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Cambrian Stratigraphy and Trilobites of the Samur Dağ Area, South of Hakkâri, Southeastern Turkey

WILLIAM T. DEAN

Department of Geology, National Museum of Wales, Cathays Park, Cardiff CF10 3NP, U.K.
(E-mail: Bill.Dean@museumwales.ac.uk)

Abstract: Carbonates of the higher Koruk Formation at Yayla Tepe, near the Samur Dağ in southeastern Turkey and about 17 km north of the Iraq border, contain peri-Gondwanan Middle Cambrian trilobites typical of the Mediterranean Subprovince; these comprise at least seven genera and include the easternmost records in the Near and Middle East of *Eccaparadoxides* and the biozonal genus *Pardailhania*. In the lower half of the succeeding, largely clastic Seydişehir Formation, Upper Cambrian trilobites from six levels in decalcified limestone interbeds include four new species [*Coosinoides parthianus, Elegantaspis? montis, Prochuangia turcica, Taishania bassifrons*] in addition to *Chuangia*? sp. and *Palaeadotes* sp. Unlike underlying Middle Cambrian faunas both here and elsewhere in southern Turkey, the affinities of the Yayla Tepe Upper Cambrian trilobites lie particularly with those of, among others, the Kushanian, Changshanian and Fengshanian stages of north and northeast China. Relationships of these and other Upper Cambrian faunas in Turkey and peri-Gondwanaland are reviewed.

Key Words: trilobites, Cambrian, biostratigraphy, Southeastern Turkey

Samur Dağ Bölgesinin Kambriyen Stratigrafisi ve Trilobitleri, Hakkâri Güneyi, Güneydoğu Türkiye

Özet: Güneydoğu Türkiye'de Irak sınırından 17 km kuzeyde Samur Dağı yakınlarında yüzeyleyen ve Koruk Formasyonun en üst kesimlerini oluşturan karbonatlar Akdeniz asprovensi için tipik olan Gondwana çevresi Orta Kambriyen tribolitlerini içerirler. Trilobitler en az altı cins içerirken, Yakın ve Orta Doğu *Eccaparadoxi*'lerin en doğu kayıtları ile biyozonal cins olan *Pardailhania*'yı kapsarlar. Bu birimleri üzerleyen ve çoğunlukla klastik sedimanlardan oluşan Seydişehir Formasyonunun en alt kesimlerinde yüzeyleyen kireştaşı arakatkılarının altı farklı düzeyinden derlenen trilobitler *Chuangia*? sp. and *Palaeadotes* sp. türlerinin yanı sıra dört yeni tür içermektedirler [*Coosinoides parthianus, Elegantaspis? montis, Prochuangia turcica, Taishania bassifrons*]. Gerek çalışma alanında gerekse Güneydoğu Türkiye'nin diğer bölgelerinde yüzeyleyen Orta Kambriyen faunasının aksine, Yayla Tepe Üst Kambriyen trilobitleri kuzey ve kuzeydoğu Çindeki Kushanian, Changshanian and Fengshanian yaşlı kaya topluluklarında bulunan trilobitlerle benzerlikler sunarlar. Gerek bu çalışma sırasından tanımlanan fosiller gerekse Türkiye ve Gondwana çevresine ait diğer Üst Kambriyen faunası arasındaki ilişkiler gözden geçirildi.

Anahtar Sözcükler: trilobitler, Kambriyen, biyostratigrafi, Güneydoğu Türkiye

Introduction

The southeasternmost corner of Turkey (Figure 1), bounded by the borders with Syria, Iraq and Iran, is a mostly high, mountainous area which has long remained isolated from the rest of Asia Minor and Mesopotamia. As long ago as the early Roman period access was almost impossible, and remained unusually difficult relatively recently, as described in an account by Freya Stark (1959). In the eastern Taurus Mountains near the Samur [or Samora] Dağ, about 25 km SSW of the regional centre of Hakkâri, Lower Palaeozoic rocks form two unequal inliers, elongated east–west. They are traversed from north to south by the valley of the River Zap [sometimes Upper or Great Zab], which runs from Hakkâri into northern Iraq, eventually to join the River Tigris south of Mosul, and exposes an extensive N–S section to the north of the small town of Çukurca (Figure 1). The area falls within the Border Folds, one of the major structural units into which Turkey has been divided (Ketin 1966a; Gútnic *et al.* 1979; Özgül 1984). Lower Palaeozoic strata were first recognised by Altınlı (1963), who reported unnamed thick Cambrian (?) limestones, overlain by almost 1000 m of Giri Formation, comprising 'Silurian' (in fact, Cambrian and Ordovician) quartzites

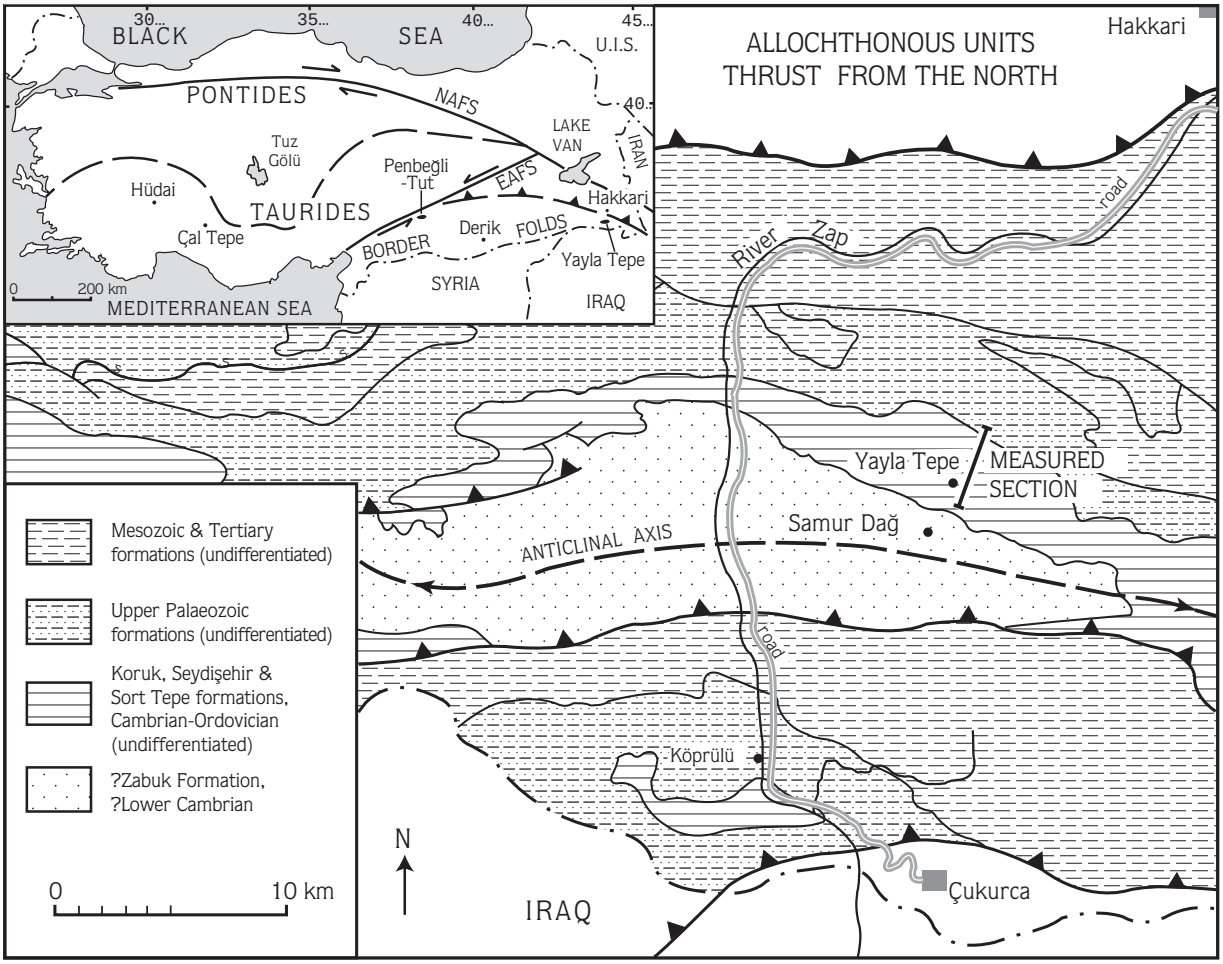

Figure 1. Inset map of Turkey shows principal structural subdivisions of the country, after Ketin (1966a), Gútnic *et al.* (1979) and Özgül (1984). The remainder of the figure is a simplified geological map of the mountainous area south of Hakkâri, showing the measured section on the east side of Yayla Tepe, based on T.P.A.O.'s map (*in* Dean *et al.* 1981; *in* Janvier *et al.* 1984). Age of units: ?Zabuk Formation = ?Lower Cambrian; Koruk, Seydişehir and Sort Tepe formations [undifferentiated] = Middle Cambrian to upper Ordovician; Upper Palaeozoic formations [undifferentiated] = Yığınlı and Köprülü formations (Devonian and Carboniferous) and Harbol Formation (Upper Permian carbonates); Mesozoic and Tertiary formations are undifferentiated but include Triassic marls, and Mesozoic and Eocene carbonates. EAFS= East Anatolian Fault System, NAFS= North Anatolian Fault System.

with subsidiary limestones and siltstones; some of the latter contained the trace fossil *Cruziana* and were compared by Altınlı with analogous rocks in northern Iraq. The succession was reviewed briefly by Dean (1975, p. 365, Figure 2) who tentatively correlated the quartzites with corresponding Arenig strata in the Seydişehir Formation of the Taurides. No Silurian outcrops have yet been proved in this part of Turkey, but the search for them continues.

The region south of Hakkâri was subsequently re-mapped by geologists of the Turkish Petroleum Corporation (T.P.A.O.), who demonstrated the importance of the reference section at Yayla Tepe (2152 m; Figure 1), about 2 km from the Samur Dağ and near the village of Ceylanlı, in the mountains about 11 km east of the Zap Valley. Field-work by the writer and Olivier Monod, with the logistical support of T.P.A.O. and its geologists, was undertaken in the summers of 1980 and 1981; the results were summarised by Dean *et al.* (1981,

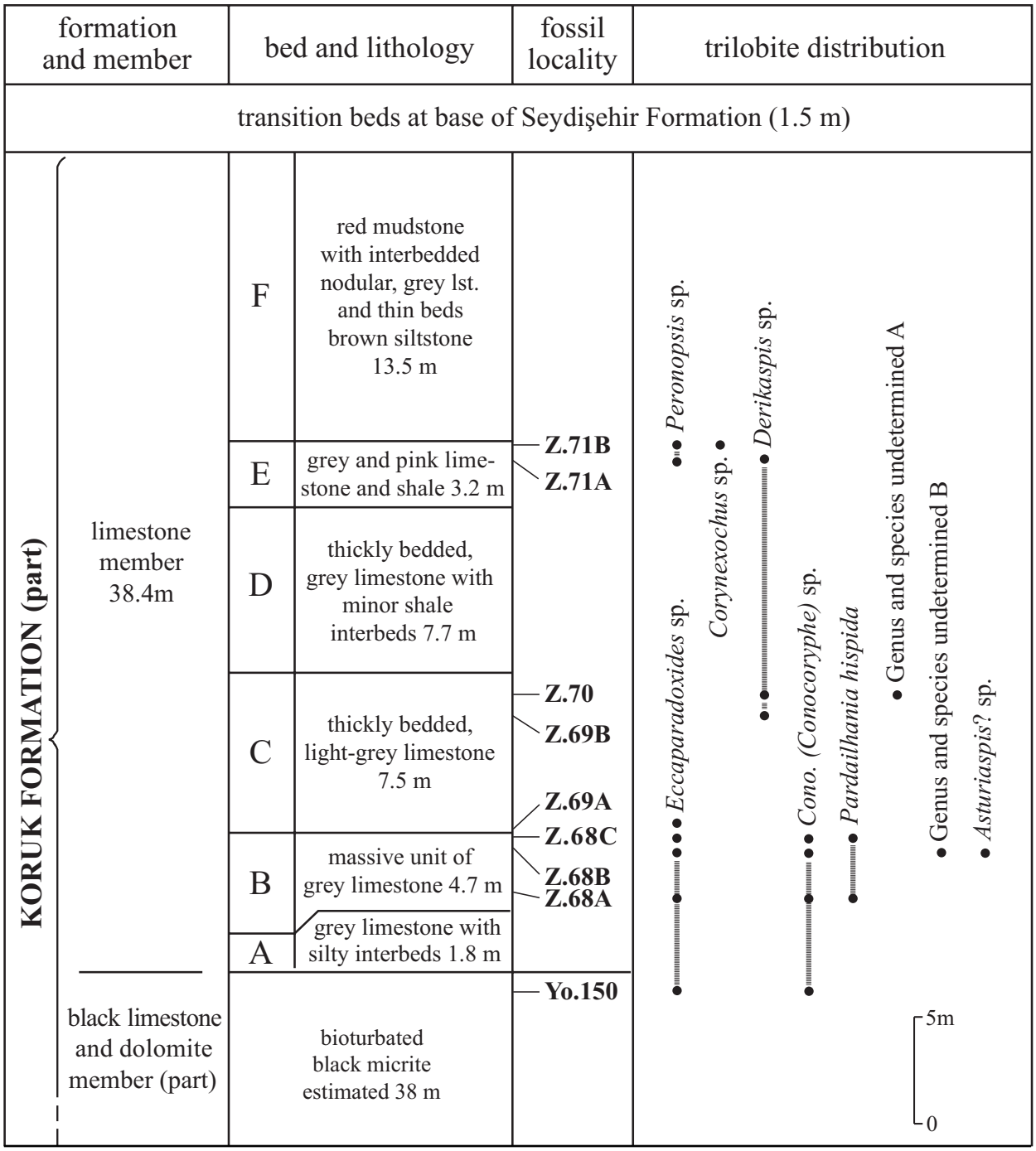

Figure 2. Measured section through the higher part of the Koruk Formation (Middle Cambrian) in the gorge along the southeastern side of Yayla Tepe, showing numbered fossil localities and vertical ranges of trilobites. Individual beds are indicated by capital letters A to E so as to avoid confusion with the lower case letters a to i used for the Upper Cambrian portion of the Seydisehir Formation in Figures 3 and 4.

p. 276), and additional comments were furnished by Dean & Monod (1997). Certain of the latter conclusions are necessarily provisional, and further fieldwork at Yayla Tepe and in the Zap Valley, undertaken with the help of T.P.A.O. during summer 2004 had to be curtailed owing to security problems in the vicinity of the Iraq border.

Lithostratigraphy

The oldest Phanerozoic rocks in the Border Folds region belong to the Zabuk Formation, listed originally by Schmidt (1965) as Zabuk quartzite/sandstone formation and named for a village in the Derik-Mardin inliers, 300 km west of the Zap Valley (Figure 1), where the unit rests unconformably on almost 500 m of andesites, spilites and tuffs with interbedded red sandstone and shale. The volcanic rocks (with base unexposed) were termed Derik Volcanics by Kellogg (1960), and Derik Formation by Rigo de Righi & Cortesini (1964), who postulated a thickness of more than 2000 m, and by Schmidt (1965). Ketin (1966b, p. 77) introduced a new name, 'Telbismi Formation', for the same rocks, but this has since been abandoned (Dean 1982a), having been used earlier (as Telbesmi Formation) by Kellogg (1960) for what is now the Sadan Formation. Positive evidence of age is lacking, but the Derik Formation is generally assigned, questionably, to the Precambrian because it is overlain disconformably by basal sandstones of the Zabuk Formation, said by Kellogg to be 584 m thick at the type section, where they pass upwards into the Koruk Formation without any discernible break. In the sides of the Zap Valley, outcrops of thickly bedded grey and brown quartzite and sandstone, often with ripple marks and cross-bedding, are referred questionably to the Zabuk Formation (Figure 1); the base is unexposed, but an intercalated limestone bed by the east side of the Zap Valley yielded a single, specifically undeterminable fragment of *Archaeocyathus*, suggesting an Early Cambrian age (Debrenne in Dean *et al.* 1981, p. 275). The Koruk Formation marks a change from clastic to carbonate deposition that is mirrored in other parts of southern Turkey. The name was introduced by Schmidt (1965) as 'Koruk Ls/Dol Fm' and corresponds to Kellogg's (1960) 'Sadan Dolomite', 243 m thick (see Dean 1982a for review of terms). At its type section, southeast of Derik, the succession is divisible into 228 m of thickly bedded dolomite, followed by 15 m of thinly bedded, grey and pink, sometimes nodular calcilutite, with minor beds of calcarenite. This bipartite subdivision is broadly applicable, although with minor, local variations in both lithology and age, along parts of the Taurides region. It is certainly appropriate for the Zap Valley and Samur Dağ areas, where an estimated >300 m of thickly bedded, grey dolomite occur, in which no macrofossils or microfossils were found. The term black limestone & dolomite member is used here (Figure 2) for the lower part of the Koruk Formation, which ends with a 38 m (estimated) unit of thickly bedded, tough, black bioturbated micrite that yielded a few fragments of Middle Cambrian trilobites; this unit represents a lithofacies that is diachronous along the length of the Taurides and resembles parts of the black limestone member which have been dated by means of trilobites as late Early Cambrian at the Çal Tepe Formation's type section near Seydişehir, 1000 km west of the Zap Valley (Dean & Monod 1970; Dean 2005), and are overlain there by basal Middle Cambrian light-grey carbonates containing the zonal species *Acadoparadoxides mureroensis*.

The succeeding limestone member, 38.4 m thick as measured in the gorge section along the southeast side of Yayla Tepe, is divided (Figure 2) into six informal beds, A to F; the lowest unit, Bed A, is thin (1.8 m of grey limstone with silty interbeds) and did not yield any macrofossils, but most of the other units comprise thickly bedded, light- or medium-grey limestone and some (B, C and E) contain trilobites which are generally difficult to extract. Bed E (3.2 m) marks a change to pink and grey limestone and calcilutite with subsidiary shale, lithologies that are essentially transitional to Bed F (13.5 m), where interbeds of grey nodular limestone and thin, brown siltstone levels occur within conspicuous, often almost brick-red mudstone from which no macrofossils or microfossils were obtained. The Koruk Formation's type section, near Derik, consists mostly of thickly or massively bedded dolomite and quartzite, but the highest 13.6 m (Dean *et al.* 1981, and author's observations) include thin (5 cm) limestone beds with regressively weathering interbeds of red and grey-green, rubbly siltstone which form an increasing proportion of the unit; no bright red mudstones and siltstones like those at the Samur Dağ were seen.

Although the Cambrian rock succession from the Zabuk Formation to the top of the Koruk Formation in the vicinity of the Zap valley can be broadly correlated

with lithologies in the Derik-Mardin inliers, the succeeding strata are lithologically distinct and coincide with an important change in palaeogeographic relationships that is related to an episode of Upper Cambrian marine transgression along the peri-Gondwanan margin. Southeast of Derik, the lowest part of the largely clastic type section, 1057 m thick, of the Sosink Formation (Kellogg 1960; Dean 1982a) comprises 225 m of brown-weathering, grey silty shale and siltstone with numerous thin (c. 5–6 cm) beds of fossiliferous grey calcilutite and calcarenite which contain a varied fauna of trilobites and inarticulate brachiopods as yet unknown from the remaining 832 m (estimated); the latter are mainly brown-weathering, thickly bedded, often current-bedded siltstones and sandstones, poorly fossiliferous but of late Middle and, in part, Late Cambrian age, which form part of a postulated 'Sosink Graben' (Dean & Monod 1990, p. 341) and extend upwards to the unconformable base of the Bedinan Formation (Ordovician, Caradoc Series).

Light-brown, fissile mudstones occur in the lower and middle Sosink Formation in its type area and are found also in the Penbeğli-Tut inlier, about 500 km west of the Zap Valley (Dean *et al.* 1997), where several characteristic Koruk and Sosink trilobites are reported. By contrast, the Koruk Formation in the Zap Valley and particularly along the conspicuous ridge of Yayla Tepe is succeeded by strata which not only differ lithologically from those at Derik but also contain, in their lowest 970 m (estimated), Late Cambrian faunas of Asiatic affinities as yet undescribed elsewhere in Turkey and distinct from latest Cambrian or earliest Ordovician genera from the Sultan Dağ and Çal Tepe areas, in the western Taurides (see later). Corresponding strata have not been seen in the Derik and Penbeğli-Tut inliers, where late Middle and/or Late Cambrian clastics are overlain successively by Late Ordovician shales and Cretaceous carbonates.

Strata forming the lower half of the Seydişehir Formation at Yayla Tepe become younger northeastwards along the ridge-like hill and are divided here into nine successive informal units, a to i (Figures 3 & 4). The Koruk/Seydişehir formational boundary coincides with the top of Bed F and forms a noteworthy bedding-plane which descends into a small gully and marks a change to more regressively weathering strata. Overlying the lowest part of the dip slope is a small section in 1.5 m of grey silty shale, interpreted as transitional strata at the base of Unit a; the remainder of the latter consists largely of green-grey silty shale with subsidiary thin layers of quartzite and sandstone, a few of which comprise deeply weathered lenses of decalcified, sandy limestone. Most of the remainder of Yayla Tepe is occupied by monotonous, brown-weathering, dark grey or green silty shales, but units b, c and d are sufficiently arenaceous and resistant to form low ridges at the southwestern end of the hill. The northeastern end of Yayla Tepe is formed by a conspicuous, large bedding-plane at the top of Unit i which descends steeply to the bank of the stream in Ceylanlı Deresi (Figure 3). Recognisable macrofossils are both rare and difficult to extract from the tough, grey micritic matrix, but the slightly undulating upper surface is marked by occasional weathered-out fragments of trilobites, assembled here under locality number Yo.162. From the valley of Ceylanlı Deresi the topography rises steeply northeast to the feature formed by resistant, transgressive Devonian rocks of the Yığınlı Formation (Janvier *et al.* 1984). The remaining 1100 m (estimated) of the Seydişehir Formation are well exposed on the hillside and comprise dark, silty shales and thinly bedded sandstones. The upper 500 m (estimated) yielded numerous examples of *Cruziana*, including the widespread ichnospecies *C. furcifera* d'Orbigny 1842, but no body fossils, and the succession resembles Arenig strata of the type Seydişehir Formation in the central Taurides.

Age and Relationships of the Trilobites

Middle Cambrian

Middle Cambrian trilobites of Acado-Baltic (including eastern Appalachian and Mediterranean) type extend from eastern North America through Central and southern Europe (France, Iberia, Bohemia) and across North Africa from Morocco at least to the basement rocks of the Qatara Depression in the Western Desert of Egypt (Andrawis *et al.* 1983). In southern Turkey they can be traced from the southwest of the country along the Taurides (including the Hüdai and Çal Tepe areas) and the Border Folds as far as Yayla Tepe.

All the genera recorded from the Koruk Formation at Yayla Tepe are typical of assemblages found in the Acado-Baltic and Mediterranean subprovinces and most, including *Peronopsis, Eccaparadoxides, Conocoryphe* and *Corynexochus*, have an extended vertical range within the

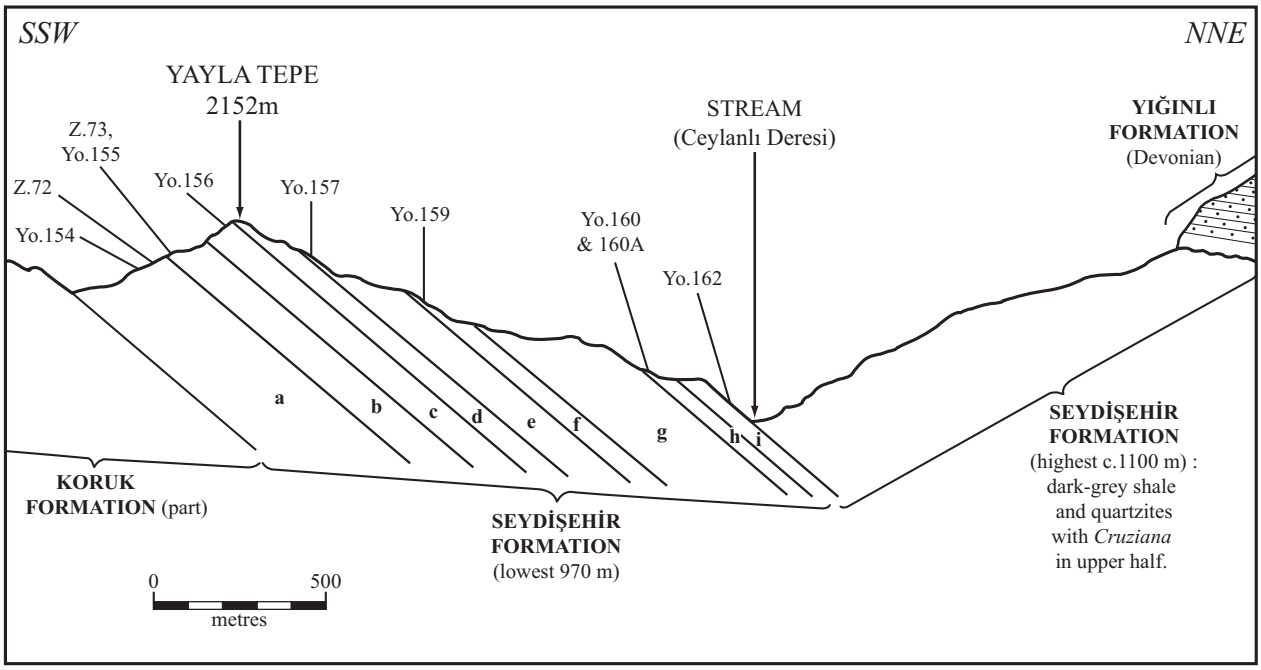

Figure 3. Ascending SSW–NNE cross-section along the crest and southeastern side of Yayla Tepe, showing position of trilobite-bearing localities in the lower half (Upper Cambrian) of the Seydişehir Formation as listed in Figure 4 (after Dean *et al.* 1981, fig. 7).

Middle Cambrian. Exceptions are *Pardailhania* Thoral 1947 and *Derikaspis* Dean 1982a. The former, based on a French species, is index genus of the *Pardailhania* Biozone; it is widespread from Iberia and southern France, through Sardinia (Rasetti 1972) into southeastern Turkey, by way of the Taurides to the Border Folds, where the Yayla Tepe material represents its, as yet, easternmost record. Shergold & Sdzuy (1984, p. 78), when discussing the evolution of solenopleurid genera in what is now the Caesaraugustian, defined *Pardailhania* as being distinguished from the stratigraphically preceding genus *Badulesia* by the appearance in the type (and biozonal) species *P. hispida* of a single, transverse row of spines on the preglabellar field, and this feature is clearly seen in specimens from Bed B (Z.68A, Z.68C) at Yayla Tepe (Plate 1 (f), (g), (l), (k), (q)). *Derikaspis*, founded on material from strata in the Derik-Mardin inliers now assigned to the topmost Caesaraugustian and Languedocian, occurs there with *Chelidonocephalus* King 1937; the latter genus, based on an Upper Cambrian type species fom Iran, is found also in the Languedocian of southern France (Dean 1982a, pp. 28, 35; Courtessole *et al.* 1988).

The oldest trilobites yet found in the Samur Dağ area are rare *Eccaparadoxides* sp. and *Conocoryphe* sp.; both are specifically undeterminable but of Middle Cambrian age and occur here (Yo.150) in the topmost Koruk Formation, in the highest part of a 38 m unit of bioturbated black micrite. The lithology has not yet been found in the Koruk stratotype near Derik, but it resembles parts of the black limestone member of the Çal Tepe Formation's stratotype in the central Taurides (Dean & Monod 1970; Dean 2005) and represents yet another example of the diachronous nature of some lithofacies in the Lower and Middle Cambrian of southern Turkey. The black limestone at the Çal Tepe is of late Early Cambrian age, yields both ellipsocephalid and protolenid trilobites, and is overlain, apparently conformably, by the light-grey limestone member, the lowest part of which contains the biozonal species *Acadoparadoxides mureroensis* (see Dean 2005). Both the Acado-Baltic and Mediterranean subprovinces are characterised particularly by the variety and abundance of *Eccaparadoxides, Paradoxides* and related genera, and the Samur Dağ represents their most easterly known occurrence in the Near and Middle East. They have not yet been recorded in adjacent parts of Iran,

but certain genera (*Abharella, Chelidonocephalus*) from the higher Middle Cambrian and Upper Cambrian of northern Iran are known from slightly lower levels (*Pardailhania* and *Solenopleuropsis* biozones respectively) in the Penbeğli-Tut and Derik-Mardin inliers, southeastern Turkey (Dean 1982a; Dean & Monod 1997; Dean *et al.* 1997). A record of *Abbarella* [sic] sp. from Niveau H (highest Middle Cambrian) of the Montagne Noire by Courtessole *et al.* (1988, p. 47, pl. 5, fig. 17) is considered doubtful.

The youngest Middle Cambrian trilobites at Yayla Tepe occur in the upper part of Bed E, and neither of the adjacent beds D and F yielded macrofossils. Genera include *Peronopsis*, which has a long range through most of the Middle Cambrian in Sweden (Westergård 1946, p. 98), together with *Derikaspis*, mainly indicative of the Caesaraugustian and lower Languedocian. *Corynexochus*, a very small, geographically widespread genus found as far distant as the Idamean of Australia, is uncommon in Bed E; it is recorded from the *Jincella* [*Solenopleura*] *brachymetopa* and *Lejopyge laevigata* biozones [= highest Middle Cambrian, and approximately upper Languedocian] in Sweden, its type area (Westergård 1953). In southern Turkey the genus is particularly abundant in red nodular limestones of the *Pardailhania* Biozone at the Çal Tepe and Hadim, central Taurides (Dean 2005); in the Montagne Noire, southern France (Courtessole 1973, pp. 72, 75) closely similar examples preserved in mudstone were recorded no higher than the *Pardailhania* Biozone. The limestone member of the Koruk Formation at Yayla Tepe may not extend as high as the top of the Caesaraugustian, and the possibility of a stratigraphic hiatus at the Koruk-Seydişehir formational boundary cannot be excluded.

The Derik-Mardin inliers of the Border Folds (Figure 1), although small in area, expose a large thickness of Cambrian rocks, including about 1060 m of mostly clastic sediments, the type Sosink Formation; these contain trilobites of late Caesaraugustian age (*Solenopleuropsis*) at the base, followed by others interpreted as earliest Languedocian within a thickness of 200 m (Dean 1982a). Succeeding strata yielded few macrofossils but beds with *Holasaphus mesopotamicus* Dean 1972, estimated to be about 450 m above the base of the type Sosink Formation, were originally assigned to the late Middle Cambrian; the latter age was later confirmed by means of acritarchs (Martin *in* Dean *et al.* 1997) for similar strata and trilobites less than 10 metres (estimated) below the regional Cretaceous unconformity at Kaplandere, in the Penbeğli-Tut inlier (Figure 1). This leaves the upper 560 m of the type Sosink, now under investigation but provisionally assigned to the Upper Cambrian; the relationship of these clastic to the lower Seydişehir Formation of Yayla Tepe is not yet clear.

Upper Cambrian

Between the highest fossiliferous level in the Koruk Formation (Bed E, Z.71B) at Yayla Tepe and the lowest fossiliferous sample in the Seydişehir Formation (Unit a, Loc. Yo.154) are some 228.5 m of strata (13.5 m of Koruk carbonates and 215 m of Seydişehir clastics) in which no macrofossils or microfossils were found. From this point upwards there is a marked change in the affinities of the faunas, which are of Chinese and Iranian type, rather than Mediterranean and Acado-Baltic.

The Upper Cambrian of China is conventionally divided into three stages, Kushanian, Changshanian and Fengshanian in ascending order, names based on corresponding 'Series' introduced for North and Northeast China by Sun (1923, 1924). These were subsequently employed by Kobayashi (1933) and by Sun (1935, tables A, B), whose sequence, after due allowance for changes in faunal nomenclature, differs remarkably little from later compilations such as those by Lu & Dong (1953, p. 183, based on a revision of type sections in Shandong), Zhang Meisheng (1989, pp. 127–130), Zhu Zhaoling & Wittke (1989), Peng (1992, p. 10), Chang & Jell (1987, p. 33) and Shergold *in* Kaesler (1997, p. 309). Sun considered his 'Kushanian or *Drepanura* Zone' to be Middle Cambrian, and the remainder of his original sequence is as follows: Changshanian Stage, C1 *Chuangia batia* or *Chuangia* Zone, C2 *Changshania conica* Zone, C3 *Kaolishania pustulosa* Zone; Fengshanian Stage: F1 *Ptychaspis subglobosa* Zone, F2 *Sinosaukia pustulosa* Zone, F3 *Quadraticephalus walcotti & Saukia acamus* Zone. The present zonal table (Figure 5) offers essentially a compromise between the interpretations of various authors, none of which differ significantly, and the following discussion is arranged in ascending stratigraphic order of stages and zones.

Kushanian Faunas. The stratotype is at Kushan [= Hushan] in Shandong [= Shantung] Province where,

according to Peng (1992, p. 9), 'The base is generally defined by appearance of *Blackwelderia*, and the Stage is characterised by by the Damesellidae, *Monkaspis* and *Liostracina*'. As noted earlier, the assemblage of *Prochuangia* and *Palaeadotes* (determined originally as *Bergeronites*) from Niveau I in the Montagne Nore was said by Chang (1996) to be of Kushanian age, and on this criterion the association of rare *Palaeadotes* with abundant *Elegantaspis*? and *Prochuangia* at Z.73 could be considered as Kushanian. The level is about 75 m higher than a single record (at Yo.154; Figure 4) of a few specimens referred questionably to *Chuangia*?; if correctly assigned, the latter may represent a genus that was redescribed by Chang & Jell (1987, p. 199) and recorded by them only from the *Chuangia* Biozone of the lowest Changshanian, that is to say from post-Kushanian strata.

Changshanian Faunas. At the stage's stratotype, in Hebei Province (Peng 1992, p. 9), the base is drawn at the appearance of *Chuangia* and *Luotuolingia*; Damesellidae disappear and are replaced by Changshaniidae and Kaolishaniidae. In the Elburz Mountains of Iran, Kushan (1973, pp. 125–128, Tables 2, 3) employed successive zones of *Drepanura, Prochuangia, Kaolishania* and *Alborsella* for the Upper Cambrian; he assigned the overlying *Saukia* Zone to the Tremadoc (basal Ordovician), as did Wolfart (1970), but the nominal trilobite is now re-assigned to *Mictosaukia* (see later) and the zone is better considered as highest Upper Cambrian.

Chuangia Zone. The occurrence of rare, poorly preserved *Chuangia*? sp. at Yo.154 (see above) in the upper third of Unit a represents the only record of the index leiostegiid from Turkey, and further material is required. Although the level pre-dates the lowest evidence of *Palaeadotes, Elegantaspis*? and *Prochuangia* at Yayla Tepe, it should be noted that in North China Lu & Qian (1983, pp. 248–249) divided the *Chuangia* Zine into two parts: an upper, or B, *Chuangia subquadrangulata* Subzone, with several subspecies of *Chuangia* or its subgenera; and a lower, or A, *Prochuangia mansuyi* Subzone, with species of, among others, *Paracoosia, Prochuangia* and *Pseudagnostus*. The same authors noted that '*Prochuangia* is usually associated with *Chuangia*, but more frequently very abundant below the beds containing *Chuangia*'. The stratigraphic position of the two genera was correlated by Lu & Qian (1983, p. 249) with approximately the upper half of the *Olenus* Zone in Sweden (Westergård 1947) and the westerly extension of the *Prochuangia-Chuangia* faunas from China through the Middle East to the western Mediterranean was noted. For present purposes the base of the Changshanian at Yayla Tepe is provisionally drawn at Z.73.

Changshania Zone. Presence not confirmed.

Maladioidella Zone. No evidence for the zone has so far been found at Yayla Tepe and the unit was omitted by Zhou & Yuan (1982, p. 294) from their zonal table for North and Northeast China, although it was retained by Zhang (1989). In the Sultan Dağ area of the western Taurides (Figure 1), some 1100 km west of Samur Dağ, the index genus was reported (as *Maladioidella kelteri*) by Shergold & Sdzuy (1984, p. 88), who also reillustrated same type material of the type species, *M. splendens* Endo *in* Resser & Endo 1937, from Liaoning Province, northeast China; they attributed to the genus an age approximating to the *Olenus* Biozone of Scandinavia and the Welsh Basin. If *M. kelteri* is correctly assigned to *Maladioidella*, the relevant Sultan Dağ fauna may represent a Changshanian level that either is younger than any of the assemblages at Yayla Tepe, or is not yet recognised there. The genus may occur in Iran, where *Saratogia latefrons* King (1937, p. 10, pl. 2, figs. 3a-c), from Imam Sayad Hassan, west of Isfahan, was referred to *Maladioidella* by Wolfart & Kürsten (1974, p. 218). The eponymous genus of the *Kaolishania* Zone, based on *K. pustulosa* Sun (1924, p. 53) from the Changshanian of Shandong (see also Chang & Jell 1987, p. 224), has not so far been found at Yayla Tepe but was recorded, as *Maloidella* [sic], from the Upper Cambrian of Oman (Fortey 1994, p. 43). Kushan listed *Kaolishania, Chuangia* and *Prochuangia* from a 52 m unit of dark-grey limestone in the Elburz Mountains of northern Iran, but Wittke (1984, p. 99) claimed that *Kaolishania* does not occur there and referred Kushan's material to a new subgenus *K. (Eokaolishania)*. *Taishania bassifrons*, from Yo.157 in the lowest part of unit e at Yayla Tepe, occurs there with *Prochuangia* and reprsents a genus whose type species, *T. taianensis* Sun (1935, p. 68, pl. 3, figs. 20–25), is recorded only from the *Kaolishania* Zone (see also Chang & Jell 1987, p. 244, pl. 120, figs. 5–12).

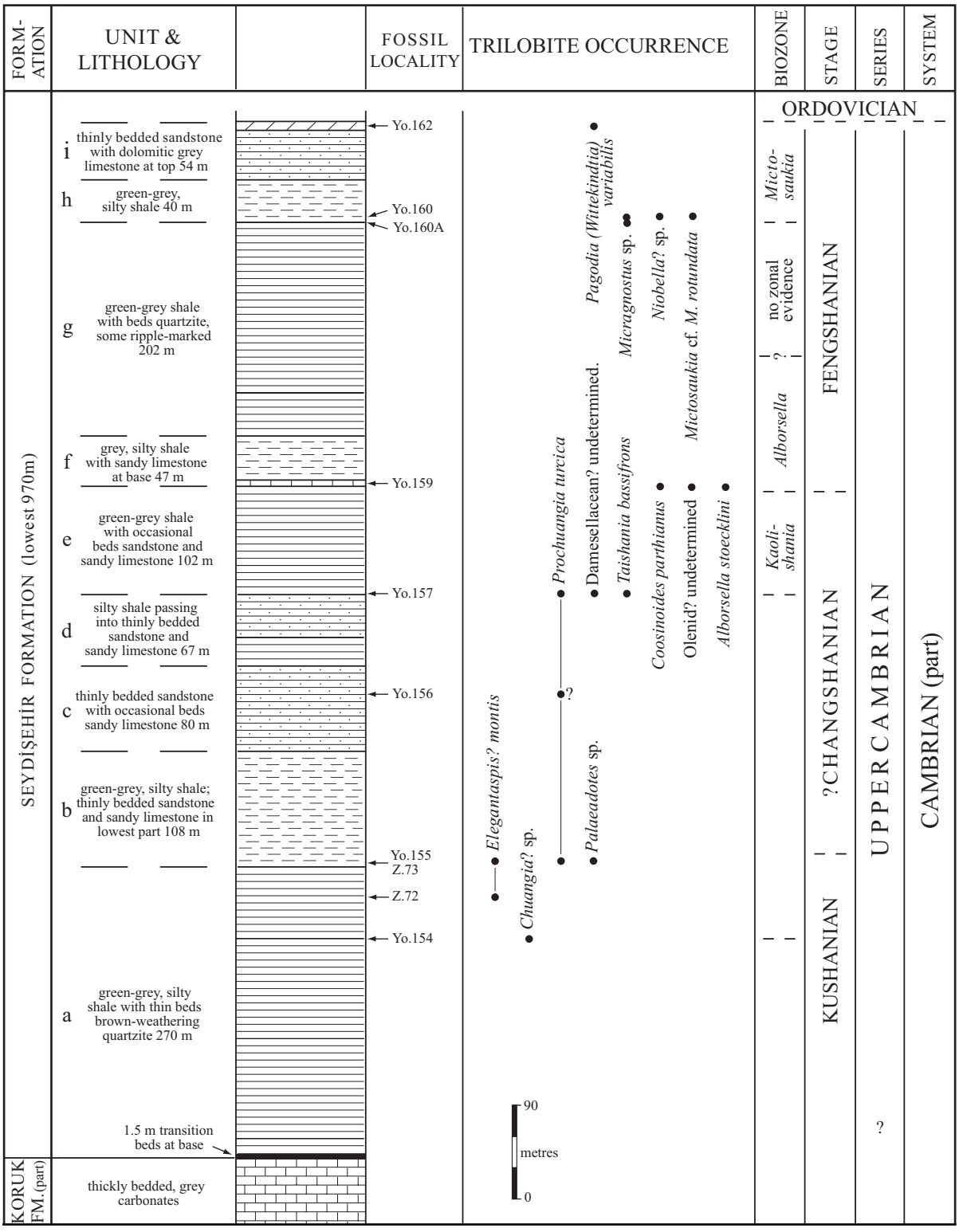

Figure 4. Stratigraphic column for the lower half (Upper Cambrian) of the Seydişehir Formation at Yayla Tepe, showing vertical ranges of trilobites and levels of fossil localities in relation to units a to i. Locality Z.85, listed in the text and positioned on the east side of the Zap Valley, 10.7 km west-northwest of Yayla Tepe, is estimated to be at the same level as Locality Z.73.

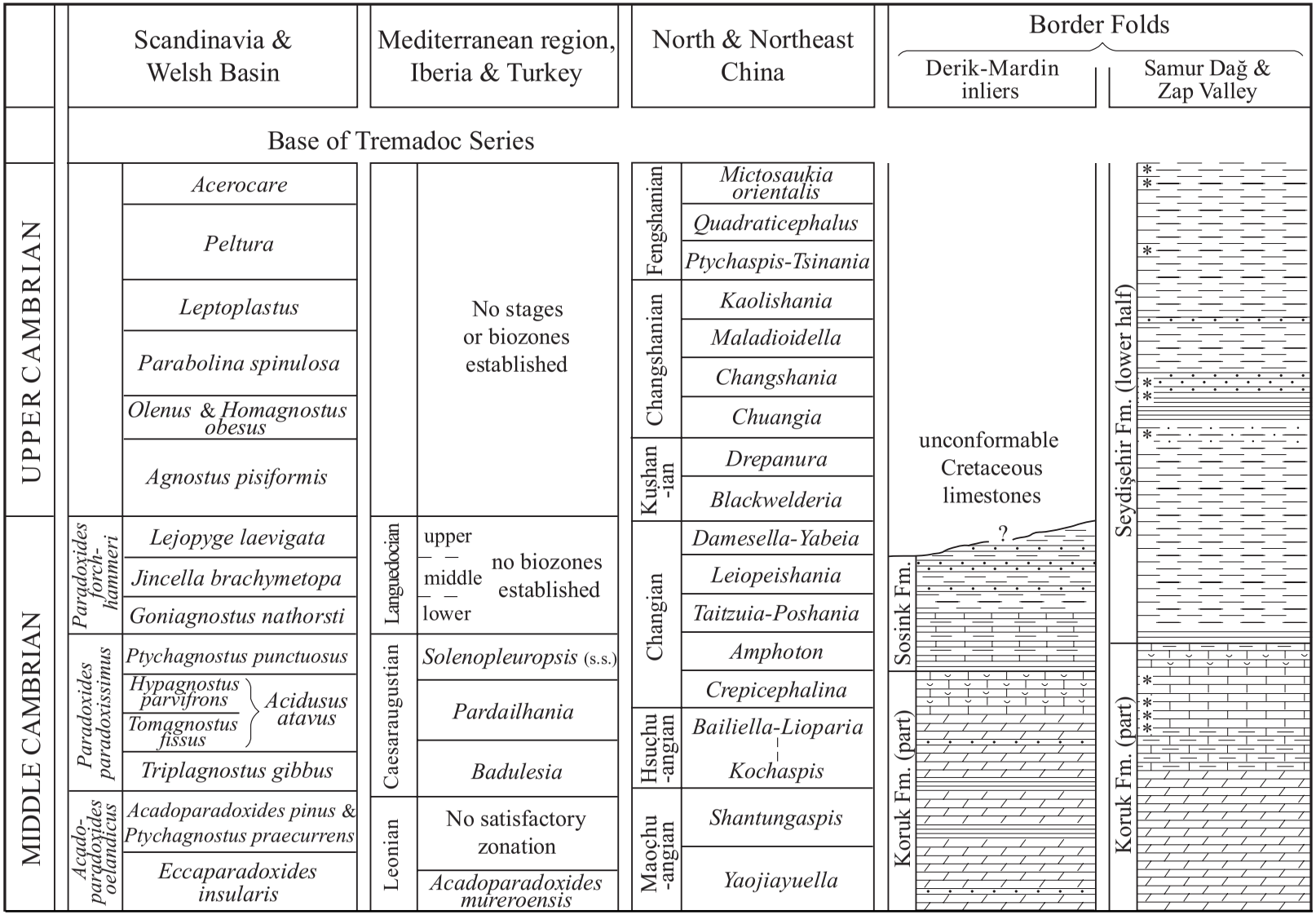

Figure 5. Table showing correlation of the Koruk Formation and lower Seydişehir Formation at Yayla Tepe and in the Border Folds of Turkey with Middle and Upper Cambrian biozones and stages in Balto-Scandia, the Mediterranean region, and North and Northeast China. Asterisks indicate approximate positions of fossiliferous levels at Yayla Tepe.

Fengshanian and Younger Faunas. At the stratotype, in Hebei Province, northeastern China (Peng 1992, p. 9), the base of the stage is drawn at the appearance of saukiid trilobites and *Tsinania*, whilst the top is marked by the entry of conodonts that pre-date the appearance of *Rhabdinopora flabelliformis* subspecies. Shergold (1991, p. 23) included within *Mictosaukia* a large number of geographically widespread species but excluded some that he had earlier (Shergold 1975) assigned to the genus, which he said was 'restricted to a relatively narrow interval at the close of the Late Cambrian', corresponding presumably to the *Mictosaukia orientalis* Zone of earlier workers. He assigned to the genus both *Saukia rotundata* Kushan (1973, p. 157) from northern Iran, and *S.*cf. *rotundata* from Yayla Tepe, Yo.160 described by Dean (1982b, p. 91). Also included in *Mictosaukia* by Shergold were *Saukia wirtzi* Wolfart (1970, p. 43) and *Saukia turgida* Wolfart (1970, p. 47), both of which came from strata in Afghanistan assigned by Wolfart to the Tremadoc but now interpreted as highest Upper Cambrian.

The lower limit of the Fengshanian at Yayla Tepe is drawn provisionally here at the base of Unit f, 47 m of grey, silty shale with a thin basal bed of decalcified limestone (Yo. 159) which yielded the ptychaspidid genius *Alborsella Kushan* (1973, p. 153), proposed by its author as index for the highest part of the Upper Cambrian as interpreted by him. An *Alborsella* Zone has not been recognised in the Chinese Upper Cambrian, but the term was retained by Wittke (1984, p. 97) for the Elburz succession and is applied here to an undetermined thickness of largely silty shale and quartzite beds above Yo.159. The stratigraphic value of the associated crepicephalid *Coosinoides parthianus* sp. *nov.* is not yet evident but the type species, *C. elegantulus* Ivshin 1962, came from the Kuyandinian Stage of Kazakhstan, which corresponds approximately to the type Changshanian. An associated, undetermined olenid? at Yo.159 adds no reliable evidence of age, but certain features (see later discussion) recall highest Upper Cambrian genera from Scandinavia reviewed by Westergård (1922) and by Henningsmoen (1957; *in* Moore 1959).

Material from Yo.160, in the lowest part of Unit h at Yayla Tepe, is now assigned to the highest Fengshanian (Upper Cambrian) rather than to the lower Tremadoc. The meagre sample includes also an incomplete, compressed asaphid cranidium and pygidium illustrated by Dean (1982b, pl. 1, figs 12, 16) as *Niobella*? sp., a genus first described from the Tremadoc of Wales but found also in the higher upper Upper Cambrian. A broadly similar form from the Sultan Dağ, western Taurides, was assigned by Shergold & Sdzuy (1984, p. 106) to *Niobella* cf. *primaeva* (Westergård 1909; see also Henningsmoen 1958), a latest Cambrian (*Acerocare* Zone) species in Sweden and Norway. The Sultan Dağ trilobite is one of an assemblage (including apecies of *Proteuloma, Koldinioidia, Onchonotellus, Macropyge* and *Parakoldinia*) that is widespread in southern Turkey and was considered as 'initial Tremadocian' by Shergold & Sdzuy, who reviewed its distribution in a belt extending from Mexico (Robison & Pantoja-Alors 1968) to China and Korea. More recently Loi *et al.* (1996) re-interpreted these Sultan Dağ faunas and related assemblages in Sardinia as highest Upper Cambrian, associated with a widespread marine regression in the *Acerocare* Zone (the *Acerocare* Regressive Event of Erdtmann 1986) and followed by marine transgression that accompanied an increase in distribution of the graptoloid *Rhabdinopora flabelliformis*.

For some years it has become increasingly clear that several trilobites previously considered indicative of the Tremadoc appeared earlier, whilst certain genera and even species may cross the Cambrian/Ordovician boundary as defined by the incoming of *R. flabelliformis*. For example, *Proteuloma* cf. *geinitzi* (Barrande 1868), recorded from the Sultan Dağ, western Taurides, by Shergold & Sdzuy (1984) refers to a species from the Lower Tremadoc of Bavaria that is recorded from the same level in the type Tremadoc area of North Wales (Rushton 1982, p. 550), where the genus, together with other 'Tremadoc' forms occurs below the first appearance of *R. flabelliformis*. In Hunan Province, southeast China, Peng (1992, pp. 10, 14) described *Proteuloma* from strata correlated with the highest part of the *Acerocare* Zone. *Macropyge* Stubblefield *in* Stubblefield & Bulman (1927), based on a British Lower Tremadoc type species, occurs in both the central and western Taurides, where its age was postulated as early Tremadocian (Özgül *et al.* 1973; Shergold & Sdzuy 1984), but the genus occurs in the Upper Cambrian of China (Peng 1992, p. 41). Relevant strata of southern and southeastern Turkey have not yet yielded dendroid graptolites and the rarity of limestone beds suitable for etching limits the use of conodonts.

The youngest trilobites collected at Yayla Tepe are leiostegiids from Yo.162, assigned by Dean (1982b, p. 91, pl. 1, figs. 1–6) to *Pagodia* (*Wittekindtia*) *variabilis* Wolfart 1970. The species was first described from the supposed Lower Tremadoc of Surkh Bum, central Afghanistan, and founded on type material from two localities which yielded, among others, *Harpides* and *Macropyge* (both widespread in the Tremadoc), an asaphid *Hazarania*, an acrocephalitid *Afghancephalites*, a pilekiid, and the two *Saukia* species noted above, now put in *Mictosaukia* and considered as highest Upper Cambrian. In northeastern Spain, *Pagodia* (*Wittekindtia*) *alarbaensis* Shergold & Sdzuy (1991, p. 214) closely resembles the corresponding Yayla Tepe material.

The Upper Cambrian/Ordovician boundary at Ferrals-les-Montagnes, in southern France, is imprecisely defined, and coincides in Courtessole *et al.*'s (1988, fig. 18) section with a trilobite-free interval of 461 m which separates the upper limit of '*Bergeronites*' [now *Palaeadotes*] and *Prochuangia* from the appearance of '*Euloma* (s.l.). *Onchonotellus* (s.l.)' in the supposed Tremadoc; in other words from genera corresponding to those in the western and central Taurides that could equally well be considered indicative of the Upper Cambrian. Assemblages like those at the Sultan Dağ are known also from impersistent pink and grey limestone beds within clastics of the Seydişehir Formation in the Çal Tepe area, central Taurides (Dean & Monod 1970; and in Dean 2005, p. 19). Samples are smaller and less varied than those from the Sultan Dağ, but *Micragnostus*?, *Niobella*? and, especially, *Proteuloma* cf. *geinitzi* are common to both areas. No graptoloids have been found in the adjacent silty clastics and the possible Fengshanian age of the trilobites remains unconfirmed. No comparable faunas are yet known from the Yayla Tepe area, where the oldest Ordovician fossils are abundant examples of *Cruziana furcifera* d'Orbigny 1842 on the mountain-side northeast of Ceylanlı Deresi (Figure 3). Selley (1976, p. 205) commented on the occurrence of the *Cruziana* ichnofacies in subtidal and shallow marine environments, and also noted records of the index genus from both post-Palaeozoic strata and fluvial formations, in which trilobites should not occur; such claims suggest that interpretation of *Cruziana* as the work of a trilobite is still equivocal or unlikely, as was postulated by Whittington (1980, pp. 202–203). In the Taurides *Cruziana furcifera* is widespread, sometimes dated as lower Arenig by means of body fossils from adjacent strata, but not in association with them. It has been suggested (references in Shergold & Sdzuy 1991, p. 201) that *C. furcifera* may grade into certain other species in Celtiberia, some of them as old as Upper Cambrian, but such evidence has not yet been published for Turkey.

Systematic Palaeontology

Terms are essentially those used in Volume O, Arthropoda 1, of the Treatise on Invertebrate Palaeontology (Harrington *et al. in* Moore 1959, p. O124) with emendations proposed by Whittington & Kelly (*in* Kaesler 1997) for the second edition of that work. Figured specimens housed in the National Museum of Wales, Cardiff, carry numbers with the prefix NMW.95.34G; other material is in Maden Tetkik ve Arama (M.T.A.) Genel Müdürlüğü, Ankara. The number of specimens found at each locality is indicated in the text as follows: rare (1–4); moderately common (5–10); abundant (11–20); very abundant (> 20). All specimens are from the Koruk Formation and Seydişehir Formation at the Yayla Tepe section (Figures 3 & 4).

Trilobites from the Koruk Formation

Family Peronopsidae Westergård 1936

Genus *Peronopsis* Hawle & Corda 1847

Type Species. Battus integer Beyrich 1845, from the Middle Cambrian of Bohemia.

Peronopsis sp.

Plate 1 (v)

Figured Specimen. Cephalon, NMW.95.34G.531, locality Z.71A. Unfigured cephalon, NMW.95.34G.532, is from Z.71A, and two further cephala, NMW.95.34G.537 and 538, are from Z.71B. Both localities are in Bed E (rare).

Discussion. No detailed comparison is made, but there is a general resemblance to the cephalon of the neotype of *Peronopsis integra* (Beyrich), illustrated by Snajdr (1958, pl. 3, fig. 2), although the latter species has a slightly wider (sag.) cephalic border. The Swedish species *Peronopsis fallax* (Linnarsson 1869), together with various subspecies, was redescribed by Westergård

(1946, p. 37, pl. 2, figs. 18–24); all show some variation in the relative length of the preglabellar field, and comparison here may be made with Westergård's pl. 2, figs 20a, b, rather than with Linnarsson's syntypes. Similar comments apply to *Peronopsis fallax sallesi* (Munier-Chalmas & Bergeron *in* Bergeron 1889), from southern France (Courtessole 1973, p. 116, pl. 2, figs. 5–14) and illustrated from Spain by Sdzuy (1961, pl. 2, figs. 1–8).

Family Corynexochidae Angelin 1854

Genus *Corynexochus* Angelin 1854

Type Species. Corynexochus spinulosus Angelin 1854, from the Middle Cambrian of Sweden.

Corynexochus sp.

Plate 1 (r)

Figured Specimen. A cranidial fragment, NMW.95.34G.535, from Bed E, locality Z.71b, is the sole recorded example from Yayla Tepe of a genus that is particularly abundant in Middle Cambrian (Caesaraugustian) carbonates of the Çal Tepe Formation in the Taurides, southern Turkey. The type species, redescribed by Westergård (1948, p. 10, pl. 3, figs. 7–9) shows some variation in the axial furrows, from straight to very slightly curved, abaxially concave. The axial furrows of the present specimens are still more curved and the glabella is wider frontally. Closer comparison may be made with *C. delagei* Miquel 1905, from southern France and redescribed by Courtessole (1973, p. 136). In the Taurides *C.* cf. *delagei* was recorded from the Çal Tepe Formation of the Sultan Dağ by Shergold & Sdzuy (1984, p. 1984, p. 74, pl. 2, fig. 9), and broadly similar material from the same formation is known from Hadim (Dean & Özgül 1981) and the Çal Tepe stratotype (Dean 2005).

Family Paradoxididae Hawle & Corda 1847

Genus *Eccaparadoxides* Snajdr 1957

Type Species. Paradoxides pusillus Barrande 1846, from the Middle Cambrian of Bohemia.

Only fragmentary evidence of the genus was found at Yayla Tepe, and none of the material proved specifically identifiable. The oldest examples were two fragments of cranidium (NMW.95.34G.497 and 498) in black, micritic limestone of the black limestone & dolomite member at locality Yo.150 (Figure 2), 0.8 m below the base of the limestone member. Rare, small fragments of cranidium and librigenae were found in Bed B at localities Z.68A (NMW.95.34G.914 to 918), Z.68B (NMW.95.34G.497, 498, 502, 503) and Z.68C (NMW.95.34G.920 to 922), with a single example in the basal part of Bed C, at locality Z.69A.

Family Solenopleuridae Angelin 1854

Subfamily Solenopleuropsinae Thoral 1947

Genus *Pardailhania* Thoral 1947

Type Species. Solenopleura (?) *hispida* Thoral 1935, from the Middle Cambrian of southwestern France.

Pardailhania hispida (Thoral 1935)

Plate 1(f), (g), (i), (k), (q)

1935 *Solenopleura* (?) *hispida* Thoral, p. 57, pl. 3, figs. 2a, b, 3.

1968 *Pardailhania hispida* (Thoral 1935), Sdzuy, p. 119, pl. 6, fig. 13.

1973 *Pardailhania hispida* Thoral 1945 [sic], Courtessole, p. 160, pl. 15, figs. 1–8; pl. 27, fig. 4. Includes synonymy.

1984 *Pardailhania hispida* (Thoral 1935), Shergold & Sdzuy, p. 77, pl. 1, fig. 4; pl. 2, figs. 12, 13.

Figured Specimens. Three cranidia, all from Bed B: NMW.95.34G.501 (Pl. 1 (g), (q)) from locality Z.68A; NMW.95.34G.517 (Pl. 1 (i), (k)) and 518 (Pl. 1 (f)) from Z.68C. No other examples found.

Description & Discussion. This distinctive biozonal species has been extensively illustrated and the Yayla Tepe material agrees well with published descriptions. The single transverse row of spine bases on the preglabellar field, considered by Shergold & Sdzuy (1984, p. 78) as characteristic of *P. hispida*, is clearly seen on the present specimens. Courtessole's (1973) generic description noted four transverse rows of glabellar tubercles but some of his illustrations show a fifth row, and five rows

of large tubercles were clearly illustrated by Sdzuy (1968, pl. 6, fig. 13).

Family Conocoryphidae Angelin 1854

Subfamily Conocoryphinae Angelin 1854

Genus *Conocoryphe* Hawle & Corda 1847

Type Species. Trilobites Sulzeri Schlotheim 1823, from the Middle Cambrian of Bohemia.

Subgenus *Conocoryphe* Hawle & Corda 1847

Conocoryphe (Conocoryphe) sp.

Plate 1 (h), (m)-(o), (t), (u)

Figured Specimens. All cranidia, from Bed B. NMW.95.34G.499 (Pl. 1 (m)-(o)) from locality Z.68A; NMW.95.34G.505 (Pl. 1 (u)) from Z.68B; and NMW.95.34G.512 (Pl. 1 (t)) and 513 (Pl. 1 (h)) from Z.68C.

Other Material. NMW.95.34G.500 & 916 (Z.68A), NMW.95.34G.504, 506 to 508 (Z.68B), NMW.95.34G. 514 to 516 (Z.68C), NMW.95.34G.916 (Yo.151). Rare at Z.68A; moderately common at Z.68B and Z.68C.

Description & Discussion. The present cranidia generally resemble *C. (Conocoryphe) brevifrons* (Thoral 1946), from the highest Caesaraugustian of southern France and redescribed by Courtessole (1973, p. 186, pl. 19, figs. 1–9). Differences include the longer (sag.), flat-topped anterior border (seen in Plate 1 (h)), and the conspicuous anterior border furrow (Plate 1 (o)) of uncompressed Turkish specimens, in which the frontal area has median length 31–35% that of the cranidium, compared with 25–30% in the French material. In southwestern Turkey Shergold & Sdzuy (1984, p. 84) reported *C. (C.)* cf. *brevifrons* from the *Solenopleuropsis* Zone of the Sultan Dağ. In the Montagne Noire the species was listed by Courtessole (1973) only from his Niveau F (topmost *Solenopleuropsis* Zone), that is to say, at a horizon higher than the *Pardailhania* Zone; the only *Conocoryphe* recorded from the latter level in France is *C. (Parabailiella) languedocensis*. As noted by Shergold & Sdzuy (1984, p. 85), *C. (Conocoryphe)* differs basically from *C. (Parabailiella)* Thoral 1946 in having a facial suture which 'remains entirely on the border'. In *Parabailiella* the suture typically cuts across the lateral border furrow, but there is a gradation between the two conditions. On this criterion the present Turkish cranidia are better placed in *C. (Conocoryphe)*, but even in a single cranidium (for example, Plate 1 (t)) the left and right sides may show slight differences in development.

?Family Ordosiidae Lu 1954

Genus *Derikaspis* Dean 1982a

Type Species. Derikaspis toluni Dean 1982a, from the Middle Cambrian of Derik, southeastern Turkey.

Derikaspis sp.

Plate 1 (a) – (e), (j)

Figured Specimens. NMW.95.34G.519 (Plate 1 (d), (e)), Z.69B; NMW.95.34G.521 (Plate 1 (a)), 523 (Plate 1 (c)) and 529 (Plate 1 (b)), Z.70, both levels in the upper part of Bed C; NMW.95.34G.533 (Plate 1 (j)), from Z.71A, upper half of Bed E.

Other Material. NMW.95.34G.520, 522, 524, 527, 528, 534, 540 & 541. Rare at Z.69B; moderately common at Z.70; rare at Z.71A & Z.71B.

Description & Discussion. The best preserved of three incomplete cranidia (Plate 1 (d), (e)) differs from that of the type species (Dean 1982a; especially figs. 53a-c) in having: straighter axial furrows; a glabella more uniformly covered with smaller tubercles except on the weakly defined L1-3; and a thicker, slightly narrower (sag.) anterior border and preglabellar field, the former carrying at least one row of tubercles coarser than those on the glabella. Better comparison may be made with *Derikaspis brianensis* (Courtessole 1973; redescribed by Courtessole *et al.* 1988, p. 39) from southern France, but both the French and Yayla Tepe specimens are slightly distorted tectonically. A large left librigena (Plate 1 (a)) closely resembles a paratype right librigena of *Derikaspis toluni* Dean (1982a, fig. 57) but carries a smaller number of larger tubercles. A single fragment of pygidium (Plate 1 (b)) shows the left pleural lobe with three and a half pairs of ribs, and the remains of an ill defined, wide border with shallow border furrow. Some comparison

may be made with Turkish pygidia referred to ? *D. toluni* (see Dean 1982a, fig. 50) and *?Chelidonocephalus anatolicus* (Dean 1982a, figs. 45a, b, 48, 49a-c), as well as with pygidia of *Chelidonocephalus* from Iran (Wittke 1984, pl. 3, figs. 2, 7, 11, 16, 17) and France (Courtessole *et al.* 1988, pl. 4, figs. 9–11).

Family Acrocephalitidae Hupë 1953

Genus *Asturiaspis* Sdzuy 1968

Type Species. Asturiaspis inopinatus [sic] Sdzuy 1968, from the Middle Cambrian of Spain.

Asturiaspis? sp.

Plate 1 (s)

Figured Specimen. A single cranidial fragment, NMW.95.34G.509, from Z.68B, in the highest part of Bed B.

Description & Discussion. The Turkish specimen, partially broken frontally, shares with the type species a tapered, sub-trapezoidal glabellar outline, a low eye ridge, a long (sag.), slightly upturned anterior border, and a broad (sag.) anterior border furrow that is slightly shallower medially. The Spanish material described by Sdzuy (1968, p. 107, pl. 5, figs. 5–10) exhibits ontogenetic changes, and smaller cranidia differ from the large holotype in having a proportionately shorter anterior border, shorter frontal area, and wider (tr.) palpebral area. The Turkish cranidium has a relatively narrow (tr.) palpebral area and narrow (sag.) preglabellar field but no detailed comparison was possible. In Spain *Asturiaspis* was recorded by Sdzuy (1971, Table 1) from the lower part of the Middle Cambrian, corresponding to the Leonian Stage.

Family Uncertain

Genus & Species Undetermined A

Plate 1 (p)

Description & Discussion. A single fragment of cranidium (NMW.95.34G.530) from Bed C, Z.70 has the glabella partly exfoliated and shows granular ornamentation over most of the surface, with traces of larger tubercles arranged in three transverse 'zones' which may correspond to L1-3. Both the transversely straight SO and the surviving left axial furrow are deeply incised, and the latter is crossed by a distinct eye ridge, directed posterolaterally. The form of the eye ridge and the traces of an intermediate lobe between the postulated L1 and L2 recall *Derikaspis* from the type area, but are insufficient for certainty and do not match other specimens of the genus from Yayla Tepe or Derik.

Genus & Species Undetermined B

Plate 1 (l)

Description & Discussion. Incomplete cranidium (NMW.95.34G.510) from Bed B, Z.68B, has an apparently almost smooth exoskeleton and the glabellar outline is subparabolic, bounded by axial furrows which shallow forwards around LA. SO is transversely straight and very shallow, defining an LO whose median length (sag.) is less than one-fifth that of the cranidium. Large, smooth eye lobe sited opposite middle of the glabella, and equal to about one-third of its length. Anterior section of the left facial suture diverges at about 20 degrees from the sagittal line and then curves strongly inwards, where a weakly defined, low anterior border occupies about half the anterior area. No satisfactory comparison has been made.

Trilobites from the Seydişehir Formation

Family Elviniidae Kobayashi 1935

Subfamily Aphelaspidinae Palmer 1960

Genus *Elegantaspis* Ivshin 1962

Type Species. By original designation, *Elegantaspis elegantula* Ivshin 1962, from the Upper Cambrian, Kuyandinian Stage, of central Kazakhstan. The genus was assigned provisionally by Ivshin to the Family Parabolinoididae Lochman 1956, but was later transferred to the Aphelaspidinae by Shergold & Sdzuy (1991, p. 209), who provided a detailed discussion of this and other supposedly related genera. Ivshin's (1962, pp. 81, 82) descriptions of *E. elegantula* and the closely similar *E. beta* from the same horizon and area employed only the cranidium and it is preferred here to use *Elegantaspis* questionably for the Turkish material. Shergold & Sdzuy's (1991, pp. 209–211) account of *Elegantaspis* cf. *beta* from northeastern Spain was

similarly restricted and the present description of the Turkish pygidium (Pl. 2 (h)-(j)) is based on an abundant assemblage composed almost solely of *Elegantaspis?* fragments, most of them cranidia, together with rare examples of the distinctive genera *Palaeadotes* and *Prochuangia*.

Elegantaspis? montis sp. nov.

Plate 2 (a)-(c), (h)-(k), (l)?, (m), (n), (o)?, (u)

Derivation of Name. montis (Latin) = of the mountain, in this case the Samur Dağ.

Diagnosis. Cranidium of aphelaspidine type, with length about three-quarters the breadth; anterior margin broadly rounded, and low frontal area divided into subequal, flat anterior border and preglabellar field. Glabella subtrapezoidal, with bluntly rounded LA; external surface smooth, but internal mould occasionally (Plate 2 (u)) shows almost indiscernible L1-3; SO transverse, shallow. Palpebral area about half breadth of adjacent glabella; palpebral lobe short (0.2 length of glabella), sited opposite L2, and linked to axial furrow by weak, curved eye ridge. Subelliptical pygidium has length two thirds the maximum breadth and its outline forms an unbroken, broadly rounded curve. Axis narrow, gently tapered, with at least five rings on anterior half; tip merges with broad (tr.), shallow, concave, unfurrowed border; at least six almost smooth ribs are present, separated by well defined pleural furrows.

Type Material. Holotype, NMW.95.34G.148 (Plate 2 (n)), Z.73; figured paratypes, NMW.95.34G.149 to 154 and 156. Unfigured paratypes: NMW.95.34G. 157 to 181, 1129 to 1136 (Z.70), 1137 to 1158 (Z.72) and 1176 to 1187 (Z.73).

Horizons & Localities. All material is from the Yayla Tepe section, as follows: unit a, Z.72 (abundant); unit b, at a single level with Z.73 (very abundant) and Yo.155 (abundant). The species, found at only two levels about 34 m apart, was easily the most abundant trilobite in the Seydişehir Formation at Yayla Tepe.

Dimensions of Holotype Cranidium. Median length= 8.7 mm, basal breadth= 11.7 mm (estimated), length of glabella= 6.5 mm, basal breadth of glabella= 5.25 mm, distance across palpebral lobes= 9.25 mm, breadth (tr.) of frontal area= 8 mm.

Description. Cranidium of low convexity, with length about 0.75 the basal breadth. Subtrapezoidal glabella as broad as long, with straight sides converging at 30–35° to circumscribe rounded LA. Front of cranidium broadly curved, and frontal area is divided into subequal halves by shallow anterior border furrow; preglabellar field is flat medially, narrows (exs.) abaxially, where it merges with fixigenae and is bounded by anterior border with almost flat top and slightly bevelled posterior edge. LO, with weakly curved posterior margin, is defined by transverse SO that is shallow medially and almost indiscernible at axial furrows. No lateral glabellar furrows visible on external surface. Low palpebral lobe, with length about 0.2 (estimated) that of glabella, is sited almost opposite L2 and shows trace of palpebral furrow; breadth of palpebral area slightly less than half that of adjacent part of glabella. Anterior section of facial suture nearly straight, slightly divergent to preglabellar furrow, where it curves adaxially to margin; posterior section forms sigmoidal curve to meet posterior border and margin so that posterior field has breadth (tr.) about 0.75 that of rear of glabella.

Pygidium semielliptical, with frontal breadth 1.6 the length; anterior margin slightly curved, truncated by narrow (exs.) articulating facets. Straight-sided axis tapers at about 15°, bounded by deep axial furrows; anterior half has five transversely straight axial rings, separated by faint ring furrows; posterior half indistinctly furrowed, ends in blunt tip that merges with posterior area. Pleural lobe plump, with six or seven flat-topped, well defined ribs, and declines to ill-defined concave border, where the pleural furrows become weaker and curve posteriorly towards lateral margin; interpleural furrows faint.

Two associated hypostomes (Plate 2 (l) and (o)) from Z.72 and Z.73 respectively, are assigned questionably to the new species. Outline is subrectangular, narrowest (tr.) frontally, the posterior half widening to 0.75 the median length. Middle body bounded by continuous rim-like border that is slightly wider medially. Anterior lobe oval, 0.75 the median length, bounded by shallow middle furrow that dies out sagittally; posterior lobe crescentic in

plan, ending opposite centre of hypostome. There is a general resemblance to an undetermined aphelaspidine hypostome from the Upper Cambrian of Antarctica figured by Shergold & Cooper (1985, p. 104, fig. 7u), who suggested its possible assignment to the associated *Apheloides? depressus* Shergold & Cooper (1985, p. 102); in any case it resembles the 'natant' form recognised by Fortey (1990).

Discussion. Photographs of the type material of *Elegantaspis elegantula* Ivshin (1962, pl. 5, figs. 5–7) are slightly modified and difficult to compare with Spanish cranidia assigned to the genus by Shergold & Sdzuy (1991, pl. 3). Ivshin's (pl. 5, fig. 7) illustration of the holotype differs from our Turkish specimens in its more strongly tapered glabellar outline and longer eye lobes; whether the anterior branches of the facial suture are straight and sub-parallel, as in Ivshin's line drawing (p. 82, fig. 19) and one paratype (Ivshin 1962, pl. 5, fig. 19), is questionable, and another paratype (Ivshin 1962, pl. 5, fig. 6) has the right anterior branch noticeably curved.

Farsia Wolfart (1974, p. 116), from the Kushanian of Afghanistan, was introduced questionably, and incorrectly, as a subgenus of *Chelidonocephalus*, the pygidium of which, as re-interpreted by Dean (1982a, p. 31) and confirmed by Wittke (1984, p. 113), is different from that of the type species *Farsia abundans.* The latter (Wolfart 1974, pl. 19, figs. 5–9) shares with *Elegantaspis? montis* a large, semicircular to semielliptical pygidium, proportionately wider frontally, with slim, straight-sided axis and straight ring furrows. But the cranidium of the Iranian genus is easily distinguished by: its more tapered, trapezoidal glabellar outline, with deep SO and more distinct S1–S3; wider (tr.) fixigenae; and the longer (sag.) anterior area, inclined frontally to form a scoop-like structure (see Wolfart 1974, pl. 19, fig. 1). Cranidium, NMW.95.34G.155 (Plate 2 (p)-(r)), an internal mould from Locality Z.72, superficially resembles *Elegantaspis? montis* in the form of the frontal area and occipital ring. However, its glabella is more tapered and the slightly curved axial furrows are abaxially convex with prominent muscle impressions in SO, S1 and S2. Narrow palpebral lobes are sited opposite L2, and the anterior branches of the facial suture diverge more strongly forwards than in *E.? montis* (about 55 degrees compared with about 30 degrees).

Family Leiostegiidae Bradley 1925

Genus *Chuangia* Walcott 1911

Type Species. Ptychoparia? batia Walcott 1905, from the Upper Cambrian of Shandong [= Shantung], Northeast China.

Chuangia? sp.

Plate 3 (e), (f). (i), (j), (o)?

Figured Specimens. NMW.95.34G.157 (Plate 3 (e)), NMW.95.34G.158 (Plate 3 (f)), NMW.95.34G.159 (Plate 3 (i)) NMW.95.34G.160 (Plate 3 (j)); questionably NMW.95.34G.161 (Plate 3 (o) ?). All from Unit a, Yo.154, where moderately common. This is the only locality at Yayla Tepe from which the genus has been recorded, even questionably.

Description and Discussion. Numerous species and specimens of *Chuangia*, including the lectotype of the type species, designated by Walcott (1906, pl. 15, fig. 3) were profusely illustrated by Chang & Jell (1987, pp. 199–200, pls. 89–92, 124, 125 in part) and by Lu *et al.* (1965). No satisfactory comparison is made with any of these or with other species from the Upper Cambrian of China, and all but one of the Turkish pygidia are both deeply weathered and dorsally compressed. The exception (Pl. 3 (j)), an incomplete, three-dimensional specimen illustrated as a latex cast, is convex and semielliptical in outline with length 0.6 the breadth; its subcylindrical axis is very slightly tapered and relatively large, with frontal breadth 0.4 that of the pygidium; there are two distinct axial rings, traces of a further two, and each pleural region carries two pairs of broad (exsag) ribs in addition to the articulating half rib.

Genus *Prochuangia* Kobayashi 1935

Type Species. Prochuangia mansuyi Kobayashi 1935, from the Upper Cambrian of South Korea.

Prochuangia turcica sp. nov.

Plate 3 (a)-(d), (g), (k)-(m), (p), (r)

Derivation of Name. turcica (Latin) = Turkish.

Diagnosis. Cranidium nearly 1.5 times wider than long; glabella almost transverse frontally, with strongly unequal L1–L3 separated by S1–S3 visible only on internal mould; deep SO flexes slightly forwards laterally and at sagittal line; palpebral lobes opposite S1. Pygidium has median length (excluding spine) 0.4 (estimated) of the overall breadth; large, gently tapered axis includes two well defined, straight axial rings, with a further three faintly defined, and ends in a very small, blunt terminal piece; conspicuous pair of marginal spines is splayed posteriorly, the large base of each spine being sited opposite the rear 0.6 of the axis; marginal furrow deepest on smaller specimens and merges with first pleural furrows.

Type Material. Holotype pygidium, NMW.95.34G.162 (Plate 3 (m); Z.73). Paratypes: NMW.95.34G.163 (Plate 3 (a); Z.73), NMW.95.34G.164 (Plate 3 (b)-(d); Z.73), NMW.95.34G.165 (Plate 3 (g); Yo. 157), NMW.95.34G.166 (Plate 3 (k), (p); Yo.157), NMW.95.34G.167 (Plate 3 (l); Z.73), NMW.95.34G.168 (Plate 3 (r); Yo. 157). At Yayla Tepe the species was found in the lowest part of Unit b (Z.73, abundant), and in the lowest part of Unit e (Yo.157, rare); questionably in the upper half of Unit c (Yo.156, rare)

Description & Discussion. Cranidium moderately convex both longitudinally and transversely, with sagittal length about 0.8 the basal breadth. Glabellar outline sub-trapezoidal, slightly constricted at S2, with basal breadth 0.6 of its median length; overall it tapers gently from SO to transversely subrectangular LA, bounded by low anterior border with length (sag.) about 0.13 that of glabella. External surface smooth but internal mould shows unequal L1–3, with faint S1–3 marked by shallow, suboval muscle impressions. LO occupies 0.2 of the glabellar length and narrows (exs.) distally where it curves forwards slightly and is bounded by sinuous SO that is visible on both internal and external mould. Small palpebral lobe sited opposite S1 and L2, where width (tr.) of palpebral area is about 0.66 that of adjacent glabella; low, distinct, oblique eye ridges curve slightly from palpebral lobes to meet axial furrows at or near S3 (Plate 3 (a), (c), (d)).

Pygidium, excluding paired posterolateral spines, has sagittal length 0.4 of breadth; anterior margin transversely straight; posterior margin gently curved between pair of broadly splayed border spines. Axis occupies about 0.3 of the overall frontal breadth, and ends in rounded terminal piece at border furrow; it is bounded by deep axial furrows which are almost straight, with slight break at third ring furrow; up to five straight axial rings in addition to the small articulating half-ring. Pleural region carries deep, broad (exs.) first pleural furrow which delimits anterior half-rib and facet; the furrow deepens and widens abaxially where it coalesces with shallower border furrow, traverses base of paired border spine, and deepens towards and behind terminal piece. A second pleural furrow is very shallow, and interpleural furrows are almost indiscernible. The paired large border spines are slightly curved, distally convex, and all available specimens (Pl. 3 (g), (k), (r)) show that they become progressively less splayed posteriorly with increase in size of the pygidium

The pygidium (excluding border spines) of the new species is distinguished from that of *Prochuangia gallica* Feist & Courtessole (1984, p. 181, pl. 1, figs. 1–7) of similar age in southern France, by its relatively shorter length (0.4 versus 0.6 estimated of the overall breadth). In addition the marginal furrow is shorter and more deeply incised, especially posteriorly, and the border spines have a notably larger basal breadth (tr.). According to Shergold *et al.* (1976, p. 278) *Prochuangia* lacks a pygidial border furrow, but this structure is visible, although broad and shallow, among the type material of the French species *P. gallica* (see above). Several Chinese pygidia illustrated as *Kaolishania*? *quadriceps* (Dames 1883) by Schrank (1975, pl. 4, figs. 4–9) exhibit variation in overall outline, median length and the form and location of the paired border spines; most are distinct from *P. turcica*, but the original of Schrank's pl. 4, fig. 5 resembles the latter species in its straight anterior margin, the median length equal to 0.46 the overall breadth, and the form and location of the paired spines. Dames's species was later referred to *Prochuangia* by Shergold *et al.* (1976, p. 277).

Prochuangia mansuyi was illustrated by Lochman-Balk (*in* Moore 1959, p. 0319, fig. 236, 1a, b) by means of line-drawings. Photographs used in Lu *et al.*'s later description (1965, p. 414, pl. 78, figs. 18–23) are not very clear but suggest that the (?compressed) glabella has straighter sides than *P. turcica*, and that the pygidium is slightly shorter, with less convex posterior margin; the

apparently posterolateral position of the large marginal spines is of questionable significance and, as suggested by the Turkish specimens, may vary during ontogeny.

Family Pterocephaliidae Kobayashi 1935

Genus *Taishania* Sun 1935

Type Species. Mansuyia taianensis Sun 1924, from the Upper Cambrian (Changshanian, *Kaolishania* Zone) of Shandong [= Shantung], northeast China. In Table B of Sun (1935) the range of *Taishania* was misprinted as extending through the three zones of the Fengshanian, but elsewhere in the same paper (p. 69 and Table A) it was given correctly as *Kaolishania pustulosa* Zone, upper Changshanian.

Taishania bassifrons sp. nov.

Plate 3 (h), (s), (v)

Derivation of Name. bassifrons (Latin) = low front, from the low preglabellar area.

Diagnosis. Taishania species with relatively long preglabellar area, one third the glabellar length and divided into equal halves by broad (sag.), shallow anterior border furrow. Glabella unfurrowed (excluding SO), straight-sided, subrounded frontally, with shallow fossula at either end of preglabellar furrow. Palpebral area of fixigena very narrow (tr.), flanked by small, gently curved palpebral lobe; posterolateral projection transversely elongated.

Type Material. Holotype cranidium, NMW.95.34G.169 (Plate 3 (v)); paratype cranidia, NMW.95.34G.170 (Plate 3 (h)), 171 and 172 (Plate 3(s)). All from Yo.157, in the lowest part of Unit e.

Dimensions of Holotype. Median length of cranidium= 6 mm; length of glabella= 3.9 mm; maximum breadth (tr.) of anterior area= 6.2 mm; median length (sag.) of anterior border= 1.0 mm; basal breadth of cranidium= > 9 mm (est.).

Description. Known only from the cranidium, which is of low convexity with basal breadth twice the sagittal length. Trapezoidal glabellar outline has almost straight sides which converge forwards at 30° to transversely straight anterior margin; preglabellar furrow slightly shallower medially and narrower than the axial furrows. No lateral glabellar furrows visible, and transversely straight SO is shallower and wider (sag.) over its median third, becoming deeper distally. LO small, with median length (sag.) about 0.2 that of glabella, and its narrow extremity merges with posterolateral portion of L1. Weakly defined, small palpebral lobe set slightly in front of centre with reference to glabella; palpebral area very narrow, about 0.2 of adjacent breadth of glabella. Posterolateral projection of fixigena distally elongated, its length (exs.) about 0.7 the breadth (tr.), and posterior section of facial suture meets posterior margin of cephalon at about 40°.

Discussion. Sun's (1935, p. 68, pl. 3, figs. 20–25) detailed description of *Taishania taianensis* illustrated three cranidia, a left librigena and two pygidia from the Tawenkou Formation (Changshanian Stage, *Kaolishania pustulosa* Zone) of Taian, Shandong. Details are difficult to discern in the photographs, and a later illustration of the cranidium by Lu *et al.* (1965, p. 351, pl. 65, fig. 2) used only an incomplete specimen, but several examples were figured by Chang & Jell (1987, p. 244, pl. 120, figs. 5–12). On the basis of the latter, *T. taianensis* resembles *Taishania bassifrons* in the glabellar outline and narrow (tr.) palpebral area, but the former species has the palpebral lobe set further forward, with its posterior margin opposite the centre of the glabella; there is no palpebral furrow in *T. taianensis*, and that apparently present in the Turkish species is seen on the internal mould. The preglabellar area in both species is divided into subequal halves by a shallower anterior border furrow, but it is relatively longer in the new taxon (0.33–0.36 of glabellar length compared with 0.24). The length (sag.) of the anterior border is less than that of the preglabellar field in the Chinese species, whereas they are subequal in the Turkish form. The anterior sections of the facial suture, not visible in Sun's illustrations, are seen to be slightly divergent in Chang & Jell's account of *T. taishanensis*, as they are in *T. bassifrons*. Most of the above comments apply to *Taishania (Weishania) constricta* Zhu & Wittke (1989, p. 216, pl. 10, figs. 1–8), type species of the subgenus and from the Upper Changshanian of Hebei Province, north China. Differences between *T. (Taishania)* and *T. (Weishania)* were said to include the latter's possession of shallow axial furrows,

'relatively long palpebral lobes', and a glabellar outline that is constricted medially, though the first two of these characters appear less significant; both subgenera have a small occipital node that is not preserved in the new species.

Taishania platyfrons Shergold (1980, p. 56, pl. 19, figs. 5–10, text-fig. 27A), from western Queensland, was placed in a new subfamily Atratebiinae, Family Uncertain. It differs from *Taishania taianensis* in its relatively shorter, less tapered glabella (0.66 the crandial length, compared with 0.75), the almost effaced SO and uniformly short (sag.) LO, and particularly in the small anterior border, which forms only a low, narrow (sag.) rim. *T. platyfrons* came from the *Peichiashania tertia* - *Prochuangia glabella* Assemblage Zone, shown as about low/mid Changshanian in a table by Shergold (*in* Kaesler 1997, p. 309), where *P. tertia* is replaced by *T. secunda*.

Anomocare persicum King (1930, pl. 17, figs. 3, 3a) was based on a single cephalon from a limestone block at Kuh-i-Namak, in Iran and about 40 km from the coast of the Persian Gulf (King 1930, fig. 1). The specimen was listed by Kobayashi (1962, p. 111) as '*Taishania' persica*, and figured under that name by Morris & Fortey (1985, pl. 2, fig. 9). Trilobites from the same locality (though not necessarily from the same block of limestone) were determined as *Kaolishania*? sp. and *Maladioides* sp. nov. by Kobayashi (1935, p. 187; 1962, p. 112) and illustrated as such by Morris & Fortey (1985, pl. 2, fig. 4, and pl. 3, fig. 2).

Family Crepicephalidae Kobayashi 1935

Genus *Coosinoides* Ivshin 1962

Type Species. Coosinoides elegantulus Ivshin 1962, from the Upper Cambrian (Kuyandinian Stage) of central Kazakhstan. Ivshin (1962, Table) correlated the Kuyandinian with most of the *Chuangia* Zone plus the remainder of the Changshanian, up to the top of the *Kaolishania* Zone (a *Maladioidella* Zone was not then recognised); that is to say, the Kuyandinian of Kazakhstan corresponded essentially to the Changshanian of North China. *C. elegantulus* came from the 'Seletinian horizon with *Irvingella'*, equated by Ivshin with the *Kaolishania* Zone and part of the underlying *Irvingella* - *Changshania* Zone.

Coosinoides parthianus sp. nov.

Plate 2 (d)-(g)

Derivation of Name. parthianus (Latin), from the ancient kingdom of Parthia.

Diagnosis. Coosinoides species distinguished particularly by the long (sag.) preglabellar area which is of low convexity, about 0.4 the cranidial length, and divided by shallow, incised preglabellar furrow into equally long (sag.) preglabellar field and anterior border. Curved SO is markedly convex forwards and becomes faint abaxially; anterior section of facial suture is strongly curved forwards, and breadth (sag.) of anterior area is equal to that across palpebral lobe.

Type Material. Holotype cranidium, NMW.95.34G.173 (Plate 2 (e)-(g)); paratype cranidium, NMW.95.34G.174 (Plate 2 (d)). Both are from the Seydişehir Formation, lowest part of unit f, at Loc. Yo.159, Yayla Tepe. Rare.

Dimensions of Holotype. Median length of cranidium= 9.5 mm; length of glabella= 5.8 mm; breadth (tr.) of anterior area= 8 mm; breadth across palpebral lobes= 7.6 mm (estimated); basal breadth of glabella= 4.3 mm; length (sag.) of anterior border= 2.2 mm.

Description & Discussion. Both the new species and *Coosinoides elegantulus* Ivshin (1962, p. 234, pl. 15, figs. 1–10) have a long, low, spatulate preglabellar area, but the latter occupies 0.3 (sag.) of the cranidial length in the Russian species, compared with 0.4 in *C. parthianus*, which also has a less tapered glabella, more blunted frontally. Preglabellar area is divided into two unequal, transverse halves by gently arched, shallow furrow (? anterior border furrow); in *C. parthianus* the anterior half is 1.5 times longer (sag.) than the posterior half, whereas in *C. elegantulus* the corresponding figure may be up to 3. In both species the palpebral area of the fixigena is narrow (< 0.5 the adjacent breadth of the glabella), and the long palpebral lobe is rim-like, narrow, with distinct palpebral furrow. The occipital ring of *C. elegantulus* is well defined, including distally, by a deep, almost transverse SO; but in the Turkish species SO is shallow and forms a curve, convex forwards, that becomes markedly shallower abaxially. Some of Ivshin's type specimens of *C. elegantulus* display angulation of the

anterior section of the facial suture at its intersection with both anterior border furrow and anterior margin; comparable angulation is less evident in the two specimens of *C. parthianus* but is seen also in cranidia of *Chelidonocephalus* and *Derikaspis* from the Middle Cambrian of the Derik-Mardin inliers, southeastern Turkey (Dean 1982a), Ordosiid? genera in which a median plectrum is present and the anterior border may become long and spatulate.

Coosinoides anhuiensis Lu & Zhu (1980, p. 19, pl. 5, figs. 13, 14), from North Anhui Province, occurs in the middle of an Upper Cambrian succession that is situated between the North and South China regions and includes intermediate lithologies in which the faunas exhibit mixed affinities. Both *C. parthianus* and *C. anhuiensis* have a long, low anterior area and are of broadly similar form. As far as comparison is possible, the Chinese species has the anterior border slightly more than twice as wide (sag.) as the preglabellar field; SO is transversely straight rather than forming an anteriorly convex curve; and the palpebral lobes are both more convergent anteriorly and located further forwards.

Family Damesellidae Kobayashi 1935

Subfamily Drepanurinae Hupë 1953

Genus *Palaeadotes* Öpik 1967

Type Species. Palaeadotes dissidens Öpik 1967, from the Middle Cambrian of Queensland, Australia, by original designation. According to Rushton (*in* Taylor & Rushton 1972, p. 18), *Palaeadotes* is a junior subjective synonym of *Drepanura* Bergeron 1899 (type species, *D. premesnili* Bergeron 1899). Lu & Zhu (1980, p. 20) placed both *Palaeadotes* and *D. (Spinopanura)* Kushan 1973 in synonymy with *Bergeronites* Sun *in* Kuo 1965 (type species, *Drepanura ketteleri* Monke 1903). More recently Chang & Jell (1987, pp. 220–21) maintained *Drepanura, Palaeadotes* and *Bergeronites* as distinct genera, a procedure followed here, but they considered *Drepanura (Spinopanura)* Kushan (1973, p. 144) to be a junior subjective synonym of *Palaeadotes*.

Palaeadotes sp.

Plate 2 (s), (t)

Figured Specimens. NMW.95.34G.175 and 176.

Horizon & Locality. Seydişehir Formation, lowest part of unit b, Yayla Tepe, Locality Z.73 (rare).

Description & Discussion. A single, incomplete, abraded but undistorted pygidium is 1 cm (estimated) broad across the anterolateral angles, with median length (excluding half ring) of 6.5 mm (estimated). The narrow axis, with frontal breadth 0.25 (estimated) that of the pygidium, carries at least four transversely straight axial rings on the anterior half; axial furrows almost straight, converging at about 15° to the blunt tip and small posterior area. Pleural lobe is divided into, probably, six pleurae that end in pleural spines, diminishing in size from first to sixth. Anterior margin curves backwards very slightly until almost level with first ring furrow, and then turns posteriorly through about 45° to form a stout spine at least 6.5 mm long with traces of a furrow; this is followed by five (?more) successively shorter and apparently unfurrowed marginal spines. As far as comparison is possible there is a general resemblance to pygidia of *D. (Spinopanura) erbeni* Kushan (1973, pl. 29, figs. 2, 3, 5), but the latter are relatively wider, with more transverse anterior margin and larger first pleural spines, and the remaining pleurae are separated by broad, deep pleural furrows. Kushan showed the lateral margin of the pygidium marked by a thickened band, outside of which the pleural spines arise, separated proximally by slot-like incised extensions of the interpleural furrows, and immediately beyond these, small fused areas occur at the bases of the free points. A small cranidial fragment (Plate 2 (t)) is insufficient for detailed comparison; L0, L1 and L2 are generally similar to those of the Iranian species, but L1 is proportionately larger and the posterior field is narrower (exsag.).

Damesellacean? Genus & Species Undetermined

Plate 3 (n)

Figured Specimen. NMW.95.34G.177

Description & Discussion. An incomplete pygidium is transversely subelliptical in outline, excluding marginal spines, with frontal breadth 16.5 cm and estimated median length 6.5 cm. The large axis, although broken off, was originally triangular in outline, its frontal breadth slightly more than one-third that of the pygidium, and

probably extended almost to the incomplete posterior margin. Pleural regions of low convexity, almost horizontal, with no distinct border furrow, and composed of three pleurae, each divided into unequal halves by a broad (exsag.), deep pleural furrow. The pleurae are bounded by faint interpleural furrows and each ends in a short, stout, curved pleural spine which may retain traces of anastomosing terrace ridges. The damesellacean affinities of the specimen are not clear, but the main characters correspond to those listed by Lochman-Balk (*in* Moore 1959, p. 0316) for the Superfamily.

Family Olenidae Burmeister 1843

Olenid? Genus & Species Undetermined

Plate 3 (q), (t), (u)

Material. Figured cranidium, NMW.95.34G.178, and unfigured cranidium NMW.95.34G.179, both from the Seydişehir Formation, basal part of unit f, at Yayla Tepe, Yo.159 (rare).

Description and Discussion. Two cranidia are preserved as weathered internal moulds. The glabella is unfurrowed apart from the shallow, transverse SO which does not reach the incised axial furrows; the latter converge gently forwards, where the glabellar outline forms an unbroken broad curve. The anterior area has a length about one-quarter that of the glabella, and consists mainly of a flat preglabellar field with a diminutive rim-like anterior border that is scarcely visible in the photograph. Eye lobe small, set well forwards. Pleuroccipital furrow shallows distally from axial furrow, and pleuroccipital border widens slightly to margin. No detailed comparison was possible, but there is a broad resemblance to "Olenid genus et species undetermined" of Shergold & Sdzuy (1991, p. 209, pl. 2, figs. 32, 33) from the Upper Cambrian of Spain, and to cranidia of olenids such as *Acerocarina* [= *Cyclognathus*], *Boeckaspis* and *Protopeltura* from Scandinavia illustrated by Henningsmoen (1957, pls. 2, 28; *in* Moore 1959, fig. 196) and Westergård (1922, pl. 16).

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Appendix: List of Fossiliferous Localities

Koruk Formation: Gorge section on east side of Yayla Tepe (Figure 2). Beds are shown by capital letters from A to E to avoid confusion with those of the Seydişehir Formation, which are indicated by lower case letters a to i in Figures 3 and 4.

Black Limestone & Dolomite Member
Locality Yo.150, 0.8 m below top of member.

Limestone Member
Locality Z.68A, 1.6 m above base of Bed B [also sampled as Yo.151 and Yo.152].
Locality Z.68B, 4.2 m above base of Bed B.
Locality Z68C, 4.5 m above base of Bed B.
Locality Z.69A, 0.05 m above base of Bed C.
Locality Z.69B, 5.5 m above base of Bed C.
Locality Z.70, 6.5 m above base of Bed C.
Locality Z.71A, 2.5 m above base of Bed E.
Locality Z.71B, 3 m above base of Bed E.
[Locality Z.71C, is at road level on the east side of the Zap Valley, about 2.25 km north-northwest of Çukurca, and corresponds in horizon to Locality Z.71B, near the top of Bed E]

Seydişehir Formation: Lowest 970 m
Upper Cambrian trilobites are described here from six numbered levels, seen in a SSW-NNE traverse along the ridge of Yayla Tepe. Localities are listed in ascending order, using the informal stratigraphic units shown in Figures 3 and 4.

Unit a.
Locality Yo.154, 205 m (estimated) above base of formation.
Locality Z.72, 243 m (estimated) above base of formation.

Unit b.
Localities Yo.155 and Z.73 are from a single level in the lowest 10 cm of a thick bed of quartzitic sandstone about 5 m above the unit base and 277 m above the formation base. The same level was sampled, as Locality Z.85, on the east side of the Zap Valley.

Unit c.
Locality Yo.156. 430 m (estimated) above base of formation.

Unit d.
No macrofossils found.

Unit e.
Locality Yo. 157. 527 m (estimated) above base of formation.

Unit f.
Locality Yo.159, a 5 cm layer of brown-weathering dolomitic calcarenite in the basal part of the unit and 627 m (estimated) above the formation base. Fragmentary trilobites were recorded by Dean (1982b, p. 91) as *Alborsella stoecklini* Kushan 1973; additional rare material is described here as *Coosinoides parthianus* sp. nov. and Olenid? genus and species undetermined. No further macrofossils were recorded from the remaining almost 47 m of Unit f.

Unit g.
No trilobites or other macrofossils were found in the more than 200 m of argillaceous strata constituting the unit.

Unit h.
Micragnostus sp. was found in the lowest 10 cm (Locality Yo.160A, 877 m (estimated) above the base of the formtion, and again, 3 m higher at Yo. 160, accompanied (Dean 1982b) by *Niobella*? sp. and *Mictosaukia* cf. *M. rotundata* (Kushan 1973).

Unit i.
Loc. Yo.162. 970 m (estimated) above base of formation. The weathered upper surface of this limestone bed yielded leiostegiid trilobites assigned by Dean (1982b) to *Pagodia (Wittekindtia) variabilis* Wolfart 1970, whose supposed Tremadocian (but now probably Late Cambrian, Fengshanian) age is discussed elsewhere in the present paper.

PLATE 1

Trilobites from the higher part of the Koruk Formation at Yayla Tepe. (a)–(e), (j) *Derikaspis* sp. (a) left librigena, Locality Z.70, NMW.95.34G.521. (b) left half of pygidium, Locality Z.70, NMW.95.34G.529. (c) latex cast of incomplete cranidium, Locality Z.70, NMW.95.34G.523. (d), (e) dorsal and anterior views of internal mould of cranidium, Locality Z.69B, NMW.95.34G.519. (j) latex cast of incomplete cranidium, Locality Z.71A, NMW.95.34G.533. (f), (g), (i), (k), (q) *Pardailhania hispida* (Thoral 1935). (f) fragmentary cranidium, Locality Z.68C, NM.95.34G.518. (g), (q) latex cast and internal mould of cranidium, Locality Z.68A, NMW.95.34G.501. (i), (k) latex cast and internal mould of partial cranidium, Locality Z.68C, NMW.95.34G.517. (h), (m)–(o), (t), (u) *Conocoryphe (Conocoryphe)* sp. (h) latex cast of cranidial fragment showing facial suture, Locality Z.68C, NMW.95.34G.513. (m)–(o) left lateral, anterior and dorsal views of incomplete cranidium, Locality Z.68A, NMW.95.34G.499. (t) internal mould of small cranidium, Locality Z.68C, NMW.95.34G.512. (u) internal mould of incomplete cranidium, Locality Z.68B, NMW.95.34G.505. (l) Genus & species undetermined B. Latex cast of cranidium, Locality Z.68B, NMW.95.34G.510. (p) Genus & species undetermined A. Partly exfoliated cranidium, Locality Z.70, NMW.95.34G.530. (r) *Corynexochus* sp.. Incomplete cranidium, Locality Z.71b, NMW.85.34G.535. (s) *Asturiaspis* sp. Internal mould of cranidium, Locality Z.68B, NMW.95.34G.509. (v) *Peronopsis* sp. Internal mould of cephalon, Locality Z.71A, NMW.95.34G.531.

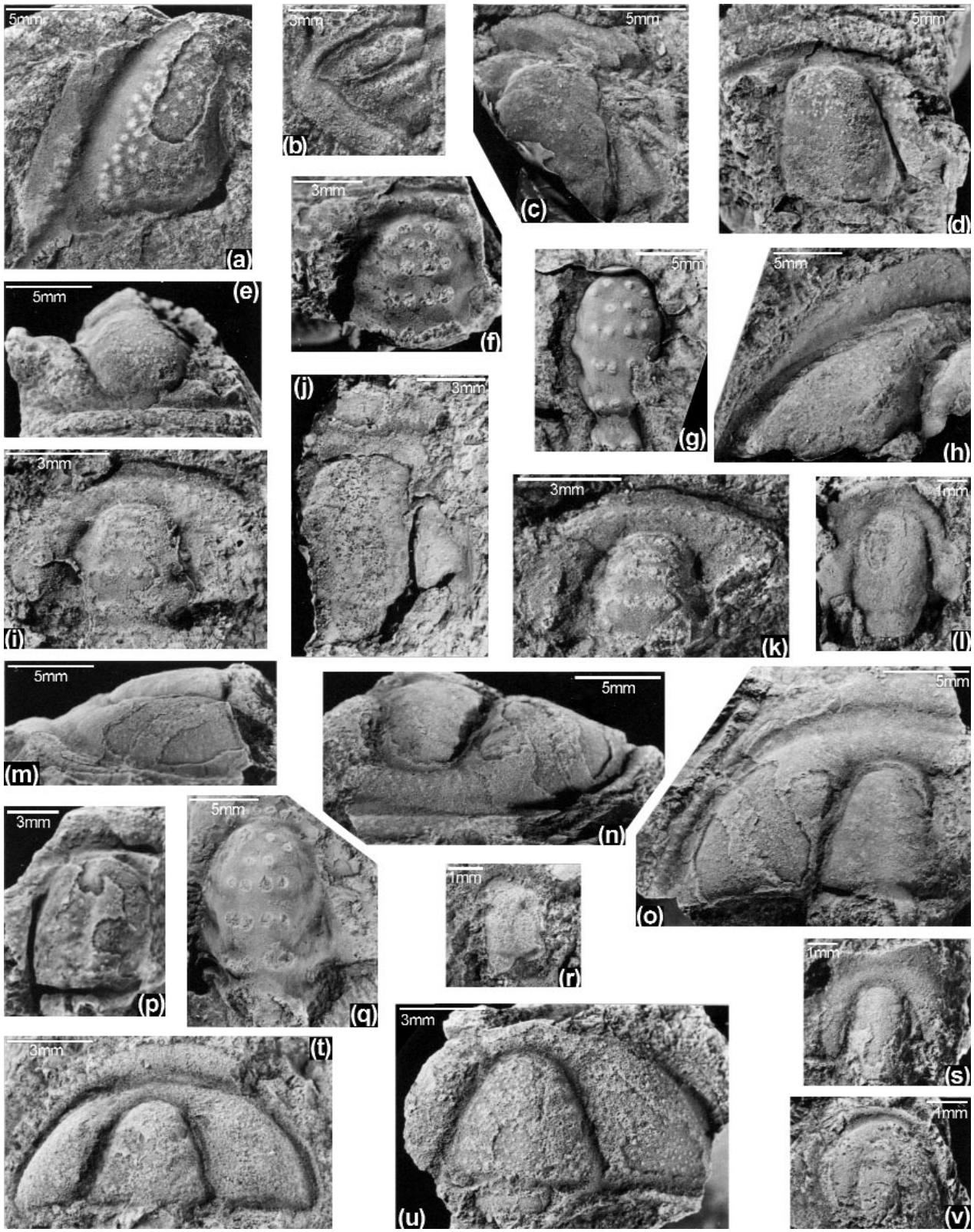
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PLATE 2

Trilobites from the lower Seydisehir Formation at Yayla Tepe. (a)–(c), (h)–(j), (k), (l)?,(m), (n), (o)?, (u) *Elegantaspis? montis* sp. nov. (a) internal mould of cranidium, paratype, Locality Yo.155, NMW.95.34G.149. (b) latex cast of cranidium, paratype, Locality Z.73, NMW.95.34G.150. (c) internal mould of pygidium, paratype, Locality Yo.155, NMW.95.34G.151. (h)–(j) posterior, left lateral and dorsal views of internal mould of pygidium, paratype, Locality Z.72, NMW.95.34G.152. (k) internal mould of cranidium, paratype, Locality Z.72, NMW.95.34G.153. (m) internal mould of fragmentary cranidium, paratype, Locality Z.73, NMW.95.34G.154. (n) internal mould of cranidium, holotype, Locality Z.73, NMW.95.34G.148. (u) internal mould of fragment of large cranidium, paratype, Locality Z.73, NMW.95.34G.156. (l)?, (o)? internal moulds of hypostomes assigned questionably to *Elegantaspis? montis*. (l)? Locality Z.72, NMW.95.34G.181; (o)? Locality Z.73, NMW.95.34G.180. (d)–(g) *Coosinoides parthianus* sp.nov. (d) internal mould of incomplete cranidium, paratype, NMW.95.34G.174; (e)–(g) right lateral, anterior and dorsal views of internal mould of larger cranidium, holotype, NMW.95.34G.173. Both from Locality Yo.159. (p)–(r) Genus and species undetermined C. Anterior, right lateral and dorsal views of internal mould of cranidium, Locality Z.72, NMW.95.34G.155. (s), (t) *Palaeadotes* sp. (s) latex cast of partial pygidium, NMW.95.34G.175; (t) latex cast of fragment of cranidium, NMW.95.34G.176. Both from Locality Z.73.

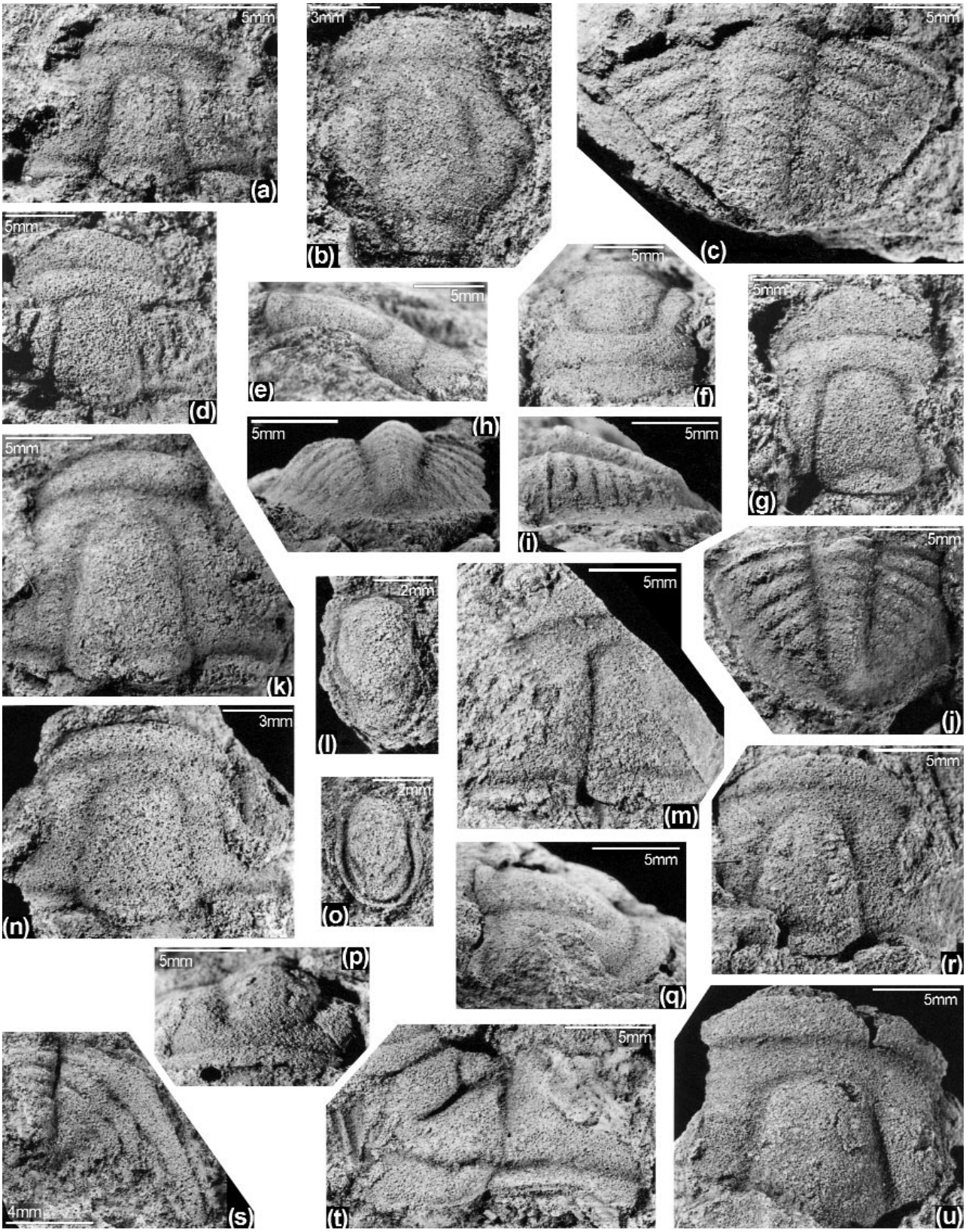
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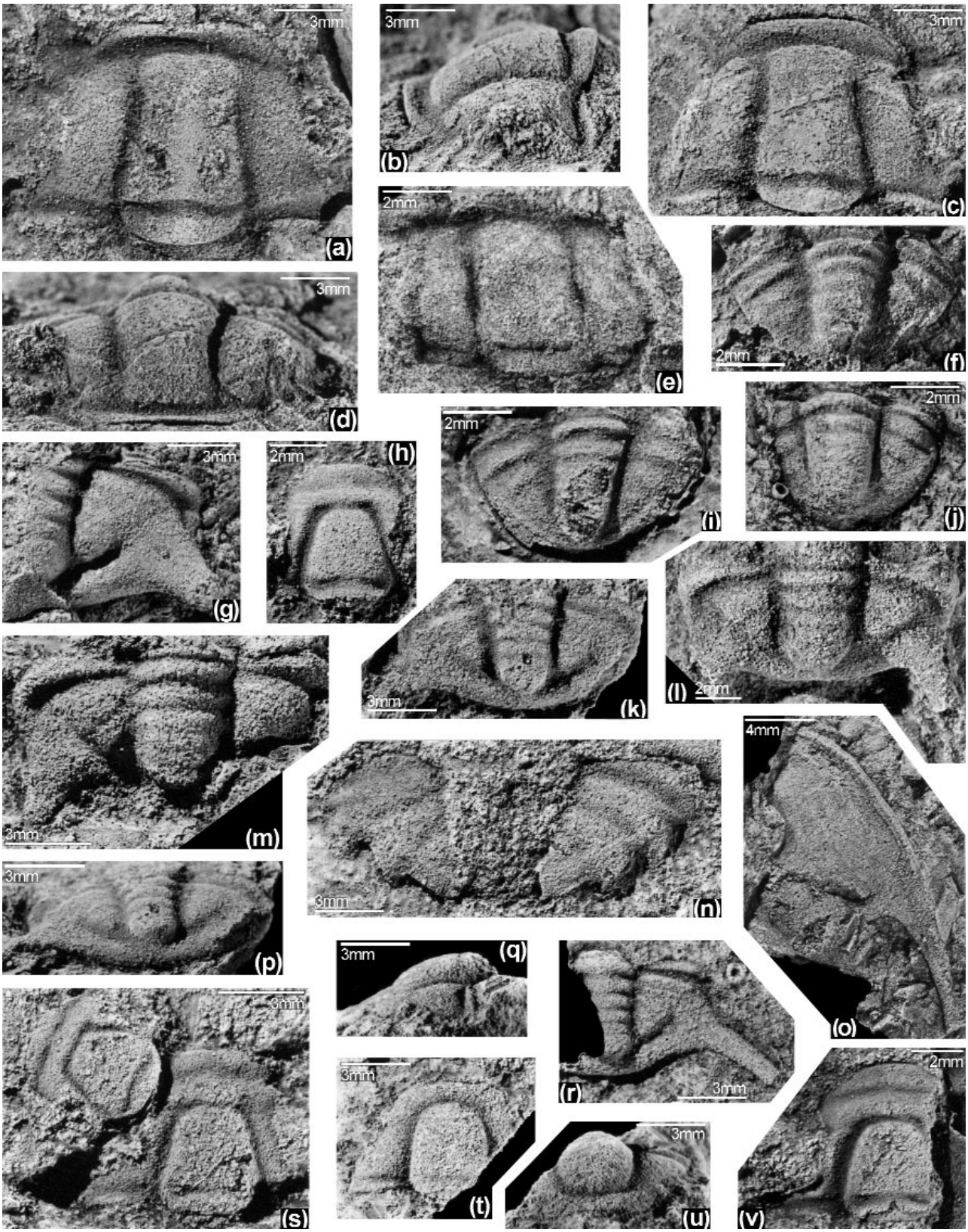
PLATE 3

Trilobites from the lower Seydisehir Formation, Yayla Tepe. (a)–(d), (g), (k)–(m), (p), (r) *Prochuangia turcica* sp. nov. (a) internal mould of cranidium showing paired muscle scars in S1 and S2, paratype, NMW.95.34G.163, Locality Z.73. (b)–(d) inclined left lateral, dorsal and anterior views of internal mould of cranidium, paratype, Locality Z.73, NMW.95.34G. 164. (g) latex cast of partial pygidium, paratype, Localiy Yo.157, NMW.95.34G.165. (k), (p) dorsal and posterior views of internal mould of pygidium, paratype, Locality Yo.157, NMW.95.34G.166. (l) internal mould of paratype pygidium, Locality Z.73, NMW.95.34G.167. (m) latex cast of pygidium, holotype, Locality Z.73, NMW.95.34G.162. (r) latex cast of partial pygidium, paratype, Locality Yo.157, NMW.95.34G.168. (e), (f), (i), (j), (o)? *Chuangia*? sp. (e) latex cast of cranidium, NMW.95.34G.157. (f) internal mould of pygidium, NMW.95.34G.158. (i) internal mould of pygidium, NMW.95.34G.159. (j) latex cast of pygidium, NMW.95.34G.160. (o)? latex cast of right librigena assigned questionably to species, NMW.95.34G.161. All from Locality Yo154. (h), (s), (v) *Taishania bassifrons* sp. nov. (h) internal mould of partial cranidium, paratype, NMW.95.34G.170. (s) internal moulds of two paratype cranidia, NMW.95.34G.171 (left) and 172 (right). (v) internal mould of cranidium, holotype, NMW.95.34G.169. All from Locality Yo.157. (n) Damesellacean? genus & species undetermined. Internal mould of incomplete pygidium, Locality Yo.157b, NMW.95.34G.177. (q), (t), (u) Olenid? genus & species undetermined. Left lateral, dorsal and anterior views of internal mould of cranidium, Locality Yo.159, NMW.95.34G.178.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