively abundant Upper Jurassic fossil and has been found as far south as Baja California, it may be useful as an index fossil for the Tithonian Stage, at least on the west coast of America.

ACKNOWLEDGEMENTS

The author wishes to thank many people who were directly as well as indirectly helpful in the preparation of this thesis. First, Mr. Keith D. Berry, for his suggestion that this project be undertaken, for obtaining the necessary permissions from Chevron USA, Western Region, San Francisco, California, for the loan of their samples, and for his generous giving of his valuable time and expertise. Second, the late Professor E. Richard Larson, for his unflagging patience, continuous encouragement, and for his field assistance. Third, Professor Joseph Lintz, Jr., for unselfishly contributing his time and invaluable suggestions, and for reading the manuscript. Fourth, Alfred Loeblich and Helen Tappan Loeblich, for graciously reviewing some of the material and suggesting procedures for examination and reconciliation of taxonomic problems. Fifth, the Chevron people: Carl Helms, Jr., Ed Welge, and Bert Amundson, who initially collected the samples; D. L. Zieglar, Chief Geologist, Chevron USA, and R. C. Blaisdell, Biostratigraphic Supervisor, Chevron USA, who approved the loan of the samples and the use of the SEM; Susan McCollom, without whose help the SEM photography would have been extremely difficult to accomplish; and all of the additional Chevron personnel, who are too many to list individually, but who helped in many different ways (the technicians who washed the samples, the technicians who initially picked them for fossils, the draftsmen who provided the maps). Special thanks are in order for my daughter, Kira, for her patience, encouragement, and assistance throughout this endeavor.

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INTRODUCTION

Jurassic Foraminifera in northern California have not been systematically studied, although preliminary observations were made in the mid 1950's by Keith D. Berry when he undertook zonation of the Lower Cretaceous and Upper Jurassic rocks of the Sacramento Valley as part of a major Chevron mapping project. In 1945, P. P. Goudkoff recognized eight foraminiferal zones in the Upper Cretaceous of the Sacramento Valley, which he designated Zones A through H. Berry (1965) recognized an additional zone and a subzone in the lower Upper Cretaceous which he named I and J-1 respectively. Continuing into the Lower Cretaceous, he named the lower subzone J-2 and further designated Zones K and L. He recognized Zone M in the Upper Jurassic (Tithonian) but was unable to systematically study the Upper Jurassic fauna due to time and workload. The Upper Jurassic samples were loaned to the author in September, 1978 for the purpose of completing an in-depth study of the fauna in preparation of this thesis. Due to the large number of taxa in the material and the faunal complexities encountered, only a small contribution can be presented at this time. It is the author's intention, therefore, to describe only the new occurrences; a new family, subfamily, genus and species, and three new species of three known genera. Diagrams of their frequency and abundance are also presented.

The samples were collected from the western side of the Sacramento Valley, approximately 18 miles west of Willows, California (Figure 1).

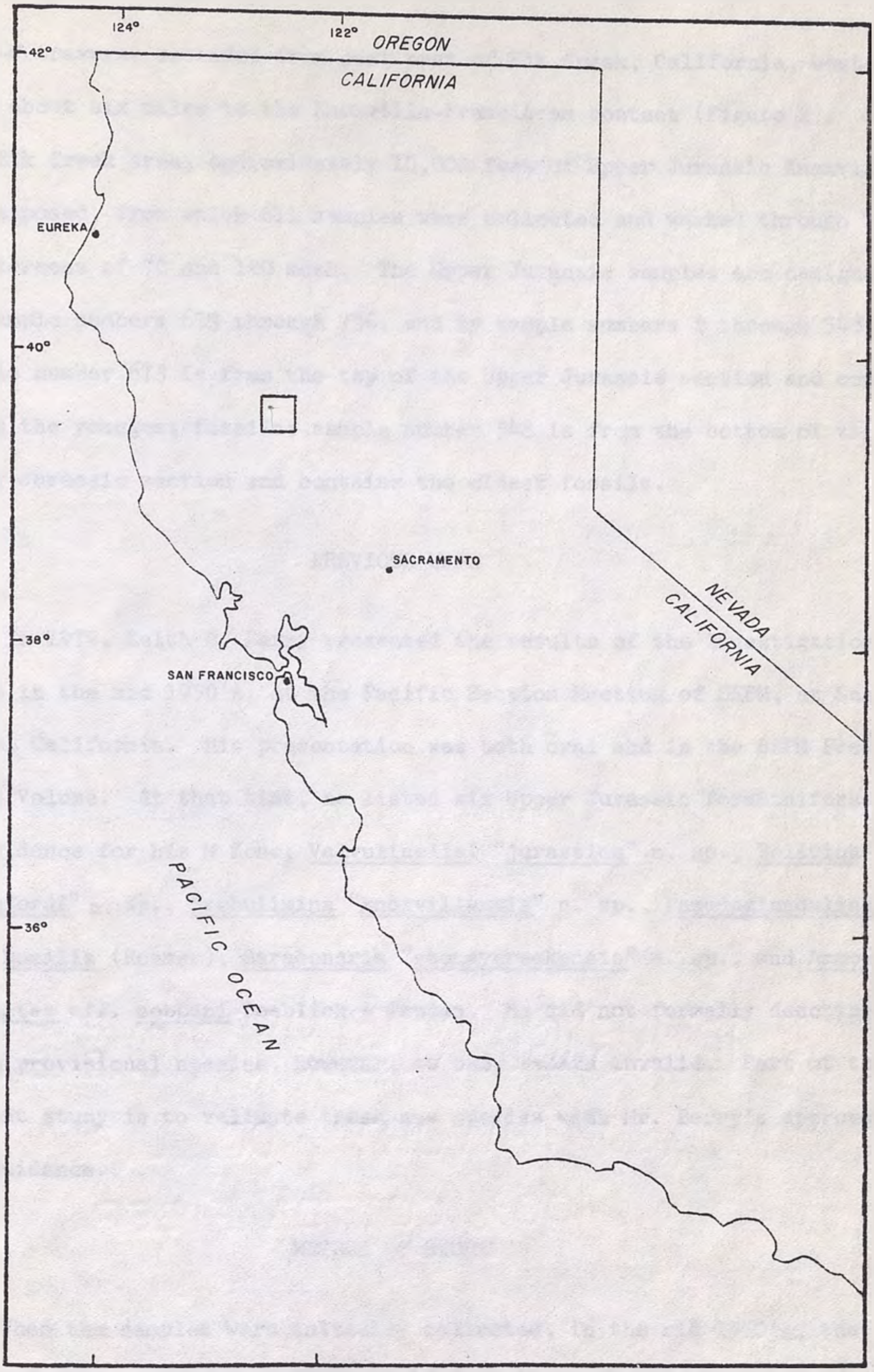

Figure 1. - Location of sampled area.

An E-W traverse extended from just east of Elk Creek, California, westward about six miles to the Knoxville-Franciscan contact (Figure 2). In the Elk Creek area, approximately 10,000 feet of Upper Jurassic Knoxville are exposed, from which 611 samples were collected and washed through Tyler screens of 70 and 120 mesh. The Upper Jurassic samples are designated by sample numbers 673 through 736, and by sample numbers 1 through 548. Sample number 673 is from the top of the Upper Jurassic section and contains the youngest fossils; sample number 548 is from the bottom of the Upper Jurassic section and contains the oldest fossils.

PREVIOUS WORK

In 1974, Keith D. Berry presented the results of the investigation begun in the mid 1950's, at the Pacific Section Meeting of SEPM, at San Diego, California. His presentation was both oral and in the SEPM Preprint Volume. At that time, he listed six Upper Jurassic foraminifera as evidence for his M Zone; Valvulinella? "jurassica" n. sp., Bolivina "lankfordi" n. sp., Neobulimina "knoxvillensis" n. sp., Pseudoglandulina aff. humilis (Roemer), Saracenaria "stoneycreekensis" n. sp., and Ammobaculites aff. cobbani Loeblich & Tappan. He did not formally describe these provisional species, however, so they remain invalid. Part of the present study is to validate these new species with Mr. Berry's approval and guidance.

METHOD OF STUDY

When the samples were initially collected, in the mid 1950's, they were selected from approximately 10-15 foot intervals along the strike of

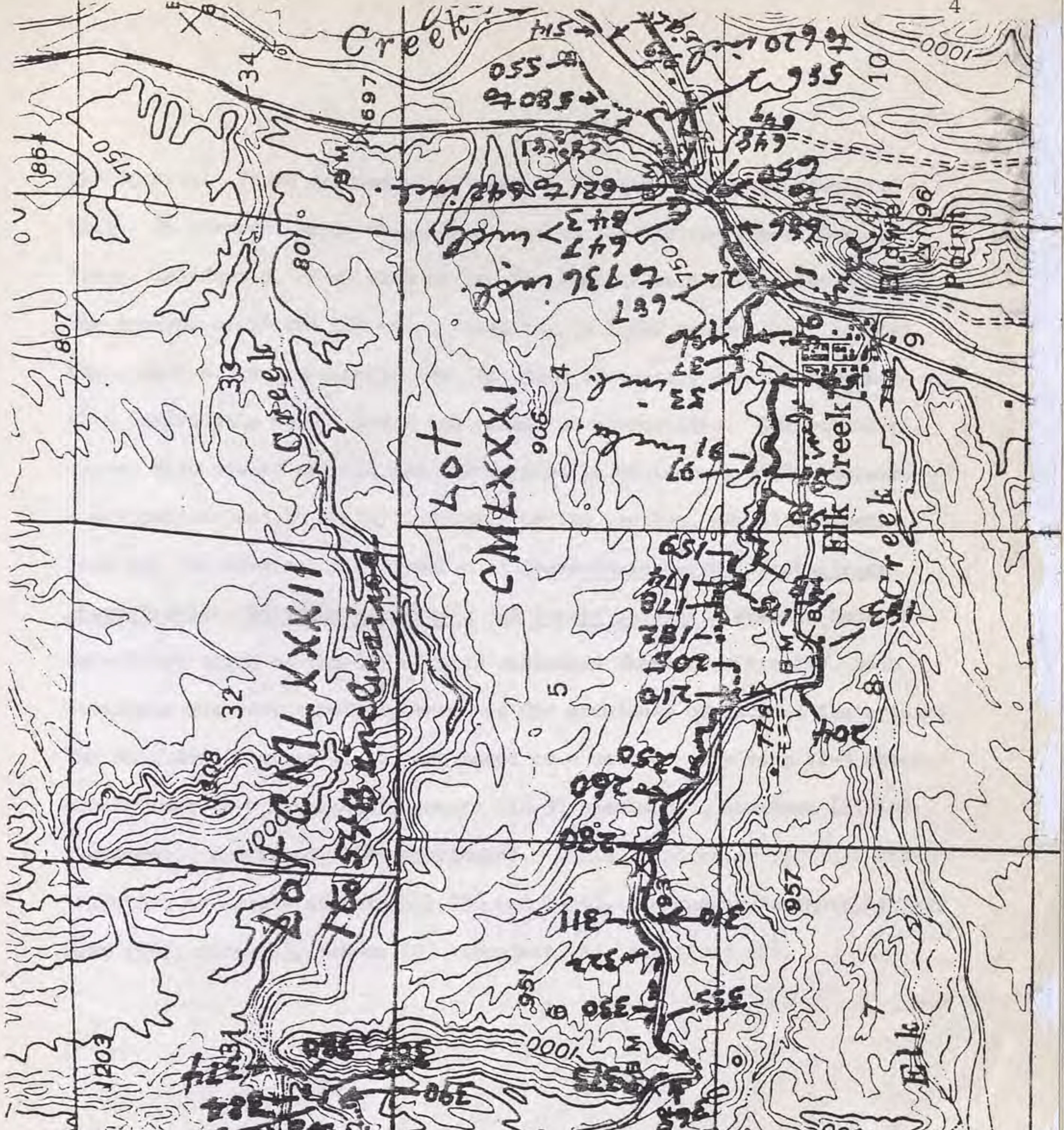

Figure 2. - Detail of sampled area.

the outcrop. Fresh samples were taken by sampling below the weathered zone. An unknown sample weight was sent to the Chevron Lab at Bakersfield, California, where each of the 611 samples were washed through Tyler screens of 70 and 120 mesh, resulting in 1,222 subsamples. At that time, each of the subsamples were examined thoroughly and all recognizable individuals were removed and placed on microslides. The author received both washed samples and microslides in September, 1978. Because a new project was to be forthcoming from the samples, new slides were made for the vertical distribution of *Saracenaria berryi*, *Neobulimina knoxvillensis*, *Bolivina lankfordi*, and *Berrya larsoni*. When it had been determined which of the 611 samples contained these four species, each subsample was very carefully examined for abundance of each of the species. The diagrams (Figures 11-14) are based on counts of very rare (1-3 specimens), rare (4-9 specimens), common (10-30 specimens), abundant (31-100 specimens), and flood (100+ specimens). Table 1 indicates vertical distribution by sample numbers 673-736 and 1-548. Frequency is shown by very rare (VR), rare (R), common (C), abundant (A), and flood (F).

STRATIGRAPHY

On the west side of the Sacramento Valley, the strata are exposed in a northerly trending belt and represent a nearly continuous record of sedimentation from late Late Jurassic (middle Tithonian) to Late Cretaceous (Irwin, 1960). The belt extends a distance of about 100 miles from near Wilbur Springs, in eastern Lake County, to a point southwest of Redding in southern Shasta County, and is less than 10 miles in average width of outcrop. Along the southern and central parts of the belt, the rocks of the Great Valley sequence are separated from those of the northern Coast Ranges by a band of ultramafics (serpentines), but along the northern part of the belt they unconformably overlie the rocks of the Klamath Mountains arc (Anderson, 1933). The Knoxville formation, as exposed along the west side of the Sacramento Valley between Wilbur Springs and Paskenta, has an average outcrop thickness of 10,000 feet. The base is not known with certainty, as along most of the valley the lowest exposed beds are in fault contact with the band of ultramafic rocks. The Knoxville formation generally consists of a thick section of thin-bedded shales with thin lenses of limestone, but interbedded graywacke and conglomerate are locally abundant. Fossils indicate that it is late Late Jurassic (middle Tithonian) in age, with one of its most characteristic and abundant species being *Buchia piochii* (Gabb). Figures 3-8.

Figure 3. - Top of the Upper Jurassic Knoxville Fm., exposed in the creekbed on the eastern side of Stony Creek, just north of Elk Creek, Cal.

Figure 4. - Surface outcrop of the Upper Jurassic Knoxville Fm., on the west side of Stony Creek bridge, just north of Elk Creek, Cal.

Figure 5. - Outcrop of thin-bedded shales (blue) and interbedded graywacke (lt. gray), on the eastern side of Stony Creek.

Figure 6. - Thin-bedded shales and interbedded gray-wacke, on the eastern side of Stony Creek.

Figure 7. - Coquina of Buchia piochii, on the eastern side of Stony Creek.

Figure 8. - Limestone lens in thin-bedded shales and graywacke, on the western side of Stony Creek.

STRUCTURAL RELATIONSHIPS

The boundary between the northern Coast Ranges and the Sacramento Valley, from near Wilbur Springs to the southern tip of the Klamath Mountains province, is an apparently continuous belt of serpentinized ultramafic rock, which is sheared, and at some places encloses small lenses of strata that appear to be fault slices (Irwin, 1960). The shear planes are most commonly north-trending and steep, as is the foliation of the slaty rocks adjacent to the west. The eastward dip of the strata of the Sacramento Valley sequence steepens toward the belt of ultramafic rock, and in some places is even overturned. Although the structure is not clearly understood, the ultramafic rock appears to be in a zone of high-angle faulting along which the slaty rocks of the Coast Ranges to the west are in juxtaposition with the Sacramento Valley sequence of generally only mildly deformed rocks to the east (E. R. Larson, personal communication). Taliaferro (1943) states that the contact between the ultramafic rock and the Sacramento Valley sequence is a high-angle thrust fault that dips 60° to 65° west in northern Glenn County, and a vertical fault in central Colusa County, but that at Redbank Creek, the contact is clearly intrusive. In essence, Taliaferro (1943) considers the ultramafic rock to be a sill that intrudes the upper part of the Franciscan and the lower part of the Knoxville, but in some places it is wholly within either Knoxville or Franciscan.

Rynearson (1946) believes the ultramafic rock to be a dike, inclined steeply westward, and perhaps intruded along a pre-existing fault that separated eastward-dipping strata of the Franciscan formation from similarly dipping strata of the Knoxville formation. Both penecontemporaneous and postdepositional deformations were observed along the line of sampled outcrops. These deformations were very local and ranged in measurement from a few inches to several feet. Figures 9-10.

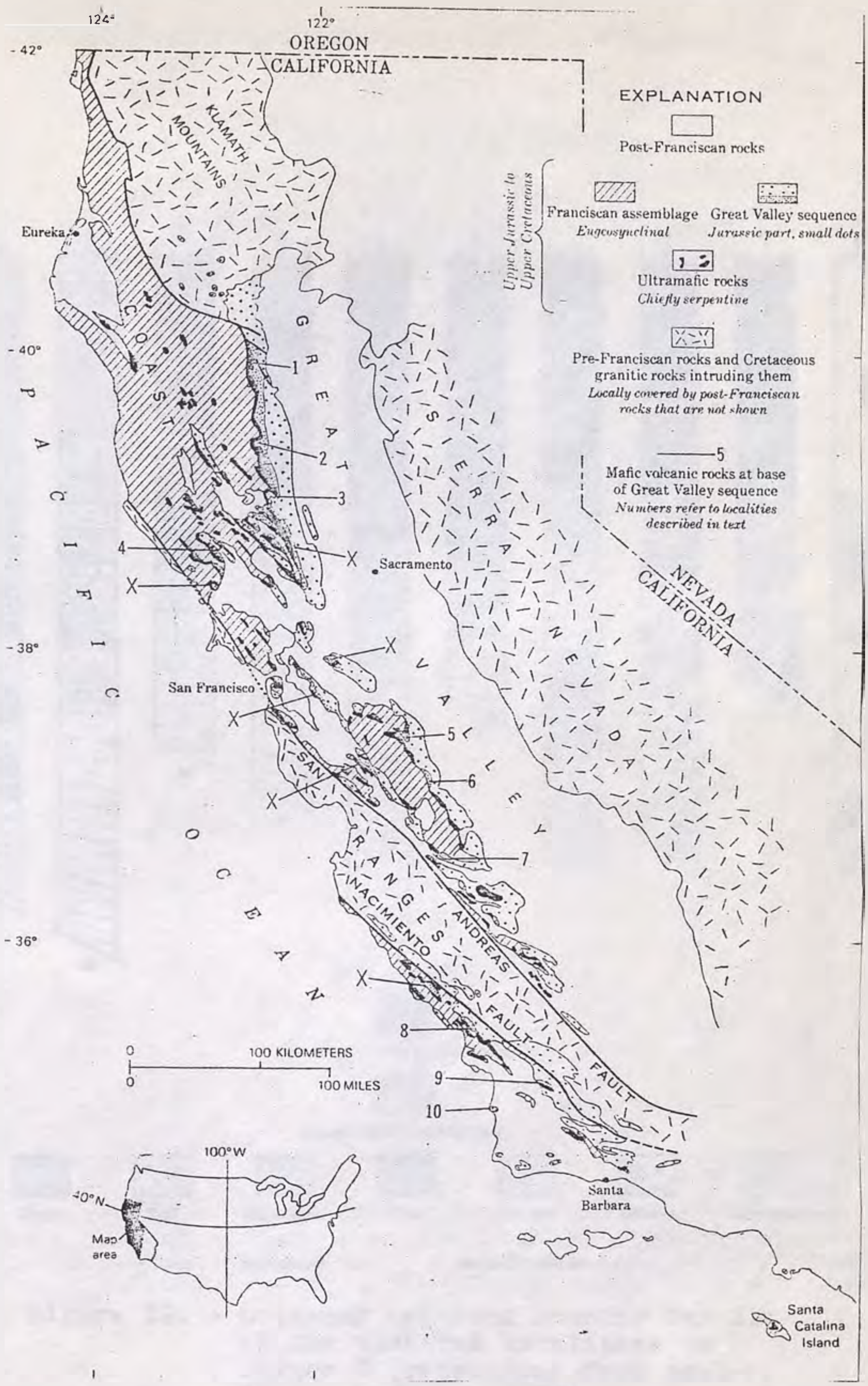

Figure 9. - Structural relationship of Sacramento Valley and the Coast Range (map reproduced from Bailey, Blake, & Jones, 1970).

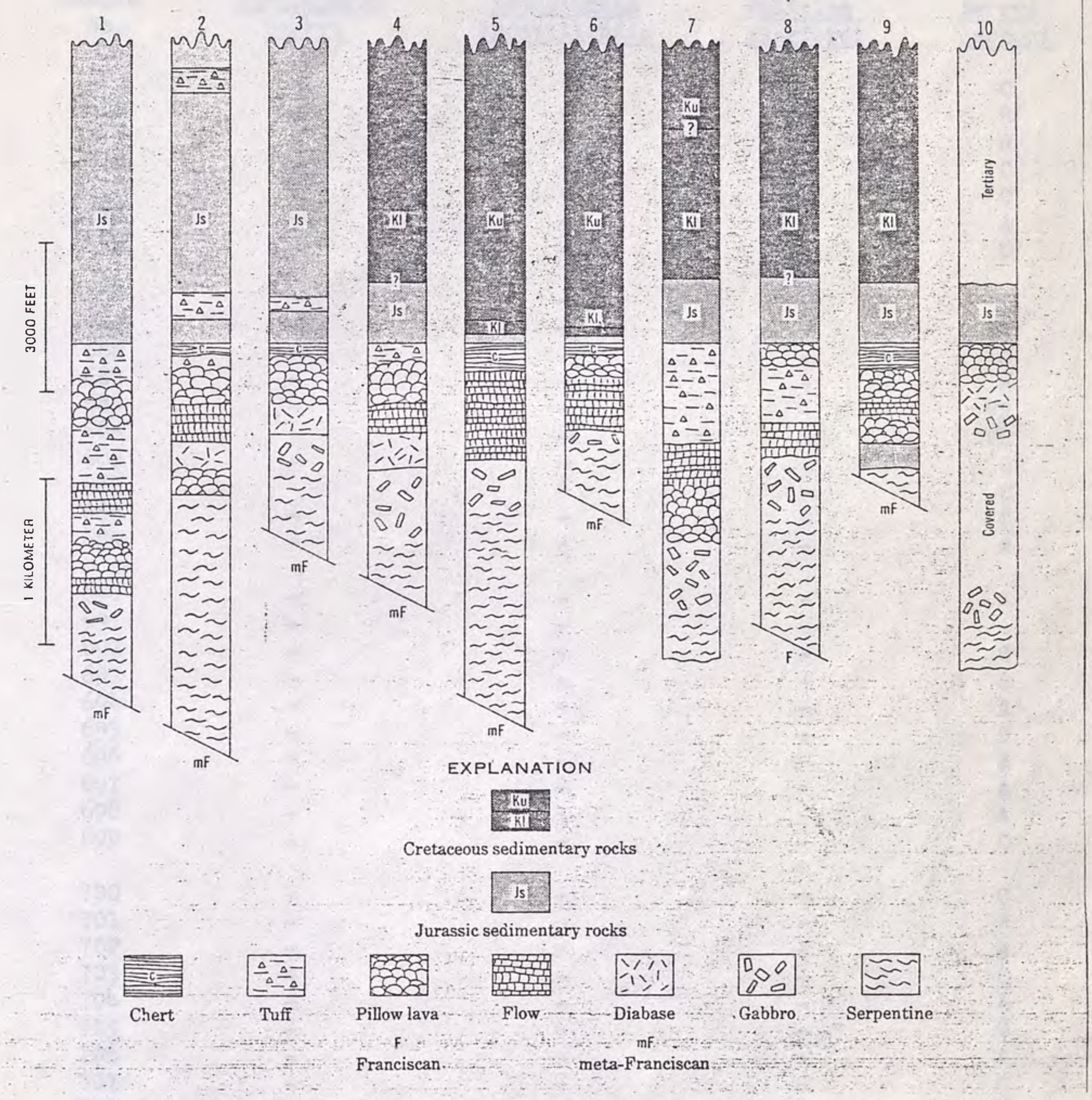

Figure 10. - Columnar sections showing details at the numbered localities on Figure 9 (reproduced from Bailey, Blake, & Jones, 1970).

TABLE 1

Vertical Distribution and Frequency

Sample No.	Saracenaria berryi	Neobulimina knoxvillensis	Bolivina lankfordi	Berrya larsoni
673	-	-	-	C
674	-	-	-	R
675	-	-	-	R
676	-	-	-	C
677	-	-	-	C
678	-	-	-	A
679	-	-	-	C
680	-	-	-	C
681	-	-	-	C
682	-	-	-	C
683	-	-	-	R
684	-	-	-	VR
685	-	-	-	VR
686	-	-	-	C
687	-	-	-	C
688	-	-	-	C
689	-	-	-	A
690	-	-	-	A
691	-	-	-	-
692	-	-	-	C
693	-	-	-	A
694	-	-	-	A
695	-	-	-	C
696	-	-	-	R
697	-	-	-	A
698	-	-	-	A
699	-	-	-	C
700	-	-	-	C
701	-	-	-	R
702	-	-	-	A
703	-	-	-	C
704	-	-	-	A
705	-	-	-	C
706	-	-	-	A
707	-	-	-	C
708	-	-	VR	C
709	-	-	-	C

Table 1--Vertical Distribution and Frequency (continued)

Sample No.	Saracenaria berryi	Neobulimina knoxvillensis	Bolivina lankfordi	Berrya larsoni
710	-	-	-	C
711	-	-	-	C
712	-	-	-	C
713	-	-	-	A
714	-	-	-	C
715	-	-	-	C
716	-	-	-	C
717	-	-	-	C
718	-	-	-	A
719	-	-	-	R
720	-	-	-	R
721	-	-	-	C
722	-	-	-	C
723	-	-	-	A
724	-	-	-	C
725	-	-	-	A
726	-	-	-	R
727	-	-	-	C
728	-	-	-	A
729	-	-	-	C
730	-	-	-	A
731	-	-	VR	R
732	-	-	-	C
733	-	-	-	R
734	-	-	-	C
735	-	-	-	C
736	-	-	-	R
1	-	-	-	C
2	-	-	-	C
3	-	-	-	VR
4	-	-	-	R
5	-	-	-	C
6	-	-	-	C
7	-	-	-	R
8	-	-	R	R
9	-	-	-	C
10	-	-	-	C
11	-	-	-	A
12	-	-	-	F
13	-	-	-	C
14	-	-	-	A

Table 1--Vertical Distribution and Frequency (continued)

Sample No.	Saracenaria berryi	Neobulimina knoxvillensis	Bolivina lankfordi	Berrya larsoni
15	-	-	-	A
16	-	-	-	C
17	VR	VR	-	R
18	VR	F	-	C
19	-	C	-	C
20	VR	R	VR	R
21	-	C	-	C
22	-	A	-	C
23	VR	A	-	A
24	R	A	C	R
25	R	A	-	VR
26	VR	A	-	VR
27	VR	C	-	VR
28	VR	C	VR	VR
29	VR	C	-	VR
30	VR	A	-	-
31	VR	R	-	-
32	-	-	-	VR
33	-	-	-	C
34	VR	C	-	C
35	VR	A	-	A
36	-	R	-	C
37	-	-	-	R
38	-	-	-	R
39	-	-	-	C
40	VR	R	-	A
41	-	-	-	C
42	-	-	-	C
43	-	-	-	C
44	-	-	-	C
45	-	-	-	R
46	-	-	-	VR
47	-	-	-	R
48	-	-	-	C
49	-	-	-	R
50	-	-	-	R
51	-	-	-	VR
52	-	-	-	C
53	-	-	-	C
54	VR	R	-	R
55	-	-	-	C
56	-	-	-	R
57	-	VR	-	R
58	-	-	-	C
59	-	-	-	C

Table 1--Vertical Distribution and Frequency (continued)

Sample No.	Saracenaria berryi	Neobulimina knoxvillensis	Bolivina lankfordi	Berrya larsoni
60	-	-	-	A
61	-	-	-	C
62	-	-	-	R
63	-	-	-	R
64	-	-	-	VR
65	-	-	-	-
66	-	-	-	VR
67	-	-	-	VR
68	-	-	-	C
69	-	-	-	C
70	-	-	VR	C
71	-	-	VR	C
72	-	-	-	A
73	-	-	-	C
74	-	-	-	C
75	-	R	R	C
76	-	-	VR	R
77	-	-	-	C
78	-	-	-	C
79	-	-	-	C
80	-	-	-	C
81	-	-	-	C
82	-	-	-	C
83	-	-	-	C
84	-	-	-	C
85	-	-	-	C
86	-	-	-	R
87	-	-	-	VR
88	-	-	-	-
89	-	-	VR	VR
90	-	-	-	VR
91	-	VR	R	R
92	-	-	-	VR
93	-	VR	VR	VR
94	-	-	VR	-
95	-	-	-	VR
96	-	-	-	VR
97	-	-	R	VR
98	-	-	-	VR
99	-	-	VR	VR

Table 1--Vertical Distribution and Frequency (continued)

Sample No.	Saracenaria berryi	Neobulimina knoxvillensis	Bolivina lankfordi	Berrya larsoni
100	-	-	-	VR
101	-	-	-	-
102	-	-	-	-
103	-	-	VR	R
104	-	-	-	VR
105	-	-	R	VR
106	-	-	R	R
107	-	-	VR	R
108	-	-	-	R
109	-	-	-	VR
110	-	-	VR	VR
111	VR	-	R	VR
112	-	-	VR	VR
113	-	-	-	VR
114	VR	-	-	R
115	-	-	C	R
116	-	-	VR	R
117	-	VR	C	VR
118	-	-	-	VR
119	-	-	-	-
120	-	-	-	-
121	-	-	-	-
122	-	-	VR	-
123	-	-	VR	-
124	-	-	VR	-
125	-	-	-	-
126	-	-	VR	-
169	-	-	VR	-
246	-	-	-	-
386	VR	-	-	-
470	-	VR	-	-

SYSTEMATIC PALEONTOLOGY

The classification followed here is that of LOEBLICH & TAPPAN (1964). Citations of dates following authors of generic and suprageneric taxa are to indicate priority only and are not necessarily cited in the references. Justification for these terms is given in LOEBLICH & TAPPAN (1964). No attempt has been made to list or describe all species recovered in this study. A large and complicated fauna is present in the samples. The superfamily Nodosariacea is conspicuously represented by a large and varied taxa, as are several other superfamilies of calcareous foraminifera. A broad spectrum of arenaceous forms is also present. Collectively, the fauna is indicative of a relatively shallow water environment (neritic zone, 0-600 ft.). Because the size and complexity of the fauna presented so many problems, the scope of this paper is restricted to proposing new Upper Jurassic taxa. The plates are SEM photomicrographs of the paratypes which are deposited in the SEM plug collection of Chevron USA, Western Region, San Francisco, California. The holotypes for *Saracenaria berryi*, *Neobulimina knoxvillensis*, and *Bolivina lankfordi* are temporarily preserved at Mackay School of Mines Museum, University of Nevada at Reno, Nevada (UNR) under the repository numbers given in the fossil descriptions. The genotype and holotype for *Berrya larsoni* are also temporarily preserved at Mackay School of Mines Museum, UNR, Reno, Nevada under the repository numbers given in the fossil descriptions, together with the thin-sections of *Berrya larsoni*.

Phylum PROTOZOA

Class SARCODINA

Order FORAMINIFERA

Superfamily NODOSARIACEA Ehrenberg, 1838

Family NODOSARIIDAE Ehrenberg, 1838

Subfamily NODOSARIINAE Ehrenberg, 1838

Genus SARACENARIA Defrance in de Blainville, 1824

SARACENARIA berryi Cutler, n. sp.

Plate 1, Figure 2-4

Saracenaria "stoneycreekensis" Berry, 1974, p. 10

Test free, planispirally coiled in early stage, later tending to uncoil, triangular in transverse section, with broad flat to somewhat convex apertural face, margins subacute to rounded. Chambers curved, elongate, gradually increasing in size as added, the holotype having about 9 chambers total. Sutures distinct, curved, limbate, thickened, raised above chambers. Wall calcareous, finely perforate, surface smooth. Aperture terminal, radiate.

Maximum diameter of holotype, 0.45 mm.; thickness, 0.25 mm.

Discussion. - This species is distinguished by the raised, thickened, limbate sutures, by the ratio of coiled to uncoiled chambers, and by the lack of similarity to any previously described Upper Jurassic species of the genus Saracenaria in the literature.

Types and occurrence. - Holotype, MSMM 6200, paratypes, Chev. P691, J-L; numerous other specimens, all from Knoxville Formation, Elk Creek, Glenn County, California.

Derivation of name. - berryi, Patronymic, K. D. Berry.

Superfamily BULIMINACEA Jones, 1875

Family TURRILINIDAE Cushman, 1927

Subfamily TURRILININAE Cushman, 1927

Genus NEOBULIMINA Cushman & Wickenden, 1928

NEOBULIMINA knoxvillensis Cutler, n. sp.

Plate 2, Figure 1-4; Plate 3, Figure 1-2

Neobulimina "knoxvillensis" Berry, 1974, p. 25.

Test free, elongate, tapering, triserial in early stages, biserial in later stages, not compressed. Chambers numerous, inflated, subglobular, increasing in size as added, final chamber approximately 1/2 the length of the entire test. Sutures distinct, depressed. Wall calcareous, finely perforate, surface smooth. Aperture loop-shaped, extending upward from base of final chamber.

Maximum length of holotype, 0.95 mm.; breadth, 0.43 mm.

Discussion. - The genus Neobulimina has not previously been reported from Jurassic strata. This species slightly resembles N. canadensis, an Upper Cretaceous form, except N. knoxvellensis has fewer and much larger chambers, is larger in overall size, and the apertural opening is at a different angle to the previous chamber than that of N. canadensis.

Types and occurrence. - Holotype, MSMM 6201, paratypes, Chev. P691, G-I; numerous other specimens, all from Knoxville Formation, Elk Creek, Glenn County, California.

Derivation of name. - knoxvillensis, Geologic, Formation.

Family BOLIVINITIDAE Cushman, 1927

Genus BOLIVINA d'Orbigny, 1839

BOLIVINA lankfordi Cutler, n. sp.

Plate 3, Figure 3-4; Plate 4, Figure 1-2

Bolivina "lankfordi" Berry, 1974, p. 25.

Test free, small elongate, biserial throughout, compressed, periphery subacute to acute. Chambers low, broad, increasing gradually in size, subrectangular. Sutures distinct, gently curved, limbate, flush to slightly elevated axially. Wall calcareous, finely perforate, surface smooth. Aperture an elongate loop in final chamber, nearly terminal.

Maximum length of holotype, 0.42 mm.; breadth, 0.18 mm., thickness, 0.07 mm.

Discussion. - In the literature available, there is only one Upper Jurassic species of Bolivina described. B. bartensteini Said & Barakat, was described as a new species from Sinai, Egypt in 1958. B. lankfordi differs from B. bartensteini by having distinct, limbate sutures, subacute to acute margins, and gradually increasing chamber size.

Types and occurrence. - Holotype, MSMM 6202, paratypes, Chev. P691, D-F; numerous other specimens, all from Knoxville Formation, Elk Creek, Glenn County, California.

Derivation of name. - lankfordi, Patronymic, R. R. Lankford.

Superfamily LITUOLACEA de Blainville, 1825

Family BERRYIDAE Cutler, n. fam.

Test free, large, trochospiral throughout, conical. Chambers globular, restricted to 5 per whorl, which increase in size as added. Wall coarsely arenaceous, imperforate. Aperture subcircular, sublateral to subcentral on umbilical side.

Maximum length of genotype, 0.80 mm; diameter, 0.60 mm.

Discussion. - A new family is herein created for the species Berrya larsoni. The examination of numerous specimens shows the chamber arrangement to be consistent. The chamber size is very tiny in the first whorl, larger in the next, increasing progressively with maturity, but restricted to 5 chambers per whorl. Keith D. Berry (1965) provisionally proposed the genus Valvulinella? to this foraminifera, but the author can find no species of Valvulinella younger than Pennsylvanian age. Also, Valvulinella is assigned to the family Tetrataxidae, exhibiting a granular, calcareous wall. Loeblich & Tappan (1964) reassigned Henson's Jurassic species Valvulinella jurassica to the genus Kurnubia, which is in the family Pavonitinidae. Berrya larsoni remains trochospiral throughout and the interior does not appear to be divided by pillars or partitions, as in the Pavonitinidae.

Types and occurrence. - Genotype, MSMM 6203, from Knoxville Formation, Elk Creek, Glenn County, California.

Subfamily BERRYINAE Cutler, n. subfam.

Test free, large, trochospiral throughout, conical. Chambers globular, restricted to 5 per whorl, increasing in size as added. Sutures indistinct. Wall coarsely arenaceous, imperforate. Aperture subcircular, sublateral to subcentral on umbilical side.

Genus BERRYA Cutler, n. gen.

Test free, large, trochospiral throughout, conical. Chambers globular, 5 per whorl, increasing in size as added. Sutures indistinct. Wall coarsely arenaceous, imperforate. Aperture subcircular, subcentral on umbilical side.

Discussion. - No previously described foraminifera even closely resemble this fossil. One very distinctive characteristic of *Berrya larsoni* is its color. The pinkish lavender hue contrasts sharply against the typical colors found in the samples. The absence of other described Upper Jurassic species in the literature make further comparisons untenable. Superficially, it could have been compared to *Valvulinella*, but close examination shows characteristics in addition to age that do not even vaguely agree. Thin sections of *Berrya larsoni* show the number of chambers to be restricted to 5 per whorl. Other genera to which *Berrya larsoni* could be compared have been described as having 3 to many chambers per whorl. The thin sections further show the absence of the pillars or partitions diagnostic of both *Valvulinella* and *Kurnubia*.

BERRYA larsoni Cutler, n. sp.

Valvulinella? *jurassica* Berry, 1974, p. 25.

Test free, large, trochospiral throughout, conical. Chambers globular, restricted to 5 per whorl, increasing in size as added. Sutures indistinct. Wall coarsely arenaceous, imperforate. Aperture subcircular, subcentral on umbilical side.

Maximum length of holotype, 0.78 mm.; diameter, 0.57 mm.

Discussion. - Berrya larsoni is very distinctive and is easily recognized by its color in the washed samples. It is particularly abundant in the upper 840-1000 feet of the Knoxville Formation. Keith D. Berry (personal communication) has found this fossil in a sample from Baja California and is using it for the basis of age-dating the Baja sample as Upper Jurassic (Tithonian).

Types and occurrences. - Holotype, MSM 6204, paratypes, Chev. P691, A-C; numerous other specimens, all from Knoxville Formation, Elk Creek, Glenn County, California.

Derivation of name. - Berrya, Patronymic, K. D. Berry; larsoni, Patronymic, the late Professor E. Richard Larson.

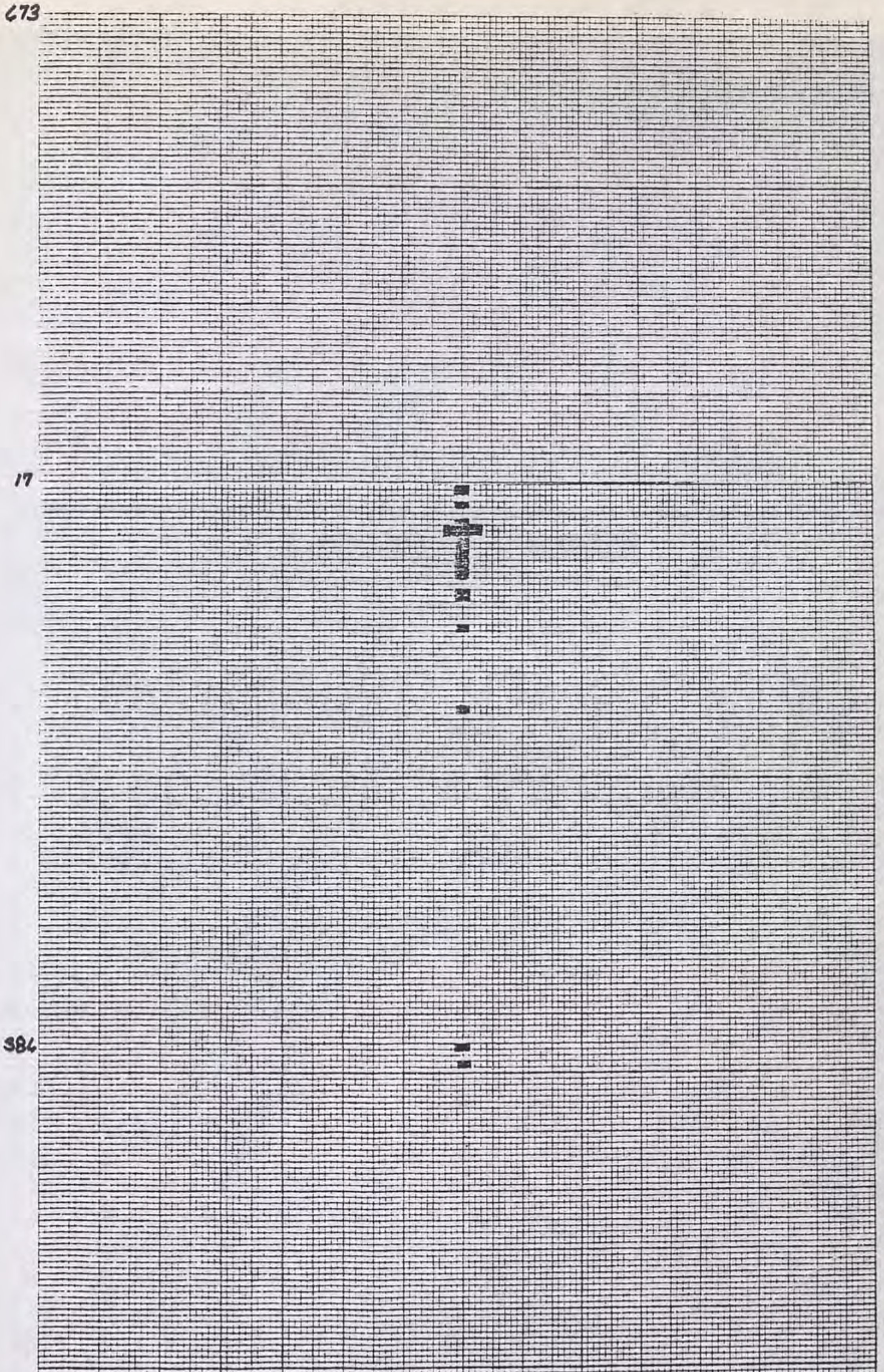

Table 2. - Saracenaria "berryi".

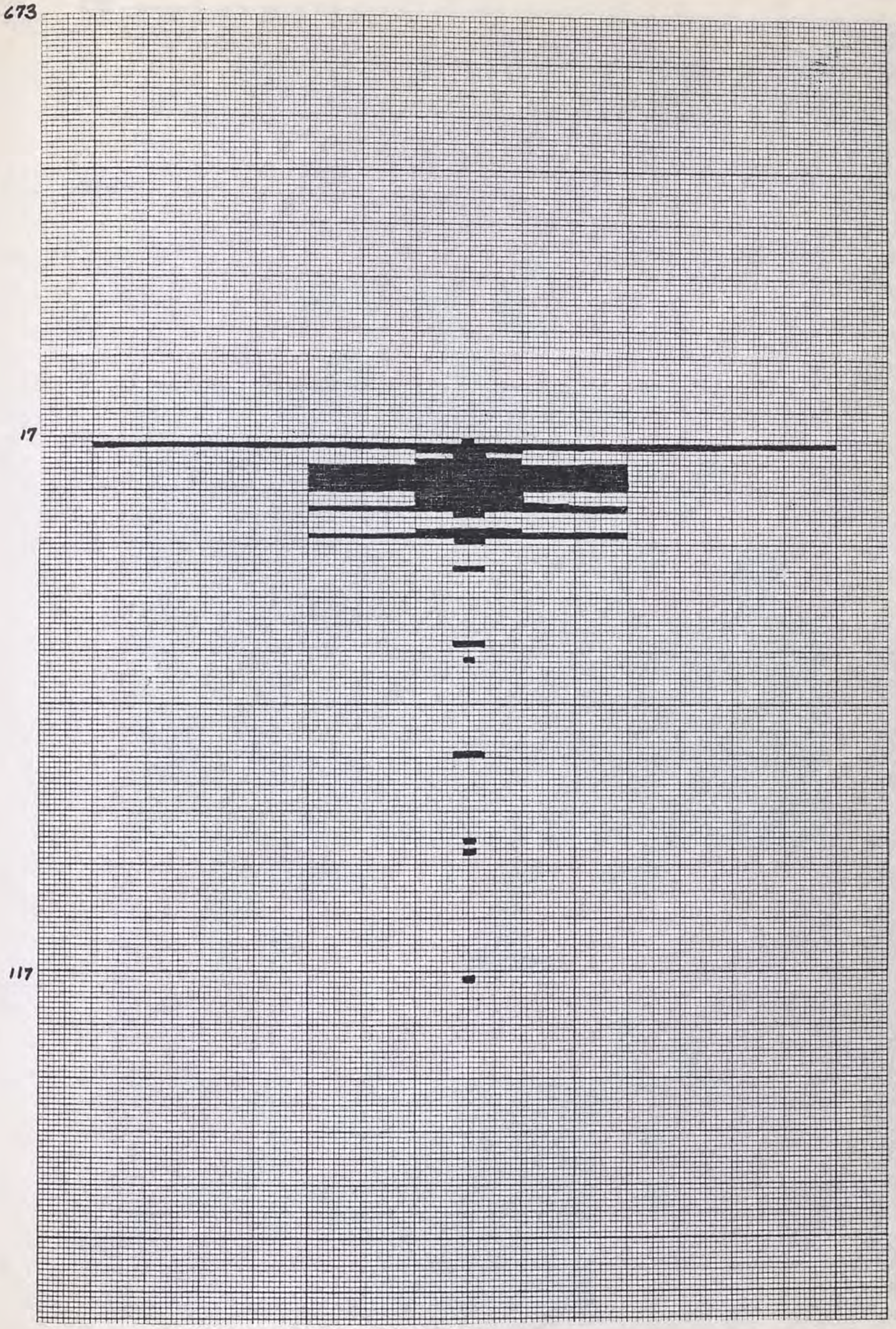

Table 3. - Neobulimina "knoxvillensis".

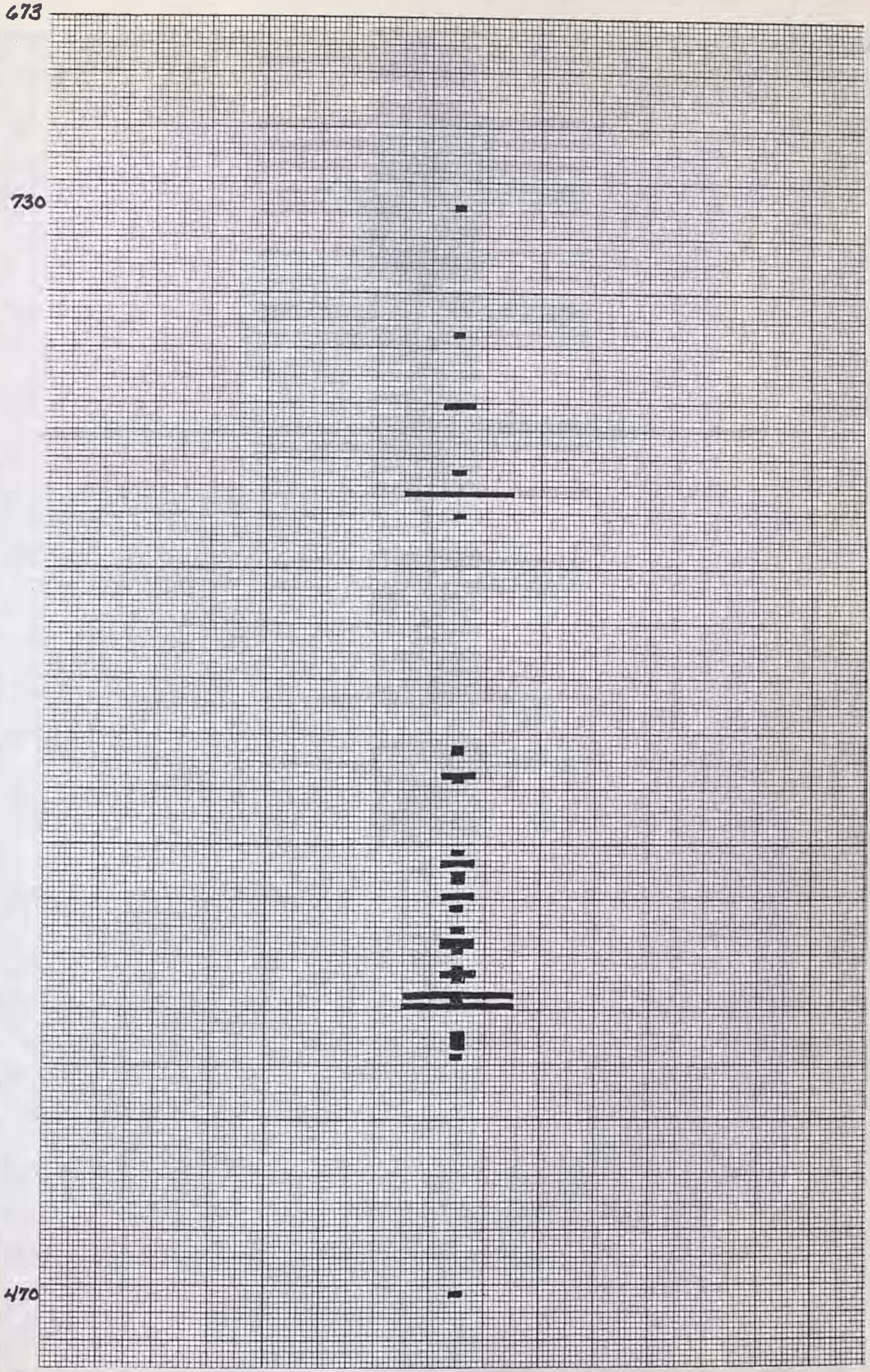

Table 4. - Bolivina "lankfordi".

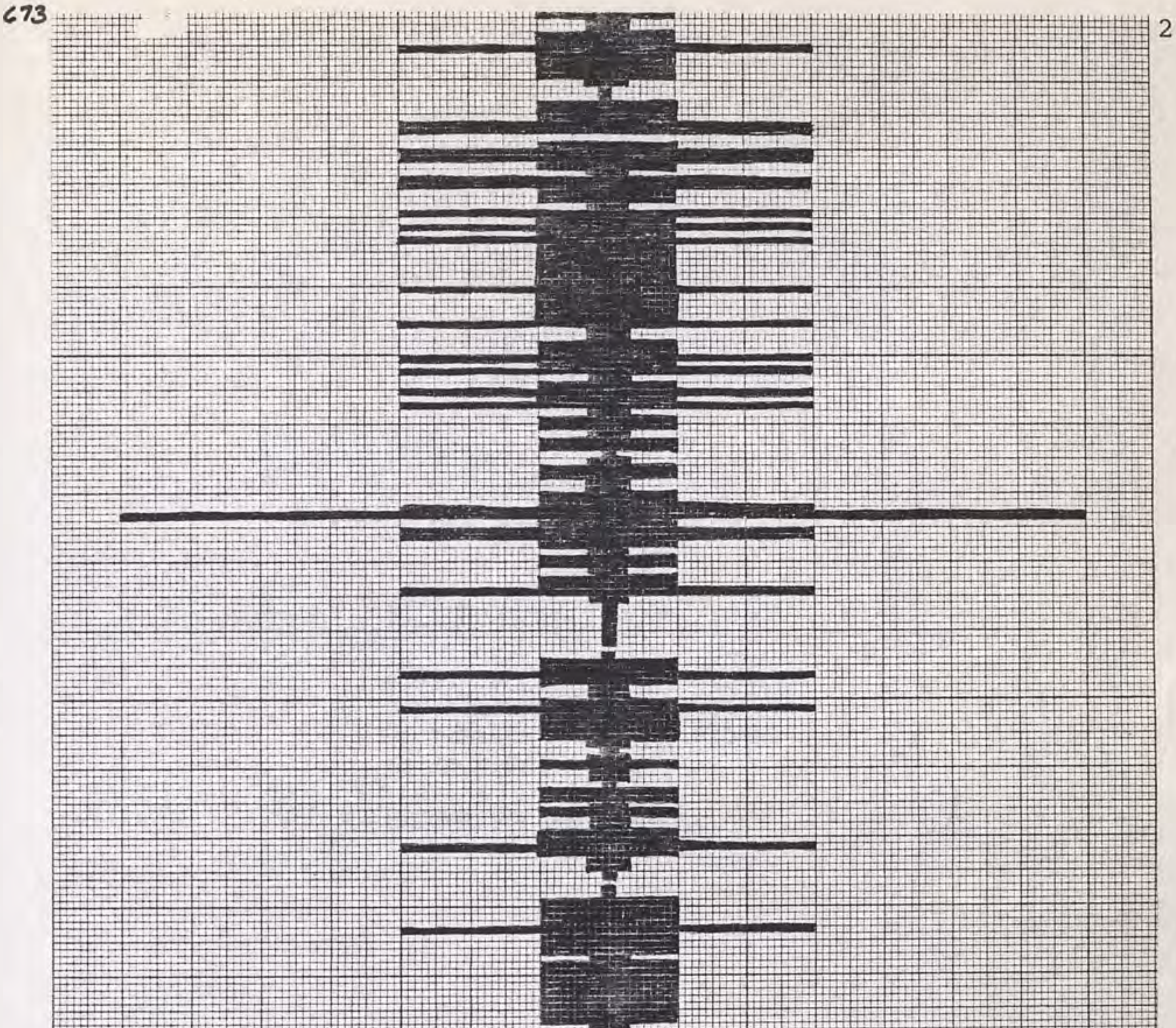

Table 5. - Berrya "larsoni".

PLEASE NOTE:

Plates and Plate Legend pages are misnumbered as received. No text is missing. Filmed as received.

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PLATE 1

Figure 1. - SEM map of all paratypes illustrated. All of the paratypes are from sample number 24.

Figure 2. - Saracenaria berryi, n. sp. Side view of paratype, Chev. P691, J.; x200.

Figure 3. - Saracenaria berryi, n. sp. Side view of paratype, Chev. P691, K.; x225.

Figure 4. - Saracenaria berryi, n. sp. End view of paratype, Chev. P691, L.; x225.

PLATE 2

Figure 1. - Neobulimina knoxvillensis, n. sp. Side view of paratype, Chev. P691, G., x200.

Figure 2. - Neobulimina knoxvillensis, n. sp. Side view of paratype, Chev. P691, G., x100. Apertural view, x300.

Figure 3. - Neobulimina knoxvillensis, n. sp. End view of paratype, Chev. P691, H., x225.

Figure 4. - Neobulimina knoxvillensis, n. sp. End view of paratype, Chev. P691, H., x100. Apertural view, x300.


Figure 1.


Figure 2.


Figure 3.


Figure 4.

PLATE 3

Figure 1. - Neobulimina knoxvillensis, n. sp. Proloculus view of paratype, Chev. P691, I., x300.

Figure 2. - Neobulimina knoxvillensis, n. sp. Proloculus view of paratype, Chev. P691, I., x100. Enlarged proloculus view, x350.

Figure 3. - Bolivina lankfordi, n. sp. Side view of paratype, Chev. P691, D., x200.

Figure 4. - Bolivina lankfordi, n. sp. Side view of paratype, Chev. P691, E., x200.

Figure 1.

Figure 2.

Figure 3.

Figure 4.

PLATE 5

Figure 1. - Berrya larsoni, n. gen., n. sp. Apertural view of paratype, Chev. P691, A., x300.

Figure 2. - Berrya larsoni, n. gen., n. sp. Side view of paratype, Chev. P691, B., x180.

Figure 3. - Berrya larsoni, n. gen., n. sp. Proloculus view of paratype, Chev. P691, C., x150.

Figure 4. - Berrya larsoni, n. gen., n. sp. Enlarged proloculus view of paratype, Chev. P691, C., x300.

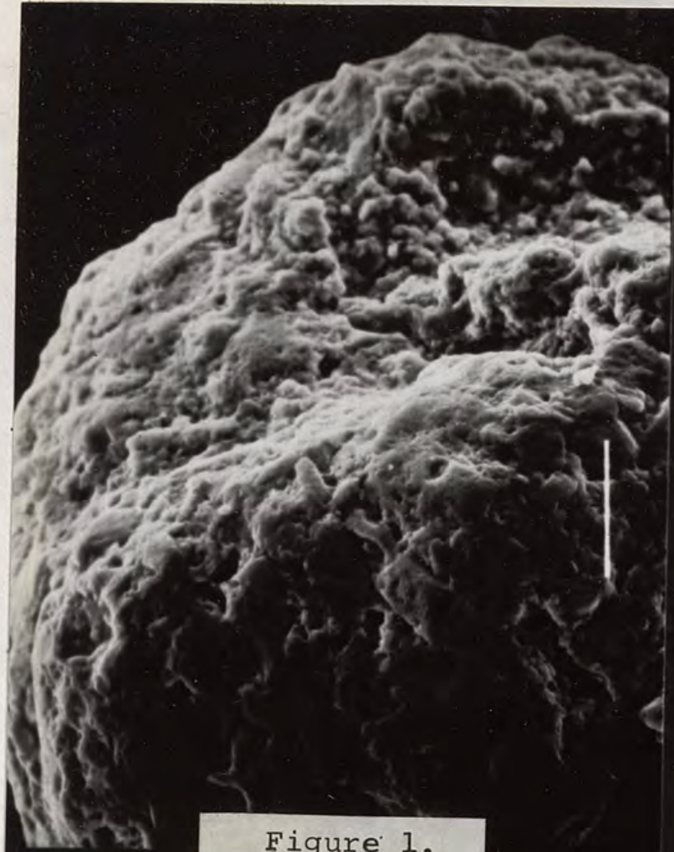

Figure 1.

Figure 2.

Figure 3.

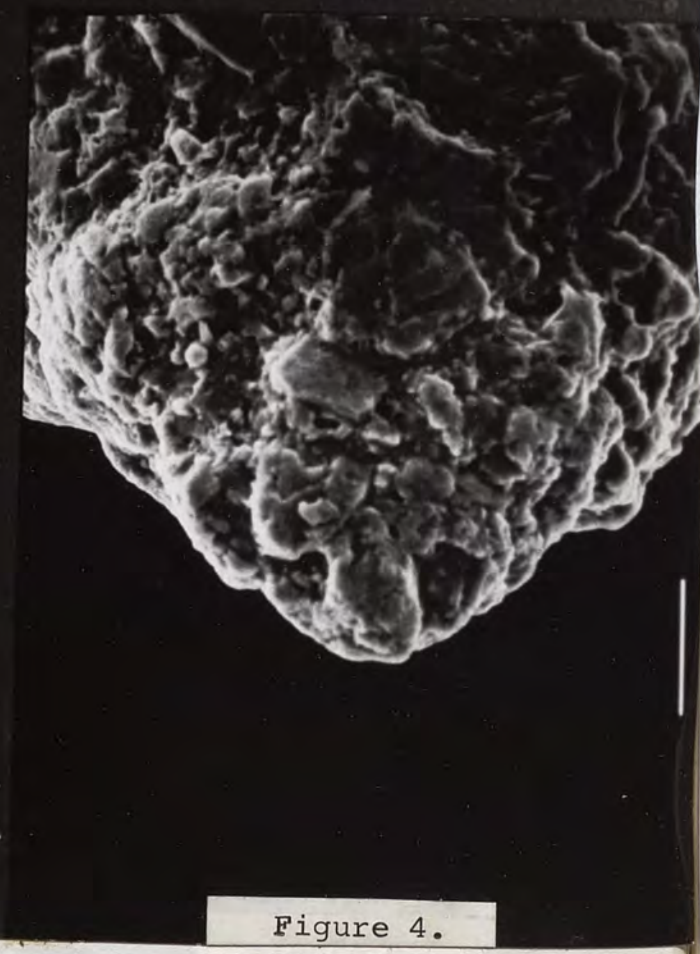

Figure 4.

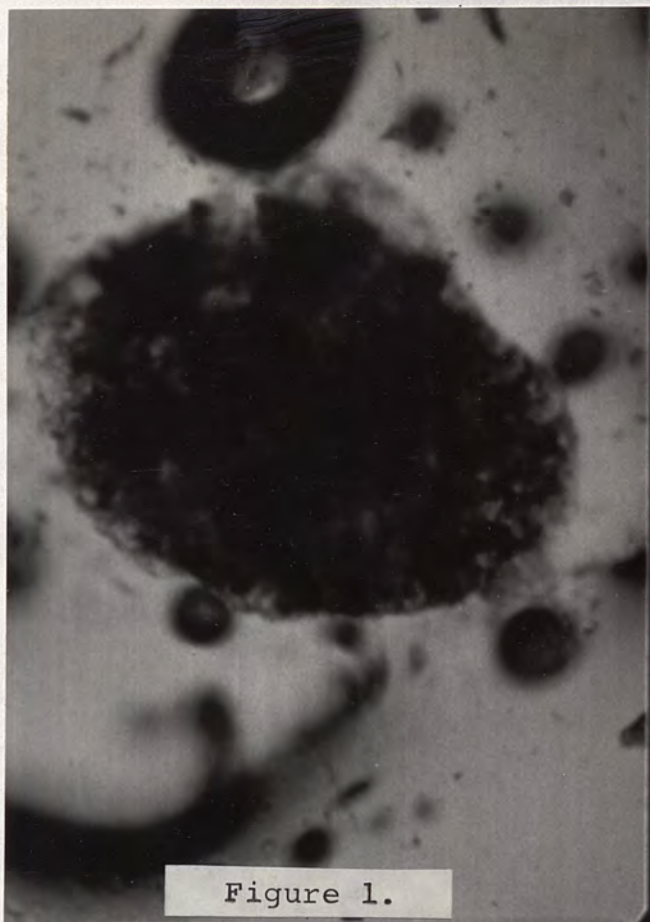

Figure 1.

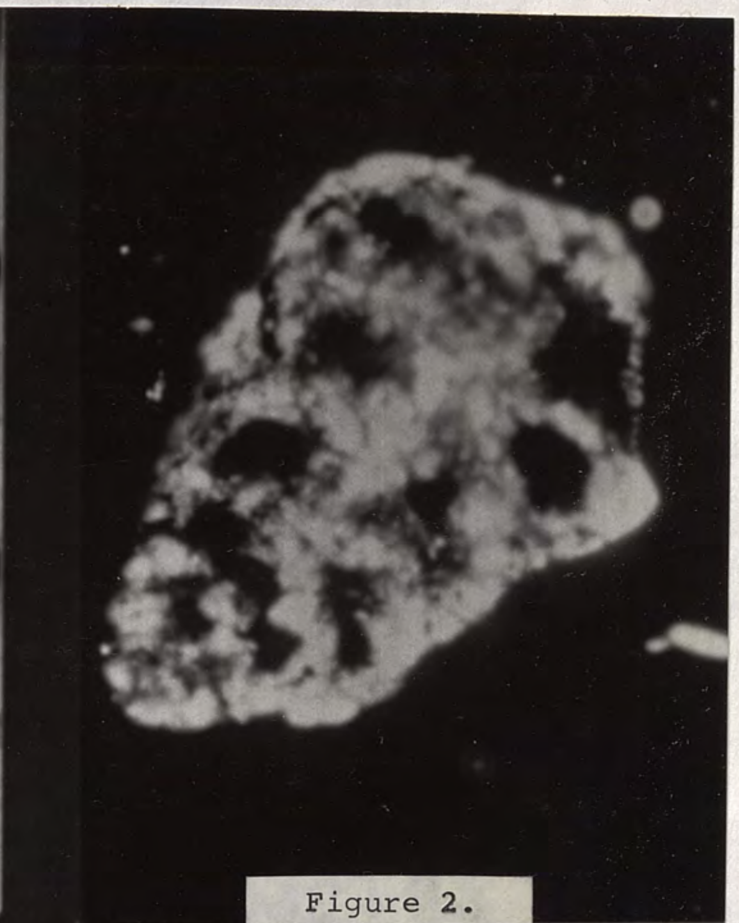

Figure 2.

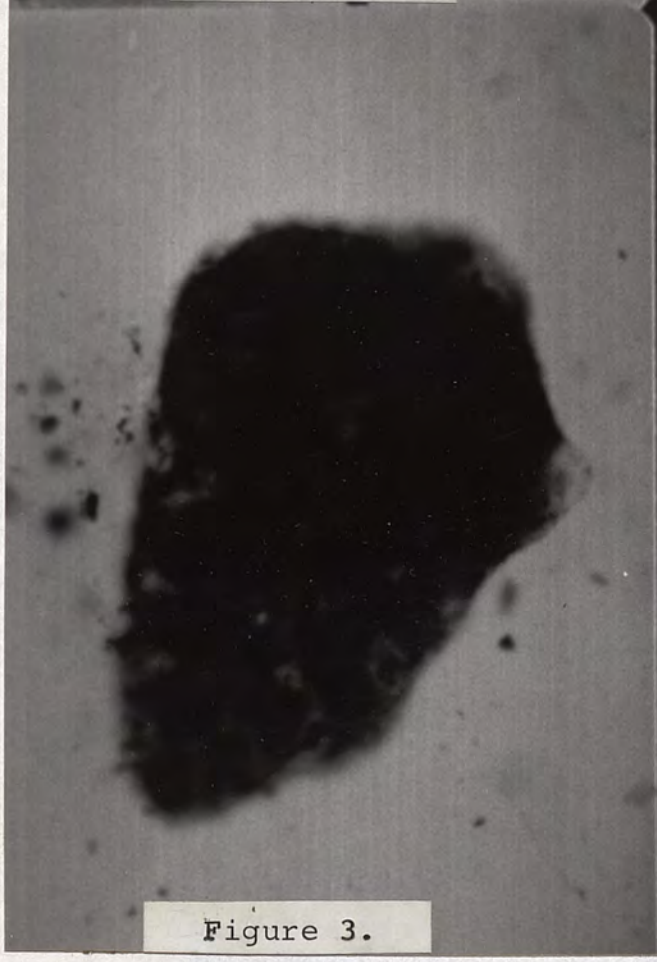

Figure 3.

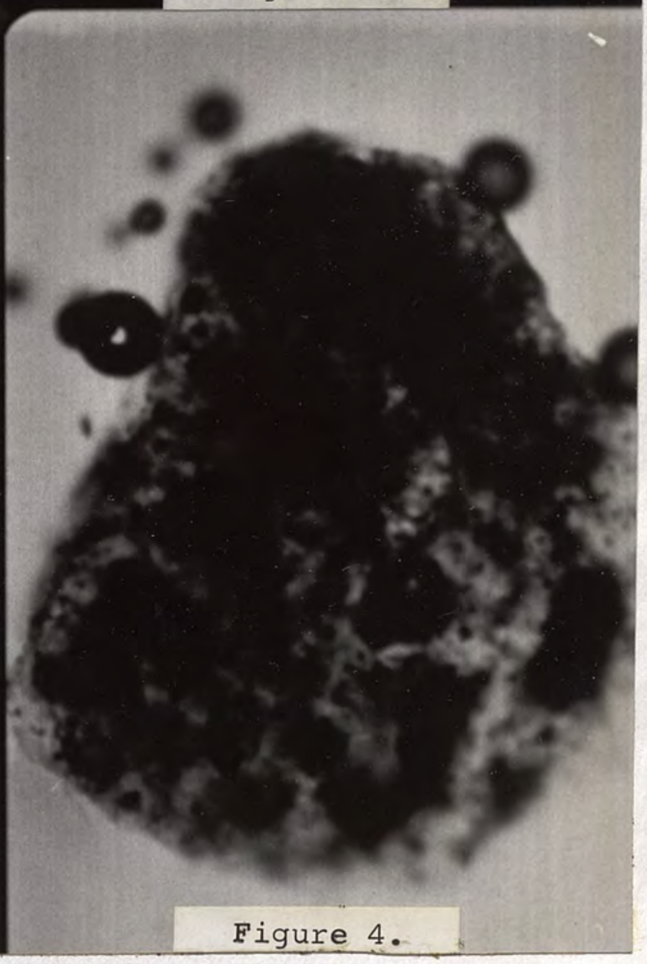

Figure 4.

SELECTED BIBLIOGRAPHY

Albritton, Claude C., Jr., 1937, Upper Jurassic and Lower Cretaceous Foraminifera From the Malone Mountains, Trans-Pecos, Texas: Jour. of Paleo., v. 11, no. 1, pp. 19-23.

Anderson, F. M., 1933, Knoxville-Shasta Succession in California: GSA Bull., v. 44, no. 12, pp. 1237-1270.

Ascoli, P., 1976, Foraminifera and Ostracod Biostratigraphy of the Mesozoic-Cenozoic, Scotian Shelf, Atlantic Canada: First Internat'l Symposium on Benthonic Foraminifera of Cont. Margins, Maritime Sediments Spec. Publ. No. 1, Halifax, Nova Scotia, Canada, pp. 653-671.

Bailey, E. H., Blake, M. C., Jr., & Jones, D. L., 1970, On-Land Mesozoic Oceanic Coast in California Coast Ranges: USGS Prof. Paper 700-C, pp. 70-81.

Berry, Keith D., 1965, New Foraminiferal Zonation, Upper Mesozoic, Sacramento Valley, California: Program Abstract, Fortieth Annual Meeting, Pacific Sections AAPG, SEG, and SEPM, Bakersfield, California, p. 21, April 1.

__________, 1974, Mesozoic Foraminiferal Zonation, Turonian to Tithonian Stages, Pacific Coast Province: SEPM Preprints, Pacific Section Meeting, April, 1974, San Diego, California, pp. 1-29.

Bhalla, S. N., & Abbas, S. M., 1976, The Age and Paleogeographical Significance of the Jurassic Foraminifera From Kutch, India: First Internat'l Symposium on Benthonic Foraminifera of Cont. Margins, Maritime Sediments Spec. Publ. No. 1, Halifax, Nova Scotia, Canada, pp. 537-544.

Cifelli, Richard, 1960, Variation of English Bathonian Lagenidae and its Phylogenetic Significance: Jour. of Paleo., v. 34, no. 3, pp. 556-569.

Conger, Susan D., & Green, Harry W., II, 1976, Preparation of Thin-foil Specimens for Transmission Electron Microscopy of Microorganism Tests: Jour. of Paleo., v. 50, no. 5, pp. 795-798.

Cushman, J. A., 1955, Foraminifera, Their Classification and Economic Use: Harvard Univ. Press, Cambridge, Mass., 589 pages.

__________, & Glazewski, K., 1949, Upper Jurassic Foraminifera From the Nizniow Limestone of Podole, Poland: Cushman Lab. for Foram. Research, v. 25, pt. 1, pp. 1-11.

Galloway, J. J., 1933, A Manual of Foraminifera: Princippia Press, Bloomington, Ind., 483 pages.

Gordon, W. A., 1961, Some Foraminifera From the Ampthill Clay, Upper Jurassic, of Cambridgeshire: Paleontology, v. 4, pt. 4, pp. 520-537.

Gordon, W. A., 1965, Foraminifera From the Corralian Beds, Upper Jurassic, of Dorset, England: Jour. of Paleo., v. 39, no. 5, pp. 828-863.

Goudkoff, P. P., 1945, Stratigraphic Relations of Upper Cretaceous in Great Valley, California: AAPG, Bull., v. 29, no. 7, pp. 956-1007.

Gradstein, Felix M., 1976, Biostratigraphy and Biogeography of Jurassic Grand Banks Foraminifera: First Internat'l Symposium on Benthonic Foraminifera of Cont. Margins, Maritime Sediments Spec. Publ. No. 1, Halifax, Nova Scotia, Canada, pp. 557-584.

__________, 1978, Jurassic Grand Banks Foraminifera: Jour. of Foram. Research, v. 8, no. 2, pp. 97-109.

Groiss, J. T., 1976, Relations Between the Upper Jurassic Foraminiferal Faunas of Western and Eastern Europe: First Internat'l Symposium on Benthonic Foraminifera of Cont. Margins, Maritime Sediments Spec. Publ. No. 1, Halifax, Nova Scotia, Canada, pp. 649-652.

Imlay, Ralph W., 1948, Characteristic Marine Jurassic Fossils From the Western Interior of the United States: USGS Prof. Paper 214-B, pp. 13-33.

Irwin, W. P., 1960, Geologic Reconnaissance of the Northern Coast Ranges and Klamath Mountains, California: Calif. Div. of Mines, Bull. 179, 80 pages.

Jones, Daniel J., 1956, Introduction to Microfossils: Harper Brothers, New York, 406 pages.

Kennedy, Clarice, 1978, An Improved Technique for Revealing the Internal Structure of Microfossils by Scanning Electron Microscopy: Jour. of Paleo., v. 52, no. 2, pp. 506-508.

__________, & Zeidler, W., 1976, The Preparations of Oriented Thin Sections in Micropaleontology: An Improved Method for Revealing the Internal Morphology of Foraminifera and Other Microfossils: Micropaleontology, v. 22, no. 1, pp. 104-107.

Kuznetsova, K. I., 1974, Distribution of Benthonic Foraminifera in Upper Jurassic and Lower Cretaceous Deposits at Site 261, DSDP Leg 27, in the Indian Ocean: Initial Reports of the Deep Sea Drilling Project, v. 27, pp. 673-677.

__________, & Seibold, I., 1975, Foraminifera From the Upper Jurassic and Lower Cretaceous of the Eastern Atlantic, (DSDP Leg 41, Sites 367 and 370): Initial Reports of the Deep Sea Drilling Project, v. 41, pp. 515-523.

Lalicker, Cecil G., 1950, Foraminifera of the Ellis Group, Jurassic, at the Type Locality: Univ. of Kansas Paleo. Contr.; Protozoa, art. 2, pp. 3-20.

Lloyd, A. J., 1959, Arenaceous Foraminifera From the Type Kimmeridgian (Upper Jurassic): Paleontology, v. 1, pt. 4, pp. 298-320.

Loeblich, Alfred R., & Tappan, Helen, 1949, Foraminifera From the Walnut Formation (Lower Cretaceous) of Northern Texas and Southern Oklahoma: Jour. of Paleo., v. 23, no. 3, pp. 245-266.

__________, & __________, 1950, North American Jurassic Foraminifera I, The Type Redwater Shale (Oxfordian) of South Dakota: Jour. of Paleo., v. 24, no. 1, pp. 39-60.

__________, & __________, 1964, Treatise on Invertebrate Paleontology, Part C, Protista 2, v. 1 & 2, GSA, Univ. of Kansas Press.

Luterbacher, H. P., 1972, Foraminifera From the Lower Cretaceous and Upper Jurassic of the Northwestern Atlantic: Initial Reports of the Deep Sea Drilling Project, v. 11, pp. 561-576.

Putrja, F. S., 1970, Jurassic Lenticulinidae of Western Siberia: Paleo. Jour., Amer. Geol. Inst., v. 4, no. 4, pp. 477-491.

Rynearson, G. A., 1946, Chromite Deposits of the North Elder Creek Area, Tehama County, California: USGS Bull. 945-G, pp. 191-210.

Said, R., & Barakat, M. G., 1958, Jurassic Microfossils From Gebel Maghara, Sinai, Egypt: Micropaleontology, v. 4, no. 3, pp. 231-272.

Sandidge, J., 1933, Foraminifera From the Jurassic in Montana: Amer. Mid. Natur., v. 14, pp. 174-185.

Sandidge, J., 1933, Foraminifera From the Mesozoics of Montana: GSA Bull., v. 44, pt. 1, p. 204 (Abstract).

Taliaferro, N. L., 1943, Franciscan-Knoxville Problem: AAPG Bull., v. 27, no. 2, pp. 109-219.

Tappan, Hellen, 1951, Northern Alaska Index Foraminifera: Contr. Cushman Found. Foram. Research, v. 2, pp. 1-8.

__________, 1955, Foraminifera From the Arctic Slope of Alaska: Part 2, Jurassic Foraminifera: USGS Prof. Paper 236-B, 90 pages.

Weynschenk, Robert, 1956, Some Rare Jurassic Index Foraminifera: Micropaleontology, v. 2, no. 3, pp. 283-286.