LOWER PALEOZOIC STRATIGRAPHY AND FAUNAS OF THE EASTERN TAURUS MOUNTAINS IN THE TUFANBEYLİ REGION, SOUTHERN TURKEY

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ABSTRACT. — Lower Paleozoic formations crop out along the Eastern Taurus mountain range near Tufanbeyli. The oldest known unit in the area is the Emirgazi Formation composed primarily of chlorite-sericite-quartz schists and metaquartzites. These rocks underlie conformably the Değirmentaş Limestone which is believed to be of Lower (?)-Middle Cambrian age. The observable thickness of the Değirmentaş Limestone is 110m and it is formed of white to light-gray and black to dark-gray limestones, with nodular limestone of various colors at the top. These are similar in character to the Çaltepe Limestone, of Lower (?)-Middle Cambrian age in the Seydişehir region, and are assumed to be of similar age. The Armutludere Formation of Tremadoc and Arenig age overlies the Değirmentaş Limestone. It consists mainly of shales with chlorite-sericite-quartz schist towards the lower levels. Silurian basal conglomerate lies unconformably upon the Armutludere Formation.

INTRODUCTION
(by N. Özgül and S. Metin)

The area is situated along the eastern part of the Taurus mountain belt in the vicinity of the town of Tufanbeyli (Mağara), 150 km north of Adana, Southern Turkey (Fig. 1). The area was studied by Blumenthal (1941) and Abdüsselamoğlu (1959). Blumenthal discovered Upper Devonian and younger units, and Abdüsselamoğlu collected Silurian graptolites in the area. Later Demirtaşlı (1967) collected some graptolites from the eastern part of the area and believed them to be of Ordovician age. In 1967 the area was subjected to a detailed study[1] by a group consisting of two of the present authors (N. Özgül and S. Metin) and other geologists from the Mineral Research and Exploration Institute of Turkey. In 1968 W:T. Dean, C. Kırağlı and S. Metin collected fossils, especially Lower Paleozoic forms, from the area.

For the stratigraphy of the Cambrian and Ordovician units of the area discussed in this article, the field study was carried out by Özgül and Metin, whilst fossil determinations are by Dean and R.B. Rickards.

I. STRATIGRAPHY
(by N. Özgül and S. Metin)

In the area Cambrian strata are believed to be represented by the Emirgazi and Değirmentaş Formations, and Ordovician strata by the Armutludere Formation. The Cambrian age is based on lithological comparison with the Çaltepe Limestone of the Seydişehir region, but the Ordovician age is based on fossil evidence.

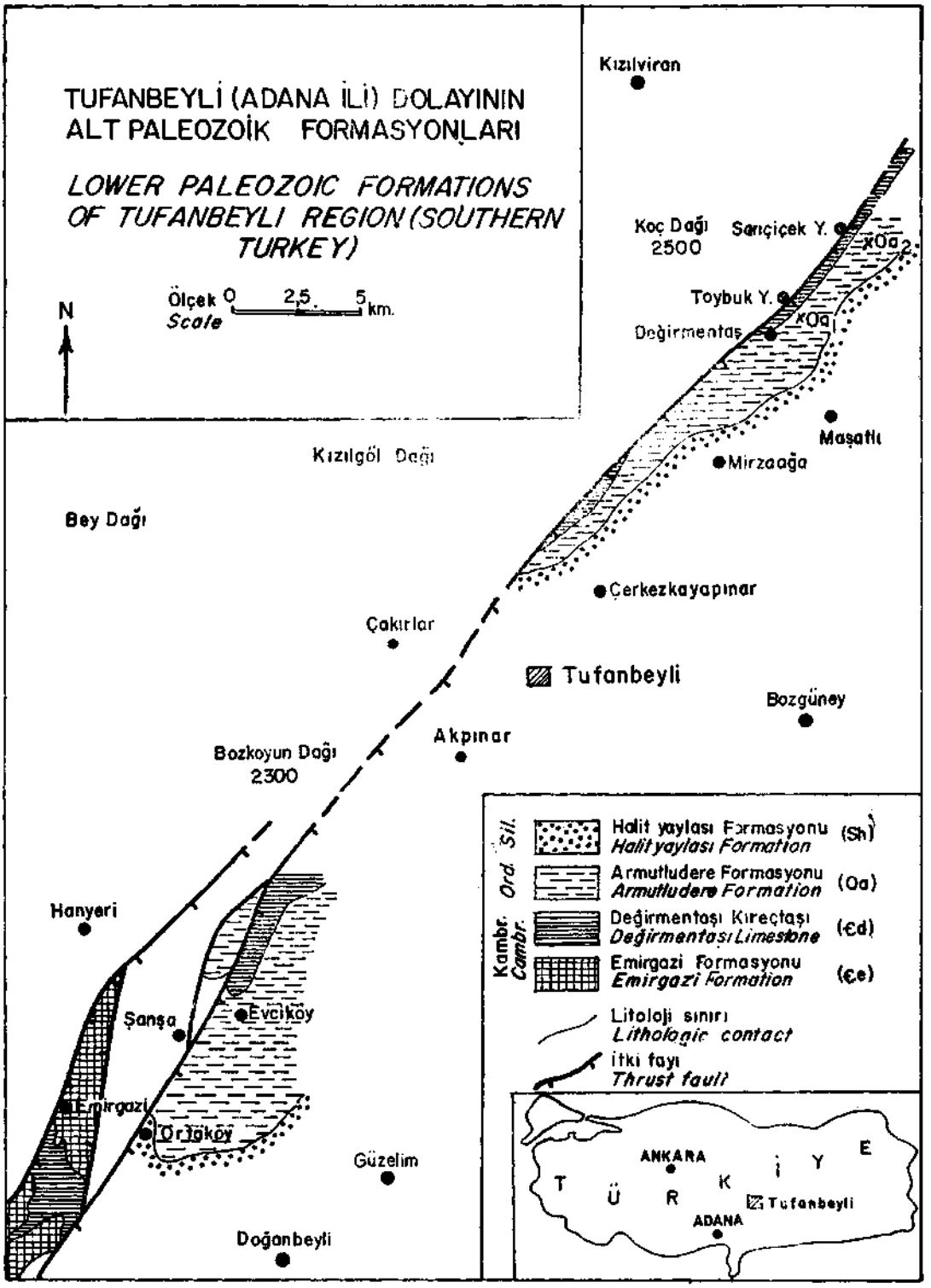
TUFANBEYLİ (ADANA İLİ) DOLAYININ
ALT PALEOZOİK FORMASYONLARI
LOWER PALEOZOIC FORMATIONS
OF TUFANBEYLI REGION (SOUTHERN
TURKEY)
N
Ölçek 0 2,5 5 km.
Scale
Kızılviran
Koç Dağı
2500
Sarıçiçek Y.
Toybuk Y.
Değirmentaş
Maşatlı
Mirzaağa
Kızılgöl Dağı
Bey Dağı
Çerkezkayapınar
Çakırlar
Tufanbeyli
Bozgüney
Akpınar
Bozkoyun Dağı
2300
Hanyeri
Şanşa
Evciköy
Emirgazi
Ortaköy
Güzelim
Doğanbeyli
Kambr. Ord. Sil.
Halit yaylası Formasyonu (Sh)
Halit yaylası Formation
Armutludere Formasyonu (Oa)
Armutludere Formation
Değirmentaşı Kireçtaşı (Ed)
Değirmentaşı Limestone
Emirgazi Formasyonu (Ee)
Emirgazi Formation
Litoloji sınırı
Lithologic contact
İtki fayı
Thrust fault
ANKARA
TÜRKİYE
Tufanbeyli
ADANA

Fig. 1

Emirgazi Formation

This formation crops out in the southwest part of the area studied and consists mainly of schist and metaquartzite, although in places there are nodular limestone levels (lithologic descriptions are given in a columnar section, see Fig. 2). As the lower boundary is faulted, the original thickness is unknown, but the observable thickness is over 100 m. The age has not been determined due to the lack of fossils in this unit, but the rocks underlie the Değirmentaş Limestone of presumed Lower (?)-Middle Cambrian age and there is a gradational contact between these two formations laterally and vertically. The Emirgazi Formation is the oldest-known unit in the area, and to our knowledge there is no other similar unit along the whole Taurus mountain chain.

Değirmentaş Limestone

This has been exposed in places by great thrust faults (Fig. 1) with northeast-southwest trend, and consists of limestones of various types and colors (lithological explanations are given in the columnar section in Fig. 2). The lower contact is always a fault plane and although the total thickness is not known, the observable measured thickness is 110 m. Variously-colored, nodular limestone which makes up the upper 42 m can be easily followed in the field. The Değirmentaş Limestone has lithological and stratigraphical characteristics similar to those of the Çaltepe Limestone which occurs in the vicinity of Seydişehir, in the western part of the Central Taurus mountains (Dean & Monod, 1970). Limestones exhibiting similar characteristics are also exposed to the north of Bağbaşı village, located to the north of Hadim in the central Taurus.[2] No fossils have been found in the Değirmentaş Limestone, but an age similar to that of the Çaltepe Formation of the Seydişehir region is suggested on lithological grounds.

Armutludere Formation

Outcrops of this formation cover a large part of the region under investigation (Fig. 1), the best being located in Armutludere, northeast of Değirmentaş village. Shales intercalated with quartzites exhibit schistose texture at lower levels (explanations of lithologies are given in Fig. 2). The formation is apparently conformable with the Değirmentaş Limestone at its lower contact.lt is overlain unconformably by Silurian basal conglomerates. Graptolites were found in the Armutludere Formation by Demirtaşlı (1967) who suggested an Ordovician age for the specimens but did not give any description or determinations. Later a group of geologists from the Geological Mapping Department of M.T.A. working in the same area found Ordovician graptolites (Özgül *et al.,* 1967; Metin *et al.,* 1967). Trilobites of Tremadoc and Arenig age were found in the same formation by Dean, Kırağlı and Metin in 1968. The Armutludere Formation has great lithological and stratigraphical affinity with the Seydişehir Formation of the Seydişehir region, part of which is also of Arenig age. Strata of the Armutludere Formation are also encountered in a tectonic window located in the Göksu valley north of Hadim, in the Central Taurus (Özgül, 1971).

Conclusions

In the vicinity of Tufanbeyli, Eastern Taurus, formations of Lower Paleozoic age crop put. The Değirmentaş Limestone (thought to be of Cambrian age) and the Armutludere Formation (Lower Ordovician) are correlated approximately with the Çaltepe Limestone and the Seydişehir Formation respectively. Although a distance of some 500 km separates these two groups of outcrops, there are striking lithological and stratigraphical similarities. Schists and quartzites, known as the Emirgazi Formation and seen only in the Tufanbeyli region below the Değirmentaş Limestone, are the oldest Lower Paleozoic rocks yet found in the Taurus orogenic belt which have escaped severe metamorphism.

2 One of the writers of this present paper, N. Özgül, is engaged in geological studies in the Hadim area, and the results are to be published in the near future.

II. THE FAUNA OF THE ARMUTLUDERE FORMATION

(by W.T. Dean)

A. FOSSILS OF TREMADOC AGE

Strata of the Armutludere Formation (1150 m) are divided by Özgül and Metin, earlier in this paper, into two members (se Fig. 2 for lithological description). Gray-green schistose rocks of the thinner (150 m) lower member yielded fossils at only one point, situated 1 km southeast of Toybuk Yaylası and shown as Oa_1 in Fig. 1. The specimens there are poorly-preserved as weathered internal and external moulds, often limonitic, and the majority comprise echinoderm fragments, though a few trilobite remains also occur.

From the point of view of dating these strata the most important fossil present is a trilobite pygidium described below as *Macropyge taurina* sp. nov. *Macropyge* was founded on a species from the Lower Tremadoc Series of the Anglo-Welsh Borderland, in which area the genus occurs also in the Upper Tremadoc Series (Stubblefield & Bulman, 1927, pp. 141, 142). Since then *Macropyge* has been reported from Tremadoc strata in Bavaria, Afghanistan and U.S.S.R., whilst a species in Utah has been considered to be of Arenig age (see later). From a systematic point of view the pygidium of *Macropyge taurina* is most closely related to that of *M. sica* Sdzuy from the Lower Tremadoc of Bavaria and may be of similar age. Geographically the new species forms a link between the European occurrences and that in Afghanistan.

The only other trilobites from locality Oa_1 are two generically undetermined specimens. The more complete (see Pl. I, fig. 2) comprises nine thoracic segments, partly disarticulated and poorly preserved as an internal mould. The low axis occupies slightly more than one-third of the overall breadth and is bounded by shallow axial furrows which converge gently backwards. The axial ring of the sixth segment is produced posteriorly to form a slim spine, the length of which is equal to at least seven times that (sag.) of one axial ring. Each pleura is divided into two unequal bands, the anterior of which is the narrower and more convex, by a slightly-curved pleural furrow which runs gently back towards the incompletely-preserved pleural points. The specimen is insufficient for even generic assignment but the median spine of the sixth segment bears some resemblance to one illustrated by Sdzuy (1955, pl. 3, fig. 88) and belonging to *Euloma geinitzi* (Barrande). A fragmentary thoracic segment (Pl. II, fig. 1) is unusually large and the surviving left pleura is almost parallel-sided and run backwards slightly to the sharply pointed tip. A gently sigmoidal pleural furrow extends almost to the tip from the axial furrow and separates unequal pleural bands, the anterior of which is notably the narrower (exsag.). The surface bears traces of fine punctation together with some wrinkling on the axial ring. No satisfactory comparison has been made.

The most abundant fossils at locality Oa_1 are fragmentary eocrinoid remains. The available material, all of which is preserved as weathered limonitic internal and external moulds, consists largely of isolated thecal plates and columnals. Two specimens, however, are more complete and each shows part of a compressed theca composed of two rows of large thecal plates together with an indeterminate number of other plates. The large thecal plates, one of which is illustrated as a latex cast (Pl. I, fig. 6), are moderately convex, slightly elongated in outline, and have six or seven sides. Conspicuous radial ridges run to the angles and often coalesce medially to form an elongated structure. In each of the two more complete specimens the theca is supported by a flexed stem of circular cross-section which diminishes rapidly in diameter towards the tip. The proximal portion of the stem is composed of columnals, with height approximately one-sixth of their diameter, which are

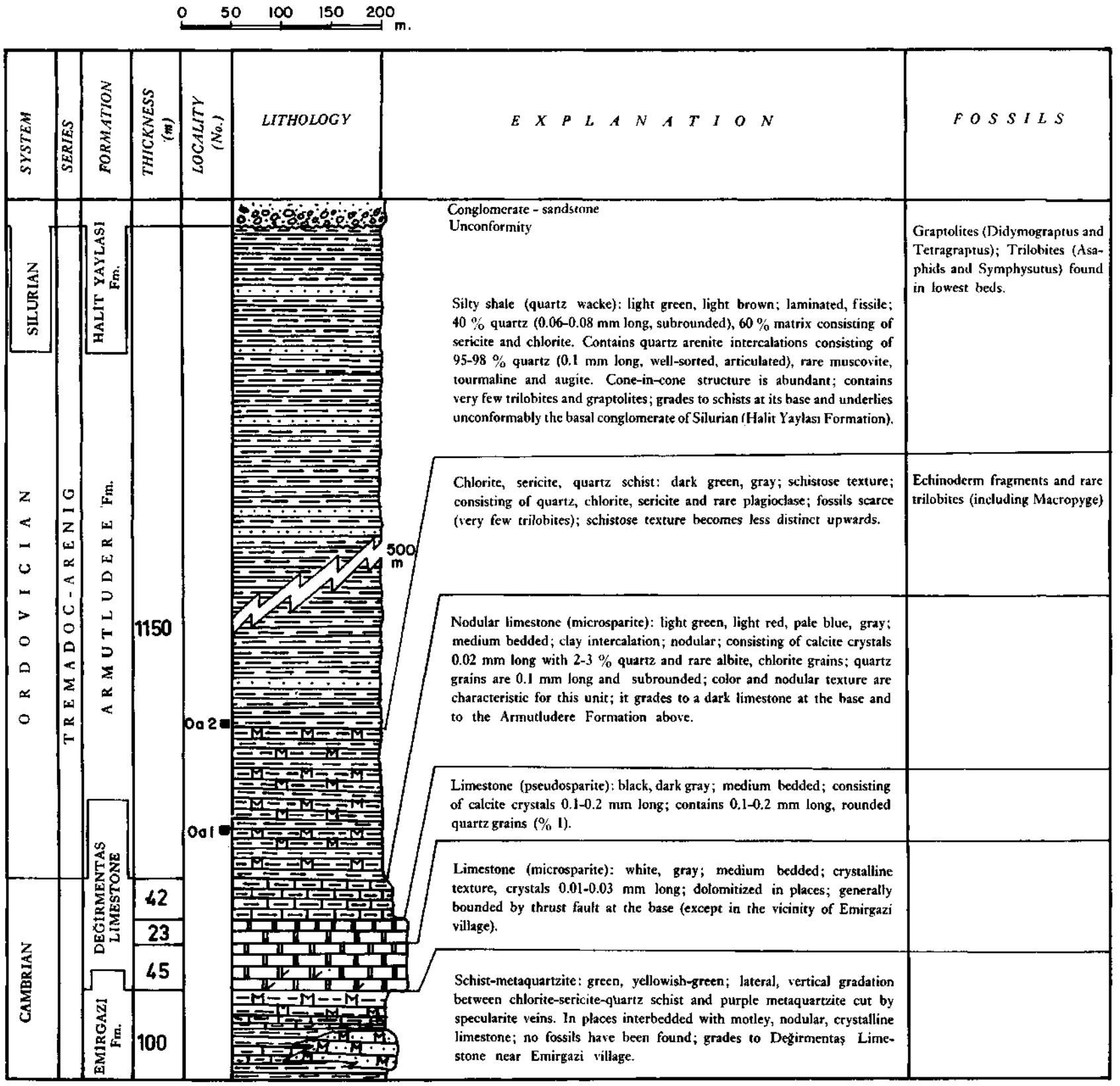

Fig. 2 - **Generalized columnar section of the Lower Paleozoic rocks of the Tufanbeyli region (Southern Turkey).**

ornamented with fine ridges and a, probably, pentamerous arrangement of nodes which alternate in position on adjacent columnals (see especially Pl. I, fig. 7). The most completely preserved example (Pl. I, fig. 5) shows ornamentation of this type extending less than half the length of the stem; beyond this point the stem is made up of columnals which become progressively longer, narrower and smoother towards the tip (not preserved).

No generic assignment of this abundant though inadequately-preserved material has been made, but certain features suggest affinities with the eocrinoid genus *Macrocystella* Callaway (1877, pl. 24, fig. 13), founded on *M. marine* Callaway from the Shineton Shales, Tremadoc Series of Shropshire. Thecal plates and columnals of *M. mariae* together with those of *M. ? bavarica* (Barrande, 1868) from the Leimitz-Schiefer, Tremadoc Series, of Bavaria have been described by Sdzuy (1955a). It is clear from Sdzuy's illustrations that the thecal plates from near Toybuk Yaylası strongly resemble those of the Bavarian rather than the British species in both outline and the ornamentation of strong radial ridges. Unlike *M. ? bavarica* the areas between the ridges are apparently smooth, though it is possible that any original ornamentation may have been affected by weathering. The Turkish material is insufficiently well preserved to show whether two types of columnals—termed «Kragenglieder» and «Zwischenglieder» by Sdzuy (1955a)—are present, and the nodes ornamenting the columnals are notably stronger than those shown by the Bavarian specimens. The taper and flexed form of the stem in the most complete example (see Pl. I, fig. 5) resemble those *of Macrocystella*.

B. SYSTEMATIC DESCRIPTION OF A NEW TRILOBITE

Family: REMOPLEURIDIDAE HAWLE & CORDA, 1847

Genus: *MACROPYGE* STUBBLEFIELD *in* STUBBLEFIELD & BULMAN, 1927

Type species. — *Macropyge chermi* Stubblefield *in* Stubblefield & Bulman 1927 by original designation.

Macropyge taurina sp. nov.

(Plate I, figures 1, 4)

Diagnosis. — *Macropyge* species with pygidial outline rounded anterolaterally and broadest opposite hindmost portion of axis. Overall outline slightly more than three times as long as broad, tapers to slim point, produced in turn to form long, needle-like spine. Pygidial axis relatively large and long, with one axial ring.

Holotype. — The only known specimen, a pygidium preserved as internal and external mould. M.T.A. Collection, Ankara.

Description. — The overall pygidial outline, excluding the needle-like terminal spine, is slightly more than three times as long as broad. The moderately-convex axis occupies about one-quarter of the length and its frontal breadth equals half the maximum breadth of the pygidium. The sides of the axis form evenly convex curves that meet at a pointed tip behind which a thin, low ridge, followed by a shallow groove, extends backwards coincident with the axial line. The pleural regions form a continuous, almost level surface; in plan view the margin of each runs in an unbroken, slightly sigmoidal curve, at first, posterolaterally from the axial furrow until opposite the hindmost quarter of the axis, and then turning gently inwards and back towards the terminal spine. The axis shows

only a single, poorly-defined axial ring whilst the pleural regions carry two pairs of shallow, gently-curved pleural furrows which run almost backwards and die out opposite the tip of the axis. No trace of surface ornamentation is visible, but may have been obliterated by weathering.

Discussion. — The species of the genus with which *Macropyge tauriria* may be most closely compared are *M. chermi* Stubblefield *in* Stubblefield & Bulman (1927, p. 141, pl. 4, figs. 12,13) and *M. sica* Sdzuy (1955b, p. 26, pl. 5, figs. 26a, b, 27, text-fig. 24; 1958). Both these attain their greatest pygidial breadth frontally and their outline is angular anterolaterally, features which alone would suffice to distinguish them from the Turkish species. In addition *M. chermi* has a shorter, straight-sided axis with a blunt tip and two axial rings, whilst the overall breadth behind the axis is notably larger, resulting in a greater degree of narrowing towards the tip of the pygidium. The slimmer pygidial plan of *M. sica* is closer to that of *M. taurina,* as is the outline of the axis, with its single axial ring; but the axis of the Bavarian species is relatively shorter and less pointed, whilst the pleural regions are proportionately narrower opposite the posterior half of the axis. *M. chermi* was described from the Shineton Shales, Tremadoc Series, of Shropshire, where it was recorded from the *Dictyonema flabelliforme* Zone, Transition Beds, *Clonograptus tenellus* Zone and, questionably, *Shumardia pusilla* Zone. *M. sica* was founded on two pygidia from the lowest of three «zones» constituting the Leimitz-Schiefer of Bavaria, and was said by its author to be of Lower Tremadoc age. It seems likely, therefore, that *Macropyge taurina* also is of Tremadoc age.

Macropyge brevicandata Wolfart (1970, p. 49) from the Tremadoc of Afghanistan and *M. gladiator* Ross (1951, p. 122) from the Arenig of Utah differ markedly from *M. taurina* and are not considered in detail here.

C. FOSSILS OF ARENIG AGE

Strata of the Armutludere Formation, though fairly well exposed in the section at Armutludere itself, southeast of Sarıçiçek Yaylası proved for the most part to be barren. During the present collecting, brownish-gray, hard, splintery shales yielded fossils at two places, closely adjacent to one another so that they can be represented on the present map (see Text-fig. 1) by only a single point, locality Oa_2, situated approximately 1.25 km southeast of Sarıçiçek Yaylası. Both fossiliferous horizons, which are separated from one another by about 15 meters of strata, are in the lowest portion of the upper member of the Armutludere Formation.

The lower fossiliferous horizon yielded a small slab of shale covered with a mat-like mass of graptolite fragments. These have been examined by Dr. R.B. Rickards, Cambridge, to whom we are much indebted for his identifications and comments. Dr. Rickards lists the following species: *Didymograptus extensus* (Hall), *D. nichohoni* Lapworth, *D.* cf. *nitidus* (Hall), *D.* aff. *deflexus* Elles & Wood, and states (personal communication) «This assemblage is certainly of Arenig age and suggests the *nitidus* Subzone of the *extensus* Zone». At the same locality were found a few fragments of trilobites, the best-preserved of which are illustrated. The compressed cephalon shown in P1. II, fig. 7 is of asaphid type with isotelinid facial suture, and prominent semicircular palpebral lobes sited, apparently, well back and immediately outside the axial furrows. There is a weakly-developed, low anterior border, broadest (sag.) frontally but narrowing laterally. There is no evidence of glabellar segmentation and the well-rounded frontal glabellar lobe is slightly crushed. The librigenae are broad and the genal angles produced to form librigenal spines of moderate size. The preglabellar field and anterior border are slightly longer than is usual for the otherwise similar *Paramegalaspis* from the Lower Ordovician of Southern France (see Thoral, 1935, p. 238 *(nom. nud.)* and Dean 1966, p. 325), but this may well be due to mechanical deformation. There is some resemblance to cranidia

illustrated as *Megistaspis (Ekeraspis)* sp. from the Lower Arenig Series of Southern France (Dean, 1966, p. 323, pl. 16, figs. 2, 9, 10). The ventral aspect of an associated compressed pygidium (PL II, fig. 5) is approximately one and a half times as broad as long, subsemicircular in outline, with a narrow, straight-sided axis that extends about three-quarters of the overall length and terminates level with the inner margin of the doublure. Mere traces remain of an undetermined number of axial rings, and the pleural regions show only faint evidence of five or six pairs of pleurae.

The higher fossiliferous horizon at locality Oa_2 was found to contain a few graptolites and poorly-preserved trilobites. Dr. Rickards has identified the former as *Tetragraptus* aff. *reclinatus* Elles & Wood and writes «This is an Arenig species which Elles & Wood record from their *extensus* and *hirundo* Zones». Associated trilobite remains (see PL II, figs. 2-4, 6) include a poorly-preserved right librigena similar to that of the cephalon from the lower fossiliferous horizon (PL II, fig. 7), and two compressed pygidia, each with part of the thorax attached (PL II, figs. 2, 6). The originals of Plate II, figs. 2, 5 and 6 may particularly be compared with smaller pygidia of Lower Arenig age from Southern France, figured by Dean (1966, p. 326, pl. 18, figs. 11, 12) as *Paramegalaspis* sp. The external mould (figured as a latex cast, PL II, fig. 4) of an incomplete dorsal exoskeleton of *Symphysurus,* though damaged and not determinable with certainty at specific level, belongs to a genus which is widely distributed in Tremadoc and Arenig rocks, but some comparison may be made with *Aeglina sicardi* Bergeron (1895, p. 478), later termed *Symphysurus angustatus sicardi* by Thoral (1935, p. 269) and said to be from the topmost Tremadoc Series in the Montagne Noire, Southern France.

D. STRATIGRAPHIC CONCLUSIONS

The lowest strata of the lower member of the Armutludere Formation contain the trilobite *Macropyge* and eocrinoid remains, both of which, by comparison with faunas in Britain and Bavaria, are considered to indicate a probable Tremadoc age. As yet no obvious evidence has been found for a physical break between the Armutludere Formation and the underlying, unfossiliferous Değirmentas Limestone. If the latter is correctly correlated on lithological grounds with the Çaltepe Formation (the upper portion of which contains Middle Cambrian fossils and is overlain by shales of probably Middle Cambrian age) of the Seydişehir region, as is suggested by Özgül and Metin elsewhere in this paper, then one must consider the possibility of a disconformity between the Değirmentaş Limestone and the Armutludere Formation, though faunal evidence is lacking. Mr. Necdet Özgül informs me (personal communication) that in the Hadim area he collected inarticulate brachiopods from a limestone bed in shales overlying the Çaltepe Limestone. The specimens were identified by Dr. İsmet Gedik as *Angulotreta* sp. and *Linnarssonella* sp., and held to indicate an Upper Cambrian age. There is as yet no faunal evidence of Upper Cambrian strata from the Tufanbeyli region.

The remainder of the lower member of the Armutludere Formation has not yet yielded fossils, and the Tremadoc/Arenig boundary is drawn only tentatively at the base of the upper member, the lowest strata of which contain graptolites of the *Didymograptus extensus* Zone. The evidence for a *post-extensus* Zone age provided by the *Tetragraptus* at locality Oa_2 is inconclusive, but the rest of the upper member, overlaift by unconformable Silurian strata, comprises some 1000 m of silty shales in which fossils have not yet been found, and it is possible that higher Ordovician zones may be represented.

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PLATES

EXPLANATION OF PLATES

PLATE -I

All the figured specimens are from the lower member of the Armutludere Formation at locality Oa1, southeast of Toybuk Yaylası, and are of Tremadoc age. Material is in the collections of M.T.A., Ankara.

Macropyge taurina sp. nov.

Figs. 1,4- Internal mould and latex cast of holotype pygidium. X 4. Note posterior extension of slim terminal spine.

Trilobite genus and species undetermined A

Fig. 2 - Internal mould of nine partly disarticulated thoracic segments, the sixth of which carries a long median spine. X 2.

Eocrinoid genus and species undetermined

Fig. 3 - Latex cast of crushed theca and proximal portion of stem. X 3.

Fig. 5 - Latex cast of part of theca with almost complete stem strongly curved and narrowing towards tip. X 3.

Fig. 6 - Latex cast of isolated thecal plate showing seven-sided outline and radiating ridges. X 6.

Fig. 7 - Latex cast of two fragmentary stems showing ornamentation of alternating nodes on adjacent columnals. X 3.5.

PLATE - II

Fig. 1 is from the lower member of the Armutludere Formation at locality Oa1, southeast of Toybuk Yaylası, and is of Tremadoc age. The remainder are from the upper member at locality Oa_2, southeast of Sarıçiçek Yaylası, and are of Arenig age.

Trilobite genus and species undetermined B

Fig. 1 - Internal mould of incomplete, very large thoracic segment. X 2.

Asaphid genus and species undetermined

Fig. 2 - Internal mould of crushed pygidium with seven attached thoracic segments. X 2.

Fig. 3 - Internal mould of right librigena. X 3.

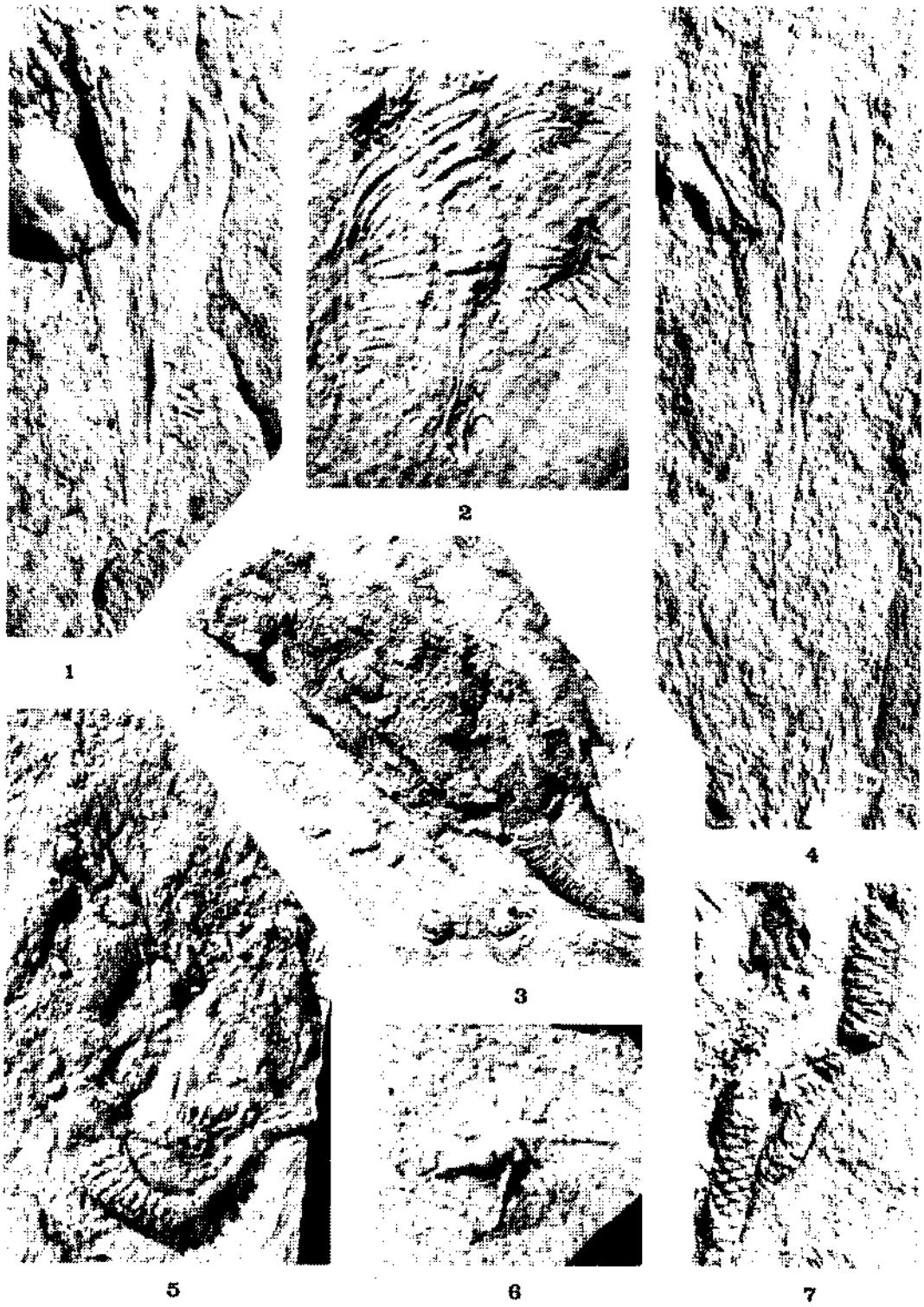
Fig. 5 - Poorly-preserved external mould of pygidium with impression of small gastropod. X 1.5.

Fig. 6 - Internal mould of compressed pygidium with five attached thoracic segments. X 1.75.

Fig. 7 - Latex cast of slightly distorted, compressed cephalon. x 2.

Symphysurus sp.

Fig. 4 - Latex cast of incomplete dorsal exoskeleton. x 2.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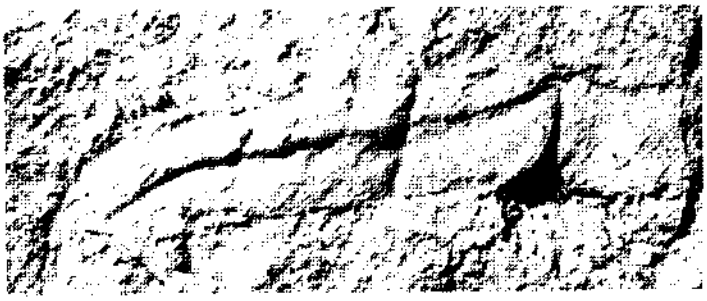

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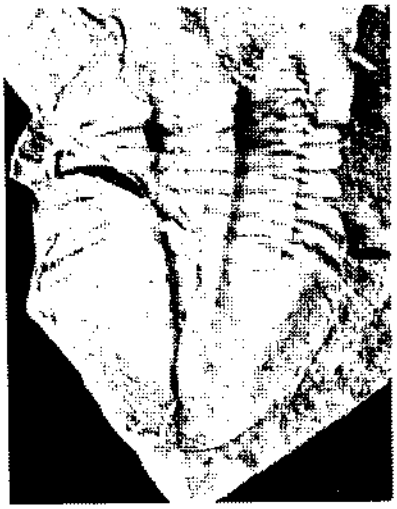

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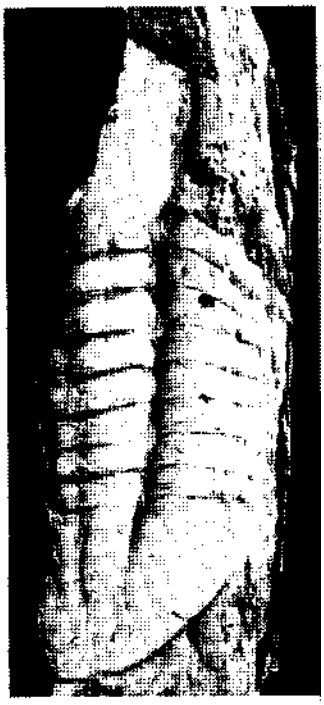

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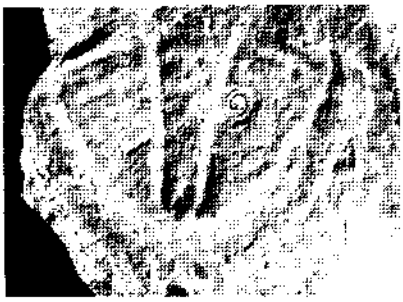

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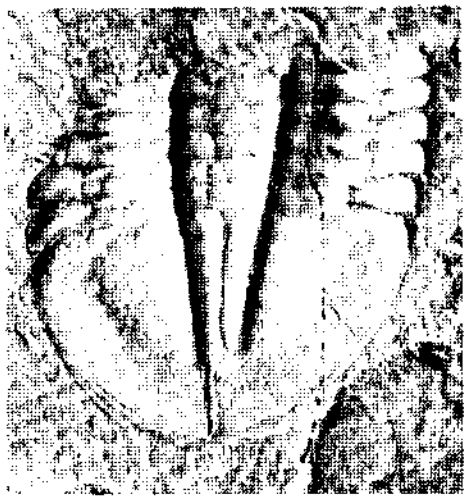

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