CAMBRIAN TRILOBITES FROM THE AMANOS MOUNTAINS, TURKEY

by W. T. DEAN and R. KRUMMENACHER

ABSTRACT. Certain Palaeozoic rocks of the Amanos Mountains in southern Turkey have been investigated, and their stratigraphical relationships are briefly reviewed. Trilobites of Middle Cambrian, or Acadian, age have been collected from strata previously assigned to the Devonian. The specimens described here include the genus *Pardailhania*, together with an indeterminate agnostid, and suggest affinities with North African and eastern North American faunas of similar age.

IN the summer of 1957 one of the writers (R. K.) was sent by the Shell Petroleum Company of Turkey to study geological sections in the Amanos Mountains. A detailed examination was made of a series of rocks previously attributed to the Devonian (Dubertret 1953), though palaeontological proof was lacking. From these were collected trilobites, now known to be of Middle Cambrian age, which are described in this paper.

The writers are indebted to the management of the N. V. de Bataafsche Petroleum Maatschappij for permission to publish the following results, and to Professor W. F. Whittard who has kindly read and criticized the manuscript.

The Amanos is the southernmost massif in the succession of coastal ranges running north–south along the Mediterranean coast from Turkey towards Israel. About the latitude of Iskenderun the Belen Pass (680 metres) divides the Amanos into two well-defined blocks, the Kizil Dag in the south, and the Giaour Dag, or Nurdaglari, in the north (text-fig. 1). The latter, culminating in the Migher Tepe (2,224 metres), exhibits on its eastern flank various geological formations which have not been encountered elsewhere in the area. A geological map on the scale 1:200,000, drawn by Dubertret, was published in 1952 by the Institut Géographique National, Paris, whilst Blumenthal and Turkenal, two geologists of the Maden Teknik Ve Arama Enstitusu, Ankara, had earlier, in 1944, completed the Malatya sheet of the 1:800,000 geological map of Turkey. In the Amanos the latter map shows mainly undifferentiated Palaeozoic rocks, limited on their eastern side by a narrow strip of Permo-Carboniferous(?) limestones.

STRATIGRAPHY

Owing to the broken nature of the terrain of the Giaour Dag, continuous successions can be followed for only short distances. The best-exposed section that has been examined lies west-south-west of Saylak, 12 kilometres north by east of Kirikhan, and it was here that trilobites were found. Access to the section is still difficult, and the following succession was established mainly along a mule track connecting Araplisagi with the mountains, and completed along a forestry road which, in 1957, was being built south-east of Dörtyol. Owing to the absence of local stratigraphical names the formations in this description are given the letters A to E in ascending order (text-fig. 2).

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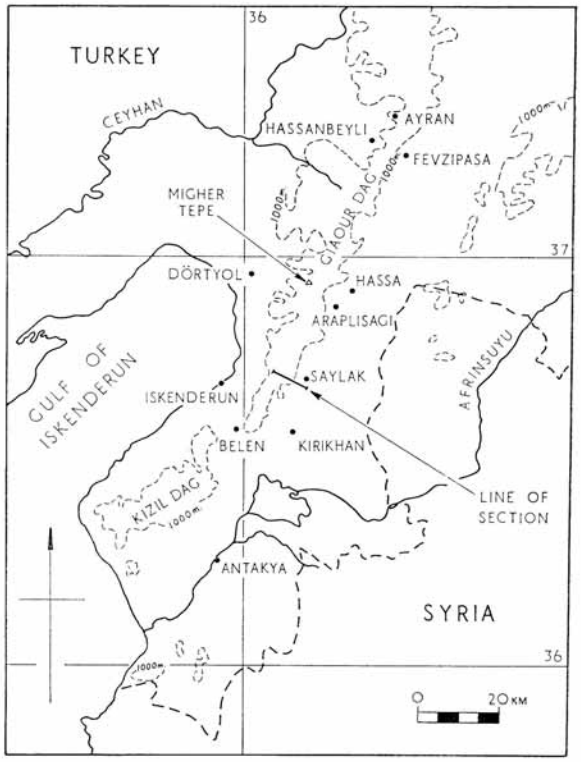
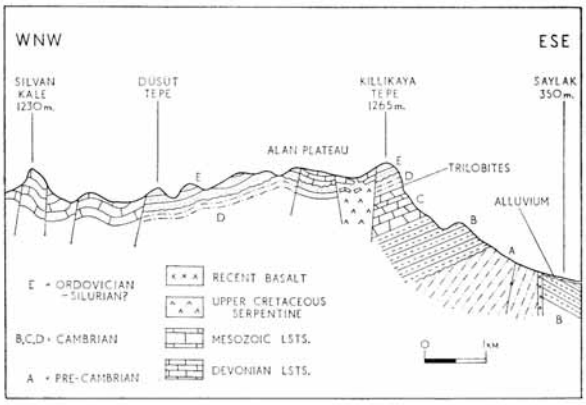


TEXT-FIG. 1. Map of southern Turkey showing the Kizil Dag and Giaour Dag blocks of the Amnos Mountains.



TEXT-FIG. 2. Section across the Amnos Mountains near Saylak. Vertical scale doubled.

Formation A. A monotonous series of alternating, well-bedded, quartzitic sandstones and phyllitic shales, dark red to dark green-brown in colour. The rocks are unfossiliferous and more than 1,000 metres thick. At Araplisagi they dip to the east-south-east at 45 degrees, but become steeper towards the Migher Tepe. The beds are separated by a strong, angular unconformity from:

Formation B. Massive, pinkish, quartzitic sandstones and conglomerates with some thin intercalations of ferruginous, micaceous shale. Pebbles of pale quartzite, dark schist, and igneous material occur throughout, and cross-bedding is common. The rocks become more ferruginous and shaly towards the top, culminating in an horizon of ferruginous shales a few metres thick. No fossils have been found and the total thickness is about 600 metres. There is a gradual passage to:

Formation C. The lower beds include lenses of blue-grey limestone, or coarsely crystalline, dark, dolomitic limestone, in a ferruginous, shaly matrix. Higher in the succession coarsely crystalline, dark-blue to black, dolomitic limestones or dolomites form beds from 20 to 50 cm. thick, with thin, shaly intercalations. The rocks are 185 metres thick, apparently unfossiliferous, and followed conformably by:

Formation D. The basal beds comprise current-bedded, calcareous shales and shaly limestone, whilst higher in the succession are dark green, calcareous shales, both laminated and cross-bedded, with vugs at some points. The basal beds contain comminuted shell fragments and worm tracks. Middle Cambrian trilobites have been collected 5 metres above the base of the formation, along the road climbing from Saylak to the Alan Plateau (text-fig. 2). Total thickness is 250 metres and the rocks are separated by a disconformity from the overlying:

Formation E. Massive, pale, coarse to conglomeratic, quartzitic sandstones. Green, sandy, micaceous shales alternate with nodular, green-brown, quartzitic sandstones higher in the succession. The topmost strata comprise a few layers of soft, sandy shale, of a characteristic deep-purple colour. No fossils have been found and the thickness, as measured above Dörtyol, is 85 metres.

The outcrop of Formation E was traced northwards as far as the village of Ayran, 8 kilometres north-north-west of Fevzipasa, where it was found to be much better developed. The sediments there, 1,115 metres thick, exhibit structures attributed to slumping in the upper part of the section, where worm tracks and the so-called trilobite tracks known as '*Fraena*' were encountered. The only stratigraphically useful fossil yet found in this formation is a badly damaged trilobite; at one time this was supposed to belong to the Silurian genus *Acaste* (Frech 1916, p. 51), but the specimen has since been redetermined by R. Richter as *Dalmanitina sp.* and held to indicate an Ordovician age (Dubertret 1953).

Above Dörtyol, Formation E is transgressed, though without angular unconformity, by a massive, blue-grey, dolomitic breccia which passes upwards gradually into a well-bedded, pale, gypsiferous, dolomitic limestone with some thick intercalations of yellowish mudstone. The only fossils found were a few indeterminate algae and polyzoa, but a regional study of the formation suggests that it can be equated with the Devonian rocks of Hassanbeyli to the north (Blankenhorn 1891, p. 60).

The Middle Cambrian or, more precisely, Lower Acadian age of Formation D is

shown by the contained trilobites, belonging to the genus *Pardailhania*. Formations B, C, and D form a conformable succession, the whole of which is believed to be Cambrian in age, and the lower beds may represent an undetermined portion of the Lower Cambrian. Formation A is thought to be Pre-Cambrian in age as it is strongly transgressed by the supposed Cambrian of Formation B. The Ordovician age of Formation E has been indicated in the Aryan area, and subsequently a general transgression at the base of the series of calcareous and dolomitic rocks of Devonian age occurred throughout the Amanos (text-fig. 3).

Generally speaking, the deposition of the Cambrian rocks throughout the Middle East commenced with a continental or littoral environment which produced mainly coarse clastics, together with occasional evaporites, viz. the 'Cambrian Salt' of Persia. In the Middle Cambrian these conditions were terminated by a marked marine transgression directed approximately southwards, carbonates being deposited as far south as Persia and the Gulf of Akaba, though they have not been reported from Saudi Arabia. At about the end of Cambrian times, sometimes following a marked disconformity, deposition of clastics recommenced and continued through the Ordovician and Silurian. The great accumulation of Lower Palaeozoic clastic rocks found in the north of the Amanos, with their general lack of fossils and abundance of worm-tracks, slumping features, and nodular shales, suggests rapid, flysch-like sedimentation under unstable tectonic conditions.

The facies of the Lower Palaeozoic rocks of the Amanos are comparable with those of the Anti-Atlas, probably forming part of the same geosynclinal area, and it is interesting that the Middle Cambrian trilobites described in this paper bear most resemblance to a Moroccan species which, in turn, exhibits affinities with an eastern North American form.

The Cambrian rocks of the Amanos apparently escaped the effects of the Caledonian Orogeny, and it is expected that they will be found to pass laterally into part of the highly metamorphosed series of the Taurus Mountains farther north. Prior to Devonian times some of the Ordovician and ?Silurian rocks were eroded in the south of the area, but during the remainder of the Palaeozoic deposition the Amanos acted as a stable 'platform' which received considerably reduced sedimentation.

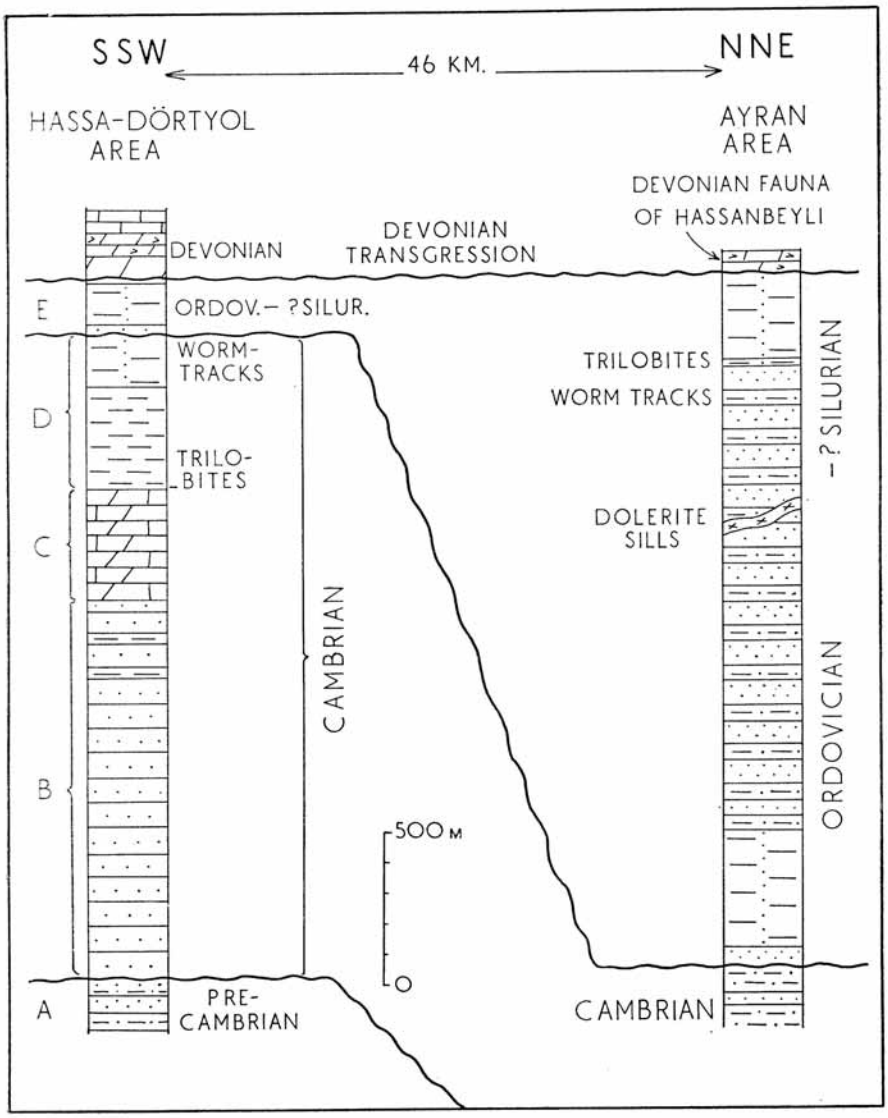
SYSTEMATIC PALAEONTOLOGY

All the fossils found in the Cambrian rocks of the Amanos are trilobites from only one locality. Ten specimens, preserved as internal and external moulds, were collected; nine belong to one species, described below as *Pardailhania* cf. *barthouxi*, and one to a generically indeterminate agnostid.

Family SOLENOPLEURIDAE Angelin 1854

Subfamily SOLENOPLEUROPSINAE Thoral 1948 (*nom. transl.* herein *ex* SOLENOPLEUROPSIDAE Thoral 1948) = SAOINAE Hupé 1953

The genera *Pardailhania* Thoral 1947, *Rimouskia* Resser 1938, *Sao* Barrande 1846, and *Solenopleuropsis* Thoral 1947, have been grouped together by Poulsen (1954, pp. 445–6; *in* Moore 1959, p. O 276) in the subfamily Saoinae, a name used originally as Family Saoidae Hupé 1953. If these genera are accepted as belonging to the same



TEXT-FIG. 3. Vertical sections in the northern Amnos Mountains.

subfamily, then the name Solenopleuropsinae, derived from the familial name proposed earlier by Thoral (1948, p. 82) for the genera *Solenopleuropsis* and *Pardailhania*, has priority.

Genus PARDAILHANIA Thoral 1947

Type species *Solenopleura? hispida* Thoral, 1935, by original designation

Pardailhania cf. *barthouxi* (Mansuy)

Plate 10, figs. 1, 2, 4, 7, 9, 10–13

1922 *Ptychoparia barthouxi* n. sp., Mansuy, p. 288, pl. 10, figs. 4*a–g*.

Description. Cephalon roughly semicircular in outline, with median length about half the breadth. Though the specimens are somewhat flattened, the glabella appears to be moderately convex, with basal breadth about one-third that of the cephalon and three-quarters or more of its own length. Glabellar outline almost a trapezium, its sides converging forwards gradually to the frontal lobe at about 20 to 25 degrees; the latter is delimited by a shallow preglabellar furrow, generally transversely straight or gently convex forwards. Almost all the specimens have a smooth, unfurrowed glabella, but one (Pl. 10, fig. 7) shows three pairs of faintly impressed glabellar furrows. First pair of furrows barely discernible; second furrows straight, extending only a short distance adaxially from axial furrows. Basal glabellar furrows run adaxially and then rearwards from the axial furrows without reaching occipital furrow, each extending across the glabella about one-quarter of its basal breadth. The three glabellar lobes so defined are of roughly equal length (*exsag.*), each about one-quarter the median length of the glabella. Axial furrows deep, almost straight or slightly convex abaxially; in only the largest specimen do they contain a pair of poorly developed anterior pits. In front of the preglabellar furrow is a broad (*sag.*), flat or slightly convex, preglabellar field, equal to about one-quarter of the glabellar length; in front of this the anterior border rises

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EXPLANATION OF PLATE 10

Figs. 1, 2, 4, 7, 9, 10–13. *Pardailhania* cf. *barthouxi* (Mansuy). Lower or lower Middle Acadian, road leading to the Alan Plateau above Saylak, north-north-east of Kirikhan, Turkey. 1, Km 565 d1, internal mould of immature cranidium. 2, 4, Km 565 d2, external mould and corresponding latex cast of cranidium showing smooth glabella and broad (*sag.*) preglabellar field. 7, Km 565 d3, latex cast from external mould to show occipital ring and traces of glabellar furrows. 9, 13, Km 565 c, external mould and latex cast of most complete specimen showing form of ocular and fixigenal ridges, and thoracic segments. 12, Km 565 b, internal mould of same individual. 10, 11, Km 566 e, external mould and latex cast of incomplete cephalon to show course of facial suture, and posterior portion of free cheek with genal angle.

Fig. 3. *Pardailhania hispida* (Thoral). Lower Acadian, Route de St. Jean de Pardailhan, Coulouma, Hérault, France. In. 42020, external mould of incomplete cranidium showing transverse arrangement of tubercles on glabella. Ocular ridge not well developed.

Figs. 5, 6. *Pardailhania granieri* (Thoral). Lower Acadian, Vigne de Cauquil, Coulouma, Hérault, France. In. 49479, latex cast and external mould of cranidium showing fusion of tubercles on glabella to form transverse ridges, and strong development of ocular and fixigenal ridges as in the Turkish specimens above.

Fig. 8. Agnostid gen. and sp. indet. Km 566 b, poorly preserved internal mould of cephalon. Horizon and locality as fig. 1.

steeply, in outline convex longitudinally, and thickening medially. Occipital furrow moderately deep and transversely straight; occipital ring convex, fairly long (*sag.*) becoming shorter (*exsag.*) towards the axial furrows. Immediately outside the axial furrows the posterior border is strongly convex, becoming narrower (*exsag.*) and less well developed abaxially until it meets the blunt genal angles.

None of the specimens has the eyes preserved. Each fixigena carries a pronounced ocular ridge which commences at the axial furrows, slightly behind the line of the preglabellar furrow, arches abaxially and backwards until, opposite the mid-point of the glabella, it turns adaxially slightly and then ends abruptly about in line with the basal glabellar furrows, when the latter are visible. In the best-preserved specimens each ocular ridge is seen to be thin and vertical frontally, becoming less steep posterolaterally and at the same time thickening slightly so as to form an overhanging palpebral lobe (see Pl. 10, fig. 13). On its adaxial side the ocular ridge is bounded by a faint palpebral furrow in the vicinity of the eye. Just to the rear of the junction of each ocular ridge and axial furrow, another ridge of similar height and thickness begins. There seems to be no suitable term in use for such a structure, and Professor Whittard has suggested (*in litt.*) that the name 'fixigenal ridge' be employed. At first each fixigenal ridge runs backwards and slightly abaxially, parallel to and bordering the axial furrow, but just before reaching the pleuroccipital furrow it turns abaxially through about 110 degrees and extends laterally, almost straight and parallel to the furrow, reaching a point a short distance adaxially from the lateral border, where it is truncated by the posterior branch of the facial suture (see Pl. 10, figs. 10, 11). As already stated, the eyes are not preserved but it is possible to determine their extent from the position of the facial suture. Anterior branches run straight forwards for a short distance from the posterolateral end of the ocular ridges, and then become slightly sigmoidal, curving first abaxially and finally forwards again to intersect the anterolateral margins. Posterior branches extend abaxially and slightly backwards from the rear ends of the ocular ridges and then curve sharply backwards, first to truncate the outer ends of the fixigenal ridges and then to cut the posterior margin of the cephalon a short distance adaxially from the genal angles. The posterior margin of the cephalon between the facial suture and the genal angle is straight and cut forwards obliquely to the blunt genal angle. The free cheeks thus differentiated are small.

Dorsal surface of the exoskeleton in all the available specimens is smooth. Hypostome unknown.

One specimen (Pl. 10, figs. 9, 12, 13) possesses at least nine thoracic segments but is so badly preserved that it is impossible to determine the total number present. Each segment has a moderately long (*sag.*) axial ring which curves forwards slightly at either end towards the axial furrows to form small axial nodes. Large articulating half-ring separated from axial ring by broad (*sag.*), deep, articulating furrow. Each pleura curves gently rearwards from the axial furrow, and then forwards, terminating in a broad, rounded tip (see Pl. 10, fig. 13). Pleura divided into two bands of unequal size, of which the anterior is the smaller, by deep pleural furrow which, commencing at the axial furrow in a median position, runs abaxially and at the same time draws nearer to the anterior margin of the pleura, finally dying out without reaching the tip. Dorsal surface smooth like that of the cephalon.

Pygidium unknown.

Locality and horizon. All the Turkish specimens described and figured in this account are from the road leading to the Alan Plateau above Saylak, 12 kilometres north-north-east of Kirikhan, Province of Hatay, Turkey (see Fig. 1). No associated fossils have been found which might indicate a precise horizon within the Middle Cambrian, or Acadian, but by analogy with material from southern France the age of the fauna is probably Lower Acadian.

As originally described by Mansuy (1922) *Pardailhania barthouxi* is a member of a fauna which includes also a *Paradoxides* said to be *P. rugulosus* Hawle and Corda, though this is possibly a misidentification. According to Strand (1929, pp. 314–15, 337, 350) the latter species is characteristic of Stage 1c δ (equivalent to the Zone of *Paradoxides davidis*, Middle Cambrian) of Norway, and a similar horizon is listed by Cobbold and Pocock (1934, pl. 39) for other successions. The Turkish and Moroccan specimens are probably older.

Figured specimens. Pardailhania cf. *barthouxi*, Km 565 b (Pl. 10, fig. 12), Km 565 c (Pl. 10, figs. 9, 13), Km 565 d1 (Pl. 10, fig. 1), Km 565 d2 (Pl. 10, figs. 2, 4), Mm 565 d3 (Pl. 10, fig. 7), Km 566 e (Pl. 10, figs. 10, 11). All these specimens are in the collections of the N. V. de Bataafsche Petroleum Maatschappij, Gravenhage, Netherlands.

The two cranidia of other species figured for comparison with the above are as follows: *Pardailhania hispida*, In. 42020 (Pl. 10, fig. 3); *Pardailhania granieri*, In. 49479 (Pl. 10, figs. 5, 6). Both specimens are in the British Museum (Natural History), London.

Discussion. The genus *Pardailhania* was founded by Thoral (1947, p. 60) on his earlier described species *Solenopleura? hispida*, from the Lower Acadian of Coulouma, Hérault, southern France, and used by him to include a number of species, all of Acadian age. In these the surface details of the cephalon vary considerably, ranging from forms in which the glabella carries tubercles arranged in transverse rows, or even fused together into transverse ridges, to others in which the surface of the glabella is smooth. Although the type-species was later described by Thoral (1948, pp. 52–55) as possessing both genal and occipital spines, in the present paper *Pardailhania* is considered to include also species lacking these features, a course followed by Thoral (1947) in his original diagnosis. Generally speaking, the species usually assigned to the genus fall into two groups as follows:

Group A. Surface of glabella ornamented with tubercles arranged in transverse rows or fused together to form transverse ridges separated by a smooth, longitudinal, median band as in the related genus *Sao*. Pair of ocular ridges usually well developed; sometimes a pair of fixigenal ridges present. Species include *P. hispida* (Thoral), *P. granieri* (Thoral), *P. multispinosa* Thoral, and *P. hispanica* Sdzuy *ex* R. and E. Richter MS.; *P. couloumana* (Miquel) may also belong here. All these species are easily distinguished by their ornate cephala from the Turkish specimens, and the first two listed above are figured here for comparison (Pl. 10, figs. 3, 5, 6).

Group B. Surface of glabella smooth, occasionally showing three or four poorly defined pairs of glabellar furrows. Pair of ocular ridges and, generally, one pair of fixigenal ridges well developed, though one species *P. paschi* Sdzuy, probably belonging here, has three pairs of fixigenal ridges, two of them small. Species include *P. tenera* (Hartt), *P. barthouxi* (Mansuy), and *P. paschi*.

The trilobite determined by G. and H. Termier (1950, p. 25, pl. 204, fig. 21) as *Pardailhania* cf. *couloumana* (Miquel) is poorly illustrated and may not belong to the genus.

Two species of North American Middle Cambrian trilobites have been referred by Shimer and Shrock (1944, p. 605) to the genus *Andrarina*, namely *A. ouangondiana* and *A. tenera*. *Andrarina*, type-species *Liostracus aculeatus* Angelin, 1854, was proposed by Raymond (1937, p. 1106) on the grounds that *Liostracus* Angelin 1854 was preoccupied by *Leiostracus* Albers 1850. This argument does not conform to the International Rules of Nomenclature and, in fact, *Liostracus* was first used by Mörch (1852, p. 26). His name was, however, an invalid emendation of *Leiostracus* Albers 1850, and as such it preoccupies *Liostracus* Angelin 1854, even though it has no validity as a generic name itself. The species *Andrarina ouangondiana* was described by Hartt (*in* Dawson 1868, p. 651) as *Conocephalites ouangondianus* but was figured for the first time by Walcott (1884, p. 37, pl. 5, figs. 4, 4*a–f*) who referred the species to *Ptychoparia*. The species appears to be a typical *Andrarina*, and Strand (1929, p. 339) has claimed that it is synonymous with *A. aculeata*. The so-called *Andrarina tenera* was also first described by Hartt (*in* Dawson 1868, p. 652) from the Saint John Formation of Portland, New Brunswick. Again the species was illustrated for the first time by Walcott (1884, pl. 5, figs. 6, 6*a*, *b*) who referred it to *Ptychoparia* and placed another species, described by Hartt (loc. cit., p. 654) as *Conocephalites neglectus* in the synonymy. There can be no doubt, however, that we are dealing with a typical *Pardailhania* of Group B as listed above. Walcott's diagrams of *P. tenera* show only the cranidium but they indicate that it differs from those of the Turkish specimens in having a more pointed glabellar outline, and a small median tubercle on the occipital ring. In addition, the largest specimen has a pair of basal glabellar furrows which meet across the centre of the glabella to form a single transglabellar furrow. The same species was redescribed as *Liostracus tener* by Matthew (1888, p. 137, pl. 1, figs. 3*a–c*) who illustrated a whole individual for the first time. The thorax of this specimen possesses fifteen segments, apparently about the same as those of the Turkish specimen described above, and an extremely small pygidium. Matthew's drawings show an even more pointed glabellar outline than do those of Walcott, with four pairs of glabellar furrows which were said to be visible only on the internal mould.

The Turkish specimens of *Pardailhania* most resemble the species first described by Mansuy (1922, p. 288, pl. 10, figs. 4*a–g*) as *Ptychoparia barthouxi* from Marakech, Morocco. All the specimens figured by Mansuy appear to be distorted by cleavage to a greater or lesser degree, but their cephala agree in all essentials with those of the Turkish material and are probably conspecific, though this cannot be certain in the absence of uncrushed specimens. The pygidium of the Moroccan species is not properly known, but the thorax consists of fifteen segments similar to those of both *Pardailhania tenera* and *P.* cf. *barthouxi* (Pl. 10, figs. 9, 12, 13).

P. paschi (Sdzuy 1958, p. 24, pl. 2, fig. 1) from the middle Murero-Schichten of Spain is easily distinguished from *P. barthouxi* by its possession of three pairs of fixigenal ridges, the two anterior pairs being small and convergent forwards, and the posterior pair comprising only transverse ridges. The carapace is smooth as in the other members of Group B, and the thoracic segments are of similar construction. The age of this species is Lower Acadian, as it has been recorded in association with *P. hispida* and *P. granieri* (Lotze 1958, p. 731).

Middle Cambrian fossils have been recorded elsewhere in Turkey from the Mardin region (Stubblefield *in* Tolum and Ternek 1952, p. 17) where the fauna includes *Paradoxides* and *Solenopleura* cf. *hispida*, indicating the presence of *Pardailhania* of Group A, though there is no record of any species of Group B.

Family AGNOSTIDAE M'Coy (s.l.)

Genus and species indet.

Plate 10, fig. 8

Only one other trilobite has been found with the specimens of *Pardailhania* cf. *barthouxi* described above. The state of preservation is extremely poor, but the fossil is figured here for the sake of completeness. It consists of the cephalon of an agnostid trilobite, about 3 mm. long and of similar breadth at the base, preserved as a damaged internal mould. Sufficient detail cannot be observed to make a firm generic determination, though numerous agnostids are known from strata of similar age in southern France (Howell 1937), some in association with *Pardailhania*, and Stubblefield (*in* Tolun and Ternek 1952, p. 17) has recorded *Peronopsis* and *Pardailhania* (= *Solenopleura* cf. *hispida*) elsewhere in Turkey.

Figured specimen. Km 566 b.

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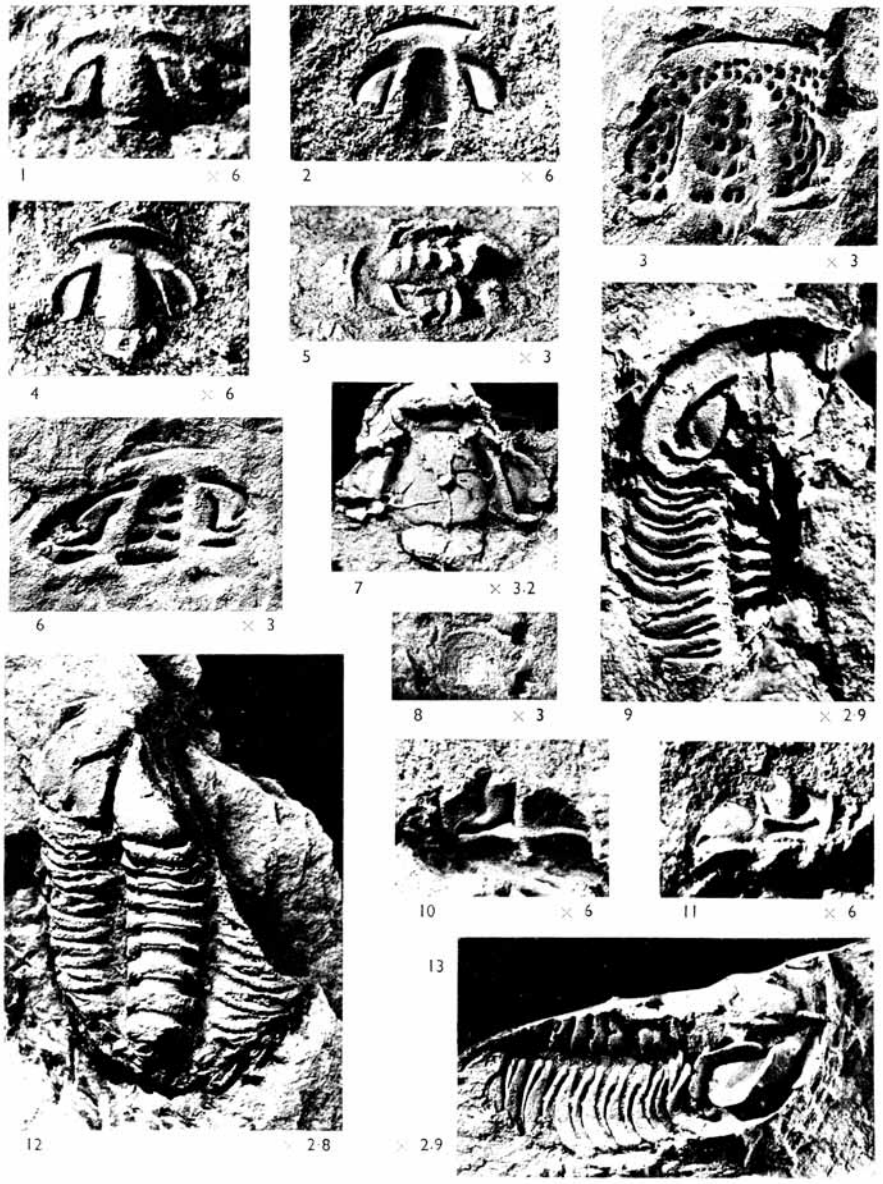

DEAN and KRUMMENACHER, *Pardailhania*