SOME PERMIAN TRILOBITES FROM EASTERN AUSTRALIA

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ABSTRACT. A new genus of proetid trilobite, *Doublatia*, occurs in the Permian of eastern Australia. It is represented by the type species, *Doublatia inflata* gen. et sp. nov., in the Artinskian Branxton Formation of New South Wales and by two species, *D. pyriforme* sp. nov. and *Doublatia* sp., in slightly older beds, the Enstone Park Limestone in north-eastern Tasmania. The new genus is more closely related to *Ditomopyge* than to other proetids. Two pygidial forms not referable to *Doublatia* also occur in the Permian of eastern Australia.

THE Permian faunas of eastern Australia have been studied since the early nineteenth century, many detailed collections have been made and from them monographs on various groups have resulted. During the past decade there have been many studies of a revisionary nature but trilobites have received little attention because they are rare and their remains fragmentary.

Whereas Teichert (1944) has described *Ditomopyge meridionalis* and *D.* sp. from Western Australian Permian strata, the only trilobite named specifically from the eastern Australian Permian is '*Griffithides*' *dubius* Etheridge (1872, p. 338, pl. 18, fig. 7), described and figured from a single pygidium and thorax joined to a damaged cranidium from the 'Don River, Queensland' in strata then stated to be of Carboniferous age. The inferred number of thoracic segments was within the range 10–12. Jack and Etheridge Jr. (1892, pl. 7, fig. 12) refigured this specimen, referring its horizon to the Permo-Carboniferous Gympie Beds; they located the Don River (p. 215) as a tributary of the Dawson River and not as might have been supposed the Don River, near Bowen. They erroneously referred the species *dubius* to the genus *Phillipsia* from evidence derived from trilobites they believed to be conspecific in the Star Beds of the Great Star River, Queensland, and another unspecified horizon in the Rockhampton area.

Mitchell (1918) restricted the name *dubius* to the Etheridge (1872) type specimen which he was unable to locate and redescribed the Jack and Etheridge Jr. (1892) material as *P. stanvellensis* Mitchell and *P. rockhamptonensis* Mitchell. He also transferred Etheridge Jr.'s (1892) *P. dubia* from New South Wales to *P. elongata* Mitchell. All these species are of Carboniferous age and will not be considered further.

Voisey (1939, p. 401; 1950, p. 67) recorded '*Phillipsia*' from the Permian of the Manning–Macleay province, north of Newcastle, New South Wales; they are indeterminate fragmentary pygidia, AM F38133–4, and were probably collected from the Cedar Party Limestone. Banks (1962, p. 207) records rare trilobites from Permian strata at Elephant Pass and Ray's Hill, near St. Mary's in north-eastern Tasmania.

The specimens described herein come from the following localities shown in text-fig. 1. They are:

1. In a quarry, 1 mile west-north-west of Mulbring, 16 miles west of Newcastle, New South Wales, at 475336 Cessnock 1:63,360 military map: *Fenestella* Shale, Branxton Formation.

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2. In the creek bed, Sawpit Gully, 1·9 miles east of 'Boorook', New South Wales, at 374426 Drake 1:63,360 military map: Cataract River Formation.

3. Above (2) and separated from it by a thin pyroclastic flow.

4. At Elephant Pass, 60468689 State Grid, on the Tasman Highway, Tasmania: upper Gray Formation or basal Berriedale Limestone-Enstone Park Limestone correlate (McNeil, 1965).

5. At Ray's Hill, near St. Mary's, 60068807 State Grid, Tasmania: basal beds of the Enstone Park Limestone.

Trilobites from Elephant Pass and Ray's Hill were not found *in situ*. Stratigraphic horizons for these localities have been deduced using palaeontological and petrological similarities.

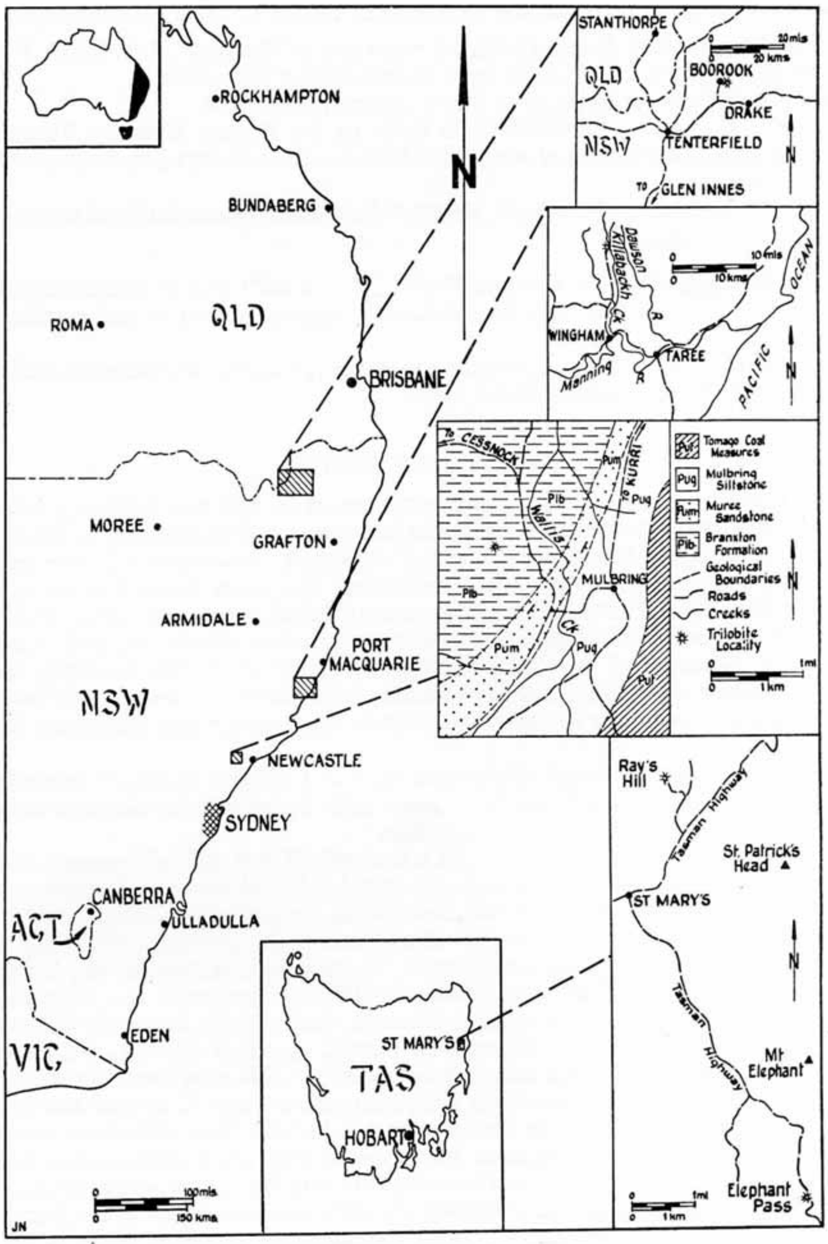
Stratigraphic units discussed are shown in Table 1. Further information is available in Banks (1962) and Runnegar (1967, 1969).

ASSOCIATED FAUNAS

The fauna associated with *Doublatia inflata* gen. et sp. nov. near Mulbring includes *Anidanthus solitus* (Waterhouse), *Ingelarella branxtonensis* (Etheridge), *Strophalosia* cf. *clarkei* (Etheridge), *Fletcherithyris parkesi* Campbell, brachiopod cf. *Notospirifer*, *Deltopecten squamuliferus* (Morris), *Pleurikodonta* sp., *Atomodesma* (*Aphanaia*) sp., *Myonia* cf. *corrugata* Fletcher, *Stutchburia costata* (Morris), *Stenopora crinita*? Lonsdale, *Protoretepora ampla* (Lonsdale), *Fenestella bituberculata* Crockford, and blastoid fragments, indicative of the Ulladulla fauna (Runnegar 1969). The *Fenestella* Shale stratigraphically above strata containing *Neocrimites meridionalis* (Teichert and Fletcher) is considered to be middle to upper Artinskian in age, agreeing with Runnegar's interpretation.

Associated with the Sawpit Gully specimens is a definite Fauna IV assemblage listed by Runnegar (1970). Its probable age is early Upper Permian although there is little published information on this assessment.

The Elephant Pass trilobite occurs in a fine-grained dark yellowish-orange (10YR 6/6) dense siltstone (UT 55297) which also contains *Euryphyllum* sp., *Stenopora* spp., *Streblascopora marmionensis* (Bretnall), fenestellids, *Strophalosia* sp. nov., *S. preovalis* Maxwell, *Anidanthus springsurensis* (Booker), *Cancrinella farleyensis* (Etheridge and Dun), *Taeniothaerus subquadratus* (Morris), *Terrakea* sp., *Spirigerella* sp., '*Spirifer*' *tasmaniensis* (Morris), *Grantonia hobartensis* Brown, *Ingelarella* sp., *Notospirifer darwini* (Morris), *Spiriferellina australis* Maxwell, *Fletcherithyris farleyensis* Campbell, *F. reidi* Campbell, *Aviculopecten tenuicollis* (Dana), *A. fittoni* (Morris), and *Streblochondria* sp. nov. *Taeniothaerus subquadratus* occurs in a thin zone about the middle of the Berriedale Limestone; *Cancrinella farleyensis* occurs above *T. subquadratus* in the Berriedale Limestone or Grange Mudstone at Mt. Nassau. Thus correlation with the Berriedale Limestone is established. Index species and other characteristic fossils enable the fauna to be identified as Fauna II (Runnegar 1969), thus suggesting correlation with the Farley or Greta Formations or possibly the lowest part of the Branxton Formation, New South Wales, an interval considered by Runnegar (1969, p. 88) to span the Sakmarian–Artinskian boundary.



TEXT-FIG. 1. Map of eastern Australia showing localities of trilobites discussed.

The Ray's Hill trilobite fragments occur in blocks of greyish-orange (10YR 7/4) or pale greyish-orange (10YR 8/3) friable and decalcified silty limestone. The fauna in the same block as the holotype of *Doublatia pyriforme* gen. et sp. nov. includes *Calcitornella stephensi* Howchin, *Frondicularia aulax* Crespin, *Stenopora* spp., *Streblascopora marmionensis*, fenestellids, *Schuchertella* sp., *Spirigerella* sp. nov., *Licharewia* sp., *Pterospirifer* sp., '*Spirifer*' *tasmaniensis*, *Grantonia hobartensis*, *Ingelarella* cf. *angulata*

TABLE 1. Stratigraphic table for portion of the eastern Australian Permian succession; based primarily on information in Runnegar (1969) and McNeil (1965).

Hunter Valley New South Wales	*Northern New South Wales*	*Eastern Australia Permian Faunas*	*Hobart Tasmania*	*Mt. Elephant Tasmania*	*Russian Stages*
Tomago			Cygnet		
	Cataract River				Kazanian
Mulbring		IV	Ferntree	Ferntree	
	Gilgurry				— — — —
Muree				Risdon–Malbina correlate	Kungurian
			Malbina		— — — —
Branxton		III; U			
			Grange	Berriedale–Enstone Park correlate	
Greta	Drake		Berriedale		Artinskian
					— — — —
Farley		II			
	Girard		Nassau	Gray	
Rutherford					
			Mersey	Mt. Elephant	Sakmarian

Campbell, *I.* ?*ingelarensis* Campbell, *Notospirifer darwini*, *Spiriferellina australis*, *Fletcherithyris reidi*, *Peruvispira* cf. *elegans* (Fletcher), *Pseudomyalina* sp., ?*Atomodesma* sp., *Streblochondria* sp. nov., and ?*Astartila* sp., as well as numerous worm castings, ostracodes, and crinoid columnals. Other specimens containing fragments assigned to *D. pyriforme* include, in addition, *Euryphyllum* sp., *Protoretepora ampla* and *Aviculopecten tenuicollis*. The fauna in the block containing *Doublatia* sp. includes *Stenopora* sp., *Polypora* sp., *Fenestella* sp., *Strophalosia* sp. nov., *Terrakea* sp., *Spiriferellina* sp., *Peruvispira* sp., and a myalinid. The associated fauna at Ray's Hill also has characteristic Fauna II species, suggesting approximate correlation with the Elephant Pass horizon.

Therefore, the occurrences of trilobites in the Permian of Tasmania is likely to be a little older than the beds containing *D. inflata*, the *Fenestella* Shale, in New South Wales.

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Specimens from the University of Queensland were collected by Banks, Dr. B. N. Runnegar, and P. Telford. Tasmanian specimens were collected by Banks, together with W. D. Palfreyman, J. B. Jago, and R. F. McShane.

Abbreviations used throughout the text are: AM—Australian Museum Collection, Sydney; SUP—Sydney University Palaeontological Collection, Department of Geology and Geophysics, University of Sydney; UQ—Department of Geology Collection, University of Queensland, Brisbane; UT—Department of Geology Collection, University of Tasmania, Hobart.

SYSTEMATIC DESCRIPTIONS

Class TRILOBITA
Order PTYCHOPARIIDA
Suborder ILLAENINA
Superfamily PROETACEA
Family PROETIDAE

The Carboniferous and Permian trilobites have been grouped in different ways by different authors over the last twenty years (compare Hupé 1953, Moore, 1959, Hahn and Hahn, 1967). Hahn and Hahn (1967) and Hessler (1963) suppressed Phillipsiidae as a family name and treated genera formerly placed therein as members of subfamilies of the Proetidae. This treatment will be followed here.

Subfamily GRIFFITHIDINAE Hupé 1953 emend. Hahn and Hahn 1967

Characterized by the forward extension of the frontal lobe of the glabella, the upwardly inflated glabella and the development of a median preoccipital lobe.

The new genus, *Doublatia*, clearly falls within this subfamily as emended by Hahn and Hahn. Hahn and Hahn (1967) recognized three groups within this subfamily and brief diagnoses of each group compiled from their text (mainly pp. 343, 345) and figs. 4 and 5 follow:

Griffithides group: cephalon more-or-less triangular in outline, glabella highly inflated, furrows 2p and 3p lacking, generally 13 or fewer rings in pygidial axis (except *Exochops*, 16).

Cyphinoides group: cephalon rounded in outline, glabellar furrow 2p always and 3p usually present; generally 11 or fewer rings in pygidial axis.

Paladin group: cephalon rounded in outline, glabellar furrows 2p and 3p present; 13 or more rings in pygidial axis.

The placing of *Doublatia* within one of these groups is difficult and will be dealt with later.

Morphology used in the following discussion is used in the sense adopted in Moore (1959), except for points on the facial suture, for which see Hupé (1953, p. 48).

In the descriptions, long or length refer to the measurements parallel to the axial line and wide or width refer to measurements transverse to the axial line.

Genus DOUBLATIA gen. nov.

Type species. Doublatia inflata gen. et sp. nov.

Diagnosis. Cephalon semicircular to parabolic in outline with narrow border; glabella strongly inflated anteriorly; glabellar furrows 2p and 3p weakly developed, lateral preoccipital lobes and occipital ring strongly developed, median preoccipital lobe developed; palpebral region opposite posterior half of the glabella; well-developed marginal crest on free cheeks; genal spines short; thorax of ? nine or ? ten segments; pygidium with axis extending only two-thirds of the pygidial length and with small number, eight or nine, axial rings, a postaxial ridge, and fewer pleurae than axial rings; no pygidial border; wide pygidial doublure; surface finely granulose.

Discussion. It is a combination of morphological features that enables this species to be placed in a new generic category. These are: the narrow border on the cephalon which is extended posteriorly to form a short, flat genal spine, the swollen glabella, the absence of a border on the pygidium, the pygidial pleurae which are clearly visible on the posterior region of the pygidium, and the wide pygidial doublure.

Doublatia inflata gen. et sp. nov.

Plate 36, figs. 1–4

Material. One nearly complete specimen and pygidium.

Holotype. SUP 12929A, B, from near Mulbring, N.S.W.

Diagnosis. Doublatia with semicircular cephalic outline, almost circular main glabella lobe and nine axial rings and eight pleurae in the pygidium.

Description. Greatest dimensions 26·2 mm long and 20·0 mm wide. Outline of the cranidium semicircular to semi-elliptical; in plan it is waisted adjacent to the palpebral lobes. The posterior margin is very slightly convex anteriorly. The glabella is slightly waisted and increases in width posteriorly from the anterior margin to the lateral preoccipital lobes. Posterior to this point it decreases in width. The glabella border furrow is deep with the greatest depth at its mid-width. It is U-shaped antero-laterally and semi-elliptical anteriorly. It possesses a sharp, upturned border which is round and, from what is preserved, increases gradually in height from the anterior portion of the glabella. The anterior border furrow is 1·0 mm (sag.) and 1·6 mm (exsag.), measured normal to the periphery. The furrow begins to shallow opposite the eye and opposite the posterior glabellar margin it is almost unrecognizable. The median preoccipital glabellar furrow is very shallow and gently convex anteriorly. It joins the lateral preoccipital lobes at their mid-length. The greatest convexity of the median preoccipital lobe is in the central portion. This lobe is depressed below the anterior region of the glabella but elevated above the occipital ring. The occipital furrow which is convex anteriorly does not vary greatly in depth; it appears deeper laterally due to the bulbous nature of the lateral preoccipital lobes. Shape of the occipital ring is difficult to determine due to preservation but is close to a semi-ellipse with only very slight curvature posteriorly. Lateral preoccipital lobes are very bulbous and are more coarsely ornamented than the rest of the glabella.

Furrows surrounding the lobes are deepest anteriorly. The frontal glabellar lobe is inflated as shown by the great convexity of the anterior and antero-lateral margins. Its central portion is relatively flat and the convexity adjacent to the lateral preoccipital lobes is not as great as in the anterior and antero-lateral regions.

The antero-lateral outline of the librigenae is gently curved. Along the facial suture, α is situated lateral to the forward projection of the axial furrow, β in the sub-marginal furrow just inside the marginal crest. The anterior limbs β–γ are sigmoidal and slightly convergent posteriorly. Point γ is situated close to the axial furrow in front of the junction of lp with the axial furrow. The palpebral lobe is a semi-ellipse, the long axis of which is directed antero-axially. Point δ is situated posteriorly on the palpebral lobe, approximately opposite the mid-length of the lateral preoccipital lobe. Point ϵ lies a little outside the axial furrow and approximately opposite the transglabellar, preoccipital furrow. From ϵ the facial suture runs postero-laterally at about 10° to the axial line for a short distance before turning laterally through about 135°. From this turning point it continues straight to the posterior margin which it meets at an angle of about 20°. The area of greatest convexity on the librigenae is the most antero-lateral region. The genal spine extends to about the second or third thoracic segment and slopes on both sides from a low ridge which bisects the spine. The ridge runs axially parallel to the posterior margin of the cephalon until reaching the facial suture where it changes curvature posterior to the palpebral lobe. There is a marked depression adjacent to the posterior end of the facial suture. Essentially, the librigenae rise gradually towards the periphery and then slope sharply in most regions to the lateral border.

Nine or ten thoracic segments are present. The axis expands to the seventh or eighth axial ring where it is approximately one-third the thoracic width; posteriorly it narrows. The greatest height of the axis is at the sixth or seventh ring, where it is elevated above the pleurae; at the most posterior ring, axis and pleurae are on a similar elevation. The greatest height of the axial rings is along their mid-width. Interaxial furrows are concave anteriorly. The junction between pleurae is normal to the axis until the fulcral lobe is reached approximately one-quarter of the distance along the pleural length. The interpleural furrow then curves posteriorly, being gently concave anteriorly. The same applies for most of the pleural furrows. In one or two cases, however, they are gently concave anteriorly and converge towards the interpleural furrows. Lateral extremities of pleurae become more posteriorly directed near the pygidial junction. The greatest height of pleurae is approximately at their mid-width adjacent to the fulcral lobe.

The pygidium is semicircular in outline. There is no border. The axis, containing nine rings, extends only two-thirds of its length. The posterior end of the axis is very steep and is extended as a faint postaxial ridge. The axis narrows from 6·0 mm at the thoracic junction to 2·9 mm at the junction of the seventh and eighth axial rings. The height of the axis decreases posteriorly to the junction of the seventh and eighth rings

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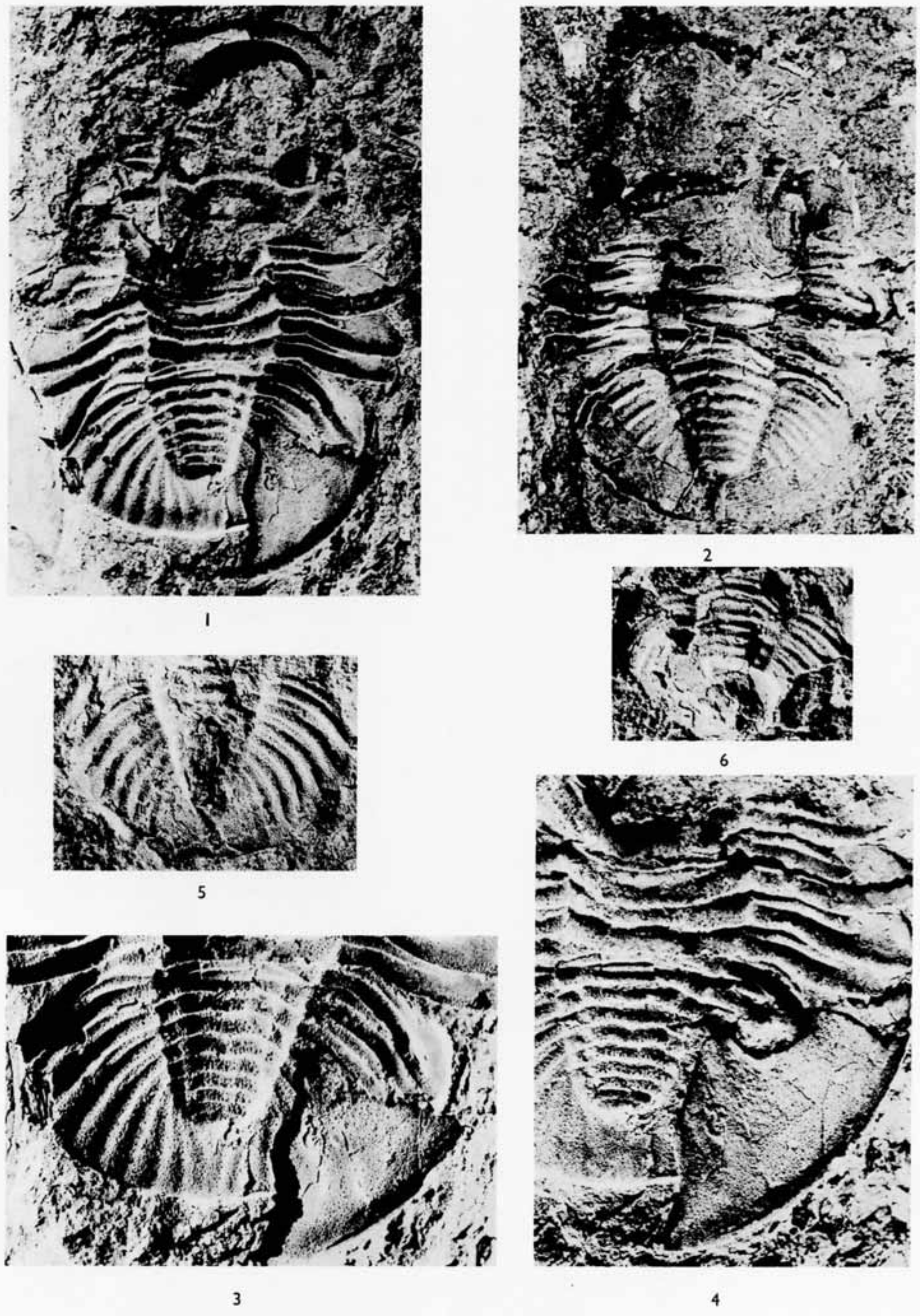
EXPLANATION OF PLATE 36

Figs. 1–4. *Doublatia inflata* gen. et sp. nov. 1, holotype, SUP 12929A, ×3. 2, SUP 12929B, ×3. 3, SUP 12929A, before removal of part of pygidium, ×5. 4, SUP 12929A, after removal of part of pygidium to reveal free cheek and facial suture, ×5.

Fig. 5. Pygidium indet., Type A. UQ F44458, ×4.

Fig. 6. Pygidium indet., Type B. UQ F44457, ×4.



WASS and BANKS, *Doublatia* gen. nov.

and then increases slightly to the ninth ring. The greatest convexity is at the mid-point of all axial rings. The posterior side of the interaxial furrow is very steep and the anterior side slopes sharply to the ring. Adjacent and parallel to the axial furrow on rings one to six, and possibly seven, is a furrow which results in the formation of a small tubercle at the ends of these rings. There are seven well-defined pleurae with an eighth poorly defined. The pleural length decreases posteriorly. The greatest height of pleurae is anteriorly. Interpleural furrows between anterior pleurae curve most in a posterior direction and the sixth pleura approximately parallels the axis. Interpleural furrows are deeper than pleural furrows; the pleural furrow separates two regions of convexity in the pleurae with the posterior part always having the greater convexity. All furrows are well defined except for some in the posterior region. The doublure is wide, extending at least as far as the posterior culmination of the axis. It is ornamented by many fine 'semiconcentric' grooves.

Doublatia pyriforme gen. et sp. nov.

Plate 37, figs. 1–12, 14, 15; text-fig. 2

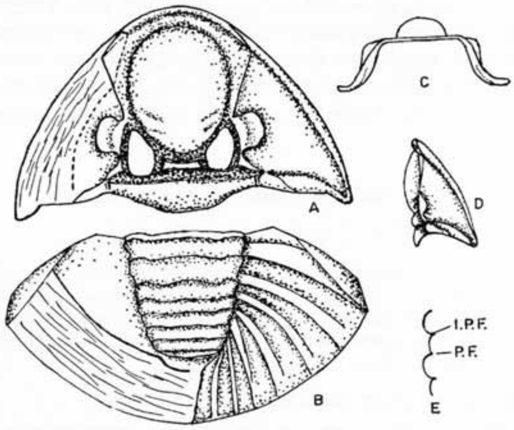
Material. The material on which this description is based consists of two cranidia, five free cheeks, other cephalic fragments, thoracic fragments, four complete pygidia, and two partial pygidia. One pygidium includes both the internal and external moulds and two other pygidia and one of the free cheeks are partly decorticated to reveal part of the doublure. Only UT 55297 is from Elephant Pass; all other specimens are from Ray's Hill, Tasmania.

Holotype. UT 90142, a cranidium from Ray's Hill.

Paratypes. UT 90113, 90144, 90155, free cheeks; UT 90094*a*, *b*, 90115, 90121, pygidia; all from Ray's Hill.

Diagnosis. *Doublatia* with pyriform main glabellar lobe, short genal spine, eight axial rings and seven pleurae in the pygidium.

Description. The holotype cranidium (a partly decalcified original skeleton, Pl. 37, figs. 1, 2, 4) is 6·5 mm long and 5·0 mm wide from β_l–β_r and about 7·0 mm from ω_l–ω_r (subscript refers to the side of the animal, left or right, on which point occurs). The anterior border (α_l–α_r) is arcuate in plan and subtends an angle of about 95° at the centre of curvature (approximately the centre point of the glabella). The facial suture rises steeply and obliquely abaxially to β on the crest of the marginal ridge whence it passes as a straight line to γ at the waist of the cranidium just over half the distance from anterior to posterior of the cranidium. The line β–γ makes an angle of about 30° with the axial line. The distance from γ_l to γ_r is about 3·4 mm. The facial suture at γ has a small radius of curvature. From γ to ϵ the suture describes a semi-elliptical path with a major diameter of about 1·5 mm. Point δ is situated about 4·0 mm behind the anterior margin and about 2·8 mm from the axis. Points γ and ϵ are both close to the axial furrow and approximately equidistant from the axial line. From ϵ the suture passes backwards for a short distance and then posteriorly and laterally to ω. The line ϵ_r–ω_r is about 45° to the axis. The line ω_l–ω_r is about 5·8 mm from the anterior margin. The posterior margin of the cranidium is crossbow shaped in plan with the convexity to the posterior. The anterior border, horizontal in front view (Pl. 37, fig. 2), is turned up sharply to form a rounded ridge about 0·3 mm across. Behind this is a deep, narrow, rather angular, preglabellar border furrow which expands laterally to form the anterior part of the fixigenae. The glabella is also waisted, the narrowest portion being at the intersection of the preoccipital (lp) and the axial furrows and a little posterior of γ. At its narrowest point the glabella is about 3·0 mm wide. From this waist the glabella widens in a gentle curve around the preoccipital lobes. The glabella is about 4·6 mm long. The main (frontal) lobe of the glabella is pyriform, the posterior margins being defined by deep



TEXT-FIG. 2. Reconstructions of *Doublatia pyriforme* sp. nov., $\times 5$. A, dorsal view of cephalon with partially decorticated free cheek to show connective suture and part of the doublure. B, dorsal view of pygidium with decorticated left pleural area showing doublure. C, hypothetical reconstruction of front view of cephalon showing inflated glabella, high palpebral lobes, and inferred position of free cheeks; doublure shown as dotted line. D, cephalon viewed from the right side. E, section of several pygidial pleurae as seen from the right-hand side. IPF = interpleural furrows. PF = pleural furrows.

preoccipital furrows (lp) which converge posteriorly from the waist of the glabella towards the axis and make an angle of about 50° with the axis. Slight shearing (top and front to the left) has made accurate measurement of the convexity of the glabella difficult. The highest point is situated half-way along the glabella and the glabella is distinctly

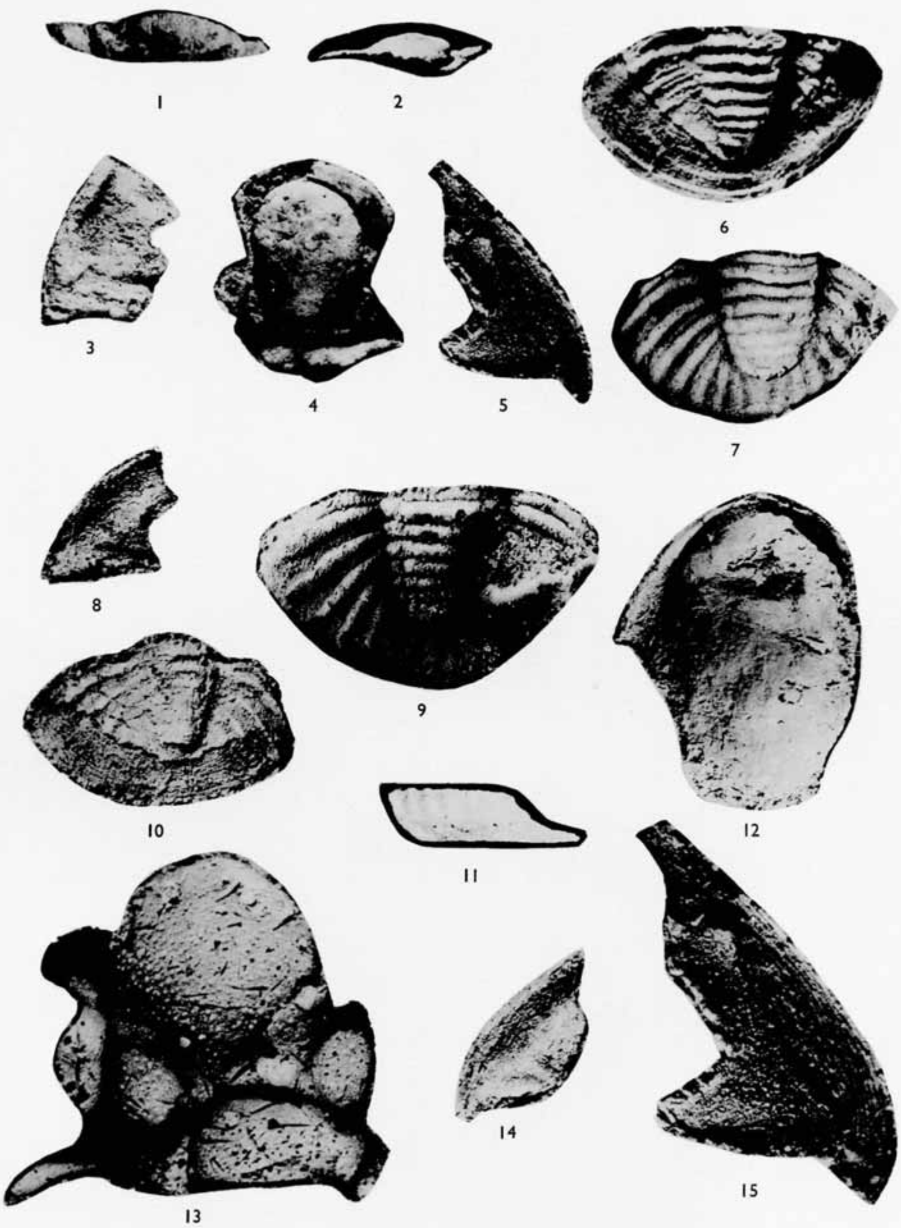
EXPLANATION OF PLATE 37

All numbers refer to the UT Collection; all specimens except 55297*a*, *b*, come from Ray's Hill.

Figs. 1–12. *Doublatia pyriforme* sp. nov. 1, Holotype cranidium from the right side, 90142, $\times 5$. 2, Holotype cranidium from the front, $\times 5$. 3, Left free cheek, 90113, $\times 5$. 4, Dorsal view of internal mould of holotype cranidium, $\times 5$. 5, Partly decorticated left free cheek (reverse printed), 90155, $\times 5$. 6, 7, Internal mould and rubber cast of external mould of pygidium, 55297*a*, *b*, $\times 5$. 8, Left free cheek, internal mould, 90144, $\times 5$. 9, Rubber cast of external mould of pygidium, 90094*a*, $\times 5$. 10, Partly decorticated pygidium, 90094*b*, $\times 5$. 11, Partly decorticated pygidium viewed from left hand side to show profile, 90094*b*, $\times 5$. 12, Dorsal view of large cranidium, 90153, $\times 5$.

Fig. 13. *Doublatia sp.*, dorsal view of external mould of cranidium, 90143, $\times 10$.

Figs. 14–15. *Doublatia pyriforme* sp. nov. 14, Large left free cheek, 90161, $\times 3$. 15, Partly decorticated left free cheek (reverse printed) showing connective suture, terrace lines and genal spine, 90155, $\times 8$.



WASS and BANKS, Australian Permian trilobites but rather uniformly convex upwards (text-fig. 2*d*; Pl. 37, fig. 1). The frontal lobe is either unsegmented or may show two short, faint, lateral furrows directed posteriorly and axially and rising close to the waist. Shearing and preservation preclude a definite statement on this point. The frontal lobe is terminated posteriorly by a shallow trans-glabellar preoccipital furrow joining the most axial points on lp, and approximately in the line ϵ_l–ϵ_r. The preoccipital segment is broken by two shallow grooves, posterior branches of lp parallel to the axis, into a more-or-less rectangular median preoccipital lobe (about 0·05 mm long and 0·15 mm wide) and two lateral preoccipital lobes which are almost trapezoidal. Before shearing and the accidents of preservation, collection, and preparation these were probably quite bulbous (Pl. 37, fig. 13). The occipital furrow is straight from the lateral edge of the cranidium to the axial furrow where it curves gently posteriorly to outline the lateral preoccipital lobes and then continues in a straight line across the axis. The occipital furrow is deep and is asymmetrical in sagittal section, (Pl. 37, fig. 1, text-fig. 2*d*), the anterior slope being very steep, the posterior gently curved and rising on to the almost flat occipital ring. The partially decorticated free cheek (UT 90155) shows that before reaching the axis the facial suture passes onto the ventral surface at a position corresponding approximately to the forward projection of the axial furrow (Pl. 37, figs. 5, 15). At the anterior margin the suture turns axially at about 90° to the margin and runs for a short distance before turning abaxially at about 100° to become a connective suture and join the inner edge of the doublure.

Five free cheeks occur in the same type of matrix as the cranidium, are of similar size and show a facial suture which matches that of the cranidium. The closest match in size occurs in specimen UT 90144 which is 3·6 mm long and 4·2 mm wide (these and other measurements are tabulated as Table 2). The outer margin is evenly curved and the axial and posterior margins almost perpendicular to each other so that the free cheeks approximate one quadrant of an ellipse. The free cheek has considerable relief. The posterior margin is straight or at most very gently curved. The lateral border is marked by a high, sharply rounded crest (up to 0·6 mm wide) which persists almost to the point of the genal spine but declines sharply near the spine. A rounded ridge rises rapidly from near the genal spine and runs just inside the occipital border, reaching a culmination about half-way from the spine to the facial suture, before descending towards the dorsal furrow. A broad shallow furrow lies inside the marginal ridge both laterally and posteriorly and the occipital part of this deepens to a pit just outside the facial suture. The palpebral lobe rises steeply from the sub-marginal and occipital furrows. The genal spine is a short, rather blunt posterolateral prolongation of the genal angle. Partial decortication of one free cheek (UT 90155) revealed the doublure marked by terrace lines (Pl. 37, fig. 15) and showed that the inner edge of the doublure lay under the axis of the broad, shallow sub-marginal furrow, at least anteriorly. The cross-section of the free cheek shows a narrow, high, rounded marginal ridge, a broad shallow furrow, and the steeply rising slopes of the palpebral lobes (text-fig. 2*c*, *d*).

Combining the shapes of the cranidium and free cheeks suggests that the cephalon was arched transversely, the free cheeks probably lying at a considerable angle to the horizontal during life (text-fig. 2*c*). It was probably approximately parabolic in plan with the genal angles projecting downwards and backwards as short, blunt spines (text-fig. 2*d*). A distinctive feature is the high ridge or crest which borders the cephalon except at the genal angles and along the axial part of the occipital ring.

Isolated fragments of cephala and thorax show clearly the finely granulose surface of the trilobite. The isolated thoracic segments suggest that the axis was wide and the pleural regions rather narrow. Fragments of the pleurae (e.g. UT 90159) suggest a width (6·5 mm) about double the length (3·2 mm) and the shape in outline of a parallelogram. The pleural furrow is directed towards the postero-lateral corner in most specimens but is almost parallel to the posterior margin in others. In crushed external moulds it is represented by a high, sharply crested, oblique ridge.

Several pygidia occur in the same type of matrix as the holotype cranidium. They have axes of approximately the same width as that of the cranidium and have the same type of ornament. On the basis of mutual and exclusive association, axis width, and ornament the pygidia (Table 2B, less UT 55297) are considered as belonging to the same species as the cranidium.

The anterior and posterior margin of the pygidia are both arcuate in plan, the radius of curvature of the anterior (8·2 mm in UT 90094*a*) being greater than that of the posterior (6·5 mm in UT 90094*a*). The anterior margin is smooth across the axis. From the axial furrows the front margin of the pleural articulating half-segments runs forward to a point situated about a quarter of the distance from the axial furrow to the lateral margin. From this point the border of the half-ring continues in a gentle curve to the antero-lateral point of the articulating facet whence it runs almost parallel to the axis and posterolaterally to the widest point of the pygidium. The pygidia are about 0·5 to 0·6 times as long as they are wide (Table 2B). The axis is widest anteriorly and its maximum width varies from about 0·32 to 0·43 of the maximum width of the pygidium. The axis tapers very gently backwards (axial furrows at 12–16° approximately to the axial line) to about the seventh ring posterior to which it narrows rapidly and slopes down to a low postaxial ridge. The axis is 0·66 to 0·77 of the length of the pygidium. In sagittal section the top of the axis is horizontal (Pl. 37, fig. 11) or slopes gently down and back from the anterior ring. In transverse section the axial rings, except the terminal one, are not uniformly curved but tend to rise steeply from the axial furrows, flatten out, or even fall a little before arching evenly over the axial line. In effect there are two furrows within the axis, parallel and close to the axial furrows and these produce a faint tubercle at the pleural ends of each axial ring. The axis contains eight rings in addition to the anterior articulating half-ring. The rings appear to be or to have been (prior to slight deformation) uniformly curved in sagittal section and to be separated by sharp furrows.

The pleural regions are very nearly uniformly convex upwards (Type A of Weller 1937, p. 342) and the axis rises only a little above the projection of the curve of the pleural regions. There is no border. Segmentation of the pleural region does not match that of the axis. There are only seven pleurae on each side in addition to the postaxial ridge. The pleurae decrease successively and gradually in height from anterior to posterior. They consist of two sections of different heights and convexities separated from one another by pleural furrows. The anterior part is low and very gently convex upwards, whereas the posterior is high and more convex (text-fig. 2*e*). The interpleural furrows are rather more distinct than the pleural, due to slightly greater depth but both sets of furrows become shallower and therefore more indistinct posteriorly. The interpleural furrows meet the axial furrows at approximately the same point as do the inter-ring furrows on the axis and the pleural furrows meet the axial furrow at points approximately half-way along each axial ring. The interpleural furrows are gently convex antero-laterally, the convexity decreasing from anterior to posterior within the pleural field and the anterior angle between the axial line and the interpleural furrows increasing from just over 90° for the most anterior segment to just over 180° for the seventh. The interpleural and pleural furrows are almost parallel (or concentric). Several specimens show that the surface was finely granulose.

TABLE 2. Cephalic and pygidial measurements of *Doublatia inflata* sp. nov., *D. pyriforme* sp. nov., and *D.* sp.

A. CEPHALIC MEASUREMENTS

(i) Glabella, in front of transglabellar, preoccipital furrow

	L	*W*	*L/W*
D. inflata (SUP 12929A)	6·5	7·5	0·87
D. pyriforme (UT 90142)	4·1	3·2	1·28
D. pyriforme (UT 90153)	> 9·3	5·0	> 1·86
Doublatia sp. (UT 90143)	> 5·4	5·0	> 1·08

(ii) Free cheeks

	L	*W*	*L/W*
D. inflata (SUP 12929A)	11·0	7·7	1·43
D. pyriforme (UT 90161)	7·8	6·2	1·25
D. pyriforme (UT 90113, 90144, 90155, 90284)			
Range	> 3·2–5·0	3·0–4·4	> 1·07–1·25

L measured exsagitally, *W* transversely

B. PYGIDIUM

	Lp	*Wp*	*La*	*Wa*	*Lp/Wp*	*La/Wa*	*Lp/La*	*Wp/Wa*
D. inflata (SUP 12929A)	9·0	19·4	6·0	6·5	0·46	0·92	1·50	3·0
D. pyriforme (UT 90094*a*, *b*, 90121, 90230–1, 55297)								
Range	3·1–7·0	5·6–12·4	≃ 2·4–4·6	2·3–4·0	0·52–0·65	≃ 1·0–1·2	≃ 1·3–1·5	2·3–3·1

All measurements in millimetres. *L* = length, *W* = width, *Lp* = length of pygidium, *La* = length of axis, *Wp* = width of pygidium, *Wa* = width of axis.

The internal moulds show that the doublure was wide. Anteriorly it extended from the outer margin about halfway to the axial furrow and it maintained this width throughout so that in the plane of symmetry it extended forward to the posterior end of the axis. It is prominently marked by numerous fine concentric grooves (terrace lines).

The dimensions and relative proportions of the pygidium of *D. pyriforme* are shown in Table 2B which includes those of *D. inflata* for comparison.

Other material. Other material probably of the same species includes a rather larger partial cranidium (UT 90153) from the same type of matrix at Ray's Hill, a larger free cheek (UT 90161) and the pygidium (UT 55297) from Elephant Pass. The cranidium is an internal mould of the part of the dorsal surface of the glabella and fixed cheeks. It has been sheared, the length of the preserved part being 9·3 mm, the width 5·0 mm. The anterior border comes to an obtuse point just to the right of the axis but this may be due to shearing. The border is marked by a high, rounded ridge only 2·0 mm across.

The preglabellar furrow is similar to that in the holotype and expands in the same way to a fixed cheek, the preserved portions of which have the same shape as the holotype. The frontal lobe of the glabella is pyriform and strongly convex upwards, the highest point being about 6 mm behind the anterior border and almost 2 mm above the general level of the base of the glabella. The anterior part of the glabella has been partly crushed.

Although this partial cranidium is approximately twice the size of the holotype, the frontal lobe of the glabella is pyriform and on this basis it is included in *D. pyriforme*. The proportions of the frontal lobe are even further from those of *D. inflata* than they are from *D. pyriforme*.

Another large specimen is the free cheek (UT 90161) preserved as an internal mould. The specimen has a length to width ratio very close to that of other specimens assigned to *D. pyriforme* and very different from that of *D. inflata*. There is a narrow (0·4 mm) ridge around the lateral margin which is lower (only 0·5 mm high) than in smaller specimens but similarly decreases in height near the genal angle. The occipital ring is similar to that in the smaller specimens, in that it rises to a culmination about half-way between the genal angle and the posterior limit of the facial suture. The occipital furrow shallows towards the genal angle. A broad shallow furrow lies inside the marginal ridge and the cheek rises steeply from this to the palpebral lobe. The top of the palpebral lobe is about 1·8 mm above the plane of the lateral margin of the free cheek. The facial suture has a similar shape in plan to those of the smaller specimens.

Although the pygidium from Elephant Pass (UT 55297, Pl. 37, figs. 6, 7) comes from a different place and lithology, it shows the same characters as the pygidia from Ray's Hill and is placed in the same species.

Discussion. The Tasmanian species is generally only about half the size of that from Mulbring. The cephalic outline which has to be reconstructed in both species described here, is semicircular in *D. inflata* and in *D. pyriforme* is a parabola approximating to the curve $y = x^2/4{\cdot}5$, where y, x are Cartesian co-ordinates in millimetres of a point on the outline relative to the front of the cephalon as origin and the long axis of the cephalon as the y axis. The cranidium of *D. pyriforme* is proportionally longer (L:W = 1·5) than that from Mulbring (L:W = 1·14). Both have a glabella waisted just in front of the preoccipital lobes but in *D. inflata* the frontal lobe is almost circular as against pyriform in *D. pyriforme*, the depth of the waist indentation is less in *D. inflata*, and the lateral preoccipital lobes are more circular in *D. inflata* than in *D. pyriforme*. The occipital region is similar in both. The preglabellar furrow is narrower and the border more upturned and higher than in *D. inflata*. In addition the border ridge is higher and the submarginal lateral furrow wider and deeper than in *D. inflata*. Shape of the facial suture is very similar but β–γ is straight in *D. pyriforme*, sigmoidal in *D. inflata*. The ornament is similar in both. Thoracic segments are similar in shape as far as can be judged. The pygidium of *D. pyriforme* is about the same shape (but half the size) as that of *D. inflata* and the relative proportions of length and width of axis and pygidium show approximately the same range (Table 2B). *D. pyriforme* does, however, differ from *D. inflata* in that it has eight axial and seven pleural segments as against nine and eight respectively in *D. inflata*. The difference in segmentation may be specific or related to a stage in holaspid development. In this latter case all the Tasmanian pygidia would represent the one holaspid stage, being earlier than that represented by the Mulbring specimens (cf. Weller 1937). While this is possible, it is rather unlikely that the only specimens collected belong to the same, and not final, holaspid stage. It is more likely that this difference is specific. The angle made by the axial furrows with the axial line is a little higher (18°) in *D. inflata* than in *D. pyriforme* (12–16°).

Doublatia sp.

Plate 37, fig. 13

A third cranidium (UT 90143) was found as an almost complete external mould in white silicified limestone at Ray's Hill. The preglabellar region and the fixed cheek on one side are missing.

Description. The glabella is 3·7 mm long and a little over 4 mm wide, and it is waisted as in *D. pyriforme*. The frontal lobe, although incomplete anteriorly, appears to be almost circular and is highly inflated, the highest point lying on the axis about 2·0 mm in front of the preoccipital furrow and at least 0·9 mm above the base of the glabella. The left-hand side of the frontal lobe shows two faint but distinct furrows arising at equal intervals of about 0·3 mm in front of the preoccipital furrow and extending inwards and backwards to about two-thirds of the way to the axis. The more posterior of these parallels the preoccipital furrow, the more anterior being more directly transverse. The preoccipital furrows run towards the axis making an angle of about 60° with it before turning back almost parallel to the axis to meet the occipital furrow. A shallow indistinct furrow joins these furrows to delineate a third, almost rectangular, median preoccipital lobe. The lateral preoccipital lobes are trigonal to trapezoidal. The occipital furrow is deep and more-or-less symmetrical in sagittal section. The occipital furrow is laterally straight but inside the dorsal furrow curves sigmoidally forward from each side. The occipital ring is very convex in both sagittal and transverse section, producing an almost bulbous appearance. The posterior margin is disrupted but appears to have been gently convex backwards. The high, arcuate palpebral lobe is preserved on the left hand side. The facial suture appears to be slightly divergent anteriorly (γ–β) and curves smoothly at the front towards the axial line (β towards α). Behind the palpebral lobe it diverges at about 60° to the axial line to just in front of the occipital ring; at this point it flattens to 45° to the axial line at which angle it meets the occipital ring which it crosses at about 75° to the axis. The pleural part of the occipital ring is still rising where it is cut by the facial suture. The whole surface of the cranidium is both coarsely and finely granulose.

Discussion. This cranidium is considered to belong to *Doublatia* on the basis of similar waisting of the glabella, glabellar segmentation, and ornamentation. The frontal lobe of the glabella is almost circular, more similar to *D. inflata* than to *D. pyriforme* (Table 2A (i)), but the lateral preoccipital lobes are closer in shape to those of *D. pyriforme* than those of *D. inflata*. The frontal limb of the facial suture (γ–β) is sigmoidally curved as in *D. inflata*. The occipital region differs only a little from *D. pyriforme* in sagittal section.

It is likely that this specimen represents a new species or perhaps is *D. inflata* but it is not complete enough to allow proper decision.

Generic affinities of Doublatia

Relationships within the Griffithidinae have recently been considered by Hahn and Hahn (1967) who used cephalic outline, degree of glabella inflation, presence of furrows 2p and 3p in the glabella, and the degree of segmentation of the axis of the pygidium as the main criteria linking genera into groups as outlined earlier. Some doubts must be expressed about the validity of these features in showing phylogenetic relationship.

Cephalic outline varies considerably within a genus. In *Ditomopyge decurtata* (Gheyselinck) and *D. fatmii* Grant (both illustrated by Grant 1966, pl. 13) the outline is parabolic but the equations of the parabolae in the two species are different. *D. scitula* (Meek and Worthen) (Weller *in* Moore 1959, p. O403, fig. 307, 5*a*) had an almost semicircular cephalic outline whereas *D. meridionalis* Teichert had an outline which was probably trigonal. The type species of *Doublatia* had an outline which was probably almost semicircular but the other species assigned here to the genus had an outline which was parabolic. It might be expected that similarity in cephalic outline would have been selected in separate lineages as an adaptation to similar habitats.

Both *Cyphinoides* and *Eocyphinium* (Reed 1942, pls. 8, 9) have glabellar inflation at least as great as some of the *Griffithides* group, for example, *Permoproetus*, although probably not as great as *Neoproetus* and *Kathwaia*. On the whole the degree of glabellar inflation seems to support the grouping adopted by Hahn and Hahn.

Glabellar segmentation, reflecting some locomotory or alimentary structures of the soft anatomy might be expected to be more conservative than cephalic outline, at least, and therefore be a better criterion for establishing relationships. Hahn and Hahn (1967) considered that the median preoccipital lobe developed independently, presumably as parallel evolutionary regressions to some early Ordovician or Cambrian precursor of the Proetidae, in at least three lineages, *Kaskia–Ditomopyge*, *Thigriffides* to the *Cyphinoides* group, and *Bollandia–Permoproetus*. They further postulated redevelopment of glabellar furrows in front of lp in the *Paladin–Kaskia–Ditomopyge–Anisopyge* lineage, in the *Thigriffides–Cyphinoides* group lineage and in the *Bollandia–Paraphillipsia* lineage. Suppression of 1p and 2p glabellar furrows in *Griffithidella doris* (Hall) leading through *Bollandia* to *Neoproetus* and *Kathwaia* might suggest, on the other hand, that such suppression could also affect the other groups. However, the over-all trend was towards increasing segmentation leading to the formation of a median preoccipital lobe and as many as three other pairs of glabellar furrows as in *Anisopyge*. In neither the *Griffithides* nor the *Paladin* group did rectilinear evolution of this feature occur, judging from the text and figures of Hahn and Hahn. In the *Griffithides* group *Permoproetus* developed a median preoccipital lobe from ancestors without one and in the *Paladin* group *Kaskia*, lacking 3p, intervened between forms with this pair of furrows. The lineage suggested by Hessler (1965, pp. 258–9) in the Cummingellinae, i.e. *Moschoglossis–Cummingella–Richterella–Ameura*, demonstrates gradually increasing suppression of glabellar furrows from anterior to posterior. It would be superficially simpler to group all genera with 1p forked or with a median preoccipital lobe and postulate derivation by increase in strength, length, and number of glabellar furrows from a genus in the Lower Devonian with unforked 1p and some furrows in front of 1p. Such a derivation might proceed through a species like *Schizoproetus celechovicensis* (Smycka) or *Cyrtosymbole escoti* (Koenen) to *Eocyphinium* and *Cyphinoides* or a similar genus and on to genera with a median preoccipital lobe and one or more furrows in front of 1p. Hupé (1953) made almost such a grouping in erecting the Ditomopyginae. However, this rectilinear increase in glabellar furrowing is not without exception, and reversal of trend would have to be postulated to accommodate *Permoproetus* and *Paraphillipsia* at least.

Another potentially useful taxonomic character is the glabellar outline which helps to characterize the Phillipsinae and Cummingellinae and to connect such genera as *Moschoglossis* and *Ameura* (Hessler 1965, pp. 258–9). Gradual lateral and forward expansion of the anterior lobe of the glabella and progressive suppression of glabellar furrows from anterior to posterior as shown by this lineage, may, if continued, have led to *Paraphillipsia*. The authors have attempted to construct a phylogenetic system based on conservation of glabellar shape or on modification of glabellar shape by anterior or later expansion but with no retrogression and taking particular note of the position of the waist or waists. However, this scheme also contains anomalies such as one species of *Ditomopyge* having only one waist at 2p and related therefore to *Cyphinoides* and *Eocyphinium* whereas others may have a second, smaller waist about midway along the length of the lateral preoccipital lobes, suggesting relationship to *Kaskia*. Another anomaly in such a scheme is the placement of species of *Griffithides* in two lineages, one with waists at the mid-length of the lateral preoccipital lobe and 1p (*G. longiceps* Portlock), the other waists at 1p and within the frontal lobe in front of 1p (*G.* (*Metaphillipsia*) *seminiferus* (Phillips)).

Yet another trend used in classification is increase in segmentation of the axis of the pygidium. However, no phylogenetic scheme yet published, nor the one mentioned earlier as having been tried by the authors, maintains this as a rectilinear trend in all lineages.

It would appear that the Proetidae, or at least the genera grouped by Hahn and Hahn (1967) as Griffithidinae, were subject to mosaic and reversible evolution, leading to difficulty in establishment of clear phylogenetic lines. Such lines may emerge when more intermediate forms are described especially from the Upper Devonian, Upper Carboniferous, and Lower Permian and make possible tracing, through small steps, evolutionary and migratory patterns. It is likely, from what is already known of the derivation of eastern Australian Permian fossils generally (Teichert 1951), that the precursor of *Doublatia* was a Carboniferous form from eastern Australia or perhaps an earlier Permian form from Western Australia.

At the present stage of knowledge and in view of the likelihood of mosaic evolution within the Griffithidinae, all that can usefully be done to establish the generic relationship of *Doublatia* is to compare it feature by feature with other genera and so assess the genus to which it is most similar. Such an assessment may reveal a real phylogenetic relationship or a distantly related genus at about the same stage in a number of evolutionary trends.

Little is to be gained by comparisons of the cephalic outlines of the *Doublatia* species. The glabella has a single waist at 1p, as have *Neoproetus*, *Kathwaia*, *Paladin*, *Bollandia*, and some species of *Ditomopyge*. The waist is about as narrow as in *Paladin*, *Bollandia*, and *Ditomopyge* but not as narrow as in *Neoproetus* or *Kathwaia*. Some species of *Ditomopyge* have a second waist, as mentioned earlier, but there is no sign of this in *Doublatia*. The widest part of the glabella in *Doublatia* is across the preoccipital lobes.

Bollandia and *Paraphillipsia* are the only other griffithidines (and *Paraphillipsia* may be a cummingelline) to show this and it may be considered a primitive feature. Other genera such as *Ditomopyge*, *Exochops*, *Neoproetus*, and *Permoproetus* approach this condition but of these only *Ditomopyge* and *Neoproetus* have similar waisting to *Doublatia*. In both these genera the frontal part of the glabella is as wide as or slightly wider than the posterior. In this feature *Doublatia* shows more resemblance to some of the earlier members of other superfamilies than to most other griffithidines. Of those genera with similar waisting only *Ditomopyge* is at all like *Doublatia* in possessing a median preoccipital lobe and glabellar furrows 2p and 3p. The degree of inflation of the frontal lobe of the glabella of *D. pyriforme* is comparable with that in some *Ditomopyge* species and *Timoraspis* whereas that of *D. inflata* is more comparable with that of *Neoproetus indicus* Tesch but less than that in *Kaskia*. The degree of forward expansion of the glabella is most similar to that of some species of *Ditomopyge*, for example, *D. sylvense* Weber, *D. fatmii*, and some specimens of *D. meridionalis* from the Lower Permian of Western Australia which had a frontal brim (Teichert 1944). *Microphillipsia* shows about the same degree of forward development of the glabella. There is considerable resemblance of the front part of the cephalon of *D. pyriforme* with the fragment figured as ?*Conophillipsia* by Campbell and Engel (1963, pl. 8, fig. 4) from the Tournaisian of New South Wales.

The occipital ring is close in shape to that of *Ditomopyge* sp. (Teichert, 1944) from the Lower Permian Fossil Cliff Limestone of Western Australia, of *Neoproetus indicus* and '*Griffithides*' *trigonoceps* Gheyselinck from Timor.

Comparison of the shape of the facial suture of *Doublatia* with that of other proetids shows that the palpebral lobe is situated comparatively far back on the cranidium (γ approximately opposite 2p, ϵ approximately opposite the transglabellar, preoccipital furrow). The position compares most closely with that in *Kathwaia*, *Permoproetus*, and *Ditomopyge*. The frontal limbs (γ–β) are slightly more divergent than in *Kathwaia* and much more divergent than in *Permoproetus* and notably straight, both features seen also in *Weania goldringi* Campbell and Engel 1963. In shape of this limb *Doublatia* is closest to *Kathwaia* but shows similarities also to some Lower Carboniferous genera (e.g. *Weania* and *Metaphillipsia*) and lesser similarities to *Paladin* and *Ditomopyge*. The posterior limbs (ϵ–ω) are similar in plan to those of *Kathwaia* with lesser resemblances to those of *Ditomopyge*, *Metaphillipsia*, *Ameura* and a number of other genera. The connective sutures are long and divergent, different in both respects from those of *Proetus cuvieri* (Struve in Moore 1959, p. O385, fig. 292) and *P. bohemicus* (Hupé 1953, p. 51, fig. 5*d*) and in their divergence they differ from those of *Carbonocoryphe bindemanni* (Struve in Moore 1959, p. O393, fig. 299, 6*a*).

The free cheeks of *Doublatia pyriforme* show a marked resemblance to those assigned by Campbell and Engel (1963, pl. 6, figs. 10–13) to *Weania goldringi* especially in the angular nature of β, the wide divergence and straightness of γ–β, and the shape of the genal spine but *W. goldringi* is closer to *D. inflata* in flatness. The genal spines in *Doublatia* are short and most closely resemble those of *Neoproetus* in both length and in the structure of the border and adjacent furrow in the immediate vicinity of the genal angle. There are lesser resemblances to *Eocyphinium*, *Bollandia*, *Weania goldringi*, *Microphillipsia*, and *Timoraspis breviceps* (Gheyselinck) in these respects.

In the majority of cranidial characters, then, *Doublatia* is closest to *Ditomopyge* and derivation from an early *Ditomopyge* species, in which the glabella did not reach the anterior margin of the cephalon and was rather narrow anteriorly, might be suggested. From such an ancestor *Doublatia* could have evolved by slight weakening of the anterior fork of 1p and by shortening of the genal spine. A collateral relationship with *Neoproetus* and *Kathwaia* is suggested by the similar waisting of the glabella, similar position of the palpebral lobe, similar genal spine (*Neoproetus* only), and somewhat similar ornament. Another genus with fairly close collateral relationship is *Microphillipsia*, as shown by similarity in glabellar extension, shape, and segmentation, and in the development of the genal spine.

Although the cephalon of *Doublatia* is essentially that of a *Ditomopyge* with a short genal spine, the pygidium is very different from that of *Ditomopyge*. The pygidium of *Doublatia* is strikingly reminiscent of some cornuproetines (*Pribylia*, *Cornuproetus*), some cyrtosymbolines (*Cyrtosymbole*, *Calybole*, *Waribole*, and *Weania*) and some tropidocoryphines (*Decoroproetus*). With these it agrees in many, but not all, of the following characters—outline, shortness of axis, lack of border, small number of segments, presence of pleural as well as interpleural furrows, presence of postaxial ridge. In almost all the characters listed and in the width of the doublure it is remarkably close to the pygidia assigned by Campbell and Engel (1963, pl. 6, figs. 1–4) to *Weania goldringi* from the Tournaisian of New South Wales. The outline, transverse profile, segmentation, presence of interpleural furrows and a postaxial ridge are similar to those in *Kathwaia* but the anterior part of each pleura was much more convex in *Kathwaia* than in *Doublatia*. The pygidium of *Doublatia* also shows many similarities to that of *Griffithidella doris* (Hessler 1965, pl. 37, figs. 1, 5, 6). The conservatism of the pygidial structure of *Doublatia* is reflected in its very close similarity to *Weania* from the Tournaisian and similarity to Devonian genera especially *Pribylia*.

Thus *Doublatia* had a cephalon moderately advanced in terms of glabellar expansion and inflation compared to many other proetids but not as advanced as many others. Development of lobation of the glabella was at an intermediate evolutionary stage and several genera had more lobes. The free cheek was advanced in terms of length of the genal spine. The most primitive feature was the pygidium. *Doublatia* was at about the same general stage of evolution as some *Ditomopyge* species but has a more primitive pygidium than any species of *Ditomopyge*. Thus it may be phylogenetically related to a primitive *Ditomopyge* from which it developed mainly by shortening of the genal spine or perhaps also by retrogressive shortening of the pygidium associated with reduction in number of pygidial segments and loss of border. Alternatively it may have arisen independently from another stock with cephalic changes parallel to *Ditomopyge*.

From general considerations of the nature of Upper Carboniferous and Permian faunas in eastern Australia (Campbell 1961; Teichert 1951) it is likely that *Doublatia* arose either from Lower Carboniferous Eastern Australian stock, protected by a barrier, probably climatic, from competition in the Upper Carboniferous with stock migrating from outside Australia, or from Lower Permian Western Australian stock which migrated around the continental block of Australia late in the Lower Permian. The similarity of the front end of the cranidium of ?*Conophillipsia* to that of *Doublatia pyriforme* and the similarity of the free cheeks and pygidia assigned to *Weania goldringi* to those of *Doublatia* support the possibility of a long eastern Australian history for

Doublatia. On the other hand, derivation from *Ditomopyge* described by Teichert (1944) from the Fossil Cliff Formation, Western Australia, cannot be rejected as the cranidia are rather similar and the age relationships are those required for such a derivation.

Trilobites are generally represented in the Permian of eastern Australia by isolated pygidia. The following descriptions are of two common forms of pygidia found in this region.

Pygidium indet., Type A

Plate 36, fig. 5

Description. The specimen, UQ F44458, is a pygidium. There are at least seven axial rings and eight pleurae with the latter being parallel to the axis at the posterior extremity. The pygidial axis is very pointed posteriorly and extends for three-quarters of the pygidial length. At the anterior end the axis occupies about one-third of the pygidial width. It increases in height until about the fourth axial segment and then slopes gradually to the posterior extremity. An extremely narrow pygidial border is present resulting in a change of slope along the ends of the pleurae.

Locality. The specimen was found in Sawpit Gully (Locality 2). Three other specimens, UQ F58160–1 from this locality and 58306 from Locality 3 appear to be closely related to the specimen described above.

Pygidium indet., Type B

Plate 36, fig. 6

Description. The specimen, UQ F44457, is also a pygidium. At least ten axial rings are preserved with small tubercles developed at the junction of the axial rings and pleurae. The axis is about one-third the pygidial width at the anterior end but it gradually decreases in width posteriorly. The posterior extremity of the axis, at three-quarters of the pygidial length, is rounded.

Locality. The specimen was found in Sawpit Gully (Locality 2). Another specimen, UQ 58305, is similar to UQ F 44457 and was found at Locality 3.

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