

Reappraisal of the Middle Ordovician Trilobites from the Jigunsan Formation, Korea

직운산층(중기 오오도비스기) 삼엽충에 대한 분류학적 재평가

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Abstract : Middle Ordovician trilobites of the Jigunsan Formation are reevaluated and redescribed based on the detailed analysis of cephalic structures of numerous specimens collected from an exposure in Napalgogae, Dongjeom area. Of 22 asaphid trilobite taxa known hitherto from the Jigunsan Formation, eighteen are found to be referable to one of the following species; i.e., *Dolerobasilicus yokusensis* (Kobayashi, 1934), *Basiliella kawasakii* Kobayashi, 1934, *Basiliella typicalis* (Kobayashi, 1934), and *Ptychopyge dongjeomensis* Lee and Cheong, 1980. The name *Ogygitoides raymondi* Kobayashi, 1934 is recommended to be applied to the holotype only, while its supposedly accompanying cranidia are transferred to *Dolerobasilicus yokusensis*. The remaining three species, namely, *Basilicus* (?) *endoi* Kobayashi, 1934, *Onchometopus* (?) *makkolensis* Kobayashi, 1934, and *Asaphus* (?) aff. *minor* (Weller, 1913), were unable to be evaluated due to poor preservation and inadequate descriptions. The generic concept of *Dolerobasilicus* Harrington and Leanza, 1942 is refined. *Parabasilicus* Kobayashi, 1934 is treated as a junior synonym of *Basiliella* Kobayashi, 1934.

요 약

강원도 태백시 동점지역의 나팔고개에 분포하는 직운산층으로 부터 채집된 삼엽충들의 머리구조(cephalic structures)에 대한 자세한 분석을 바탕으로 직운산층의 삼엽충에 대한 분류학적 재평가를 시도하였다. 지금까지 직운산층으로 부터 알려진 22종의 asaphid 삼엽충 중 18종은 다음과 같이 3속 4종으로 재동정되었다; *Dolerobasilicus yokusensis* (Kobayashi, 1934), *Basiliella kawasakii* Kobayashi, 1934, *Basiliella typicalis* (Kobayashi, 1934), 그리고 *Ptychopyge dongjeomensis* Lee and Cheong, 1980. 1934년 Kobayashi가 제안했던 신속 *Ogygitoides*의 개념은 완모식(holotype)에만 국한시키며 *Ogygitoides raymondi*로 동정되었던 표본중 일부를 *Dolerobasilicus yokusensis*에 소속시켰다. 나머지 3종, 즉 *Basilicus* (?) *endoi* Kobayashi, 1934, *Onchometopus* (?) *makkolensis* Kobayashi, 1934, 그리고 *Asaphus* (?) aff. *minor* (Weller, 1913)은 보존이 불량하고 충분한 기술이 되지 않았으므로 이연구에서 시도하였던 재평가 대상에서 제외하였다. 1942년 Harrington과 Leanza가 제안했던 *Dolerobasilicus*속의 개념을 재정립하였고, 또한 1934년 Kobayashi가 제안했던 *Parabasilicus*는 *Basiliella*의 동속이명으로 해석하였다.

INTRODUCTION

The Jigunsan Formation has been well known to produce abundant and diverse trilobite fossils in Korea, since Kobayashi (1934) published an

extensive study on macroinvertebrate faunas of the Jigunsan and Duwibong Formations. Trilobites described from the Jigunsan Formation by Kobayashi (op.cit.) were seventeen taxa, of which three genera, eleven species and one variety were new

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to science. Later, Ma (1938) noted that *Basilicus* from the Jigunsan Formation is phylogenetically distinct and consequently erected a new genus *Basilicoides* along with several new species. However, all of the new species proposed by Ma (1938) are considered to be *nomina nuda*. Shikama and Ozaki (1969) established three biozones within the Jigunsan Formation, namely, *Orthis nipponica*, *Basilicus deltacaudus*, and *Basilicus yokusensis* Zones in ascending order, and also provided a somewhat detailed description of *Basilicus yokusensis*. Lee *et al.* (1980) added five new species of trilobites from the Jigunsan Formation: *Basilicus jigunensis*, *Basilicus weoni*, *Basiliella jangseongensis*, *Parabasilicus gangweonensis*, and *Ptychopyge dongjeomensis*. The macroinvertebrate fauna of the Jigunsan Formation has been correlated to the Llandeillian of Europe or Chazyan of North America (Kobayashi, 1966), while a recent conodont study (Lee and Lee, 1990) provided the age of the Jigunsan Formation to be Llanvirnian.

The specific purpose of this paper is to reassess the Jigunsan trilobite fauna, which includes taxonomic revision and redescription. All of the Jigunsan trilobites hitherto known belong to the Family Asaphidae. As most asaphids are commonly effaced with growth, it is often difficult to recognize the cephalic structures clearly which are of prime importance in classifying this group. The Jigunsan asaphids are also significantly effaced and their occurrences as external and internal molds further obscure the detailed morphology of cephalic structures. Since effacement becomes more prominent with growth, the cephalic structures such as axial and glabellar furrows are in general more clearly impressed in younger, and thus smaller, specimens. Accordingly, it seems extremely important to find or observe smaller specimens of certain species and to trace their morphological variation with growth. In this study, great attention has been given to the identification of glabellar structures, which may have become obsolete during ontogenetic development and post-mortem processes. Of 22 taxa known from the Jigunsan Formation, three species were unable to be evaluated due to poor preservation and inadequate

descriptions: They are *Basilicus* (?) *endoi*, *Onchometopus* (?) *makkolensis*, and *Asaphus* (?) aff. *minor*. The application of the name *Ogygitoides raymondi* Kobayashi, 1934 is recommended to be restricted to the holotype, while all of its supposedly accompanying cranidia are assigned to *Dolero-basilicus yokusensis*. The remaining 18 taxa are referable to one of the following species; *Dolero-basilicus yokusensis*, *Basiliella kawasakii*, *Basiliella typicalis*, and *Ptychopyge dongjeomensis*.

FOSSIL LOCALITY AND MATERIALS

Trilobite specimens for this study were obtained from the upper part of the Jigunsan Formation, exposed in Napalgogae, Dongjeom area (Fig. 1). The Jigunsan Formation in Napalgogae is estimated to be about 20 m in thickness: The lower part of the formation is, however, covered by soils and vegetation and thus the contact between the Jigunsan Formation and the underlying Maggol Formation is not clearly drawn, whereas the upper 7 m interval of the formation is easily accessible for lithologic observation and fossil collection. The lithology of the upper part consisting predominantly of black or dark grey shale grades upwards into marlstone and limestone of the Duwibong Formation. In this exposure, fossils occur abundantly in the lower 3 m interval, while the upper 4 m interval is virtually devoid of fossils. However, fossil specimens that are directly collectable from the fossiliferous interval are limited. On the other hand, well-preserved specimens are frequently found in the pile of debris just below the exposure, from which materials for this study were also collected. Exoskeletons of most specimens are completely dissolved away, thus leaving internal and external molds. The number of specimens exceeds 2000, but about 440 specimens are relatively well-preserved and were used for measurement of their dimensions. Silicon-rubber casts were made to show the detailed, otherwise unidentifiable, morphology of certain structures. All of the specimens illustrated and used in this study are stored in the paleontological collections of Seoul National University (SNUP), Seoul, Korea.

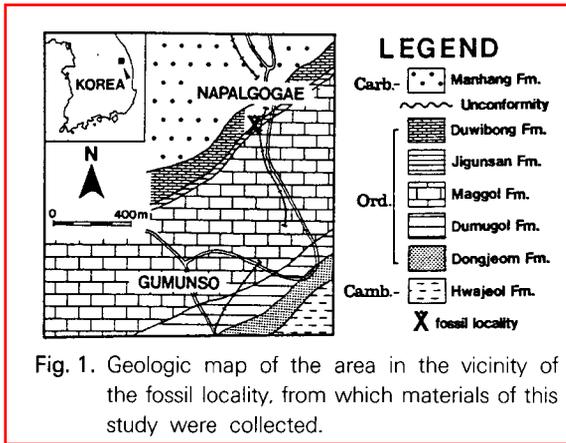


Fig. 1. Geologic map of the area in the vicinity of the fossil locality, from which materials of this study were collected.

Some nearly complete *Dolerobasilicus* specimens were loaned from Mr. Dal Gi Weon, an amateur fossil collector resided in Seoul.

SYSTEMATIC PALEONTOLOGY

Superfamily Asaphacea Burmeister, 1843

Family Asaphidae Burmeister, 1843

Genus *Dolerobasilicus* Harrington
and Leanza, 1942

Type species. *Basilicus yokusensis* Kobayashi, 1934

Diagnosis.—Asaphid trilobite with a mesial ridge on the preglabellar field and prominent paradoublural lines. Glabella elongately rectangular, with rounded anterior margin; axial furrow distinct in front of palpebral lobe and obsolete behind it; S1 glabellar furrows long, deeply incised, and directed backwards and inwards; a pair of swellings located on L3 lobes close to axial furrows. Occipital ring with a faint intraoccipital furrow. Palpebral lobes situated a little behind the cranial mid-length. A pair of baculae, though obsolete, developed as elongated ridges along the adaxial sides of posterior fixigena. Postocular facial suture divergent straight. Ovoid hypostome with long (exsag.) anterior wings prominently forked; hypostomal condition conterminant. Cephalic doublure broader than border; a distinct forward indentation in its median portion. Pygidium with more than 20 pleurae and distinct pleural furrows; axial ring

with three tubercles.

Discussion.—*Basilicus yokusensis* Kobayashi, 1934 was established based on an incomplete carapace and several pygidia collected from the Jigunsan Formation. The cranidium of its holotype (Kobayashi, 1934, pl. 33, figs. 3-4) is poorly preserved and therefore gives little information on the cranidial features. A carapace illustrated by Shikama and Ozaki (1969, pl. 3, fig. 1) still has an imperfect anterior portion of cranidium, and also does not show its cranidial features clearly.

The distinctiveness of *Basilicus yokusensis* was first noted by Ma (1938) who established the genus *Basilicoides* to comprise forms of *Basilicus yokusensis* Kobayashi, 1934 and *Basilicus delta-caudus* Kobayashi, 1934. However, the name *Basilicoides* was preoccupied by Harrington (1937, p. 117), which is in turn a junior synonym of *Thysanopyge* (Jaanusson in Moore, 1959; Zhou and Fortey, 1986). Subsequently, the genus *Dolerobasilicus* with *Basilicus yokusensis* as a type species was proposed by Harrington and Leanza (1942) to replace the name *Basilicoides* Ma, 1938. Meanwhile, in Treatise on Invertebrate Paleontology (Jaanusson in Moore, 1959, p. 0354), *Dolerobasilicus* is described as 'type species poorly known' and is placed within the subfamily uncertain under the family Asaphidae.

The genus *Dolerobasilicus* bears resemblance to *Basilicus* and allied genera. In particular, pygidia of this genus may not be easily distinguishable from those of *Basilicus* which leads Zhou and Fortey (1986) to synonymize two genera. However, cranidia of *Dolerobasilicus* are quite distinct from those of *Basilicus* in having a mesial ridge on the preglabellar field, more anteriorly situated palpebral lobes, and wider cranial doublure represented by paradoublural lines. This genus is also related to *Lonchobasilicus*, which is distinguished by longer glabella, palpebral lobes situated more posteriorly close to glabella, and pygidia with a stout terminal spine (cf. Zhou and Fortey, 1986, p. 184). Small cranidia of *Lonchobasilicus gansuensis* has been known to have a raised mesial ridge in the preglabellar field which, however, disappears in the late holaspid period (Zhou and For-

tey, 1986, p. 185), while the preglabellar mesial ridge in *Dolerobasilicus* persists throughout the ontogenetic stages.

The cranium of the holotype of *Ogygitoides raymondi* Kobayashi, 1934 closely resembles that of *Dolerobasilicus yokusensis* in the course of facial suture. Its cranial and pygidial features, however, are not discernible due to poor preservation and therefore it is not possible to evaluate the species at the moment. Judging from the description of Kobayashi (1934, p. 484-485), *Ogygitoides raymondi* may be distinguished from *Dolerobasilicus yokusensis* in having an obsolete pygidium with less number (more than eight) of pleurae. However, if the obsolescence is preservational and it has comparable number of pleurae with *Dolerobasilicus yokusensis*, then two species may be indistinguishable and *Ogygitoides* would have a priority over *Dolerobasilicus*. Of 17 nearly complete exoskeletons in the present collections, no specimens assignable to *Ogygitoides raymondi* are found. For the time being, it is suggested that the concept of *Ogygitoides raymondi* is restricted to its holotype, while all of the supposedly accompanying cranidia of the species illustrated by Kobayashi (1934) are reassigned to *Dolerobasilicus yokusensis* (see synonymy and remarks of *Dolerobasilicus yokusensis* below).

***Dolerobasilicus yokusensis* (Kobayashi, 1934)**

Pl. 1, figs. 1-14; Pl. 2, figs. 1-4; Fig. 2

- 1934 *Basilicus yokusensis* Kobayashi: p. 465, pl. 33, figs. 1-7; pl. 34, figs. 1-3; pl. 35, figs. 9, 10; pl. 40, fig. 9.
- 1934 *Basilicus deltacaudus* Kobayashi: p. 466, pl. 34, figs. 4-6; pl. 36, figs. 2, 3; pl. 40, figs. 8.
- 1934 *Basilicus deltacaudus* var. *tyrannoides* Kobayashi: p. 466, pl. 33, fig. 8.
- 1934 *Basilicus* sp. undt., Kobayashi: p. 468, pl. 34, fig. 7.
- 1934 *Basiliella minima* Kobayashi: p. 474, pl. 37, figs. 5-7.
- 1934 *Ogygitoides raymondi* Kobayashi: [partim] p. 484, pl. 43, figs. 3-5; [fig. 2 = holotype

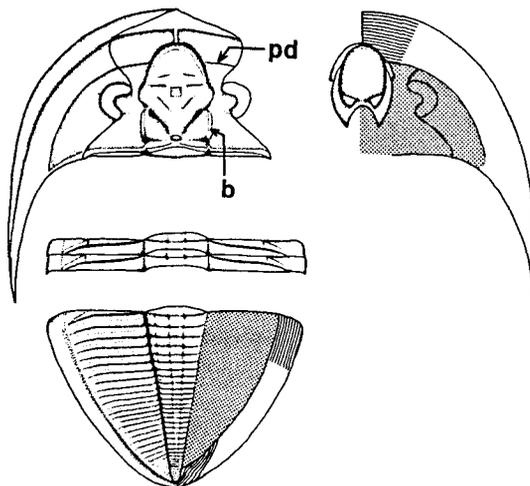


Fig. 2. *Dolerobasilicus yokusensis* (Kobayashi, 1934) (pd: paradoublural lines, b: baccula).

- of *Ogygitoides raymondi* Kobayashi, 1934; pl. 40, figs. 5, indeterminate]
- 1938 *Basilicoides yokusensis* (Kobayashi): Ma, p. 123 [materials not illustrated]
- 1938 *Basilicoides deltacauda* (Kobayashi): Ma, p. 124 [materials not illustrated]
- 1942 *Dolerobasilicus yokusensis* (Kobayashi): Harrington and Leanza, p. 135.
- 1969 *Basilicus yokusensis* Kobayashi: Shikama and Ozaki, p. 46, pl. 3, figs. 1-3, text-fig. 5.
- 1980 *Basilicus jigunensis* Lee and Cheong in Lee *et al.*: p. 123, pl. 1, fig. 1.
- 1980 *Basilicus weoni* Lee and Cheong in Lee *et al.*: p. 124, pl. 1, fig. 2.

Materials.—9 carapaces, 102 cranidia, 62 pygidia, 38 hypostomata, and 15 free cheeks. All but DGW 384, 385, and 386 are deposited in the paleontological collections of Seoul National University (SNUP). Specimens of DGW 384, 385, and 386 are in the care of Mr. Dal Gi Weon.

Description.—Carapace moderately convex, elongately elliptical in outline. Glabella elongately rectangular, with rounded anterior margin, about two to three times longer than broad, occupying more than two-thirds of cranial length; surface ornamented with fine granules. Parafrenal band crescentic. Four pairs of glabellar furrows; S1 lo-

cated behind the palpebral areas, deeply incised, long, strongly oblique backwards, shallowing adaxially; S2 located between the palpebral areas, faint and short (tr.); S3 located opposite the anterior ends of palpebral lobes, nearly transverse or weakly directed forwards and inwards, short (tr.) and fairly distinct; S4 faint and occasionally transcurrent; L1 convex, divided into two triangular lobes by L2; L2 chevron-shaped, containing a median tubercle; L3 differentiated into three parts, a median part and two small lateral swellings which are adaxially delimited by faint furrows. Preglabellar furrow deep. Axial furrow deep, broad, and subparallel in front of palpebral lobe, but parallel and obsolete behind it. Occipital ring rectangular in outline, arched backwards, divided into anterior and posterior bands by a forwardly convex intraoccipital furrow (or band furrow), and one-sixth of glabellar length (sag.); its posterolateral corners marked by a pair of small pits; an impression of posterior cephalic doublure on the posterior band. Occipital furrow (SO) deep, shallowing adaxially, obsolete immediately behind a median glabellar tubercle. Anterior cranial border elongately triangular (tr.), slightly upturned; its surface ornamented with anastomosing lines. Anterior border furrow represented by a backwardly down-sloping face, and thus frontal area wholly shows a stair-like appearance in cross section (exsag.). Preglabellar field narrow (sag.) and furnished by a slender mesial ridge which extends from border to anterior margin of glabella. Anterior fixigena nearly flat; paradoublural line on the fixigena located behind the anterior margin of glabella parallel to cephalic margin, and represented by narrow ridge or furrow. Palpebral lobe crescentic, sited a little behind the cranial mid-length (sag.), its width (exsag.) being one-sixth of cranial length; palpebral furrow faint; palpebral area excluding palpebral lobes weakly convex; its surface covered with bertillon-patterned lines; ocular ridge short (tr.). Posterior fixigena triangular and nearly flat; a pair of bacculae slender, elongated and slightly raised, located along the adaxial sides of posterior fixigena, adaxially defined by faint posterior axial furrows and abaxially by

relatively distinct furrow. Posterior border narrower than occipital ring (exsag.), divided into an anterior transverse ridge and a posterior flat area; border furrow faint. Facial suture supramarginal and opisthoparian; preocular suture diverges forwards and outwards; anterior suture crosses diagonally the anterior border and meets at the sagittal line to form an ogive; postocular suture divergent straight, crossing posterior cephalic margin.

Eye with holochroal facets, reniform, convex, supported by band-like eye socle above the level of free cheek. Free cheek with a stout and long genal spine which extends to the anterolateral corner of pygidium; paradoublural line parallel to lateral margin and divides librigena into a flat adaxial area and an inclined abaxial area; lateral border narrow, convex, clearly defined by lateral border furrow, which becomes shallower posteriorly. Cephalic doublure four times broader than border and ornamented with closely-spaced subparallel terrace lines; inner margin of doublure parallel to cephalic margin, while its median edge indented forwards and upturned dorsally; median suture present.

Hypostome ovoid in shape with deeply forked posterior margin and broadly rounded anterior margin; anterior border narrow, downturned, and prolonged into anterior wing; anterior wing longitudinally triangular, separated from lateral border at the anterolateral corner of median body, projecting dorsally, extending to the hypostomal mid-length (exsag.); median body differentiated into two lobes by deeply incised median furrow; anterior lobe convex, occupying most of the median body, while posterior lobe further differentiated by median furrow and W-shaped posterior border furrow into a pair of prominent triangular maculae; lateral border weakly upturned and widening backwards; posterior border narrow and convex; closely spaced terrace lines on the ventral surface of hypostome subparallel to the margin.

Thorax parallel-sided, composed of eight segments. Axial region parallel-sided, strongly convex, bounded by deeply incised axial furrows, and roughly one-fourth of thoracic breadth (tr.); axial ring rectangular (tr.) with three tubercles; articulating

half ring clearly distinguished from axial ring proper by a backwardly convex articulating furrow and covered with semi-concentrically arranged terrace lines. Pleura straight (tr.) and directed backwards in distal portion, ending in a blunt tip; pleural furrow run obliquely, reaching to two-thirds of pleural breadth; fulcrum developed at the half of pleural breadth.

Pygidium subtriangular to parabolic, slightly convex, with straight anterior margin and often truncated posterior margin in larger specimens; axial furrow deeply incised. Axial region with more than 20 axial rings, strongly convex, gradually tapering backwards and nearly reaching to posterior margin; its convexity abruptly increases in the posterior one-fourth portion of axial region; its frontal breadth (tr.) one-fifth of pygidial frontal breadth; axial ring has three tubercles, one located in the medial line and the others on the flanks of axial ring; these medial nodes often fuse to form a ridge-like appearance. Articulating half ring convexo-convex lens-shaped. Pleural field convex and with more than 20 pleurae; pleural furrow relatively deep, subparallel to anterior margin of pygidium, becoming oblique backwards posteriorly; interpleural furrows shallow or obsolete. Articulating facet elongately triangular (tr.), occupying a distal half of frontal breadth of pleural region. Border furrow represented by a steeply inclined face. Border flat or slightly concave and uniform in breadth. Pygidial doublure broader than border, slightly indented posteromedially, and ornamented with terrace lines.

Remarks—*Basilicus deltacaudus* was originally differentiated from *Basilicus yokusensis* in having a triangular rather than elongately triangular pygidium, while cranidia of both species were considered to be similar to each other (Kobayashi, 1934). Apparently, detailed cranidial features of these species are not discernible from the illustrations and descriptions of their holotypes. Neither dissociated cranidia of *Basilicus yokusensis* nor those of *Basilicus deltacaudus* were illustrated. However, our observation based on numerous specimens confirms that these two species are conspecific. Later deformation due to compres-

sion resulted in superficial differences among individual specimens; some are laterally compressed (Pl. 1, figs. 1, 2 and 5), while the others are antero-posteriorly compressed (Pl. 1, figs. 3 and 4). Also, ontogenetic changes are responsible for these differences; small triangular pygidia (Pl. 1, fig. 2) represent earlier ontogenetic stage than larger elongately triangular pygidia (Pl. 1, figs. 9 and 13). A similar observation has also been documented in *Lonchobasilicus gansuensis* (Zhou and Fortey, 1986). Disarticulated hypostomes of *B. yokusensis* and *B. deltacaudus* illustrated by Kobayashi (1934) have been drawn to have very short anterior wings. Apparently, his drawings are incorrect due to the incomplete exposure of specimens. Hypostomes of *D. yokusensis* have very long anterior wings that extend to the hypostomal mid-length (exsag.) (Pl. 2, figs. 2 and 3).

Basilicus deltacaudus var. *tyrannoides* Kobayashi, 1934 erected based on a single pygidium was differentiated from *Basilicus deltacaudus* in having a parabolic outline, steeply inclined border furrow, and inflated posterior axial lobe. All these features are visible in many pygidia of *Dolerobasilicus yokusensis*. One pygidium ascribed to *Basilicus* sp. undt. is evidently an antero-posteriorly compressed specimen of *D. yokusensis*. Kobayashi (1934, p. 468) also doubted that its semicircular outline may be a result of secondary deformation.

Basiliella minima Kobayashi, 1934 was established based on small specimens. This species was typified by its small size and the presence of prelabellar mesial ridge. Kobayashi (1934, p. 475) noted the possibility of *B. minima* representing the young stage of *Basiliella*. However, it is interpreted herein that *B. minima* merely represents the early holaspid stage of *D. yokusensis* based on the presence of a mesial ridge on the prelabellar field. The cranidial length of *B. minima* illustrated by Kobayashi (1934) is approximately 3 mm, which falls within the range of cranidial length of early holaspid *D. yokusensis* (Pl. 1, fig. 11).

As already mentioned in the section of generic description, the concept of *Ogygitoides raymondi* is restricted to its holotype only. All dissociated cranidia of *O. raymondi* illustrated by Kobayashi

(1934) are referable to *D. yokusensis* and also display the compressional effect: specimen of pl. 43, fig. 3 is laterally compressed and that of pl. 43, fig. 5 is antero-posteriorly compressed. One pygidium (pl. 40, fig. 5) referred to *O. raymondi* is indeterminable, but may be better placed within species of *Basiliella*.

Lee and Cheong (*in Lee et al.*, 1980) erected two new species under the genus *Basilicus*, namely, *Basilicus jigunensis* and *Basilicus weoni*. *B. jigunensis* was distinguished from *B. deltacaudus* in having a preglabellar mesial ridge. The ridge is one of the diagnostic features of *Dolerobasilicus yokusensis*. Judging from the cranidial length (6.5 mm) of *B. jigunensis* and its triangular pygidial outline, the species represents the early holaspid stage of *D. yokusensis*. *B. weoni* has been characterized to have a semicircular pygidium, more than 25 axial rings, and circular eyes. These features are herein interpreted as intraspecific variation of *D. yokusensis*; the illustrated specimen is also compressed antero-posteriorly.

Genus *Basiliella* Kobayashi, 1934

Type species. *Asaphus barrandei* Hall, 1851

Diagnosis.—Asaphid trilobite with very narrow or without preglabellar field. Glabella rectangular with rounded anterior margin, slightly expanded in front of palpebral lobes. Two pairs of glabellar furrows observed. Preglabellar furrow deep and confluent sagittally with anterior border furrows. Axial furrows behind palpebral lobes effaced. Palpebral lobes located slightly behind the cranidial mid-length. Baculae completely merged with L1 lobes. Cephalic doublure with a median indentation slightly broader than border. Hypostome forked; hypostomal condition conterminant. Pygidium semicircular, with about 10 pleurae; pleural furrows commonly obsolete.

Discussion.—In 1934, Kobayashi proposed two new genera, *Basiliella* and *Parabasilicus*, from the Jigunsan Formation: Cranidium of *Basiliella* was described to bear a resemblance to that of *Basilicus*; *Basiliella* was distinguished from *Basilicus* in

having a semicircular pygidium with smaller number of pleurae; *Parabasilicus* was further differentiated from *Basiliella* in having obsolete cephalon and pygidium with wider axial lobe. Meanwhile, in Treatise on Invertebrate Paleontology, Jaanusson (*in Moore*, 1959) treated *Basiliella* as a subgenus of *Basilicus* within Subfamily Asaphinae: *Basilicus (Basiliella)* was differentiated from *Basilicus (Basilicus)* in having subcircular pygidium and angular cephalic border. Also, Jaanusson (*in Moore*, 1959) described *Parabasilicus* as 'type species poorly known' and placed the genus within the Subfamily Isotelinae. Ma (1938) distinguished *Basiliella* from *Parabasilicus* in that the former has niobiform facial suture, while the latter has isoteliform facial suture. However, Lake (1942) proved that niobiform facial suture is identical to isoteliform facial suture.

Zhou and Fortey (1986) supposed that *Basilicus*, *Basiliella*, and *Parabasilicus* may be synonymous. In particular, Zhou and Fortey (1986) thought that *Parabasilicus* may be an effaced *Basiliella*, but tentatively treated *Basiliella* and *Parabasilicus* as separate subgenera of *Basilicus*. Judging from the morphological features of these genera, they have similar cranidia and differences among them appear to lie in pygidial outline, number of pleurae, and effacement. We consider that these differences are not reliable generic features, unless ontogenetic, intraspecific, and preservational variations are considered. Especially, effacement should not be treated as a generic feature, because effacement in general becomes prominent with growth. For instance, Dean (1963) suggested that *Parabasilicus? marstoni* with distinctly furrowed pygidium may be a synonym of *Parabasilicus powisii* which has a larger and obsolete pygidium. Similarly, pygidia assigned to *Parabasilicus* by Kobayashi (1934) are generally larger than those of *Basiliella*, which implies that *Parabasilicus* may represent later ontogenetic stages of *Basiliella*. In addition, the wider axial lobe in *Parabasilicus* that was quoted by Kobayashi (1934) as one of the criteria distinguishing *Parabasilicus* from *Basiliella* does not appear to be significant. In summary, it is concluded that *Parabasilicus* is a junior syno-

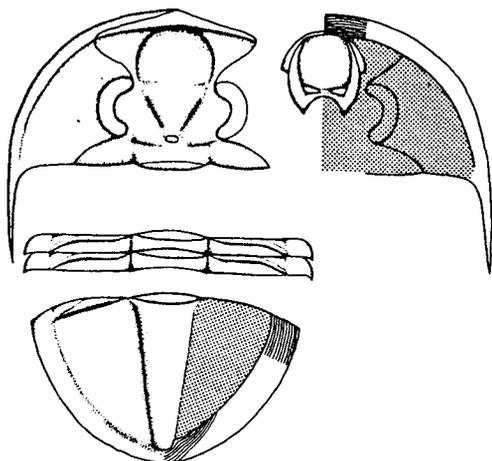


Fig. 3. *Basiliella kawasakii* Kobayashi, 1934.

nym of *Basiliella* and *Basiliella* can be distinguished from *Basilicus* in having a semicircular, rather than subtriangular, pygidium with less number of pleurae.

***Basiliella kawasakii* Kobayashi, 1934**

Pl.2, figs.5-17; Pl.3, figs.1-5; Fig.3

- 1934 *Basiliella kawasakii* Kobayashi: p. 470, pl. 35, figs. 4-7; pl. 37, fig.10.
 1934 *Basiliella* aff. *kawasakii* Kobayashi: p. 471, pl. 37, fig. 11.
 1934 *Basiliella pyriformis* Kobayashi: p. 471, pl. 35, figs. 1-3, fig. 8; pl. 37, fig. 8.
 1934 *Parabasilicus yamanarii* Kobayashi: p. 480, pl. 36, fig. 1; pl. 38, figs. 3-5; pl. 39, figs. 3, 5, 6; pl. 40, figs. 1-3.
 1934 *Parabasilicus* (?) sp. aff. *Asaphus laevis* Weller: Kobayashi, p. 482, pl. 37, fig. 9; pl. 41, fig. 5; pl. 42, fig. 1-3.
 1980 *Basiliella jangseongensis* Lee and Cheong in Lee *et al.*: p. 125, pl. 1, fig. 3.
 1980 *Parabasilicus gangweonensis* Lee and Cheong in Lee *et al.*: p. 126, pl. 1, fig. 4.

Materials.—3 complete carapaces, 4 incomplete carapaces, 70 cranidia, 98 pygidia, 54 hypostomata, and 34 free cheeks.

Description.—Carapace moderately convex and elliptical in outline. Glabella convex and elongately rectangular, with rounded anterior margin, slightly

expanded in front of palpebral lobes; its sagittal length 75% of cranial length; surface covered with fine granules. Two pairs of glabellar furrows: S1 deeply impressed, long, obliquely directed backwards and inwards; anterior furrow, presumably representing S3, located opposite the anterior ends of palpebral lobes, pit-shaped; L1 convex, not defined abaxially; a median tubercle just in front of occipital furrow strongly raised. Preglabellar furrow deeply incised and conjoined with anterior cranial border furrow at sagittal line; preglabellar field very narrow or even absent. Anterior axial furrow deeply incised and shallowing posteriorly; posterior axial furrow completely effaced and thus L1 and bacculae indistinguishable from each other. Occipital ring rectangular (tr.), slightly arched forwards, and postero-laterally defined by a pair of small pits; its sagittal length one-eighth the cranial length and its width (tr.) one-third of posterior cranial margin; a distinct impression of posterior cephalic doublure represented by a forwardly arched furrow or ridge; occipital furrow (SO) curved backwards, shallowing sagittally and obsolete behind the median glabellar tubercle. Anterior cranial border narrow (sag. and exsag.); anterior border furrow represented by a steeply inclined face. Anterior fixigena slightly convex. Palpebral lobe crescentic, situated slightly behind cranial mid-length (sag.) and sometimes defined by faint palpebral furrow. Posterior fixigena strongly convex; a pair of bacculae completely merged with L1 lobe due to effacement of posterior axial furrow. Posterior border presumably narrow; posterior border furrow indistinct. Facial suture supramarginal and opisthoparian; preocular suture diverges forwards and outwards; anterior suture crosses the border and meets at sagittal line; postocular suture divergent straight or slightly convex and cuts posterior cephalic margin.

Eye with holochroal facets, reniform, supported by a band-like socle, standing above the level of free cheek. Free cheek with a stout and moderately long genal spine; adaxial area flat or slightly convex, declining abaxially; lateral border narrow and convex, defined by deep border furrow. Cephalic doublure broader than border, covered with terrace lines; its inner margin parallel to ce-

phalic margin, but its posteromedian margin slightly indented forwards and upturned dorsally; median suture present.

Hypostome elliptical with forked posterior and rounded anterior margins; anterior border very narrow and downturned; anterior wing triangular, reaching to hypostomal mid-length; median body ovoid, moderately convex, laterally and posteriorly well defined by border furrow, and divided into two lobes by median furrow; anterior lobe occupying most of median body; posterior lobe small and elongated (tr.) and differentiated into a pair of prominent, triangular or rod-shaped maculae; lateral border slightly upturned, widening backwards; posterior border convex and narrow (sag.); forked portion of posterior margin a quarter the hypostomal length (sag.); hypostomal surface covered with terrace line.

Thorax with eight segments. Axial region convex, well bounded by deep axial furrow, gradually tapering backwards, its breadth (tr.) being a little less than one-third of thoracic breadth; each axial ring rectangular (tr.); articulating half ring clearly separated from axial ring proper by a furrow, occupying one-third the breadth of axial ring (sag.). Pleura straight (tr.); the distal portion slightly directed backwards, ending in a truncated tip; pleural furrow deep, obliquely directed backwards, extending to two-thirds the pleural breadth; articulating facet triangular.

Pygidium semicircular to semi-ovate, slightly convex to flat, with nearly straight anterior and broadly rounded posterior margin, and about two times broader than long; axial furrow moderately incised. Axial region with more than ten axial rings, gently convex, and relatively broad, tapering abruptly in anterior portion and then gradually in posterior portion, ending with a rounded extremity; its frontal breadth (tr.) a quarter of pygidial frontal breadth; Articulating half ring elongated lens-shaped (tr.) and well delineated by straight and distinct furrow. Pleural field with more than ten pleurae, slightly convex, and separated from border by gently inclined border furrow; pleural and interpleural furrows progressively fainter posteriorly or obsolete, while the antermost pleural

furrow deeply incised and directed backwards; anterior band of the first pleura triangular (tr.) and strongly raised. Articulating facet elongately triangular (tr.), gently inclined downwards and occupying roughly two-thirds the frontal breadth of each pleural region. Border with uniform width flat or slightly concave. Pygidial doublure broader than border, with indented posterior margin, and covered with terrace lines parallel to pygidial margin.

Remarks.—*Basiliella* aff. *kawasakii* was originally differentiated from *Basiliella kawasakii* in the flatness of border and mid-glabellar position of eye (Kobayashi, 1934). However, such differences are interpreted herein as preservational effect or intraspecific variation. *Basiliella pyriformis* was distinguished from *B. kawasakii* in having a distinct occipital ring and median glabellar tubercle (Kobayashi, 1934). However, the obsolescence of occipital ring and glabellar tubercle in *B. kawasakii* also appears to be preservational. The superficial difference in outline between two species may have been resulted from the differential compression; Specimens of *B. pyriformis* are apparently compressed antero-posteriorly. Sheng (1958) reported a single specimen of *Basiliella pyriformis* with six thoracic segments and incomplete pygidium. However, it is impossible to evaluate the specimen due to poor preservation.

Parabasilicus yamanarii bears a great resemblance with *B. kawasakii*, except that the carapaces attributed to the former are effaced and larger in size. As the effacement is in general prominent in later ontogenetic stages, *P. yamanarii* is considered to represent late holaspides of *B. kawasakii*. All of the pygidia assigned to *Parabasilicus* (?) sp. aff. *Asaphus laevis* by Kobayashi (1934) are difficult to be assessed due to poor preservation, but can best be considered to display intraspecific variation of *B. kawasakii*.

Basiliella jangseongensis and *Parabasilicus gangweonensis* were erected as new species based on the inward curvature of S1 furrows and wider glabella and hypostome, respectively (Lee *et al.*, 1980). However, these features can also be manifested by later deformation and should not be

employed as specific discrimination. These species accord well with the description of *B. kawasakii* given herein.

Basiliella kawasakii is similar to *Basilicus* (*Basiliella*) *asper* Zhou and Fortey, 1986 from North China in having rectangular glabellar shape, but differs in having broader (tr.) anterior fixigena and less convex and narrower pygidial axis. *Basilicus* (*Basiliella*) *jinlini* Zhou and Fortey, 1986 can be distinguished from *Basiliella kawasakii* in having three pairs of glabellar furrow and more convex pygidial axis.

***Basiliella typicalis* (Kobayashi, 1934)**

Pl. 3 figs. 6-12; Fig.4

- 1934 *Parabasilicus typicalis* Kobayashi: p. 477, pl. 37, figs. 2-3; pl. 38, fig. 2; pl. 39, figs. 1-2; pl. 40, fig. 4.
 1934 *Parabasilicus shirakii* Kobayashi: p. 479, pl. 37, fig. 4; pl. 38, fig. 1; pl. 41, figs. 1-4; pl. 42, fig. 5.

Materials.—34 crania, 25 pygidia, and 5 hypostomata

Description.—Cranidium as long as broad. Glabella gently convex and rectangular with rounded anterior margin; its sagittal length three-fourths the cranial length. Two pairs of glabellar furrows; S1 relatively short, shallow, and directed obliquely backwards, but completely effaced in larger specimens; S3 sited opposite the anterior ends of palpebral lobes, weakly impressed, and sometimes transcurrent; L1 divided into two triangular lobelets by S1; a median tubercle just in front of occipital ring. Preglabellar furrow moderately deep and conjoined with anterior border furrow. Anterior axial furrow relatively shallow and more or less parallel; posterior axial furrow completely effaced. Occipital ring rectangular (tr.), postero-laterally delineated by a pair of small pits; its sagittal length one-ninth the cranial length and its width (tr.) about a half of posterior cranial margin; an impression of posterior cephalic doublure present; occipital furrow (SO) deep, shallow adaxially, and obsolete behind the glabellar

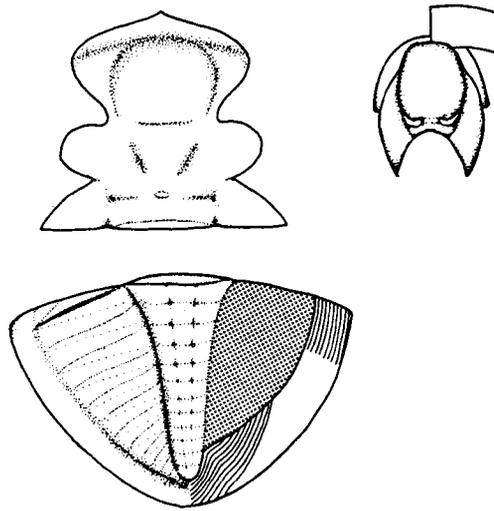


Fig. 4. *Basiliella typicalis* (Kobayashi, 1934).

lar tubercle. Anterior cranial border narrow (sag. and exsag.); anterior border furrow represented by a backwardly inclined face, confluent sagittally with preglabellar furrow, and thus preglabellar field absent. Anterior fixigena triangular, relatively narrow (tr.); faint paradoublural lines parallel to the cephalic margin at the level of or slightly behind the glabellar front. Palpebral lobe semi-circular, poorly defined by faint palpebral furrow, and sited slightly behind the cranial mid-length. Posterior fixigena triangular and nearly flat; a pair of baculae completely incorporated with L1 lobes, leaving no trace of axial furrows. Posterior cranial border ridge-like (tr.), narrower (exsag.) than the width of occipital ring, and defined by faint border furrow; in large specimens, posterior border not clearly defined. Facial suture supramarginal and opisthoparian; preocular suture diverges forwards and outwards; anterior suture cuts diagonally the anterior border and meets at sagittal line to form an ogive; postocular suture divergent convex.

Hypostome ovoid with deeply forked posterior and rounded anterior margins; median body hexagonal in shape, slightly convex, clearly bounded by lateral border furrow, and divided into two lobes by a moderately distinct median furrow; posterior lobe contains a pair of crescentic maculae; lateral border slightly upturned, widening poste-

riorly; posterior border moderately convex and narrow (exsag.); posterior margin deeply forked.

Pygidium semicircular or subparabolic, moderately convex, with arched anterior margin; axial furrow fairly distinct. Axial region with more than ten axial rings broad and convex; its antermost portion abruptly convergent, tapering gradually backwards, and ending with a rounded extremity; its frontal breadth roughly one-third of the pygidial breadth; each axial ring rectangular and with a medial node, which often fuses each other to form a ridge. Articulating half ring semi-elliptical (tr.) and very narrow (sag.). Pleural field with roughly ten pleurae relatively flat; anterior band of first pleura elongately (tr.) triangular, strongly convex, defined by deeply incised first pleural furrow; pleural and interpleural furrows shallow, becoming progressively obsolete posteriorly. Articulating facet triangular (tr.), occupying two-thirds the frontal breadth of pleural region. Border flat or slightly concave; its breadth uniform, one-tenth of pygidial breadth; border furrow represented by a steeply inclined face, becoming more steeply inclined posteriorly. Pygidial doublure slightly broader than border in anterior portion, becoming progressively broader posteriorly, but forming an indented posteromedian margin, and ornamented with closely-spaced terrace lines.

Remarks.—Kobayashi (1934) originally differentiated *Parabasilicus typicalis* from *Parabasilicus shirakii* in having longer cephalon, narrower border, and less effaced glabella, although he doubted that the former may be a younger stage of the latter. We also consider that morphological differences employed by Kobayashi (op. cit.) in discriminating two species may have been manifested during ontogenetic development and thus these species are synonymous: *P. typicalis* represents the earlier ontogenetic stage than *P. shirakii*.

Basiliella typicalis can be discernible from *Basiliella kawasaki* in having less divergent preocular suture, shallower and shorter S1 furrows, transcurrent S3 furrows, more deeply forked hypostomal posterior margin, and a median node on the pygidial axial ring.

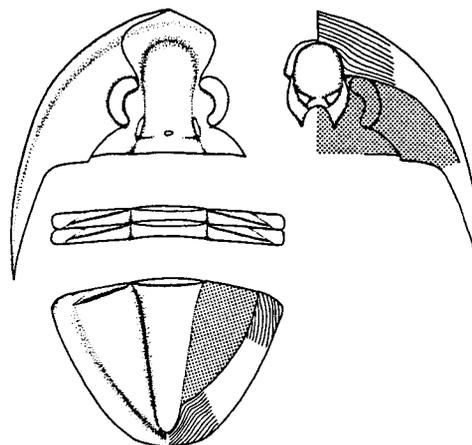


Fig. 5. *Ptychopyge dongjeomensis* Lee and Cheong in Lee et al., 1980.

Genus *Ptychopyge* Angelin, 1854

Type species. *Asaphus angustifrons* Dalman, 1827

Ptychopyge dongjeomensis Lee and Cheong in Lee et al., 1980

Pl. 3, figs. 13-16; Fig. 5

1934 *Ptychopyge* (?) sp. aff. *Ptychopyge thebawi* Reed: Kobayashi, p. 487, pl. 43, fig. 6.

1980 *Ptychopyge dongjeomensis* Lee and Cheong in Lee et al.: p. 127, pl. 1, fig. 5.

Materials.—1 incomplete carapace, 7 cranidia, and 5 pygidia

Description.—Carapace elliptical, two times longer than broad. Cranidium as long as broad. Glabella rectangular with rounded anterior margin, weakly convex, slightly constricted behind the palpebral area, twice longer than broad; its sagittal length 80% of cranial length; no glabellar furrows developed. Preglabellar furrow shallow. Anterior axial furrow weakly incised; posterior axial furrow obsolete. Occipital ring elongately (tr.) trapezoidal, poorly defined by occipital furrow, but postero-laterally well delimited by a pair of small pits; its breadth (tr.) more than a half of posterior

cranial margin; it contains an impression of posterior cephalic doublure. Anterior cranial border furrow indistinct, and thus anterior cranial border poorly defined; preglabellar field narrow, slightly concave or nearly flat. Anterior fixigena narrow (tr.). Palpebral lobe semi-circular, situated behind the cranial mid-length. Posterior fixigena, posterior border, and posterior border furrow not clearly defined due to effacement and poor preservation; a pair of elongated bacculae along the adaxial sides of posterior fixigena. Facial suture supramarginal and opisthoparian; preocular suture divergent and nearly straight; anterior suture crosses the border diagonally and meets sagittally to form an acute ogive; postocular suture divergent convex.

Eye with holochroal facets, reniform, situated above the level of free cheek. Free cheek prolonged into a stout genal spine which extends to the antero-lateral corner of pygidium; adaxial area nearly flat, becoming inclined abaxially; lateral border narrow and convex, well defined by border furrow.

Hypostome rectangular, with forked posterior and nearly straight anterior margins; anterior border upturned; median body with oval shape, slightly convex, well defined by lateral and posterior border furrow, and divided into large anterior and small posterior lobe by median furrow; posterior lobes contains a pair of prominent triangular maculae.

Thorax with eight segments; axial furrow distinct. Axial region convex and parallel-sided, occupying 30% of the thoracic breadth. Pleura straight (tr.) with rounded pleural tip; pleural furrow deep, obliquely directed backwards, reaching abaxially to two-thirds of pleural breadth.

Pygidium parabolic, with slightly convex anterior and truncated posterior margins, broader than long; axial furrow distinct. Axial region with ca. ten axial rings, moderately convex; its antermost portion abruptly tapering backwards, then gradually converging posteriorly, and ending with a rounded extremity; its frontal breadth one-third of pygidial breadth; postaxial field relatively broad, occupying more than 10% of pygidial length

(sag.). Articulating half ring elongately (tr.) elliptical and well defined by a backwardly curved furrow. Pleural field nearly flat and separated from border by steeply inclined border furrow, which becomes more steeply inclined posteriorly; pleural and interpleural furrows mostly effaced, except for the first pleural furrow which is deeply incised; anterior band of first pleura elongately (tr.) triangular and strongly convex. Articulating facet triangular and gently inclined downwards. Border with uniform breadth flat or slightly concave. Pygidial doublure as broad as the border in anterior portion, becoming progressively broader posteriorly to be twice broader than border in posterior portion; its posteromedian portion deeply indented; its ventral surface covered with terrace lines.

Remarks.—*Asaphus angustifrons*, the type species of *Ptychopyge*, has a pair of characteristic nodes developed on the fixigena behind eyes (Jaanusson *in* Moore, 1959), which was interpreted as constricted bacculae by Fortey (1980). In *Ptychopyge dongjeomensis*, a pair of elongated bacculae, though obsolete, are observed on posterior fixigenae. Kobayashi (1934) described *Ptychopyge* (?) sp. aff. *Ptychopyge thebawi* Reed based on one incomplete cranidium. Its morphological features such as pointed anterior suture, triangular anterior border and ovate glabella are all visible in the cranidia of *Ptychopyge dongjeomensis*. Pygidia of *Basilicus* (*Basilicus*) *wusungensis* from North China (Zhou and Fortey, 1986) are very similar to those of *P. dongjeomensis* in having truncated posterior margin, effaced pleural field and axial region, and posteriorly steeper border furrow, but its cranidia are clearly discernible in having deep anterior border furrow and strongly convex glabella.

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Explanation of Plates

Plate 1

Figs. 1-14. *Dolerobasilicus yokusensis* (Kobayashi, 1934).

1. DGW 384, complete carapace (silicon rubber cast), x1.8; 2. SNUP 892240A1, cranidium, x3.2. Note that a mesial ridge is developed on the preglabellar field and paradoublural lines are located behind the glabellar front; 3. SNUP 891945A1, cranidium, x3.4; 4. SNUP 892042A1, pygidium, x3.7; 5. SNUP 892002A1, a. pygidium, x2. b. oblique view of 5a, x1.7. Note three axial tubercles on each axial ring; 6. DGW 385, complete carapace, x2.7; 7. SNUP 892291A1, thoracic segments preserved as external mold, showing axial rings ornamented with semi-concentrically arranged lines, x1.9; 8. SNUP 891514A1 (silicon rubber cast), a. glabella ornamented with fine granules, x4.4. b. anterior border ornamented with anastomosing lines, x4.1; 9. SNUP 891301B1, pygidium, x2.6; 10. SNUP 89123A15, cranidium, x4.6; 11. SNUP 892187A2, early holaspid cranidium, x5; 12. DGW 386, complete carapace, x2.2. Note that hypostome is impressed on glabella; 13. SNUP 892290A1, incomplete carapace with slightly displaced cranidium and hypostome, x1.7; 14. SNUP 891855A1, holochroal eye with band-like eye socle, x6.6.

Plate 2

Figs. 1-4. *Dolerobasilicus yokusensis* (Kobayashi, 1934).

1. SNUP 891230A1, free cheek, x1.7. Note that doublure is indented medially and is ornamented with closely spaced terrace lines; 2. SNUP 891852A4, hypostome with long anterior wing, x2.2; 3. SNUP 891550B4, hypostome, x1.7; 4. SNUP 891596A1, free cheek which is laterally compressed, x5.2.

Figs. 5-17. *Basiliella kawasakii* Kobayashi, 1934.

5. SNUP 891384A2, early holaspid cranidium, x4.6; 6. SNUP 891080A1, complete carapace with an impressed hypostome, x4.9; 7. SNUP 891068A1, complete carapace which is compressed antero-posteriorly, x5.4; 8. SNUP 892114A2, cranidium, x3.9. Note that preglabellar field is absent; 9. SNUP 7892021A1, cephalon (silicon rubber cast), x3.7; 10. SNUP 891712B2, pygidium, x3.9. Note that most pleural and interpleural furrows are obsolete but antermost pleural furrow is deeply incised; 11. SNUP 891007A1, cranidium, x6; 12. SNUP 892186A1, pygidium, x3; 13. SNUP 891828B1, pygidium, x2; 14. SNUP 891085A2, cranidium, x5.8; 15. SNUP 891781A1, incomplete thoraco-pygidium with seven thoracic segments, x1.5; 16. SNUP 891735A1, nearly complete carapace with a displaced free cheek, x2.3; 17. SNUP 891967A1, hypostome preserved as external mold x4. Note that its surface is ornamented with closely-spaced terrace lines.

Plate 3

Figs. 1-5. *Basiliella kawasakii* Kobayashi, 1934.

1. SNUP 891703A5, free cheek, x4.9; 2. SNUP 892095A3, hypostome with downturned anterior border, x2.7; 3. SNUP 892052A1, hypostome, x3.3; 4. SNUP 891542A1, free cheek, x3.9. Note the doublure is slightly indented medially; 5. SNUP 891810A3, three thoracic segments, x4.2.

Figs. 6-12. *Basiliella typicalis* (Kobayashi, 1934).

6. SNUP 891773A2, cranidium, x8; 7. SNUP 891976B1, pygidium, x1.8; 8. SNUP 891254A1, cranidium, x7. Note the transcurrent S3 glabellar furrow; 9. SNUP 891564A4, hypostome with deeply forked posterior margin, x1.5; 10. SNUP 891320A1, early holaspid cranidium, x3.5; 11. SNUP 891794A1, cranidium, x5.5. Note that paradoublural lines are located slightly behind the glabellar front; 12. SNUP 891277A1, a. pygidium showing a ridge-like elevation on axis which is formed by fusion of medial nodes, x1.3. b. posterior part of 12a, showing indented doublure and terrace lines, x3.

Figs. 13-16. *Ptychopyge dongjeomensis* Lee and Cheong in Lee *et al.*, 1980.

13. SNUP 892192B6, cranidium, x1.8; 14. SNUP 892129B1 (silicon rubber cast), incomplete carapace with impressed hypostome, x4.5; 15. SNUP 891793B1, pygidium, x1.5; 16. SNUP 892245A1, pygidium with truncated posterior margin, x1.9.

Plate 1

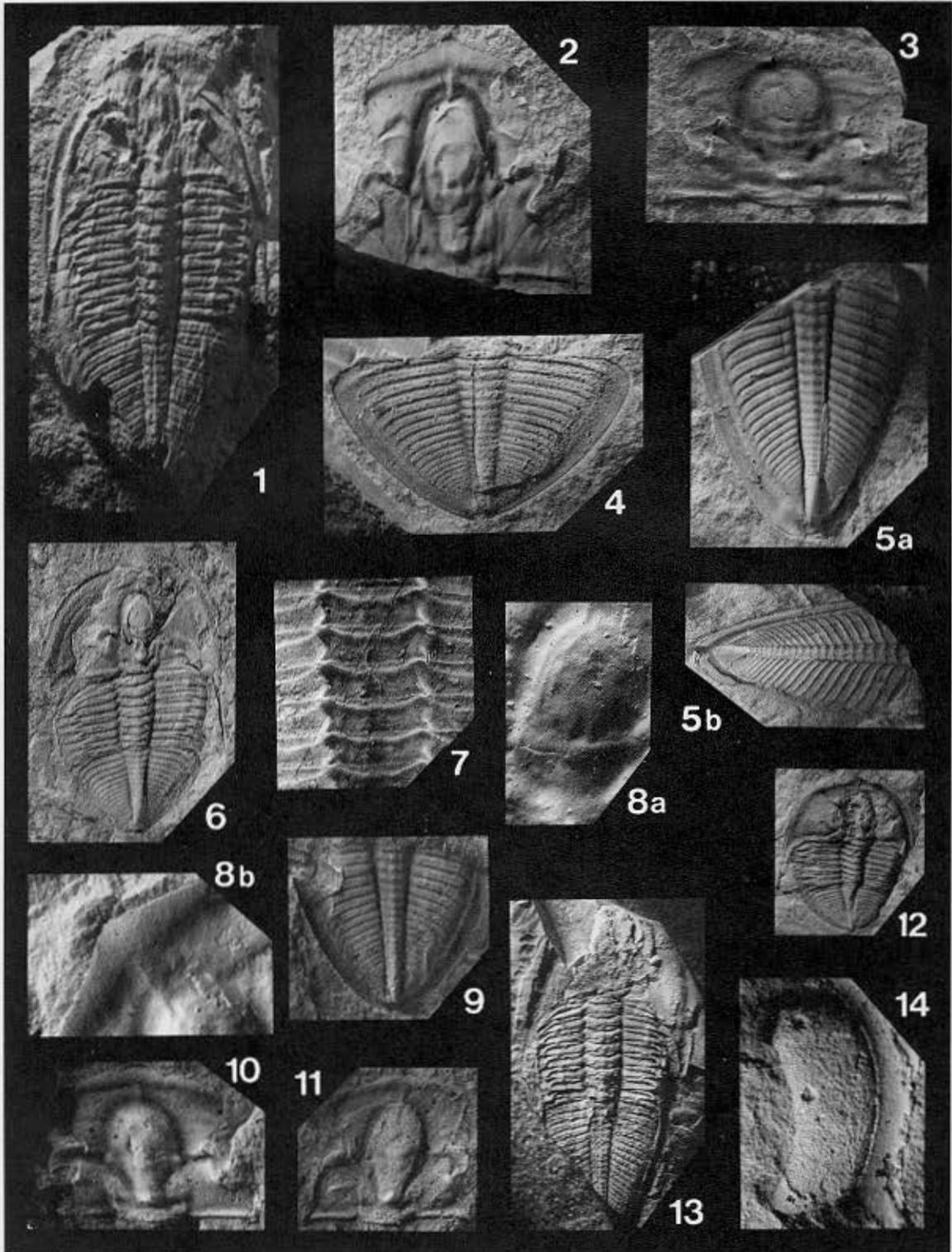


Plate 2

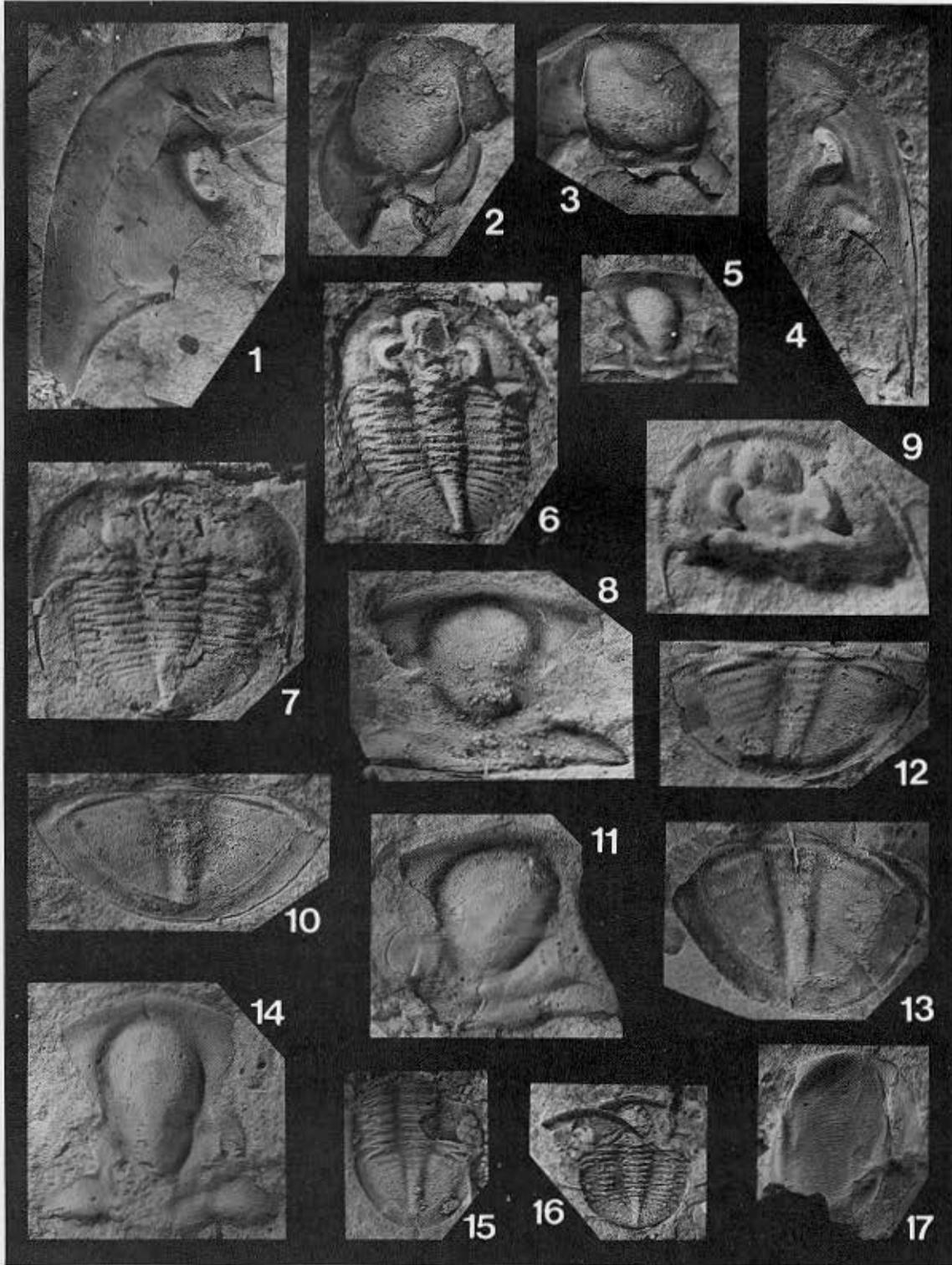


Plate 3

