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Journal of Paleontology, Vol. 35, No. 1 (Jan., 1961), 168-175.

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SILURIAN TRILOBITES FROM THE KLAMATH MOUNTAINS, CALIFORNIA

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ABSTRACT—The Gazelle formation in the Klamath Mountains is a eugeosynclinal suite of rocks from which well-preserved Silurian brachiopods and trilobites were discovered. A faunule containing the trilobites *Leonaspis (Acanthalomina) minuta* (Barrande), *Dicranopeltis* cf. *C. decipiens* (Weller), *Trochurus* sp. indet., *Scutellum* sp. indet., *Proetus* sp. indet., *Cheirurus* cf. *C. insignis* Beyrich, *Enocrinurus (Cromus) beaumonti* (Barrande) is described. *Enocrinurus* and *Proetus* are the only genera previously reported from the western states. *Leptaena rhomboidalis* Wilckens?, *Atrypa reticularis* Linnaeus var. *orbicularis* Sowerby?, *Atrypella scheii* (Holte-dahl)?, and *Gypidula* sp. are brachiopods from this faunule.

Gazelle trilobites are very closely related to the classical Bohemian fauna and some are conspecific. In addition the brachiopod assemblage more closely resembles the Alaskan and Asian faunas than those of the Great Basin and eastern North America.

INTRODUCTION

THIS paper describes a Silurian trilobite and brachiopod faunule from the Gazelle formation (Wells *et al.*, 1959; Churkin and Langenheim, 1960) which crops out near the eastern edge of the Klamath Mountain province, Siskiyou County, California.

The early Paleozoic sequence that underlies a wide region in the eastern Klamath Mountains is very poorly known. Metamorphic environments have obliterated fossil remains over large areas and only isolated limestone bodies have yielded datable fossils. In the summer of 1957 a detailed strati-

graphic study was made of an area west of Gazelle that escaped metamorphism (Churkin and Langenheim, 1960). The trilobite faunule described in this paper was collected during this work. Discovery of well-preserved Silurian trilobites from poorly known rocks in northern California and the strong affinities of the trilobites with Bohemian species seem of sufficient interest to warrant publication.

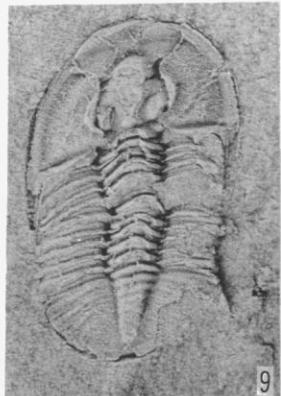
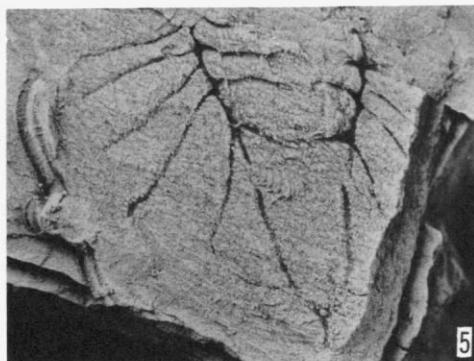
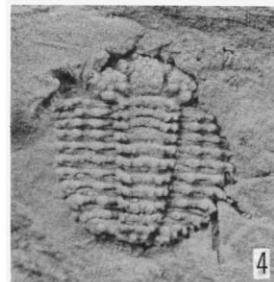
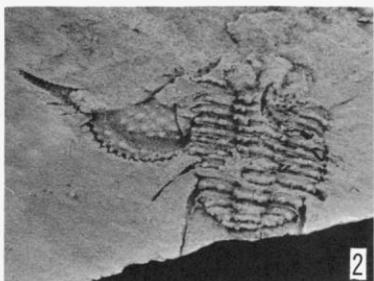
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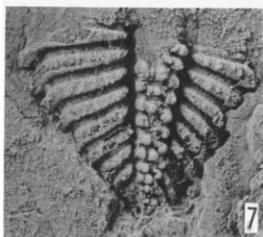
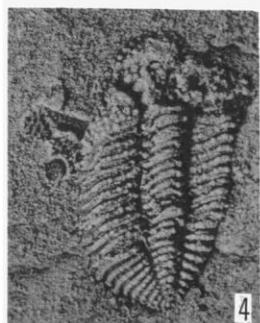
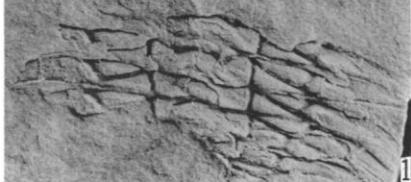
Fossiliferous limestone along Willow Creek, southwest of Gazelle, has long been

EXPLANATION OF PLATE 35

- FIGS. 1-4—*Leonaspis (Acanthalomina) minuta* (Barrande). 1, Incomplete specimen, $\times 4$, hypotype no. 34583; 2, Almost complete specimen and detached free cheek from larger specimen, $\times 4$, hypotype no. 34584; 3, Large almost complete cephalon with part of the thorax attached, genal spines broken off the free cheeks, $\times 4$, hypotype no. 34585; 4, Small almost complete specimen, $\times 4$, hypotype no. 34586. Gazelle formation, loc. B-5247.
- 5-6—*Dicranopeltis* cf. *D. decipiens* (Weller). 5, Incomplete, flattened pygidium, $\times 4$, hypotype no. 34581; 6, Artificial replica of incomplete pygidium, $\times 3$, hypotype no. 34582. Gazelle formation, loc. B-5247.
- 7—*Trochurus* sp. indet. Pygidium, $\times 4$, hypotype no. 34587. Gazelle formation, loc. B-5247.
- 8—*Scutellum* sp. indet. Incomplete pygidium, $\times 3$, hypotype no. 34588. Gazelle formation, loc. B-5247.
- 9—*Proetus* sp. indet. Almost complete specimen, glabella damaged, $\times 4$, hypotype no. 34589. Gazelle formation, loc. B-5247.

All figured specimens are in the type collection of The Museum of Paleontology, Department of Paleontology, University of California, Berkeley, California.





known. In an early report (Diller, 1886) C. D. Walcott assigned a "*Lithostrotion*" collected at Willow Creek by J. S. Diller to the Carboniferous. Later, corals collected from limestone along Willow Creek southwest of Gazelle were identified as Devonian by Schuchert (Diller and Schuchert, 1894). This limestone was subsequently referred to as a northern extension of the Devonian Kennett formation of the Redding Quadrangle (Diller, 1906). Stauffer (1930) also described corals from limestone $3\frac{1}{2}$ to 4 miles southwest of Gazelle as Devonian.

Merriam (1940) collected fossils from the rocks along Willow Creek, $3\frac{1}{2}$ miles southwest of Gazelle, and identified them as Silurian. Furthermore, he compared his fossils with Diller's collection in the U. S. National Museum and reports that the two collections "undoubtedly represent approximately the same zones" (Merriam, 1940, p. 48). Stauffer's material also probably came from the same locality and as far as can be determined this spot is locality B-5247 (Univ. of Calif., Berkeley, Mus. of Paleon.) from which all of the material described in this paper was quarried.

ACKNOWLEDGMENTS

The writer acknowledges the helpful suggestions of C. W. Merriam of the U. S. Geological Survey, F. Prantl and A. Přibyl of the National Museum, Prague, Czechoslovakia, kindly read the manuscript, examined the original plates, and offered many valuable critical comments regarding

the relationship between the Gazelle and Bohemian trilobites.

Sincere thanks are due R. L. Langenheim, Jr. for introducing the writer to the problem, assistance in the field, and for criticizing the manuscript. Research funds of the Department of Paleontology of the University of California defrayed in part the field expenses.

STRATIGRAPHY AND LOCATION

Over 600 feet of eugeosynclinal rocks, including graywacke, shale, bedded chert, conglomerate and limestone crop out in the Gazelle area (Churkin and Langenheim, 1960). Shale and graywacke predominate, but lateral gradation from one lithologic type to another is characteristic and discontinuous lenses of bedded chert, conglomerate and limestone are widespread. These rocks, assigned to the Gazelle formation of Wells *et al.* (1959), are bounded by an overthrust mass of schist and phyllite, igneous intrusion, or alluvium in the Gazelle area and neither the top nor bottom of the formation is exposed. The youngest rocks in the outcrop area are probably those of the Payton Ranch limestone member (Churkin and Langenheim, 1960) which forms cliffs and bold outcrops on the ridges along the north and middle branches of Willow Creek. The top of the Payton Ranch limestone member, however, is either an erosion surface or a fault contact and its relation to rocks cropping out to the west is therefore indeterminate.

EXPLANATION OF PLATE 36

- FIGS. 1-3—*Cheirurus* cf. *C. insignis* Beyrich. 1, Incomplete cephalon and thorax, $\times 3$, hypotype no. 34590; 2, Pygidium and dissociated thoracic segments, $\times 3$, hypotype no. 34591; 3, Single isolated pleuron, $\times 4$, hypotype no. 34592. Gazelle formation, loc. B-5247.
- 4-9—*Encrinurus* (*Cromus*) *beaumonti* (Barrande). 4, Small almost complete specimen, cephalon without free cheeks, $\times 3$, hypotype no. 34593; 5, Large cephalon without free cheeks, $\times 4$, hypotype no. 34594; 6, Small cephalon without free cheeks, $\times 4$, hypotype no. 34595; 7, Almost complete pygidium of average size, $\times 4$, hypotype no. 34596; 8, Flattened pygidium of large size, $\times 4$, hypotype no. 34597; 9, External mold of complete pygidium, axis slightly damaged, $\times 4$, hypotype no. 34598. Gazelle formation, loc. B-5247.

All figured specimens are in the type collection of The Museum of Paleontology, Department of Paleontology, University of California, Berkeley, California.

All the trilobites described in this paper were collected from brown-black shale interbeds in the thin-bedded basal portion of limestone which forms a small knob (elev. 3,600') on the ridge trending north from the middle branch of Willow Creek in the NW $\frac{1}{4}$, SW $\frac{1}{4}$, NW $\frac{1}{4}$, Sec. 19, T. 42N, R. 6W, China Mountain 15-minute quadrangle, Siskiyou County, California and is about 3,400' N 45°E of BM 3333 in Sec. 24, T 42W, R. 7W, of the same quadrangle. This locality is numbered B-5247 which serves to identify the fossil collections made from this spot and stored in the Museum of Paleontology, University of California, Berkeley, California.

COMPOSITION OF THE FAUNA

Most of the limestone within the Gazelle formation is sparsely fossiliferous, containing poorly-preserved corals, brachiopods, crinoid columnals and echinoderm fragments. Only unidentifiable fossil fragments were recovered from the graywacke, shale and bedded chert. The thin-bedded basal portions of the limestone units, however, locally contain abundant well-preserved brachiopods and trilobites.

At locality B-5247 a collection was made of well-preserved trilobite molds and associated brachiopods, coral fragments and crinoid columnals. Only a few entire trilobite impressions were found in the shale in contrast to hundreds of free cheeks, cranidia, thoracic segments and pygidia. The following fossils from this collection have been identified:

Trilobita

- Leonaspis (Acanthalomina) minuta* (Barrande)
- Dicranopeltis* sp. cf. *D. decipiens* (Weller)
- Trochurus* sp. indet.
- Scutellum* sp. indet.
- Proetus* sp. indet.
- Cheirurus* cf. *C. insignis* Beyrich
- Encrinurus (Cromus) beaumonti* (Barrande)

Brachiopoda

- Leptaena rhomboidalis* Wilckens?
- Atrypa reticularis* Linnaeus var. *orbicularis* Sowerby?
- Atrypella scheii* (Holtdahl)?
- Gypidula* sp.

AGE AND CORRELATION

Individual elements and particularly the total impression stamp the fossil assem-

blage as indisputably Silurian and, probably, Middle or Upper Silurian. Closer correlation, however, must depend upon further collection in the Gazelle formation and upon more extensive and detailed descriptions of other Silurian fossil assemblages from western North America. At present these faunas are very poorly known and the isolated Gazelle assemblage must be compared directly with fossils from the standard sections of eastern North America, England, Bohemia and Siberia.

The Gazelle fossils are most strikingly similar to the classical Silurian fauna of Bohemia described by Barrande (1852). Several trilobite species from Gazelle show no significant differences from the Barrandian lectotypes and were tentatively assigned to the Bohemian species. These specific comparisons were then reviewed by Prantl and Přibyl of the National Museum of Prague, who reported that "The trilobites of Gazelle are very closely allied to the Bohemian ones. Some of them in our opinion are really conspecific" (personal communication, 1959). With their confirmation, two Bohemian species—*Encrinurus (Cromus) beaumonti* (Barrande) and *Acanthalomina minuta* (Barrande) have been recognized at Gazelle.

The cosmopolitan aspect of the trilobites thus far identified in the Gazelle fauna can be more easily explained if they are considered to have been planktonic. Ruedemann (1934, p. 39) states that "there are trilobites that undoubtedly belong to the plankton . . . these include some forms of *Lichas*, especially *Acidaspis* and *Odontopleura* with large crowns of horizontal spines." These spiny forms are among those collected at Gazelle and it is thought that they were indeed planktonic and that their discarded molts sank to the sea bottom where brachiopods and corals were living. Here they were subsequently buried by argillaceous sediment.

The trilobite fauna of the Gazelle formation includes *Dicranopeltis*, *Trochurus*, *Cheirurus*, *Leonaspis* and *Scutellum*, all of which are previously unreported from the western states. Although these genera occur in eastern and middle-western North America, specific comparisons clearly indicate that the Gazelle trilobites are more

closely related to Middle and Upper Silurian trilobites of Bohemia and Asia. Furthermore, the brachiopods also seem more closely related to those of Alaska and Asia than to those of interior and eastern North America. Thus the faunal aspect of the Gazelle formation is in accord with the conclusion of C. W. Merriam (personal communication) that the Lower Paleozoic faunas of northern California have their closest affinities with Alaskan and Asian assemblages and are distinctly different from those of the Great Basin.

SYSTEMATIC DESCRIPTIONS

Class TRILOBITA

Order ODONTOPLEURIDA Whittington, 1959

Family ODONTOPLEURIDAE Burmeister, 1843

Subfamily ODONTOPLEURINAE
Burmeister, 1843

Genus LEONASPIS Richter and
Richter, 1917

Subgenus ACANTHALOMINA Prantl
and Přibyl, 1949

LEONASPIS (ACANTHALOMINA) MINUTA
(Barrande)
Pl. 35, figs. 1-4

Acidaspis minuta BARRANDE, 1852, pl. 37, figs.
18-22.

Acanthalomina minuta (Barrande), PRANTL and
PŘIBYL, 1949, p. 164, pl. 1, figs. 26-29, pl. 10,
figs. 6,7.

Description.—Small opisthoparian trilobite with carapace strikingly spinose; cephalon very convex, short, wide, semicircular in outline, genal spines bending sharply outwards and secondarily spinose; cephalon rimmed by narrow, raised border bearing small spines (less than 1 mm. long) normal to margin; glabella with well-developed, elongate, very convex, median lobe and two pairs of less prominent lateral lobes; anterior lateral lobes strongly convex, sub-ovate in outline and separated by sharp furrows from median lobe, and from large pair of basal lateral lobes by deeper posterior furrows that curve backward and inward to join occipital furrow; occipital furrow broadly rounded and deep; occipital ring simple and apparently with only single median granule; anterior branches of facial sutures branch off from ocular ridge and converge slightly to anterior margin of cephalon, forming two small subtrigonal

areas between them and glabella; fixed cheeks much smaller than free cheeks, both moderately convex; eyes small and subcircular; entire surface of cephalon finely tuberculate; thorax of nine segments; thoracic axis strongly convex with rounded axial rings bearing as many as seven spinose tubercles; deep, rounded, articulating furrows separate rings; thoracic pleura slightly convex with narrow, raised ridges running out into long hollow spines; spines paralleling each other and bent posteriorly; pleural ridges apparently with three or possibly four rows of spinose tubercles; outer tubercles less prominent than inner pair and on some pleura appear to consist of two smaller tubercles branching from a single base; pygidium subtrigonal with convex axis and flattened pleural lobes; axis divided into two tuberculate rings; anterior ring with about four spinose tubercles and posterior ring with two centered tubercles on terminal end of axis; pleural lobes tuberculate; pair of faint ridges, with two tubercles on each ridge extending from dorsal furrows opposite anterior ring to margin where they continue into pair of long, principal spines; pygidial margin spinose bearing four or five pairs of slender spines with second pair from posterior end longer than others; spines at ends of thoracic pleura several times longer than pygidial spines.

Dimensions of a cephalon (hypotype no. 34584) are: length 3.5 mm., width 10 mm., length of genal spines 3 mm., width of glabella at base 2.5 mm., width of median lobe 1.3 mm., width of glabella at mid-length 4 mm.

Dimensions of a small pygidium (hypotype no. 34583) are: length 3 mm., width at anterior end 5 mm., width of axis at anterior end 1.5 mm..

Dimensions of an incomplete, small, dorsal mold (hypotype no. 34586) are: length 6.5 mm. (of which 1.5 mm. belong to cephalon, 4 mm. to thorax, and 1 mm. to pygidium), cephalon is 6 mm. wide at genal angles, thorax 6 mm. wide at anterior end, pygidium 4 mm. wide at anterior end, thoracic axis 2 mm. wide at anterior end and pygidial axis 1 mm. wide at anterior end.

This species is represented by six almost complete molds, numerous free cheeks, and pygidia.

Hypotypes.—Univ. Calif. Mus. Paleo. Type Coll. nos. 34583, 34584, 34585, 34586.

Discussion.—The Gazelle specimens agree very closely with the illustrations and descriptions given by Barrande and Prantl and only differ from the lectotype of *A. minuta* by having the main pygidial spines longer than secondary spines. Prantl and Přibyl agree that the Gazelle forms are conspecific with the type *A. minuta* in Bohemia (personal communication, 1960).

Occurrence and range.—Locality B-5247, Gazelle formation. “*A. minuta* is in Bohemia seemingly restricted to the Kopanina Limestones—e β_1 (Lower Ludlovian), where it occurs in the characteristic association with *Encrinurus (Cromus) beaumonti* (Barr.), *Cheirurus quenstedti* Barr., etc.” (Prantl and Přibyl, 1949, p. 165).

Order LICHIDA Moore, 1959

Family LICHIDAE Hawle and Corda, 1847
Subfamily LICHINAE Hawle and Corda, 1847

Genus DICRANOPELTIS Hawle and Corda, 1847

DICRANOPELTIS sp. cf. D.
DECIPiens (Weller)
Pl. 35, figs. 5, 6

Description.—Pygidium semielliptical in outline; axis strongly convex anteriorly and with two rounded annulations passing backward into convex bulbous portion, depressed posteriorly into wedge-shaped post-axial area; two dorsal furrows bound post-axial region and converge to posterior margin; pleural lobes slightly convex and divided into three, broad, grooved ribs, all produced marginally into short, free points; entire surface finely tuberculate.

Dimensions of a pygidium (hypotype no. 34582) are: length 7 mm., width at anterior margin 12 mm., width of axis anteriorly 3.5 mm. Collection consists of two isolated pygidia.

Hypotypes.—Univ. Calif. Mus. Paleo. Type Coll. nos. 34581, 34582.

Discussion.—The pygidia closely resemble those of *D. decipiens* Weller (Weller, 1907, p. 237, pl. 22, fig. 11) and *D. decipiens* (Weller) (Phleger, 1936, p. 612, fig. 66) but more complete specimens are needed before identity can be established.

Occurrence and range.—Locality B-5247, Gazelle formation. *Dicranopeltis* occurs in

the Upper Ordovician of Europe and the Silurian of Europe and North America. *D. decipiens* is represented in the Niagaran of the eastern United States.

Subfamily CERATARGINAE Tripp, 1957

Genus TROCHURUS Beyrich, 1845

TROCHURUS, sp. indet.

Pl. 35, fig. 7

Description.—Lichadian pygidium of “*Trochurus-Euarges type*” (Phleger, 1936); pleural lobes divided into three sections by two pairs of ridges passing into marginal spines (1 mm. long); anterior portion of axial lobe marked by two rings continuous with these ridges; axis tapers posteriorly into short ridge (1.5 mm. long) opposite small terminal spine on margin; two broad spines (0.5 and 1.5 mm. long) occur on each side of this terminal spine making a total of nine marginal spines; axis bounded by deep dorsal furrows; entire pygidium moderately convex and covered by small tubercles.

Dimensions of the largest pygidium (hypotype no. 34587) are: length 6 mm., width at anterior end 7 mm., length of axial lobe 4.5 mm., width of axial lobe 2 mm. Collection consists of four isolated pygidia.

Hypotype.—Univ. Calif. Mus. Paleo. Type Coll. no. 34587.

Discussion.—These specimens resemble *Lichas palmata* (Barrande, 1952, pl. 28, figs. 1, 9, 10) but have nine large marginal spines instead of six.

Occurrence and range.—Locality B-5247, Gazelle formation. The genus *Trochurus* occurs in the Upper Ordovician-Middle Silurian of Europe and North America.

Order PTYCHOPARIIDA Swinnerton, 1915

Suborder ILLAENINA Jaanusson, 1959

Family THYSANOPELTIDAE Hawle and Corda, 1847

Genus SCUTELLUM Pusch, 1833

SCUTELLUM, sp. indet.

Pl. 35, fig. 8

Description.—Pygidium elliptical in outline; axis very short with radiating furrows extending from it across broad, flattened, pleural surfaces to margin.

Dimensions of a pygidium (hypotype no. 34588) are: length 9 mm., width at anterior margin approximately 11 mm., width of

axis anteriorly 3 mm. Collection consists of two incomplete pygidia.

Hypotype.—Univ. Calif. Mus. Paleo. Type Coll. no. 34588.

Discussion.—Such features as are preserved indicate the genus *Scutellum*.

Occurrence and range.—Locality B-5247, Gazelle formation. *Scutellum* occurs in Ordovician to Devonian rocks and has a cosmopolitan distribution.

Superfamily PROETACEA Salter, 1864

Family PROETIDAE Salter, 1864

Subfamily PROETINAE Salter, 1864

Genus PROETUS Steininger, 1831

PROETUS, sp. indet.

Pl. 35, fig. 9

Description.—Cephalon semicircular in outline and somewhat larger than pygidium; glabella tumid, moderately convex, rounded in front and extending to within 1 mm. of anterior margin; two pairs of glabellar furrows, anterior pair faint, posterior furrows deeply impressed, originating opposite eyes and extending obliquely inward and backward producing a slight convex curve near occipital furrow; occipital furrow narrow, well-defined and with pair of small, subovate, occipital lobes back of posterolateral glabellar angles; cheeks smooth, and slightly convex, sloping from dorsal furrows laterally and anteriorly to within 1 mm. of margin; raised, flattened, continuous, marginal border rims cephalon and passes posteriorly into broad genal spines lying against first six thoracic segments; posterior margin of each cheek with well-developed posterior cheek furrow running from dorsal furrow, opposite the occipital furrow, to inner side of marginal border; facial sutures opisthoparoid with divergent anterior branches; fixed cheeks narrow; free cheeks broad, apparently containing eyes of moderate size close to dorsal furrows; thorax composed of nine smooth segments; axial lobe strongly convex, bounded by deep dorsal furrows; thoracic pleura convex, inclined slightly backwards and apparently weakly furrowed; pygidium semicircular; axis strongly convex, and bordered sharply by dorsal furrows, tapering posteriorly and terminating bluntly just within marginal border; axis with about seven annulations; pleural lobes flattened bearing faint ribs continuous with axial an-

nulations, and rimmed by narrow flat border.

Dimensions of the hypotype no. 34589 are: total length 12 mm., length of cephalon 4 mm., length of thorax 5 mm., length of pygidium 3 mm.; cephalon 7 mm. wide at genal angles, glabella 2.5 mm. wide at base, thorax and anterior end of pygidium 6 mm. wide, thoracic axis 2 mm. wide opposite genal spines and pygidial axis 1.5 mm. wide at anterior end. Represented by numerous detached pygidia and a single, entire dorsal mold.

Hypotype.—Univ. Calif. Mus. Paleo. Type Coll. no. 34589.

Discussion.—These specimens do not belong to any described species of *Proetus* known to the writer, but poor preservation of the cephalon does not warrant description of a new species.

Occurrence and range.—Locality B-5247, Gazelle formation. *Proetus* occurs in the Middle Ordovician-Upper Devonian rocks of Europe, North America, South America, Africa and Asia (Přibyl, 1946).

Order PHACOPIDA Salter, 1864

Suborder CHEIRURINA Harrington and Leanza, 1957

Family CHEIRURIDAE Salter, 1864

Subfamily CHEIRURINAE Salter, 1864

Genus CHEIRURUS Beyrich, 1845

CHEIRURUS sp. cf. C. INSIGNIS Beyrich Pl. 36, figs. 1-3

Description.—Cephalon roughly semicircular in outline, slightly convex, with genal angles apparently produced into short spines; glabella large, constituting more than one-third of cephalon, expanded anteriorly, reaching frontal margin, and convex but not elevated much above cheeks; three pairs of lateral furrows impressed in glabella, all slope gently backward with anterior furrows nearly crossing glabella, posterior pair open directly into neck furrows near middle of glabella and isolate triangular basal lobes; fixed cheeks larger than free cheeks; facial sutures extend from in front of genal angles inward to eyes and then obliquely forward, cutting anterior margin in front and on each side of glabella; cheeks slightly convex and marked laterally by marginal furrows continuous with posterior cheek furrows; eyes apparently small; sur-

face of cheeks pitted, glabella smooth; number of thoracic segments unknown; axial lobe less than one-third width of thorax; axis moderately convex, bounded by sharp dorsal furrows, and tapering gently backward; each pleuron divided by node-like constriction into an inner third and outer two-thirds; inner third of pleuron cut by deep diagonal furrow, outer two-thirds produced into broad spine bending posteriorly; pygidium broad and short; axis with three distinct annulations and fourth rudimentary one; pleura flat, broad, and produced into three pairs of broad spines directed obliquely outward and backward, posterior pair of spines much shorter than others; inner third portions of pleura marked by oblique deep furrows.

Dimensions of a cephalon (hypotype no. 34590) are: length of cephalon 6 mm., width of cephalon about 16 mm., width of glabella at base 4 mm., width of glabella at anterior end 6 mm.

Dimensions of largest pygidium (hypotype no. 34591) are: length 3 mm., width at anterior margin 6 mm., width of axis anteriorly 1.5 mm. Collection consists of two cephalas, detached thoracic segments and two pygidia.

Hypotypes.—Univ. Calif. Mus. Paleo. Type Coll. nos. 34590, 34591, 34592.

Discussion.—Only incomplete specimens were collected and the characters needed for specific identification are obscure or missing. No significant differences, however, could be found between the fragmentary remains and the descriptions and illustrations of *C. insignis* of Barrande (1852, pl. 41, figs. 1-13), Barton (1915, p. 129, fig. 19), Prantl and Přibyl (1947, p. 14, pl. 5, figs. 5,6). Among the American cheirurids, *Cheirurus welleri* (Raymond, 1916, p. 34, pl. 3, fig. 6; pl. 4, figs. 7,8) closely resembles the Gazelle specimens and is also characterized by anterior lateral furrows that nearly cross the glabella. The pygidium of *C. welleri* is not certainly known, preventing more thorough comparison.

Occurrence and range.—Locality B-5247, Gazelle formation. *C. insignis* occurs in the Llandoveryan-Wenlockian Motol beds, e.g. of Bohemia. The genus *Cheirurus* has a cosmopolitan distribution and is almost exclusively Silurian, although its first representa-

tives occur in the Upper Ordovician (Prantl and Přibyl, 1947). *C. welleri* occurs in the Niagaran at Wauwatosa, Wis., the Clinton of New York, the Waldron of Indiana, Silurian of Tennessee, and Guelph of Ontario (Raymond, 1916, p. 35).

Family ENCRINURIDAE Angelin, 1854

Subfamily ENCRINURINAE Angelin, 1854

Genus ENCRINURUS (CROMUS)

Barrande, 1852

ENCRINURUS (CROMUS) BEAUMONTI

(Barrande)

Pl. 36, figs. 4-9

Enocrinurus (Cromus) beumonti BARRANDE, 1852, pl. 43.

Description.—Cephalon sub-trigonal in outline and moderately convex; glabella prominent, inflated anteriorly and bounded by deep dorsal furrows; four pairs of short (notch-like) lateral furrows divide glabella into four lateral lobes and an anterior lobe; first three lobes and anterior lobe sub-equal, basal lobes about one-half as large; occipital furrow deep and rounded; occipital segment narrow; fixed cheeks moderately convex with deep posterior cheek furrows originating at dorsal furrows and extending nearly to genal angles; genal angles rounded and not produced into genal spines; entire surface of cephalon, including occipital segment and posterior marginal border, covered with rounded tubercles; three small entire specimens have eleven thoracic segments each; thorax with deep axial furrows; axis strongly convex and slightly tapering posteriorly; pleural lobes flat with sharp downward flexure near margins; pleura ridged, straight in flat region, but curved slightly anteriorly starting at downward flexure; pleural furrows continuous with articulating furrows of thorax; tiny tubercles line pleural ridges and axial rings; pygidium trigonal, wider than long; axis strongly convex, bounded by deep dorsal furrows, and extending nearly to posterior margin; about eleven axial rings extend continuously across axis becoming finer and less distinct posteriorly; pleural lobes with nine paired ribs; last pair apparently fused to axis; first five rib furrows continuous with ring furrows; six axial rings, two without corresponding ribs occur back of fifth ring; ribs arched backward and last two pairs almost com-

pletely paralleling axis; circular-shaped notches, developed on ends of rib furrows produce serrate margin; axial rings tuberculate with smaller tubercles produced on ribs.

Dimensions of small, nearly complete specimen (hypotype no. 34593) are: total length 10 mm., length of cephalon 3 mm., length of thorax 4 mm., length of pygidium 3 mm., width of pygidium at anterior end 3 mm., width of cephalon between tips of genal angles 6 mm., greatest width of glabella 2.5 mm., width of axis at occipital segment 1.5 mm.

Dimensions of large cephalon (hypotype no. 34594) are: length along median line 8 mm., distance between tips of genal angles 13 mm., greatest width of glabella 4 mm., width of occipital segment 3 mm.

Dimensions of large pygidium (hypotype no. 34598) are: length 7 mm., width at anterior margin 9 mm., width of axis at anterior margin 2 mm. Collection consists of numerous disassociated pygidia, cephalae and several nearly complete specimens.

Hypotypes.—Univ. Calif. Mus. Paleo. Type Coll. nos. 34593, 34594, 34595, 34596, 34597, 34598.

Discussion.—The Gazelle specimens have smaller tubercles on their cheeks and glabellae than does the Bohemian lectotype and lack tubercles on the posterior borders and occipital rings. Smooth or sparsely tuberculate pygidia and cephalae, however, are also present in the Gazelle collection.

According to Prantl and Přibyl (personal communication, 1960) these differences in carapace ornamentation result from different modes of preservation and are not of specific value.

Detached free cheeks (about 3 mm. wide and 10 mm. long) with raised borders and containing a small eye near the middle of their inner edges probably belong to the same species.

Occurrence and range.—Locality B-5247, Gazelle formation. *E. (Cromus) beaumonti* is restricted to the Silurian in Bohemia and the genus *Encrinurus* attained cosmopolitan distribution in Middle Ordovician-Silurian time.

REFERENCES

- BARRANDE, J., 1852, Système Silurien du Centre de la Bohême: v. 1, 935 p., pls. 1-51, Prague and Paris.
- BARTON, D. C., 1915, A revision of the Cheirurinae with notes on their evolution: Pub. Washington Univ., Ser. 4, v. 3, no. 9, p. 101-152, figs. 1-25.
- CHURKIN, M., JR. & LANGENHEIM, R. L., JR., 1960, Silurian strata of the Klamath Mountains, California: Am. Jour. Sci., v. 258, p. 258-273, 4 figs.
- DILLER, J. S., 1886, Notes on the geology of northern California: U. S. Geol. Survey Bull. 33, 21 p.
- , 1906, The Redding folio, California: Geol. Atlas U. S., U. S. Geol. Survey.
- DILLER, J. S. & SCHUCHERT, CHARLES, 1894, Discovery of Devonian rocks in California: Am. Jour. Sci., 3rd Ser., v. 47, p. 416-422.
- MERRIAM, C. W., 1940, Devonian stratigraphy and paleontology of the Roberts Mountains region, Nevada: Geol. Soc. America, Spec. Paper no. 25, 114 p., 7 figs., 16 pls.
- PHLEGER, F. B., 1936, Lichadian trilobites: Jour. Paleontology, v. 10, p. 593-616, 83 figs.
- PRANTL, F. & PŘIBYL, A., 1947, Rozšíření některých českých Cheiruridii (Trilobitae) [Classification of some Bohemian Cheiruridae (Trilobitae)]: Sborn Národ. Mus. Praze (Acta Mus. Nat. Prag.), v. 3-B, no. 1, Geol. Paleon. 1, p. 1-44, pls. 1-6.
- , 1949, Studie o Trilobitech Nadčeledi Odontopleuracea nov. superfm.: Rozpravy, sv. 12, Stát. Geol. Úst. Československé Rep., Praha, p. 1-221 (Czech. and English text), pls. 1-11.
- PŘIBYL, A., 1946, Notes on the recognition of the Bohemian Proetidae (Trilobitae): Bull. Intern. Czech. Acad. Sci., XLVI Année (1945), Prague, p. 91-131, pls. 1-4.
- RAYMOND, P. E., 1916, New and old Silurian trilobites from southeastern Wisconsin, with notes on the genera of the Illaenidae: Mus. Comp. Zool., Harvard Univ., Bull. v. 60, p. 1-41, pls. 1-4.
- RUEDEMANN, RUDOLF, 1934, Paleozoic plankton of North America: Geol. Soc. America Mem. 2, 141 p., 26 pls.
- STAUFFER, C. R., 1930, The Devonian of California: California Univ. Pub. Geol. Sci., v. 19, no. 4, p. 81-118, pls. 10-14.
- WELLER, STUART, 1907, The paleontology of the Niagaran limestone in the Chicago area; the Trilobita: Chicago Acad. Sci., Nat. Hist. ser., Bull. 4, p. 161-281, 15 figs., pls. 16-25.
- WELLS, F. G., WALKER, G. W. & MERRIAM, C. M., 1959, Upper Ordovician(?) and Upper Silurian formations of the northern Klamath Mountains, California: Geol. Soc. Amer. Bull., v. 70, p. 645-650, pl. 1.