

UPPER CAMBRIAN TRILOBITES FROM SANTU, SOUTHEASTERN KUEICHOU

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(With 3 Plates)

The Upper Cambrian fossils were not known in South and Southwestern China before 1938, though a thick limestone series ranging from not less than 100 m to over one thousand meters known as the Ichang Limestone of the Gorge district of the Yangtze and the Loushankwan Limestone of North Kueichou has been partially referred by various authors to represent some part of the Upper Cambrian. No palaeontological evidence was ever provided. In 1939, Prof. Y.C. Sun and his party discovered a fauna including *Eoorthis shakoutumensis* Sun, *Pseudagnostus cyclopyge* (Tullberg), *Saukia acamus* (Walcott), *S. grabaui* Sun, *Quadraticephalus yunnanensis* Sun, *Tsinania* sp. and *Xenostegium* sp. at Pupiao of Paoshan, W. Yunnan. The fossils were collected from a yellow shale series which Sun named the Paoshan Shale. In addition to these fossils, *Calvinella walcottii* (Mansuy), *Conocephalina waltheri* Sun and *Hyalolithes* sp. were obtained by Y.T. Huang in 1939 in the same shale series at the adjacent locality Touyentsun and *Pseudagnostus* sp. and *Shirakiella laticonvexa* Kobayashi were found by H.C. Wang in 1941 at Sankoshu. All these fossils are decidedly of late Upper Cambrian age and may be well correlated with the Fengshanian and the upper Changshanian faunas of North China and that of the upper part of Changpoung series of Yunnan-Tonkin border. In 1944, T.C. Ku collected at Tahopa of Kwangyuan, N. Szechuan a few specimens of *Stephanocare* and *Changshania* in an earthy yellow and greyish green limestones intercalated with yellow and purple shales and fine-grained sandstones amounting to ca. 120 m in thickness. As far as the faunal assemblages and the lithic facies are concerned, these beds may be the southern equivalent of the Kushan shale plus the lower part of the Changshan formation distributed widely in North China, S. Manchuria and Yunnan-Tonkin border.

In marked contrast to the occurrence of the faunas of northern province in

southwestern China, Kobayashi in 1938 identified a single trilobite, *Proceratopyge* (= *Lopnorites*)¹⁾, collected by Noda in a dark grey calcareous argillite at Lanhsi, Yuanling (Chinchoufu) of Hunan. The solitary existence of the genus *Proceratopyge* in South China is of great interest, for it bears a striking resemblance to the contemporaneous Upper Cambrian fauna of eastern Tianshan but is rather different from those of North China and Manchuria.

The material dealt with in the present paper was collected by C.C. Chang and H.S. Lee in a yellowish grey calcareous shale, 1 m thick, at a locality about 2 km to the north of the Santu (Sanho) city, SE Kueichou. The shale, for which the name Santu shale is here proposed, is embedded in a 50 m thick limestone formation that forms an isolated hill situated on the side of the motor road leading from Santu to Makiang. The limestone formation in general is believed most probably to be correspondent to the upper part of the Loushankwan formation or in part of the Ichang Limestone. The trilobites described here comprise the following forms:-

Agnostus (?) sp.

Lotagnostus lermontovai Lu (sp. nov.)

L. sp.

Eosaukia latilimbata Lu (gen. et sp. nov.)

Hedinaspis kweichouensis Lu (sp. nov.)

Charchagia sp.

Of the above species *Hedinaspis kweichouensis* is the most abundant one that occupies more than 90% of the collection. Others are rather rare. Generally, this fauna indicates a close relationship with that of the Torsuq tagh formation of eastern Tianshan where *Hedinaspis*, *Charchagia* and *Lotagnostus* are the three most common genera occurring near the uppermost part of this formation in association with *Obolella* (?), *Lingula*, *Agnostus*, *Rhaptagnostus*, *Geragnostus*, *Proceratopyge*, *Diceratopyge*, *Westergardites*, *Haniwa*, *Solenoparia* and *Acrocephalina*. According to Troedsson, the Torsuq tagh fauna is more closely related to that of the Olenidian in Europe than to any other known faunas. The presence of *Proceratopyge* suggests more precisely an early Upper Cambrian age, because this genus is restricted to the beds from topmost Paradoxian to lowest Olenidian.

1) According to A.H. Westergard, *Lopnorites* Troedsson 1937 may be a synonym of *Proceratopyge* Wallerius 1895 (Sveriges Geologiska Undersokning, Ser. C. No. 489, p.8, 1947).

This view is supported by the finding of *Proceratopyge* and *Charchagia* in the *Eugonocare* and *Glyptagnostus* stages in northeastern Australia where it is said to be associated with *Pseudagnostus*, *Glyptagnostus*, *Olenus* (?), *Eugonocare*, *Corynexochus* and *Rhodonaspis*. The *Eugonocare* and *Glyptagnostus* stages in NE Australia have been considered by Whitehouse to be directly correlative with the *Olenus* and *Agnostus pisiformis* zones of Europe.

The exact correlation between the *Hedinnaspis-Proceratopyge-Charchagia* fauna of Santu, Tienshan and Australia and the early Upper Cambrian fauna of North China and S. Manchuria can not be made at present, but as a result of recent extensive field works, new information has been secured which adds to the knowledge of the relationships of the faunas of these two provinces. In a collection made by the present writer and his colleagues in 1950 in the Taitzeho Valley, S. Manchuria, several excellent preserved specimens of *Irvingella* were discovered. The associated fauna consists of *Changshania conica* Sun and *Pseudagnostus* cf. *chinensis* (Dames), all species are of the lower Changshan formation of North China and S. Manchuria. *Irvingella*(?) sp. has also been found from the Torsuq tagh formation of eastern Tienshan and *Irvingella succica* and var. have been reported by Westergard in the older Upper Cambrian rocks of Sweden. Thus these three widely separated faunas are all directly correlative. On the other hand, the presence of a *Drepanura* in form of *D. eremita* in the Swedish *Agnostus pisiformis* zone cannot be overlooked, and the *Drepanura* fauna of the Kushan formation of North China is most probably the approximate equivalent of the *pisiformis* zone. The faunal and stratigraphic evidences now available suggest that the *Hedinnaspis-Charchagia-Proceratopyge* fauna is equivalent, in part at least, to the lower Changshanian fauna, and a part of the fauna may be as old as the Kushan formation.

In connection with the faunal relations just discussed, it is interesting to note that the appearance of a primitive saukid, the here described new genus *Eosaukia* in the Santu fauna of SE Kueichou is an extraordinary feature of Cambrian stratigraphy and ecology. So far as our knowledge goes, all saukids are confined to the late Upper Cambrian of eastern Asia and North America. No representatives have been recorded in the Torsuq tagh and its corresponding fauna of Europe. As far as its primitive nature is concerned, *Eosaukia* may be an ancestral form of the saukids that flourished in the late Upper Cambrian time on both sides of the Pacific Ocean which Grabau and Sun have repeatedly postulated as a Palae-

ozoic center of faunal evolution and dispersal.

A brief summary of the outstanding palaeogeographical feature of Asia in the early Upper Cambrian time will be given here. From the faunal and sedimentary evidence given above, it is quite certain that the *Hedinaspis-Charchaqia* fauna of Santu is united probably through the Tienshan-Nanshan geosyncline by way of the southern Tsinling trough with the Torsuq tagh fauna in one hand and is connected with the *Proceratopyge* fauna of Hunan and the Lower Yangtze or even with the *Olenus-Acrocephalina* fauna of South Chosen on the other. In the Lower Yangtze Valley, *Proceratopyge* has been found by C.H. Chao, N.T. Tung and K.Y. Shieng in association with other Upper Cambrian trilobites and brachiopods in a thick dolomitic limestone series at Chuhsien, S. Anhui. A similar limestone containing *Proceratopyge*, *Lotagnostus* and other form is also reported by S.F. Sheng to occur in several places in W. Chekiang. A careful examination of all the lithic facies and of the account of localities shows the fact that the Yangtze region was a fairly deep geobasin roughly bounded on the west by the old Tibetia and the Palaeocathysian lanmass on the southeast. This condition may represent either a local deepening of the sea carrying *Hedinaspis-Charchaqia-Proceratopyge* in the central portion of this region or else a change in the condition of sedimentation which resulted in the deposition of dolomitic limestones and thin shales. The great basin was once connected with the Australia geosyncline through the Indo-Pacific ocean from which the marine invasion took place, and may be also opened to the northeast, where it was occupied by an aggrading continental sea that laid shallow water sediments mainly composed of shales, edgewise conglomerates and thin-bedded limestones (known as the Kushan shale and the lower Changshan formation) in the vast area of North China, S. Manchuria and northwestern Chosen. If it should have been the case that the northern sea communicated with the southern one, this would permit of the free transport of larval life of the northern type (*Drepanura-Changshania* fauna) which inhabited in a shallow water environment, to the littoral regions of the Yangtze geobasin. The presence of a rich *Drepanura-Changshania* fauna in the lower-middle part of the Changpoung series of the borderland between Yunnan and Haut-Tonkin and in the northern part of Szechuan indicates that a faunal analogy of the northern and southern provinces is present and also that the lithological characters of the littoral regions of the Yangtze geobasin and the northern province are similar.

DESCRIPTION OF SPECIES

Superfamily Agnostacea Salter, 1864.

Family Agnostidae (Corda, 1847) Salter, 1864.

Subfamily Agnostinae (Jackel, 1909).

Genus *Agnostus* Brongniart, 1822.

Genotype: *Entomolithus paradoxides* γ *pisiformis* Linnaeus, 1757.

***Agnostus* (?) sp.**

Pl. I, Fig. 1.

A mold of small pygidium with circular outline, length and width subequal, about 1.4 mm. Pygidial axis convex, transversely trilobed, cylindrical, rounded posteriorly and provided with a strongly elevated median tubercle at the center. The present form is referred to *Agnostus* s.s., but there has no indication of marginal spines which usually occurred on both postero-lateral sides of the pygidium in that genus.

Genus *Lotagnostus* Whitehouse, 1936.

Genotype: *Agnostus trisectus* Salter, 1864.

Whitehouse established this genus for the group of *Agnostus trisectus* Salter. The outstanding features of this group, as remarked by Whitehouse (1936, p.101), are as follows: "The glabella which is smooth has prominent anterior and posterior lobes and the accessory lobes are large. The pygidium has a pair of marginal spines. The pygidial axis has a chequered appearance due to the prominent trifid division both longitudinally and laterally. The cheeks of both cephalon and pygidium have radial and sub-reticulate ornament." In addition to the genotype *A. trisectus* and the species *L. asiaticus* Troedsson from eastern Tienshan, Kobayashi included also *Agn. americanus* Billings, *Agn. innocens* Clark and *Agn. hedini* Troedsson in the genus. As shown by the specimens figured by Rasetti (1944, p.36, figs. 1-2), the accessory lobes (basal lobes) of the *americanus* are rather small as compared with those of *trisectus* and *asiaticus*, but somewhat like our forms from Kueichou described below. The posterior axial lobe of the pygidium of *americanus* is faintly marked by a pair of very shallow longitudinal furrows while in *innocens* and *hedini* the lobe is fairly smooth. In view of the increasing prominence of the axial ridge toward the posterior axis of the pygidium

as noted above, Kobayashi suggests that *Lotagnostus* may be derived from *Aagnostus*, probably through such forms as *innocens*, *hedini* and *americanus*. This opinion seems to be quite plausible in regarding to the striking similarity between the Tien Shanian forms, *Aagnostus hedini* and *Lotagnostus asiaticus* and in regarding to the striking similarity between the corresponding European species, *Aagnostus pisiformis* and *Lotagnostus trisectus*.

As pointed out by Troedsson, the reticulation on the cheeks of cephalon and on the pleural lobes of the pygidium cannot be considered as one of the most important generic characters of this genus. He found that the fresh specimens of *L. asiaticus* is smooth, but that the weathered specimens have a markedly reticulate and radiate sculpture. Such sculpture belongs according to Troedsson, to the inside of the test and is formed for strengthening the carapace. In our collection two types of the surface features are also met with, one of them, *L. lermontovai*, with original test of the pygidium preserved, is entirely smooth, and the other, *Lotagnostus* sp., which is preserved as a mold has a reticulate cheeks of the cephalon.

***Lotagnostus lermontovai* Lu (sp. nov.)**

Pl. I, Figs. 2-3.

Diagnosis: Distinct from the genotype by having narrow glabella, small basal lobes and a comparatively short pygidium.

Description: Specimens are represented by a pygidium and its external mold with the cephalon and thorax partially preserved.

Shield except the axial portion gently convex. The frontal portion and left side are damaged, therefore the outline of the cephalon as well as the frontal margin of the glabella cannot be exactly figured out. Axial furrows of head well-defined, deep anteriorly and gradually shallowing backwards. Glabella narrow, about one-half the breadth of the cheek, slightly tapering, inconsiderably elevated above the cheeks. Anterior glabellar lobe not completely preserved, separated from the posterior portion by a shallow, broad and straight transverse furrow; posterior glabellar lobe with a pair of very shallow lateral impressions at about anterior third and with a small but strongly elevated median tubercle. Basal lobes small, triangulate, separated from the base of glabella by two longitudinal furrows which extend nearly parallel from behind the lateral impression to the posterior margin. Cheeks tapering backwards, smooth. Rim very narrow, sub-

equal in breadth, convex, marginal furrow broad and shallow.

Thorax badly preserved, with only one segment of the pleurae in the right side anterior to the pygidium.

Pygidium semi-elliptical in outline, length a little shorter than the breadth, of about the same convexity as the cephalon. Axial furrows faintly marked posteriorly, rather distinct in the anterior portion. Anterior margin almost straight in the axial part and oblique laterally to form a pair of facets. Axis wide, well-defined, pointed backwards, widest at the front and tri-parted by a pair of parallel longitudinal furrows which run from the anterior margin to the posterior end of the axis. The axis is also transversely divided by two shallow and slightly incurved furrows into three lobes: the anterior one is the shortest; second lobe rather long, provided with a small tubercle in the center, this tubercle sloping gently forwards and ending steeply and highly on its posterior side; posterior lobe of the axis widening rearwards to the median line, then narrowing to the pointed posterior end. Lateral lobes wide in front, gradually narrowing backwards, confluent behind the axis. Rim proportionally equal in width to the cephalic rim, flat or slightly convex, postero-lateral margin destroyed; marginal furrow shallow.

Surface of the test apparently smooth.

Remarks: The anterior portion of the cephalon and the postero-lateral border of the pygidium are not preserved in our collection, therefore whether or not the axial furrow in front of the glabella and the postero-lateral spines on pygidium are really present in this species cannot be ascertained, but the laterally trisected character of the pygidial axis, the well-defined anterior and posterior lobes of the glabella are decidedly of the "*trisectus*"-type.

The present species is distinguished from *L. asiaticus* Troedsson of eastern Tienshan by its narrow glabella and small basal lobes. The pygidium in our form is rather short and the anterior lobe of pygidial axis is completely separated from the posterior portion by a continuous furrow. And in other congeneric forms, it is represented by a pair of furrows which do not meet at the center. Rims both in cephalon and pygidium are very narrow, somewhat like those of the genotype and *americanus* Billings. In *asiaticus* Troedsson, the rims are much wider especially in the pygidium.

***Lotagnostus* sp.**

Pl. I, Fig. 4.

Description: Cephalon semicircular in outline, moderately convex, with a narrow and uniform rim followed by a deep furrow. Glabella convex, about three-fourths the length and about one-third the breadth of the cephalon, slightly tapering forwards; anterior lobe occupied more than one-third the length of glabella, rounded or gently angulate in front; posterior lobe with a pair of shallow transverse furrows on both sides at the middle and, between them, a small median tubercle. Axial furrows deep and narrow, united in front of the glabella. Basal lobes of median size, triangular. Cheeks tapering forwards, separated by a weak preglabellar furrow, ornamented with radiate and reticulate furrows.

Thorax including two segments, axis about same width as glabella at the base, pleurae less than one-third the width.

Remarks: The material now available for study is only a mold of cephalon with the thoracic segments attached. The specimen was distorted and some of the surface features cannot be determined with certainty. This may be due to slight compression of the rock diagonally to the axial direction of the cephalon. On account of the bad preservation of the material, any definite specific identification cannot be made for the present. It agrees with the genotype in the narrow rim and in some features of the cheeks, but it differs in its more or less cylindrical glabella and in the small basal lobes. From *L. asiaticus*, the present species is distinguished by a larger anterior lobe of the glabella and a narrower rim of the head.

Family Dikelocephalidae Miller, 1890.**? Subfamily Saukiinae Ulrich & Resser, 1933.****Genus *Eosaukia* Lu (gen. nov.)****Genotype: *Eosaukia latilimbata* Lu (sp. nov.)**

Diagnosis: Opisthopian trilobite in which the cranidium is quadrate in outline. Glabella bounded by very broad and deep dorsal furrows on both sides and in the front, subquadrate or slightly tapering, frontal margin straight. Three pairs of glabellar furrows: posterior pair very deep, continuous; second pair deep, relatively short, anterior pair very short. Occipital furrow well defined, deep. Occipital ring slightly expanded in the middle. Border convex, wide, separated

from the posterior portion in the antero-lateral sides of the glabella by a pair of oblique shallow furrows. Fixed cheek less than half the width of glabella at the middle. Eyes of median size, situated in the midline opposite to the glabella. Free cheek large, margined by thick border, with a long genal spine, cheek body marked by inosculating concentric lines. Facial sutures marginal. Thorax composed of eleven segments, pleurae pointed. Pygidium transverse, short, axis extending rearwards to a very narrow marginal border, pleural furrows not reaching the border. Surface of the cranium, thorax and the pygidium pustulated.

Remarks: In regard to the narrow and convex border of the cranium, the nature of the anterior branches of the facial sutures and the thickly rimmed free cheeks, this new genus bears a close affinity to members of the subfamily Saukiinae, but differs from all genera of that subfamily in its wide fixed cheeks and short pygidium. The pygidium of the typical forms of Saukiinae is always comparatively longer and its border, too, is always more concave. However, forms with rather short pygidium and narrow convex border from the Upper Cambrian rocks of eastern Asia have also been referred to the genera of the Saukiinae. They are *Prosaukia brizo* (Walcott), *Saukia* (?) *orientalis* Resser & Endo, *Calvinella walcotti* (Mansuy), *C. bella* (Walcott), *Tellerina chinhsiensis* (Sun) and *T. sulcatifera* Endo. It is only with considerable hesitation that the writer retains *Eosaukia* in the same subfamily.

The genus *Eosaukia* is distinguished also from *Saukia* Walcott by the broad border of the cranium and a short glabella. The number of the thoracic segments is 11 in the former and 12 in the latter. From *Saukiella* Ulrich & Resser, it is distinguished by its pustulated surface of the shield and narrow marginal furrow in front of the glabella. *Eosaukia* also resembles *Calvinella* Walcott and *Tellerina* Ulrich & Resser in some respects, but *Calvinella* possesses an occipital spine, and *Tellerina* has a surface markings of inosculating lines. The Persian saukid, *Iranaspis* King, has smooth surface, very faintly marked glabellar furrows; its anterior border and fixed cheeks are narrower than those of our new genus. There are also differences in the shape of the pygidium and in the broad marginal border.

It is of interest to note that all other genera of the subfamily Saukiinae are confined to the late Upper Cambrian strata of Asia and North America, while *Eosaukia* is known only in the early Upper Cambrian of SW China. As far as the phylogenetic relationship is concerned, *Eosaukia* may be one of the ancestral

forms of the Saukiinae in the evolutionary line of development. The wide fixed cheeks and the short and broad pygidium of this genus must be considered as two important characters that typify the primitive and generalized form in the early Upper Cambrian time. It is certain, however, that other genera of this subfamily are more advanced; this is not only indicated by their higher stratigraphical position, but also by the increasing proportionate lengths of the pygidium and by the increasing size of the fixed cheeks during their progressive growth through the long geological time. Similar evolutionary change is also recognized by different authors in other groups of trilobites.

Eosaukia latilimbata Lu (sp. nov.)

Pl. I, Figs. 5-6.

Description: A complete but slightly distorted dorsal shield and its external mold.

Shield ovate, moderately convex. Cephalon semicircular with genal angles extended backward in long spines. Cranidium quadrate in outline; dorsal furrow deep and wide. Glabella well-outlined, subrectangular or slightly tapering forwards, straight in front. Three pairs of glabellar furrow present: posterior pair very deep and wide, running from the dorsal furrow directly inwards and slightly backwards and meeting across the glabella; second pair extending in a same direction as the preceding ones, discontinuous, deep on both sides and shallowing towards the center; anterior pair very short, only faintly impressed on the sides. Occipital furrow deep and wide, well-defined throughout, straight or slightly arched forwards at the middle, oblique at the sides. Occipital ring expanded towards the axial line, narrowing laterally. Border convex, wide, about one-third the length of the glabella, gently curved in front, separated from the posterior portion by a pair of wide and shallow furrows which extended obliquely from the antero-lateral corners of the glabella to the anterior edges of the cranidium. Eyes crescentic, medium size, elevated above the cheeks and situated in a position between the anterior and posterior glabellar furrows opposite to the glabella. Fixed cheek large, a little less than one half the breadth of glabella between the eyes, gently convex, slightly sloping inwards and merging into the dorsal furrow. Posterior limb triangular, somewhat narrower than the occipital ring; posterior border narrow, separated from the posterior limb by a deep furrow. Free cheek fairly broad, with a well-defined thick border which extends rearwards into a long genal spine.

Ocular platform (cheek body) marked by inosculating concentric raised lines around the eye. Some lineate ornament also occurs on the surface of the cheek border and the genal spine.

Thorax composed of 11 segments. Axis convex, in the anterior segments a little narrower than the pleuron, continuously tapering. Pleurae strongly geniculate, deeply furrowed and terminating in short slender spines directed outwards and slightly backwards. Anterior and posterior bands raised into prominent ridges.

Pygidium broadly transverse, semicircular. Axis convex, narrowing backwards and extending almost to a very narrow border with three rings besides the rounded end-lobe; ring furrows deep. Pleural lobe triangular, broader than the width of axis in the anterior margin, with three pairs of well impressed pleural furrows which do not reach the margin; interpleural grooves effaced.

Surface of cranium, thorax and pygidium except their furrows ornamented with pustules

Family Olenidae Burmeister, 1843.

Subfamily Oleninae Kabayashi 1935.

Genus *Hedinaspis* Troedsson, 1951.

(=*Hedinia* Troedsson 1937, non Navas 1936)

Genotype: *Hedinia regalis* Troedsson

***Hedinaspis kueichouensis* Lu (sp. nov.)**

Pl. I, Fig. 9; Pl. II, Figs. 1-8; Pl. III, Figs. 1-4.

Diagnosis: Distinct from the genotype by comparatively shorter glabella and strongly curved anterior branches of facial sutures.

Description: Specimens represented by a number of detached parts of dorsal shield and several individuals of larval forms.

Holotype (Pl. II, Fig. 6), cranium. Glabella gently convex, tapering very gradually forwards and rounded in front, with a ratio of the length and the width in the middle 5:4. Four pairs of discontinuous glabellar furrows present, all of them do not reach the dorsal furrows. Posterior pair of the furrows rather deep on the sides, shallowing gradually inwards and backwards and finally vanishing at the central axis of glabella; second pair in front of these furrows short and shallow, extending less oblique backwards; third pair very short, almost horizontal, beginning more inside from the dorsal furrows; anterior or fourth pair faintly marked, arising rather close to the dorsal furrows and inclined forwards,

but disappearing rapidly in a short distance. Occipital furrow oblique, also not reaching the dorsal furrows, well impressed at the sides, and almost effaced at the middle. Occipital ring narrowing laterally with straight posterior margin. Brim flat, slightly elevated in the axial portion. Anterior border of the cranium as high as the glabella, uniform in breadth, arching slightly backwards. Palpebral lobes small and situated opposite the second and fourth glabellar furrows. Ocular ridges well defined, extending from the dorsal furrows horizontally outwards. Fixed cheeks less than half the width of glabella between the palpebral lobes, flat or nearly so. Posterior border quite narrow, separating from the posterior limb by very shallow and weak posterior furrow. Anterior branches of the facial sutures running from the palpebral lobes outwards then curving rapidly forwards and inwards, the space between them being nearly as broad as the breadth of glabella at the middle.

Pl. III, Figs. 3-4, external mold of a large, fragmentary cranium. Glabella short, slightly contracted at the middle, with rounded front. Glabellar furrows and occipital furrow fairly deep and broad, and situated as in the holotype. Anterior border thin, uniform in width, bending slightly backwards at the center to form a concave arc. Anterior branch of facial sutures partly preserved, cutting the border in a strong curve-line.

Pl. III, Fig. 1, an external mold of thorax and pygidium of a large specimen. Specimen elongated parabolical in shape, 55 mm long, 40 mm wide in the anterior portion, comprises 30 or 31 segments of which the last 2 or 3 are quite coalesced. Axis very narrow about one-sixths the width of the body, slightly elevated above the pleural lobes and gradually tapering towards the rounded terminal lobe of pygidium. Pleurae flat and straight, all with pointed ends except the last two on which the lateral margins are damaged. Main part of the pleurae extending horizontally outwards, the posterior ones rather short and oblique so that they nearly join the triangulate coalesced pleural portions of the pygidium. Pleural furrow very broad and flat, running uniformly throughout all the length, from the dorsal furrow to its terminal point, and bounded by a thread-like and sharply elevated pleural ridge on each side. The exact boundary of the thorax and pygidium can hardly be determined with certainty, because the lateral and posterior margins of the latter are badly preserved and the pleurae in front of the coalesced pleural lobes are closely similar to those just mentioned. Though a very narrow pleural groove seems to be present in front of the second pleura (counting upwards

from the coalesced pleural lobes), it is not certain whether this groove can really be regarded as the true boundary line at present.

A great many fragmentary specimens of the thorax with same kind of axis and pleurae as described above have been secured in the present collection. They are all alike, with only difference in their size and the depth of the dorsal furrows. One of them with the pygidium attached is depicted on Pl. II, Fig. 8. In this specimen, the pygidium is also well joined to the thorax and a definite boundary line between them can not be readily recognized.

Figs. 1-5 on Pl. II form a series of growth stages.

The smallest specimen figured on Pl. II, Fig. 1 is a cranium with four thoracic segments. Cranium 3 mm long and 3 mm wide at the base with an even convexity except the elevated axis. Glabella rectangular, outlined by the parallel dorsal furrows and a well developed occipital furrow; four pairs of short glabellar furrows indistinctly indicated on each side of the glabella. Occipital ring convex and almost uniform, though somewhat narrowing towards both ends. Brim nearly flat, about half the length of the glabella, and emarginated in front by narrow and slightly elevated border. Palpebral lobes small, incurved, and situated opposite to the anterior corners of the glabella. Ocular ridges well marked, extending outwards and slightly upwards from the dorsal furrows and then connected with the palpebral lobes to form continuous lines. Fixed cheek evenly convex, as wide as the glabella between the palpebral lobes. Posterior limb very broad, with lateral slopings, and separated from the narrow posterior border by a broad and deep marginal furrow. Anterior branches of facial sutures short, extending nearly parallel to the palpebral lobes towards the anterior margin, posterior ones very long, running in a gentle curve to cut the posterior margin. Axis of the thorax narrow, elevated, well defined by deep dorsal furrows. Pleurae very broad and flat, furrowed widely and deeply throughout.

A somewhat weathered specimen of slightly advanced stage is shown on Pl. II, Fig. 2. Outline of the shield circular, length and width subequal, about 4.5 mm. Axis almost entirely removed, quite narrow and gradually tapering backwards and almost reaching the posterior margin. Cranium flattened, about two-fifths the length of the whole body. Surface features of the cranium essentially agreeing with the preceding stage, but the ocular ridges running more horizontally. Free cheeks small, bounded by narrow marginal borders and produced into genal spines of moderate length. Thorax composed of six segments. Pleurae straight and flat,

pointed on both ends with very broad pleural furrows. Pygidium about one-fifth the length of the shield, straight in front, with rounded posterior margin. Pleural lobes of pygidium marked by four or five transverse and fairly coalesced pleurae, and also marked by a narrow but prominent posterior border.

Fig. 3. on Pl. II shows the mold of a cephalon with 9 thoracic segments. Cephalon moderately convex, 2 mm long and 5 mm wide; almost straight in the front and regularly curving backwards towards the pointed genal spines. Glabellar furrows badly preserved, with only the posterior ones faintly indicated on the left side, short and oblique. Brim broad and flat, bounded in front by a narrow and slightly elevated border. Occipital furrow shallow, slightly bending backwards. Occipital ring broad in the center, gradually decreasing its breadth towards both sides. Fixed cheek flat, a little narrower than the glabella across the eye. Free cheek larger than the preceding stage, marginal portion gently sloping downwards, otherwise flat; genal angle prolonged into a short and stout spine. Anterior branches of facial sutures cutting the brim in a convex arc, the width of the brim between them being equal to the width across the palpebral lobes; posterior branches very long, and strongly incurved postero-laterally. Thorax with nine segments preserved, flattened except the vaulted axis. Pleurae straight and very wide about three times the width of the axis, with very broad and flat pleural furrow bounded by narrow and elevated border on each side, terminating in short spine.

An entire dorsal shield of a more advanced larval form is shown on Pl. II, Fig. 4. Specimen subovate in outline, 7 mm long and 5.5 mm wide at the transverse mid-line. Glabella subrectangular, elevated; lateral furrows short and not reaching to the dorsal furrows. Occipital furrow shallow, slightly oblique inward-backward; occipital ring as wide as the glabella, narrowing gradually laterally. Brim broad, moderately concave in the front of glabella. Border very thin, slightly bending rearwards. Eye small, situated anterior to the median line of glabella. Thorax of 12 segments; axis narrow, elevated, slightly conical; pleurae straight in the anterior portion, posterior segments bending steeply backwards to join the frontal margin of the pygidium. Pygidium small, more or less fusiform; axis annulated, not reaching the posterior margin, with 2 or 3 rings and a rounded but narrow terminal lobe; in the pleural lobe, 3 or 4 oblique and well-coalesced pleurae are discernible under strong lens, pleural furrows same as in the thorax. Posterior border very thin, almost imperceptible. Posterior margin nearly

straight or slightly sinuated.

The last growth stage of the larval forms in our collection is a dorsal shield with its marginal border merged into the rock matrix and the surface strongly weathered (Pl. II, Fig. 5). Specimen elongate ovate in shape, with a length of about 15 mm and width 11 mm. Glabella short, slightly tapering forwards and rounded in front; glabellar furrows more or less weathered, somewhat like the holotype but a little shorter. Brim narrower than the preceding stage, slightly concave. Border narrow, elevated, bending backwards in a concave arc. Fixed cheek narrow, about half the width of the glabella between the palpebral lobes. Posterior limb triangular in shape, broad, gently convex, about twice the breadth of the occipital ring. Anterior branch of facial sutures short and incurved, posterior branch very long, running in a smooth curve from the eye to cut the posterior margin. Thorax and pygidium well joined, with a total number of about 25 segments including the coalesced pleural portions. The boundary line between the thorax and the pygidium can not be ascertained due to the state of preservation, and the pygidium is not complete in its posterior end.

The major features in the development of the five young individuals as well as the adult forms mentioned above may be summarized briefly as follows: (1) the glabella is rectangular and comparatively narrow in the smallest stage, it increases its size and widens at the base in the later stages, (2) the border in the first and second stages bends forwards in a smooth curve, then it becomes straight in the third stage and finally turns its course to form a concave arc until the trilobite attained maturity, (3) in connection with the transfer of the marginal border, the space between it and the glabella becomes narrower and narrower and an elevated but low area situated just in front of the glabella begins to appear in the fifth stage and in the adult forms, (4) the fixed cheek is at first wider than the glabella in the earliest stage, but as it develops it decreases steadily in the successive stages and arrives at a minimum width in adult.

Remarks: *Hedinaspis* has been known hitherto only by the genotype, *H. regalis*, in the Upper Cambrian Torsuq tagh formation of eastern Tianshan. This is the only strictly comparable material. Generally, the present new species is similar to the genotype in the shape and the outline of the head, in the shape of the glabellar furrows, fixed cheeks, in the small eyes, in a great number of the thoracic segments, in the narrow thoracic axis and very wide and transverse pleurae and a small pygidium, but the glabella is relatively shorter, the anterior

branches of the facial sutures are more strongly curved (so as to make the antero-lateral corners of the cranidium more rounded) and the ridges bounded in each side of the thoracic pleurae are very narrow, thread-like. The development of the larval forms in both species is also alike, thus in their younger stages the glabella is rather narrow, with sides nearly parallel or slightly convergent, the fixed cheeks are very large, the brim is broad and the marginal border is arched forwards. There seems to be no great morphological differences between these two species in their larval stages.

Recently, Kobayashi figured a specimen of trilobite with only a part of the thorax and pygidium obtained from the Kanairi formation of South Chosen and he referred this to *H. rögalis* Troedsson on account of the "unusual proportion of its narrow axial lobe and the broad pleural lobe and the aspects of the latter lobe". This form is certainly very close to the genus *Hedinaspis*, but the specimen is too fragmentary and the size, too, is too small (7 mm.), to warrant for a specific or even a generic reference. Furthermore, species of *Hedinaspis*, occurring in the Upper Cambrian rocks of Tienshan and Kueichou, are apparently somewhat younger in age than the Chosenian form which is in association with *Amphoton*, *Kogenium*, *Ptychoparia* and *Anomocarella* of Middle Cambrian age.

Family Asaphidae Burmeister, 1843.

Genus *Charchaia* Troedsson, 1937.

***Charchaia* sp.**

Pl. I, Fig. 7.

Specimen on hand is a mold of almost complete dorsal shield, but some of the most important features are too badly preserved to warrant for any definite specific identification. The shield is about 14 mm in length and 11 mm in width measured at the middle. The cephalon is semicircular in outline, occupying two-fifths the length of the shield. The sides of the glabella are nearly parallel or very slightly convergent. No indication of the glabellar furrows and occipital furrow can be seen, but the pleural part of the neck segment, i. e. the posterior border of the cheek is clearly defined. The fixed cheek is a little more than half the width of the glabella across the eyes. The body of the free cheeks is wide, sloping laterally downwards and bounded by a narrow, flattened border. The genal spine is short and stout. The palpebral lobes are small and situated some-

what anterior to transverse median line of glabella. The anterior branch of facial sutures, as shown on the left side of the mold, is slightly divergent from the eye and almost perpendicular to the anterior margin; the posterior one runs in a smooth curve line to cut the posterior border. The central portion of the thorax has been entirely destroyed, with only one very obscure longitudinal depression indicating a narrow and tapering axis. The total number of the segments is not known, as only seven pleurae are partially preserved; they are deeply and broadly furrowed. The pygidium is smaller than the cephalon. The axis is somewhat damaged and thus the real shape can not be made out exactly. On the pleural portions no furrows can be discerned.

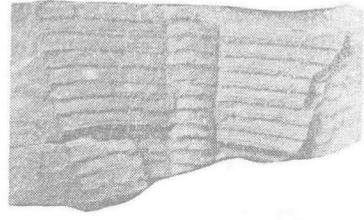
Remarks: The present form is referred to the genus *Charchagia* mainly on account of its smooth rectangular glabella without occipital furrow. In 1937, Troedsson described three species of *Charchagia* (*C. norini* T., *C. lata* T. and *C. curvata* T.) from Tienshan and later in 1939 Whitehouse added another one *C. erugata* W. from Northeastern Australia. Comparing such forms with our Kueichou specimen, it is found that *C. norini* (Pl. 1, Fig. 8) is distinguished by its highly elevated frontal margin and distinctly furrowed pygidium; *C. lata* is characterized by a more straight posterior branch of facial sutures and more anterior eyes; *C. curvata* is distinguished by its relatively rather narrow fixed cheek and the broad anterior border, and *C. erugata* has comparatively large palpebral lobe and a very thick pygidial border. *Liostracus* (?) *superstes* Linnarsson (the genotype of *Eoasaphus* Kobayashi), a Swedish Cambrian asaphid, is another similar form, but that species has a characteristic truncato-conical glabella, a faint occipital furrow and light traces of other glabellar furrows.



3



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9



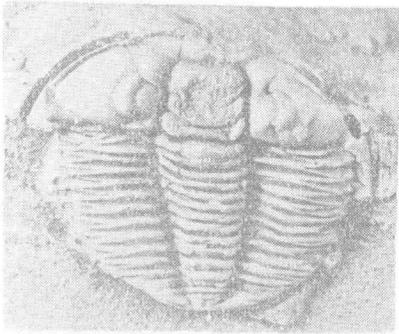
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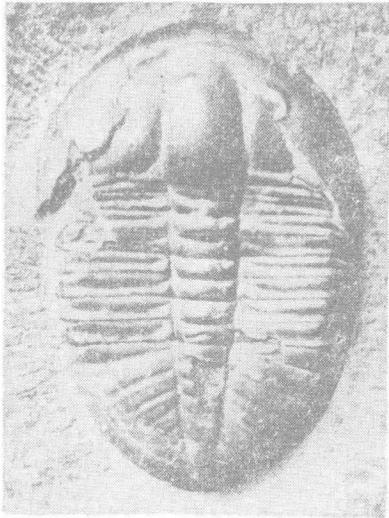
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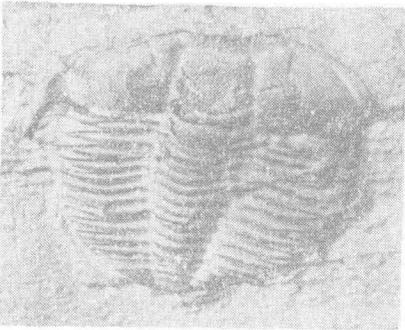
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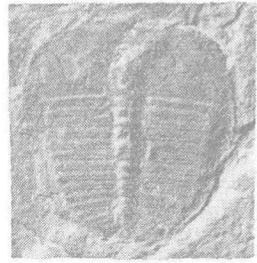
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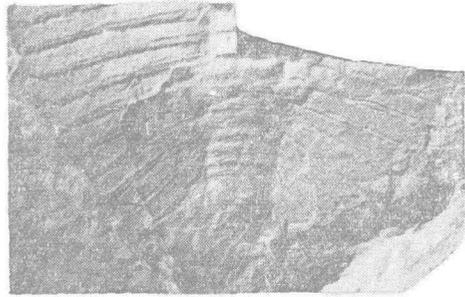
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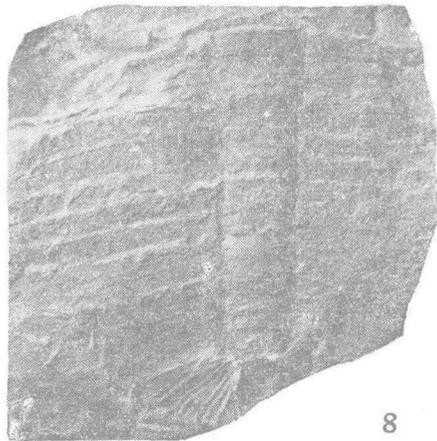
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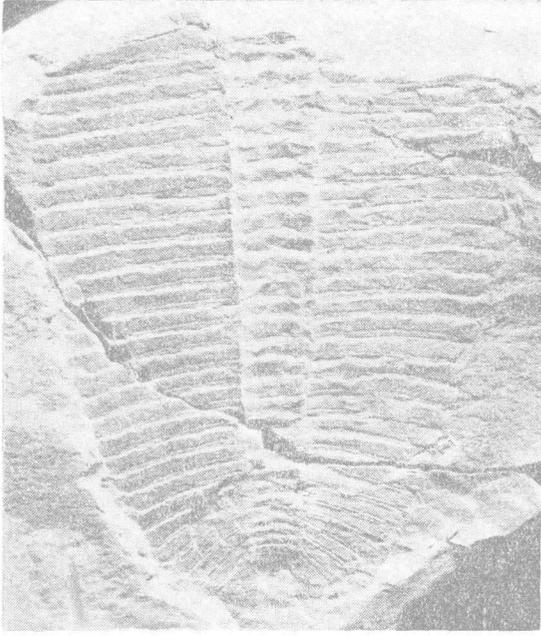
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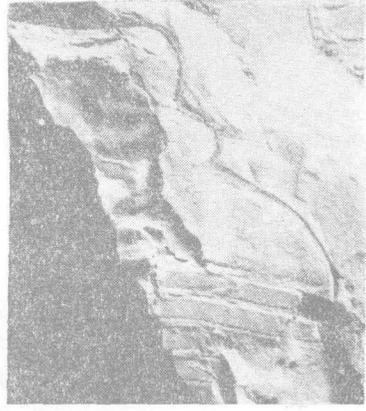
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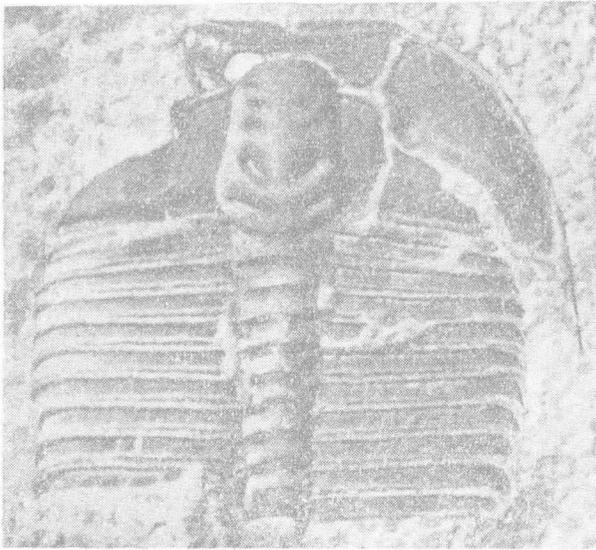
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圖 版 說 明

圖 版 I

- 圖 1. *Agnostus* (?) sp. 尾部的外模印。放大 8 倍。登記號碼: 7222。
- 圖 2—3. *Lotagnostus lemontovai* Lu (新種)。
2. 尾部。放大 8 倍。正型標本。登記號碼: 7223。
 3. 同上圖的尾部及與此相連的頭部與胸部的模印。放大 8 倍。登記號碼: 7224。
- 圖 4. *Lotagnostus* sp. 頭部及胸部的模印。放大 4 倍。登記號碼: 7225。
- 圖 5—6. *Eosaukia latilimbata* Lu (新屬, 新種)。
5. 完整背殼。放大 4 倍。屬型正型標本。登記號碼: 7226。
 6. 同上圖背殼的模印。放大 4 倍。登記號碼: 7227。
- 圖 7. *Charchaia* sp. 背殼的模印。放大 3 倍。登記號碼: 7228。
- 圖 8. *Charchaia norini* Troedsson. 用作與圖 7 比較。放大 3 倍。新疆天山東部上寒武紀突爾沙克塔格統。(採自 Troedsson, 1937, pl. VI, fig. 11)。
- 圖 9. *Hedinaspis kueichouensis* Lu (新種)。胸部的一部分。原大。登記號碼: 7229。

圖 版 II

- 圖 1—8. *Hedinaspis kueichouensis* Lu (新種)。
1. 幼蟲的頭蓋及胸部。放大 4 倍。登記號碼: 7230。
 2. 幼蟲的背殼。放大 4 倍。登記號碼: 7231。
 3. 幼蟲頭蓋及胸部的模印。放大 4 倍。登記號碼: 7232。
 4. 幼蟲背殼的模印。放大 4 倍。登記號碼: 7233。
 5. 幼蟲的背殼。放大 3 倍。登記號碼: 7234。
 6. 頭蓋。放大 3 倍。正型標本。登記號碼: 7235。
 7. 圖版 I, 圖 9 胸部及其相連尾部的模印。放大 2 倍。登記號碼: 7236。
 8. 胸部及尾部。放大 2 倍。登記號碼: 7237。

圖 版 III

- 圖 1—4. *Hedinaspis kueichouensis* Lu (新種)。
1. 圖版 I, 圖 9 胸部及其相連尾部的模印。放大 1.5 倍。登記號碼: 7236。
 2. 破碎的頭蓋及胸部的模印。放大 2 倍。登記號碼: 7238。
 3. 破碎的頭蓋模印。光線自後方來, 特別顯示其頭鞍溝及頸溝。放大 2 倍。登記號碼: 7239。
 4. 同上。光線自左上方來。特別顯示外邊緣形狀。
- 圖 5. *Hedinaspis regalis* (Troedsson). 用作與 *Hedinaspis kueichouensis* 比較。放大 2 倍。新疆天山東部上寒武紀突爾沙克塔格統。(採自 Troedsson, 1937, pl. VIII, fig. 7)。

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