LATE PERMIAN TRILOBITES FROM THE SALT RANGE, WEST PAKISTAN

by RICHARD E. GRANT

ABSTRACT. Three enrolled trilobites are the first reported from the Permian of the Salt Range. Two are assigned to *Ditomopyge fatmii* sp. nov., the third to *Kathwaia capitorosa* gen. et sp. nov. Correlations point to a Late Permian age (late Guadalupian or early Dzhulfian) making these among the youngest trilobites known.

FOSSILS have been known from the Productus Limestone of the Salt Range for more than 110 years. The first were collected in 1848 by Dr. A. Fleming, and described by Davidson (1862, p. 25). Since then the unusual abundance and excellent preservation of invertebrates in this region has attracted the attention of several palaeontologists who made large and detailed collections. The outstanding major work on invertebrates of the Productus Limestone is a series of monographs by W. Waagen, published between 1879 and 1891, based on collections made by Waagen and by several geologists of the Geological Survey of India. This was supplemented by several papers and a large monograph by Reed (1944), based on collections by Reed and others, especially E. R. Gee who spent several years mapping the geology of the Salt Range. Despite the extensive search for fossils in these strata, however, no trilobites were reported from the Productus Limestone. Waagen (1883, p. 402) does mention that 'trilobites' were reported from the Productus Limestone by Theobald, but that these turned out to be fragments of leptotid brachiopods.

During the winter of 1963–4 the writer and A. N. Fatmi of the Geological Survey of Pakistan had the opportunity to collect fossils from the Productus Limestone, and were fortunate enough to find three well-preserved enrolled trilobites. These are described here because of the importance of the Productus Limestone fauna to the Permian of the world, and because their extreme rarity makes it unlikely that additional trilobite specimens will be available soon.

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Stratigraphy of the Productus Limestone. The Productus Limestone is composed of three units, traditionally designated the Lower, Middle, and Upper Productus Limestones. Teichert (in press) has recognized that these are palaeontological units as currently defined, following usage by Waagen (1889) and subsequent workers. However, they also approximate the actual lithic breakdown of the Productus Limestone, and, in fact, have been mapped as rock units by E. R. Gee (unpublished data).

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The Lower Productus Limestone (i.e. the lower lithostratigraphic unit) is 200–500 ft. thick, mostly sandstone, with the proportion of calcareous cement increasing upward. Near the top it is sandy or silty, and in places argillaceous. It contains fusulinids, predominantly *Parafusulina kattaensis* (Schwager), in the lower three-fourths; these forms are especially abundant in two rusty brown calcareous sandstone ledges that normally occur about 40–80 ft. below the top. These fusulinids are considered by Dunbar (1933) and Dunbar *et al.* (1960) to be Artinskian in age, near the middle of the Lower Permian of the present classification (Sarycheva, ed. 1960, p. 10; Cohee 1960, p. 1578; Dunbar *et al.* 1960).

The Middle Productus Limestone is the only unit of the group that actually is predominantly limestone. It is a thick-bedded biosparite that forms a prominent cliff ranging from about 200 ft. to more than 500 ft. in height. The lower beds are somewhat clayey or silty, with bedding planes 3–6 ins. apart; the middle beds are much thicker, up to 5 or 6 ft.; the upper beds of the cliff-forming limestone are thinner, like those near the base. At the top of the cliff a very fossiliferous unit of shaly limestone and calcareous shale or siltstone that normally weathers back from the cliff into irregular nodular beds is included in the Middle Productus Limestone.

Above the nodular beds are about 40 ft. of weakly resistant green shale, or less commonly fine-grained sandstone, forming the base of the Upper Productus Limestone. This is followed by beds of sandstone, varying in grain size, amount of calcareous cement, and abundance of fossils, which bring the aggregate thickness of the Upper Productus Limestone to about 200 ft. The ammonoid *Cyclolobus* occurs in the upper third of this unit, indicating a Late Permian (Dzhulfian) age (Glenister and Furnish 1961, p. 684).

Occurrence and age of the trilobites. All three specimens are from the uppermost beds of the Middle Productus Limestone, weathered out of the unit of alternating calcareous shale and nodular argillaceous limestone. This upper unit is 43 ft. thick at Zaluch Nala where *Ditomopyge* was found (fig. 1, loc. 2) and 23 ft. thick in the vicinity of Kathwai where *Kathwaia* was collected (fig. 1, loc. 1).

The uppermost beds of the Middle Productus Limestone are faunally similar to the Upper Productus Limestone, and faunally distinct from the Lower Productus Limestone (for faunal lists *see* Waagen 1889, pp. 180–242). Therefore the trilobites can be considered late Guadalupian or early Dzhulfian, depending upon the range of *Cyclolobus* and the significance attached to the faunal similarity of the uppermost Middle and the Upper Productus Limestone. If this assignment is correct, the Salt Range trilobites are among the latest known (Harrington *et al.* 1959, pp. O 399–O 403).

Two fragmentary pygidia from the Chitichun Limestone of Tibet (Diener, 1897, pp. 3–6) were found with brachiopods that closely resemble many from the top of the Middle Productus Limestone, and therefore may be the same age as the Salt Range trilobites. However, Diener (1903) found the ammonoid *Cyclolobus* in the same unit as his trilobites, which suggests that they may be slightly younger than the Salt Range specimens.

Classification. Meaningful classification of the few genera of Permian trilobites necessarily depends upon correct understanding of the systematic affinities of their Carboniferous forebears. Hessler (1963, p. 543) has undertaken such a study in conjunction with his work on Mississippian Proetidae, and has indicated that he will offer a classification

of this group in a forthcoming paper. Therefore, no suprageneric breakdown of proetids or phillipsiids is attempted here.

Genus DITOMOPYGE Newell 1931

1931 *Diotomopyge* Newell, p. 267, emend. 1935, Weller, J. M., p. 505.
1933 *Cyphinium* Weber, pp. 45, 81.
1937 *Neophillipsia* Gheyselinck, p. 56.

Type species. D. lansingensis Newell 1931, p. 268, pl. 31, figs. 31–32.

Diagnosis. Cephalon subtrigonal in outline, genal spines short. Glabella anteriorly expanding, but not strongly inflated; three preoccipital lobes at posterior. Eyes prominent, reniform, not elongate, located beside posterior third of glabella. *Thorax* with nine segments. *Pygidium* nearly the same as cephalon in size and outline. Axis with 12–18 segments, pleural regions with somewhat fewer. Border distinct but without border furrow; flat or concave, downsloping. *Ornamentation* weak, consisting of striations on cephalic border and underside of pygidial border, and a transverse row of low pustules or slightly elongated tubercles on each axial ring. Other ornamentation, such as low granules or shallow pits on cephalon, may be present.

Discussion. The generic position of *Cyphinium* Weber has been discussed fully by Weller (1935, p. 504; 1936, p. 711); it is to be regarded as a junior synonym of *Ditomopyge*.

The genus *Neophillipsia* Gheyselinck was established on a supposedly Upper Carboniferous specimen from Kansas, and Weller (1944, p. 320, pl. 49, fig. 3) demonstrated beyond doubt that it belongs to *Ditomopyge*. In addition, he offered convincing evidence that it was collected from beds in southern Kansas that now are considered to be Lower Permian.

Mudge and Yochelson (1962, p. 96) report a specimen from the Lower Permian of Kansas which they identify as *Ditomopyge*? *decurtata* (Gheyselinck). Their specimen was collected from slightly higher in the section than where Weller surmised Gheyselinck's was obtained. They mention that the border continues around the anterior of the glabella and thus differs from Weller's (1936, p. 711) diagnosis. The Salt Range specimens also differ in this feature, and perhaps are more closely related to the stratigraphically slightly higher form described by Mudge and Yochelson; other characters resemble closely those of *D. scitula* (Meek and Worthen) and *D. decurtata* (see Pl. 13, figs. 4, 5).

Comparisons. Only *Pseudophillipsia* Gemmellaro (1890, p. 14) resembles *Ditomopyge* sufficiently to warrant comparison here. To judge from reconstructions of *Pseudophillipsia* by Gemmellaro (1890, pl. 2, fig. 4) and Weller (1944, pl. 49, fig. 10; also *in* Harrington *et al.* 1959, fig. 307, no. 4) and a systematic analysis by Goldring (1957), it differs from *Ditomopyge* in its more anteriorly divergent facial sutures, smaller and sharper basal pre-occipital lobes, strong granular ornamentation of the posterior of the glabella, and its great number of pygidial segments.

Presence of a distinct cephalic border on the Salt Range species, and the Kansas Permian specimens called *Ditomopyge*? *decurtata* by Mudge and Yochelson (1962) may be another indication of the close relationship of *Ditomopyge* with *Pseudophillipsia* that was emphasized by Goldring (1957, pp. 197 et seq.). Goldring suggested that *Ditomopyge* as now constituted may involve two subgenera, one with a border, presumably

more closely related to *Pseudophillipsia*, and one lacking a border. *Ditomopyge* is distinguished from *Pseudophillipsia* by other features, important among which is its smaller number of pygidial segments (Goldring 1957, p. 199).

Ditomopyge fatmii sp. nov.

Plate 13, figs. 2*a–d*, 3

Diagnosis. Cephalon with distinct border, slightly raised to form short flange; shallow border furrow continuing around anterior of cranidium; genal spines short; pygidium with seventeen axial segments and broad border.

Description. Carapace essentially smooth, ornamented only by few granules on posterior part of glabella, weak striations on cephalic border and underside of pygidial border, and by transverse row of low sagittally elongate tubercules on crest of each axial ring of thorax and pygidium. *Cephalon* subtrigonal in outline, somewhat flattened on top, then sloping steeply toward border, thus producing strong curvature of anterior end of glabella, and of librigenae. Glabella elongate, anteriorly expanding but not inflated, with three distinct pre-occipital lobes; lateral pair slightly longer than median one. Glabellar furrows other than those outlining pre-occipital lobes, absent. Occipital ring without median tubercle. Palpebral lobes small, crescentic, located posterior to mid-length of glabella. Facial sutures strongly divergent anterior to eyes, then convergent across border; posterior course cutting diagonally postero-laterally across posterior border. Eyes prominent, outline nearly semicircular, not elongate. Librigenae trapezoidal, posterior border furrow flexed posteriorly, distal edge of cheek produced to form short genal spine. *Thorax* composed of nine segments; distal ends of pleurae bent gently downward. *Pygidium* proportionately large: size and outline conforming to that of cephalon. Axis with seventeen segments and terminal axial piece, crest flattened and nodular; pleural regions with twelve slightly sigmoidal segments; interpleural furrows shallow, pleural furrows indistinct. Border distinct, rather broad, gently concave, without border furrow.

Measurements (in mm.)

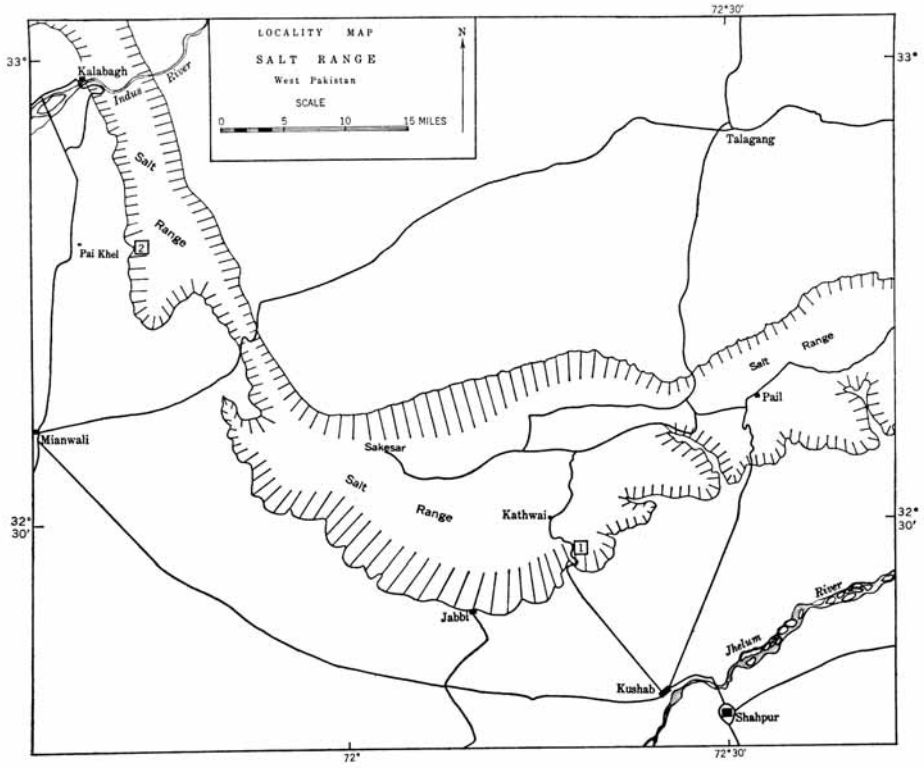
	Cephalon		*Thorax*		*Pygidium*	
	Length	*Width*	*Length*	*Width*	*Length*	*Width*
Holotype, G.S.P.B. no. 88 Plate 13, figs. 2*a–d*	8·8	11·5	10·8	10·2	8·8	10·7
Paratype, G.S.P.B. no. 89 Plate 13, fig. 3	7·9	*c.* 10		9·5		

Locality. Both specimens were collected from the Middle Productus Limestone, on the divide between Kala Wahan and Zaluch Nala, east of Pai Khel, Survey of Pakistan map 38 P/9 (text-fig. 1, loc. 2). These beds can be traced along this divide between the two valleys, about one mile upstream from their mouths. The holotype was found nearer Zaluch Nala, and the paratype nearer Kala Wahan.

Repository. The specimens are deposited in the collections of the Geological Survey of Pakistan, where they have been assigned catalogue numbers G.S.P.B. 88 and 89.

Comparisons. Ditomopyge fatmii differs from *D. scitula* (Meek and Worthen) in its more distinct cephalic border marked by a border furrow that continues around the

anterior of the glabella, its smaller eyes which are distinctly less than half as long as the glabella, its greater number of pygidial segments, and probably also in its much shorter genal spines. The spines are broken from both of the available specimens, but the shape of the librigenae and the posteriorly directed course of the posterior border furrow are



TEXT-FIG. 1. Map of part of Salt Range, showing localities from which trilobites were obtained.

similar to those of *D. decurtata* (Gheyselinck), which has only short genal spines (Pl. 13, figs. 4, 5). The Salt Range species differs from *D. decurtata* in its complete cephalic border and border furrow, somewhat greater number of pygidial segments, and its wider and more concave pygidial border.

Ditomopyge meridionalis Teichert (1944, p. 458) was described from the Wandagee Formation of Western Australia, considered to be of Artinskian age (Teichert 1944, p. 456; Glenister and Furnish 1961, p. 679). This species differs from *D. fatmii* in its proportionately shorter and more bulbous glabella, less prominent pre-occipital lobes, and by the much smaller number of axial and pleural segments on the pygidium. In addition Teichert (1944, p. 460) remarks on the unusual length, for a Permian species, of the genal spines of *D. meridionalis*.

Among Lower Carboniferous species described by Weber (1933) none seem closely similar to *D. fatmii*. The cephalic border of *D. acanthicaudum* (Weber) is very narrow, according to Weber (1933, p. 84), and the pygidium has somewhat fewer axial and pleural segments. The eyes seem to be proportionately larger than in *D. fatmii*, and the pre-occipital lobe more prominent. *Ditomopyge kumpani* (Weber) is ornamented by conspicuous granules, and although the variety *crassicrusta* appears smooth, Weber (1933, p. 85) says that it is exfoliated.

The Artinskian species *D. artinskiense* (Weber) differs from *D. fatmii* in its more anteriorly expanding glabella, distinctly fewer pygidial segments, and more or less transverse, rather than subcircular, median pre-occipital lobe. According to Weber (1933, p. 89) the genal spines extended posteriorly nearly to the pygidium, much further than in *D. fatmii*, and more like the Australian species *D. meridionalis* Teichert. The trend toward decreasing length of genal spines in stratigraphically younger species of *Ditomopyge* has been noted by Weller (1937, p. 346, text-fig. 4). The short spines of *D. fatmii* argue further for its Late Permian age.

Genus KATHWAIA gen. nov.

Type species. Kathwaia capitorosa sp. nov.

Diagnosis. Cephalon semicircular in outline, genal spines absent. Glabella inflated, protruding anterior to border, with two small but prominent lateral pre-occipital lobes. Eyes small, near mid-length of cephalon. *Thorax* with nine segments. *Pygidium* short, with border but no border furrow. *Ornamentation* granular, present on all parts but strongest on cephalon.

Description. The genus is monospecific at present; therefore its characters are given below in the description of the type species.

Comparisons. This genus shares features with several genera of phillipsioid trilobites. It resembles *Phillipsia* Portlock in its general shape, granular ornamentation, and indistinctly delimited pygidial border. It differs from that Lower Carboniferous genus in its lack of genal spines, its non-continuous cephalic border, smaller eyes located farther anterior, absence of glabellar furrows (other than those outlining pre-occipital lobes) and in its fewer pygidial segments. It is similar to *Griffithides* Portlock in its granular ornament and lack of genal spines, but differs in its swollen glabella, non-continuous cephalic border, semicircular rather than semi-oval or subtrigonal outline of the cephalon, more prominent lateral pre-occipital lobes, and fewer pygidial segments. Despite the Early Carboniferous age of *Griffithides*, it is the genus most similar to *Kathwaia*.

Humilogriffithoides Inai, recently discussed by Endo and Matsumoto (1962, p. 159), resembles *Kathwaia* in its swollen glabella and lack of genal spines. It differs from the Salt Range genus in its smooth carapace, sharp genal angle, larger eyes, short lateral glabellar furrows, and its well-defined pygidial border.

Among Permian genera only *Neoproetus* Tesch resembles *Kathwaia* in more than general aspect. The glabella of *Neoproetus* is bulbous and overhangs the anterior margin as in *Kathwaia*, similarly the ornamentation of the cephalon is granular, although *Neoproetus* also has some wrinkles on the anterior part of the glabella (Weller 1944, p. 325).

Kathwaia differs from *Neoproetus* in its semicircular rather than subtrigonal cephalon, its proportionately longer glabella, more inflated lateral pre-occipital lobes, smaller eyes, more rounded genal angle, divergent anterior course of the facial sutures, and in the granular ornamentation that is present over the whole carapace, not confined to the cephalon as in *Neoproetus*. The number of pygidial axial segments is 9 or 10 in both species of *Neoproetus*, *N. indicus* Tesch and *N. verrucosus* (Gemmellaro); it is 8 on the one known specimen of *Kathwaia*. In addition, the pygidium of *Neoproetus* is described by Gheyselinck (1937, p. 76) and Weller (1944, p. 325) as having a slightly segmented or crenulated border. This feature is not present in *Kathwaia*.

The Middle Permian genus *Paraphillipsia* Toumansky (1935) from the Crimea and Himalaya differs from *Kathwaia* in its broader glabella, wider and more inflated pre-occipital lobes, small eyes, and its proportionately short pygidium with laterally short pleurae and very broad, granular, convex border.

Other Permian genera such as *Pseudophillipsia* Gemmellaro, *Ameura* Weller, and *Anisopyge* Girty seem to belong to the group of trilobites containing *Ditomopyge*, and do not strongly resemble *Kathwaia* or *Neoproetus*. *Neogriffithides* Toumansky from the Permian of the Crimea has rounded genal angles similar to those of *Kathwaia*, although according to Weller (1944, p. 326) these were reconstructed from disassociated librigenae, and may not belong to *Neogriffithides*. This doubt is reflected by Weller in his reconstruction of that genus in the *Treatise on Invertebrate Paleontology* (Harrington *et al.* 1959, fig. 306, no. 6). The multi-segmented pygidium of *Neogriffithides*, with its flattened distinct border, is the chief distinction from *Kathwaia*.

Additional species. The granular species *Proetus*? *girtyi* Toumansky, from Crimean rocks considered by Toumansky (1935, p. 38) to be Guadalupian in age, may belong to *Kathwaia*. It differs rather strongly from the type species, *K. capitorosa*, in features that may be considered generic. It has a proportionately broader axis, 10 rather than 9 thoracic segments, stronger granular ornament, and differs markedly by possession of a cephalic

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EXPLANATION OF PLATE 13

All figures ×3.

Figs. 1*a–d*, *Kathwaia capitorosa* gen. et sp. nov., enrolled holotype from upper part of Middle Productus Limestone, south of Kathwai (text-fig. 1, loc. 1), USNM 145320. *a*, dorsal view of cephalon and part of thorax; *b*, dorsal view of pygidium and part of thorax; *c*, left lateral view of enrolled specimen; *d*, anterior view.

Figs. 2*a–d*, *Ditomopyge fatmii* sp. nov., enrolled holotype from upper part of Middle Productus Limestone at Zaluch Nala (text-fig. 1, loc. 2). GSPB 88. *a*, dorsal view of cephalon and part of thorax; *b*, dorsal view of pygidium and part of thorax; *c*, right lateral view of enrolled specimen; *d*, anterior view.

Fig. 3, *D. fatmii* sp. nov., incomplete enrolled paratype from locality 2 (text-fig. 1), GSPB 89. Dorsal view of cephalon and part of thorax.

Figs. 4*a–c*. *Ditomopyge decurtata* (Gheyselinck), enrolled topotype from Permian Beattie Limestone near Wichita, Kansas, for comparison with *D. fatmii*, USNM no. 145322. *a*, dorsal view of cephalon and part of thorax; *b*, dorsal view of pygidium and part of thorax; *c*, left lateral view of enrolled specimen.

Figs. 5*a–b*, *D. decurtata* (Gheyselinck), enrolled specimen from Florena Shale Member of Beattie Limestone, East of Grand Summit, Kansas, for comparison with *D. fatmii*, USNM no. 145321; *a*, dorsal view of cephalon and part of thorax; *b*, dorsal view of pygidium and part of thorax.

border, which is said to be longitudinally striated. Aside from this possible additional species, no species other than the type is known to belong to *Kathwaia*.

Kathwaia capitorosa sp. nov.

Plate 13, figs. 1*a–d*

Diagnosis. Glabella strongly inflated, projecting anteriorly beyond cephalic border. Occipital ring rather broad sagittally, with small median node. Pygidium with eight axial segments plus terminal piece, length about two-thirds that of cephalon, border flat to slightly convex, broad but indistinctly delimited from pleural areas, lacking border furrow.

Description. *Carapace* with relatively strong granules randomly and rather densely distributed on cephalon, and in apparent rows on axial rings; weaker granules on pleural regions of thorax and pygidium. Edge of border to cephalon and pygidium weakly striated. *Cephalon* approximately semicircular in outline, strongly convex. Glabella (exclusive of lateral preoccipital lobes) strongly inflated to tear-drop shape, extending anteriorly beyond border, interrupting anterior course of border except at very margin. Lateral pre-occipital lobes proportionately large, inflated, each subtrigonal in outline. Eyes small, hemispherical (not elongate); midlines located at furrows marking anterior ends of lateral pre-occipital lobes, about midlength of cephalon (exclusive of anterior glabellar protrusion). Facial sutures nearly parallel to axis between eyes and posterior border furrow, then strongly divergent posteriorly across border; anterior course moderately divergent anterior to eyes, then convergent around glabella. Librigenae strongly convex laterally; sides nearly vertical; genal angle gently and evenly curved, without genal spines. Occipital ring somewhat constricted laterally by posterior edges of lateral pre-occipital lobes; low node on crest. *Thorax* with 9 segments; pleural segments strongly flexed and sloping steeply to lateral margins. *Pygidium* about two-thirds actual length of cephalon (excluding protrusion of glabella). Axis with 8 rings and terminal axial piece; pleural regions with 7 pleurae, each subdivided by shallow furrow increasing in depth laterally. Border broad, border furrow absent, proximal edge marked only by terminations of pleural and inter-pleural furrows. Margin weakly striated, outline conforming exactly to that of cephalon, forming tight seal during enrolment.

Measurements (in mm.)

	Cephalon		*Thorax*		*Pygidium*	
	Length	*Width*	*Length*	*Width*	*Length*	*Width*
Holotype, USNM no. 145320	8·5	12·0	16·7	12·0	6·5	10·7
Length of cephalon including protruding glabella	9·0					

Locality. *Kathwaia capitorosa* was collected from beds at the top of the cliff of Middle Productus Limestone, 5·5 miles road-distance south of Kathwai, on the road to Kushab, Survey of Pakistan map 43 D/3 (fig. 1, loc. 1). The Middle Productus Limestone is faulted in such a manner that part of the cliff and the uppermost beds are repeated three times. The road passes over the lowermost fault block; the trilobite was collected from the uppermost one, two fault 'steps' above the east side of the road, about 250 ft. above road level.

Discussion. With only one specimen available, it is uncertain which characters are diagnostic of the species. The diagnosis was composed with reference to species of the seemingly most nearly related genus, *Neoproetus*, with the assumption that species characters in *Kathwaia* are analogous.

Repository. The specimen is deposited in the United States National Museum.

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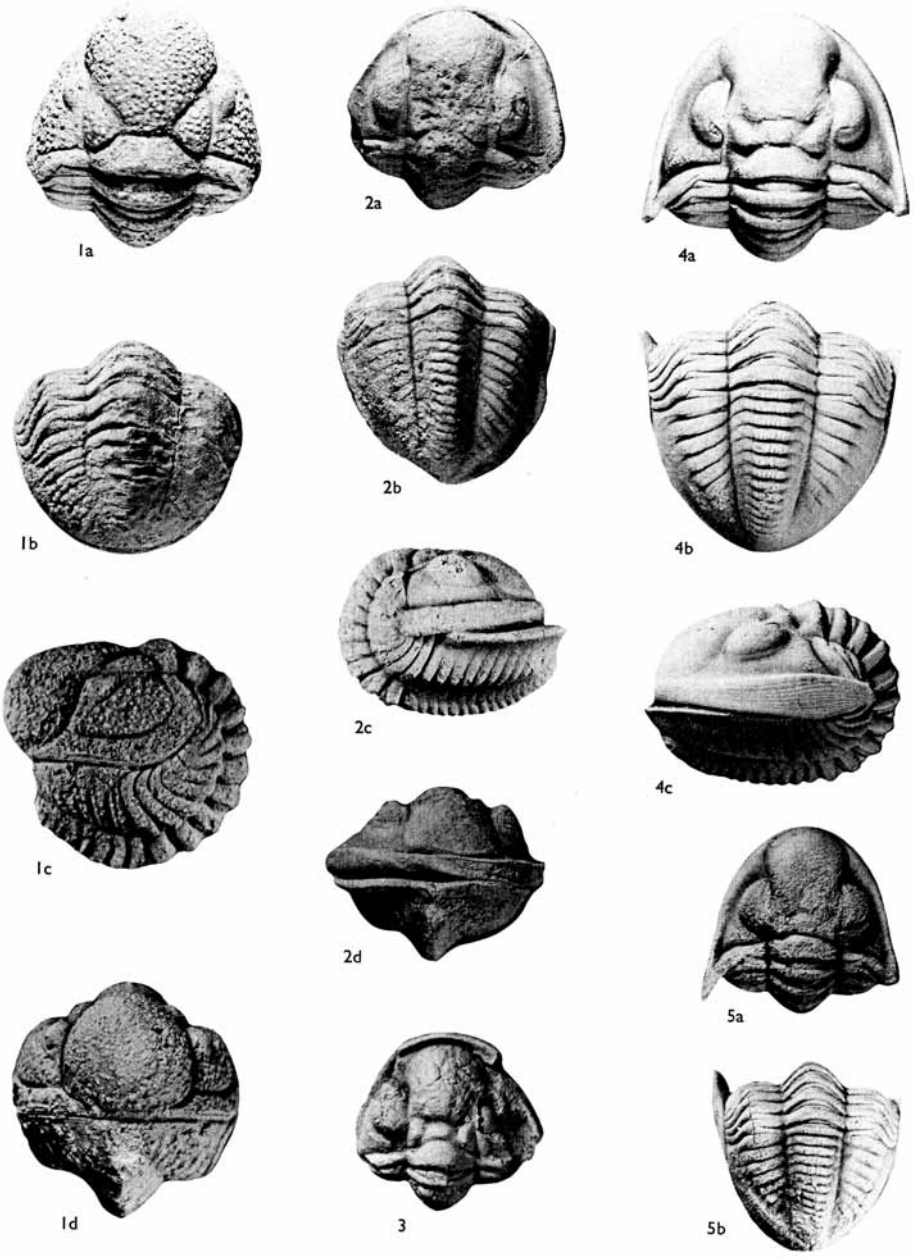

GRANT, Permian trilobites