

THE LOWER PALAEOZOIC STRATIGRAPHY
AND FAUNAS OF THE TAURUS MOUNTAINS
NEAR BEYŞEHİR, TURKEY.

I. STRATIGRAPHY



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THE LOWER PALAEOZOIC STRATIGRAPHY AND FAUNAS OF THE TAURUS MOUNTAINS NEAR BEYŞEHİR, TURKEY.

I. STRATIGRAPHY

By W. T. DEAN & O. MONOD

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SYNOPSIS

The Lower Palaeozoic strata of the Beyşehir region, south-west of Konya, are described. The Cambrian rocks are well developed as the Çal Tepe Formation, at least 130 metres thick and divisible into four parts. The lowest two subdivisions consist of unfossiliferous dolomite and unfossiliferous black limestone respectively. The third part comprises light-grey limestones which contain trilobites of both Lower(?) and Middle Cambrian age. The highest beds contain Middle Cambrian trilobites and are succeeded by the shales of the Seydişehir Formation, Ordovician at least in part. The succession exhibiting the junction of the two systems is overturned on the Çal Tepe itself and the neighbouring hills. Large outcrops of the Seydişehir Shales have yielded small numbers of trilobites, graptolites, brachiopods and molluscs which indicate an Arenig age for the upper half of the Seydişehir Formation and exhibit affinities with other faunas of Tethyan type in the Mediterranean region. The Seydişehir Shales are succeeded by a small thickness of "Upper Greywackes", followed in turn by the Sobova Formation. The latter is best developed, as limestones, in the Sobova Valley, south of Beyşehir, and contains a trilobite fauna of Arenig age in which predominantly Baltic elements occur, together with a minority of Tethyan forms. Grey shales, also of Arenig age, immediately above the Sobova Limestone at its type locality, pass laterally into red sandstones at Taraşçı, and both are overlain unconformably by limestones of Triassic or Jurassic age.

I. INTRODUCTION AND ACKNOWLEDGMENTS

THE Taurus mountain range stands between the plateau of Central Anatolia, to the north, and the Mediterranean Sea, to the south. It extends eastwards from the southern Aegean coast of Turkey to northern Iran, and its overall width varies considerably. Most of the mountains which make up the Taurus are composed of Mesozoic formations, but an older substratum of Palaeozoic rocks appears occasionally, mainly along the northern border of the range. North of the region around

Beyşehir, about 100 kilometres southwest of Konya (see Fig. 1), the Taurus runs south-southeastwards along the southern margin of an older Palaeozoic massif, the Sultan Dağ, the rocks of which have been metamorphosed and strongly deformed tectonically. The geology of part of the Sultan Dağ was described by both H. Haude and D. Kelter in unpublished theses of the University of Münster, the contents of which have recently been summarized by Haude (1969). Prior to the discovery of

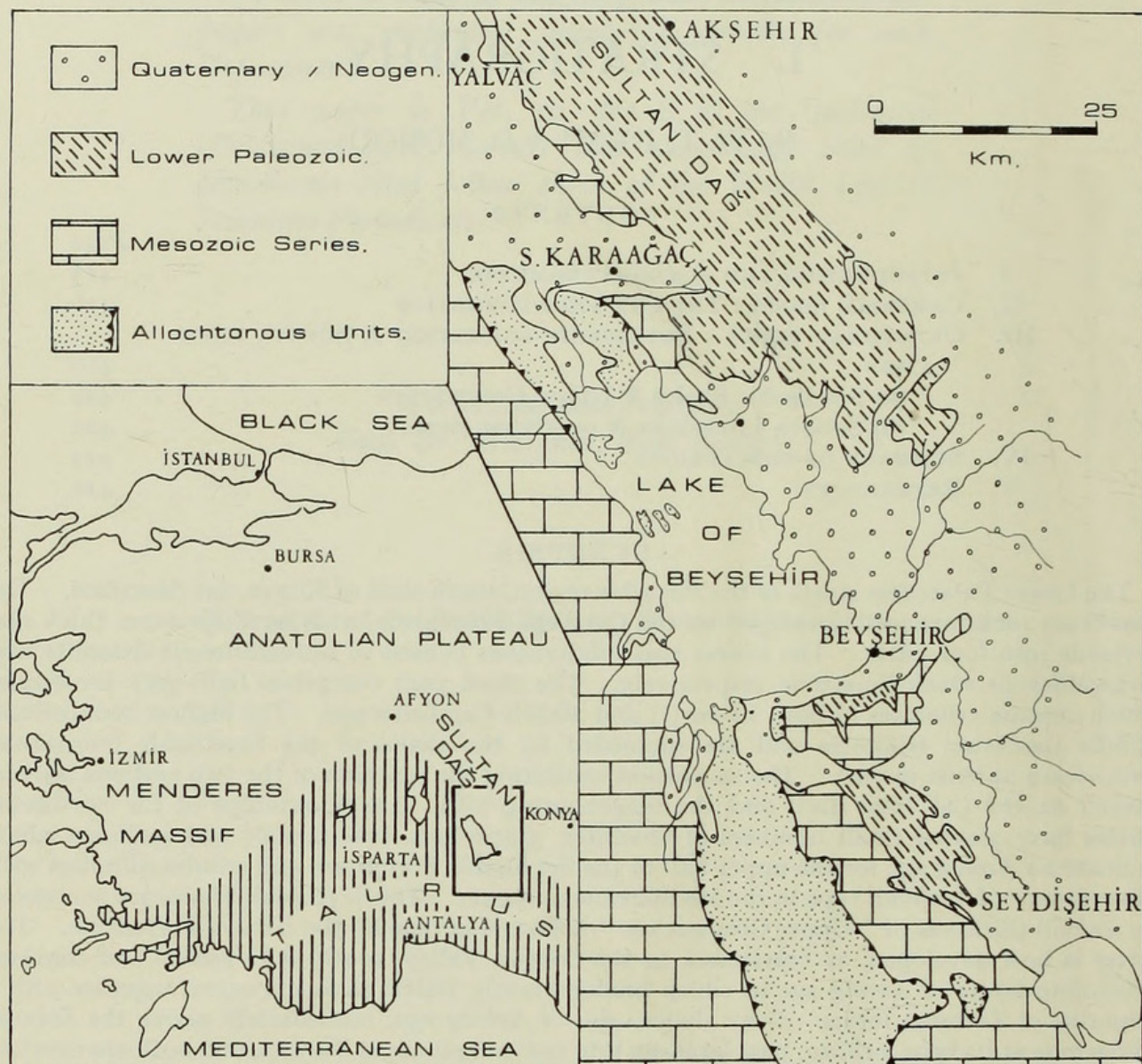


FIG. 1. Geological sketch-map showing the location of the area investigated in the western Taurus Mountains. Modified from the Konya Sheet of the 1 : 500,000 geological map of Turkey.

Cambrian rocks in the Beyşehir region Kelter and Haude had found Middle Cambrian fossils on the Sultan Dağ, and this information proved useful in the search for fossiliferous horizons on Çal Tepe.

South of Beyşehir, large outcrops of some of the older formations of the Sultan Dağ occur, but in this region the rocks are less disturbed tectonically and numerous

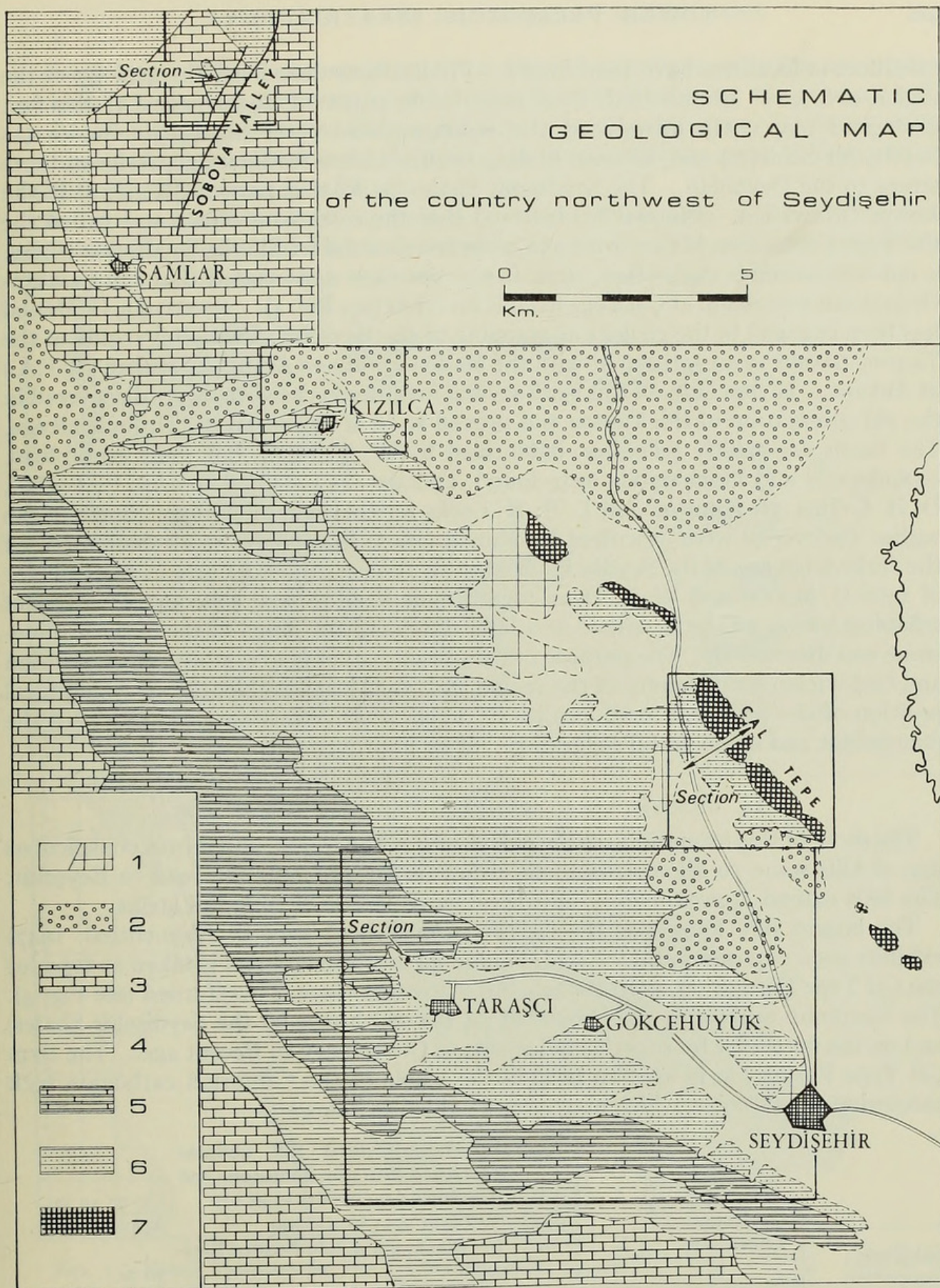


FIG. 2. Schematic geological map of the country northwest of Seydişehir. Geological boundaries by O. Monod. 1 = Recent deposits and Quaternary travertine ; 2 = Upper Neogene conglomerates and marls ; 3 = Jurassic and Cretaceous limestones ; 4 = Şarpiar Formation (Upper Trias—Lias ?) ; 5 = Tıraşçı Limestones (Middle Trias) ; 6 = Seydişehir Formation (Lower Ordovician in part) ; 7 = Çal Tepe Formation (Lower ?—Middle Cambrian). Rectangles show position of areas in Figs. 3, 5 and 6.

fossiliferous localities have been found. Publications describing the geology of the region are few. Blumenthal, in a remarkable paper of 1947, provided the first geological map. He introduced the stratigraphical term Seydişehir Shales (as Seydişehir-Schiefer) and, without finding fossil evidence for their age, assigned these strata to the Devonian. The Seydişehir Shales (at least in part) are here put in the Lower Ordovician. Blumenthal believed that the calcareous strata now called the Çal Tepe Formation, of Cambrian age, were interbedded within the Seydişehir Shales, a not unreasonable suggestion, since it was not then appreciated that the Cambro-Ordovician succession at Çal Tepe itself is inverted (see Fig. 4). Since 1965 O. Monod has been engaged in the geological mapping of the Beyşehir-Seydişehir region of the Taurus, thanks to an agreement with the Maden Tetkik ve Arama Enstitüsü (M.T.A.) at Ankara. In the course of this work several fossiliferous localities were discovered in the old substratum of the Taurus and proved to be of Cambrian and Ordovician age. The fossils are mostly trilobites, identified by W. T. Dean, but some graptolites, cephalopods and brachiopods were found, and we are indebted to Drs. P. Toghil, D. H. Collins, H. Brunton and L. R. M. Cocks for their identification. Some of the earlier discoveries were described by Monod (1967) in a paper which demonstrated the Ordovician age of the Seydişehir Shales for the first time. Early in the summer of 1968 O. Monod and W. T. Dean together made additional collections, mostly of trilobites which will be described at a later date, and the fauna of the Sobova Limestone was discovered. The purpose of the present paper is to establish the Cambrian and Ordovician stratigraphy of the region and, as far as possible, the stratigraphical position of the principal fossil localities. Prof. H. B. Whittington kindly read the manuscript and made useful suggestions for its improvement.

II. CAMBRIAN ROCKS: ÇAL TEPE FORMATION

The rocks of this formation are the oldest seen in the region, and form a conspicuous line of hills some 10 kilometres north of Seydişehir and near the road to Beyşehir. The hills extend approximately northwestwards in the direction of strike.

The largest hill, known as the Çal Tepe (or İdisçal Tepe *in* Blumenthal, 1947) exhibits good exposures and the section near its southeastern end is taken as type for the Çal Tepe Formation, even though the succession there is overturned (see Fig. 4). The Cambrian outcrop here is bounded on the southwest by the Seydişehir Shales, and on the northeast by superficial deposits of Quaternary to Recent age. The term Çal Tepe Formation is used to include the whole of the Cambrian carbonate rock succession at this point, which may be subdivided as follows :—

Çal Tepe Formation	{	Çal Tepe Limestone	{	U	Bed d. Thinly-bedded red nodular limestone with grey limestone bed (less than 1 metre thick) at top	Up to 40 m.
					Bed c. Light-grey limestone	Approx. 10 m.
		Çal Tepe Dolomite	{	L	Bed b. Black, massively-bedded limestone	30 m.
					Bed a. Massively-bedded, coarsely-crystalline dolomite	more than 50 m.

Bed a. forms the lower part of the northeastern flank of Çal Tepe, and is fairly well

exposed there. The rocks, which have not yielded any traces of fossils, are at least 50 metres thick and the stratigraphical base has not been seen, the outcrop being terminated by Quaternary to Recent deposits. The dolomite may be traced south-eastwards along the strike to the neighbouring, smaller hill of Guvercin Tepe and the still smaller hill beyond (see Fig. 3).

Bed b. is a massive, black, crystalline limestone which forms a conspicuous small cliff along the crest of Çal Tepe and Guvercin Tepe. No traces of fossils were found.

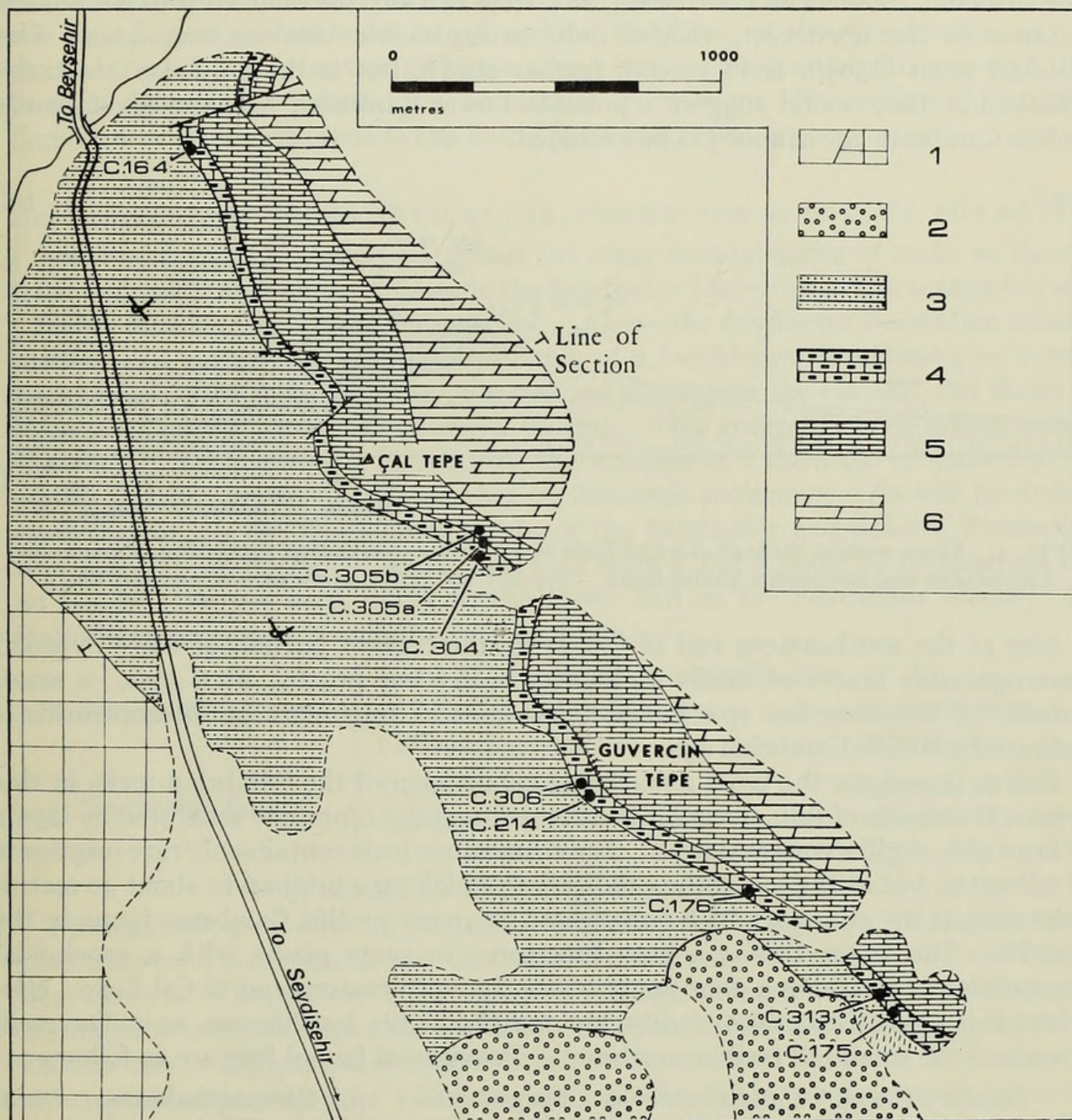


FIG. 3. Fossil localities in the Cambrian rocks of the Çal Tepe district. Geological boundaries by O. Monod. 1 = Recent deposits and Quaternary travertine; 2 = Upper Neogene conglomerates; 3 = Seydişehir Shales; 4-6 = Çal Tepe Formation. 4 = Red nodular limestone; 5 = Light to dark-grey limestone; 6 = Dolomite. The broken oblique shading near C.175 denotes superficial talus deposits.

Bed c. comprises well-bedded limestones which are mostly light-grey in colour with occasional patches of pink limestone. Although only about 10 metres thick, this subdivision is of particular importance on account of the fossils it contains.

Locality C.305b., at the southeastern end of Çal Tepe (see Fig. 3), contains the oldest fossils yet known from the area. These comprise fragments of protolenid (?) trilobites together with a large, as yet undetermined form thought to be a paradoxidid, which occur in a pinkish-grey limestone band, a few centimetres thick, near the base of Bed c. Localities C.181 and C.182, from broadly the same horizon but a short distance to the northwest, yielded only unidentifiable trilobite fragments. The material from C.305b. is to receive further study, but if the trilobites are truly protolenids, they would suggest a possible Lower Cambrian age, though an early Middle Cambrian age cannot yet be excluded.

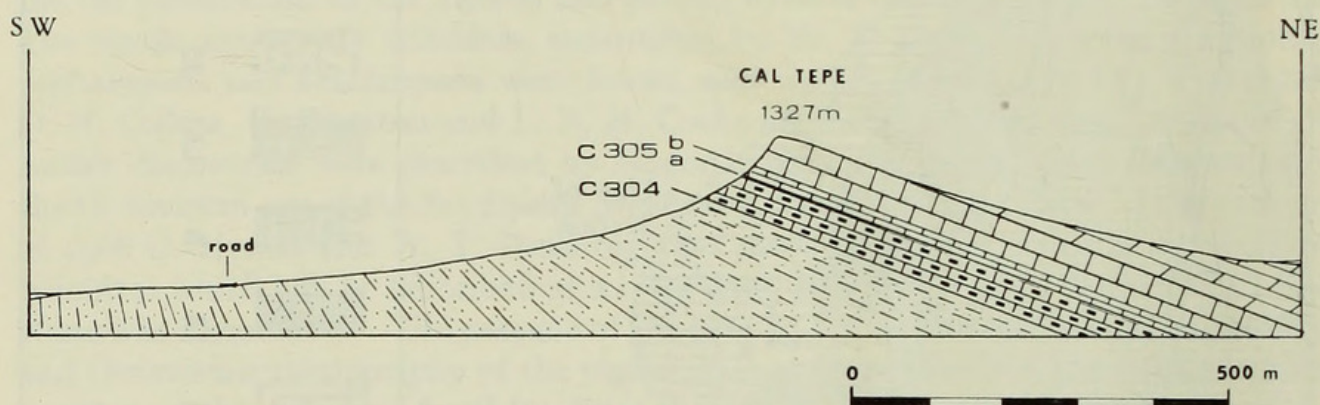


FIG. 4. Cross-section through the Çal Tepe showing the overturned succession of Çal Tepe Limestones and Seydişehir Shales there. For key to Cambrian rocks, see text and Fig. 3.

Also at the southeastern end of Çal Tepe, the highest portion of Bed c. yielded unrecognizable traces of fossils at locality C.183 but nearby, at C.305a., a small faunule of *Corynexochus* sp., *Paradoxides* sp. and fragments of solenopleurids(?) indicated a Middle Cambrian age.

Bed d. is perhaps the most remarkable subdivision of the Cambrian rocks in this area. It consists of thin, irregular beds of red, nodular limestone separated by layers of brownish, argillaceous material. These limestone beds contain only rare fragments of trilobites, but at the top of the subdivision, which may total up to about 40 metres thickness, is the stratum which has yielded the most prolific Cambrian fauna in the district. The latter bed is a grey limestone, in some places with a conchoidal fracture and containing a poor fauna, as at the southeastern end of Çal Tepe; elsewhere it is rubbly, crumbles readily, and may be highly fossiliferous, as on Guvercin Tepe and the small hill farther southeast. Provisional faunal lists are as follows:—

- Locality C.175. *Conocoryphe* sp., *Corynexochus* sp., *Ctenocephalus* sp., *Paradoxides* sp., *Peronopsis* ? sp. *Solenopleuroopsis* sp.
- Locality C.214. *Conocoryphe* sp., *Corynexochus* ? sp., *Paradoxides* sp.
- Locality C.304. *Corynexochus* sp., *Paradoxides* ? sp.
- Locality C.313. *Conocoryphe* ? sp., *Corynexochus* ? sp., *Paradoxides* sp., *Peronopsis* sp.

The same horizon crops out on an adjacent hill sited about 1500 metres northwest of Çal Tepe and immediately west of the Beyşehir-Seydişehir road. There, locality C.237 yielded Agraulid (?) gen. et sp., *Corynexochus* sp. and *Paradoxides* sp.

All these trilobites indicate a Middle Cambrian age and are essentially of Tethyan type, similar assemblages of genera having been described from the Western Mediterranean area, Bohemia, the Anglo-Welsh area and eastern Newfoundland. The Çal Tepe Limestone is followed, apparently conformably, by about 50 metres of yellow shales which pass, in turn, into a succession of sandstones and shales. In the latter, one may find occasional lenses of red nodular limestone, of the type forming part of the Çal Tepe Limestone, but all these strata have proved unfossiliferous and they have been included within the Seydişehir Formation. No evidence of Upper Cambrian or Tremadoc faunas has been found in the district.

III. ORDOVICIAN ROCKS: SEYDİŞEHİR FORMATION & SOBOVA FORMATION

The Seydişehir Formation comprises the main detrital series of rocks in the district, and the term is taken to include the Seydişehir Shales *sensu stricto* together with a higher member, the Upper Greywackes. Above the Seydişehir Formation comes a distinct and variable set of beds, consisting of a fossiliferous limestone (the Sobova Limestone) at the base, followed by either red sandstones (at Taraşçı), red shales (at Kızılca) or grey shales (at the Sobova Valley). This group of strata is here termed the Sobova Formation; it constitutes the uppermost Palaeozoic formation of the region and is overlain disconformably by Mesozoic sediments. As will be demonstrated later, all the fossiliferous strata of the Seydişehir and Sobova Formations belong to the Arenig Series, as far as is now known, but it must be emphasized that no fossils have yet been found in the lower half of the Seydişehir Shales. The Ordovician rocks may be subdivided as follows :—

b. Sobova Formation	{	Grey shales, passing laterally into	
		red shales and sandstones	. . approx. 20 m.
		Sobova Limestone	. . 0 to 10 m.
a. Seydişehir Formn	{	Upper Greywackes	. . approx. 20 m.
		Seydişehir Shales (s.s.)	. . more than 1000 m.

(a) Seydişehir Shales and Upper Greywackes

First named, as Seydişehir-Schiefer, by Blumenthal (1947), the Seydişehir Shales crop out over a considerable area and occupy a tract of country which extends north-westwards from Seydişehir to the village of Kızılca, a distance of some 18 kilometres. A smaller area of outcrop occurs mid-way between Kızılca and Beyşehir, and in this district the small, partially faulted inlier of the Sobova Valley is of considerable stratigraphical importance. Lithologically the Seydişehir Shales consist essentially of a succession of psammitic quartzites alternating with silty, micaceous shales. This monotonous lithology occupies most of the total thickness, which is roughly 1000 metres or more.

Though most of the succession is barren, fossils occur sporadically throughout the upper half of the Seydişehir Shales, and become more frequent towards the top.

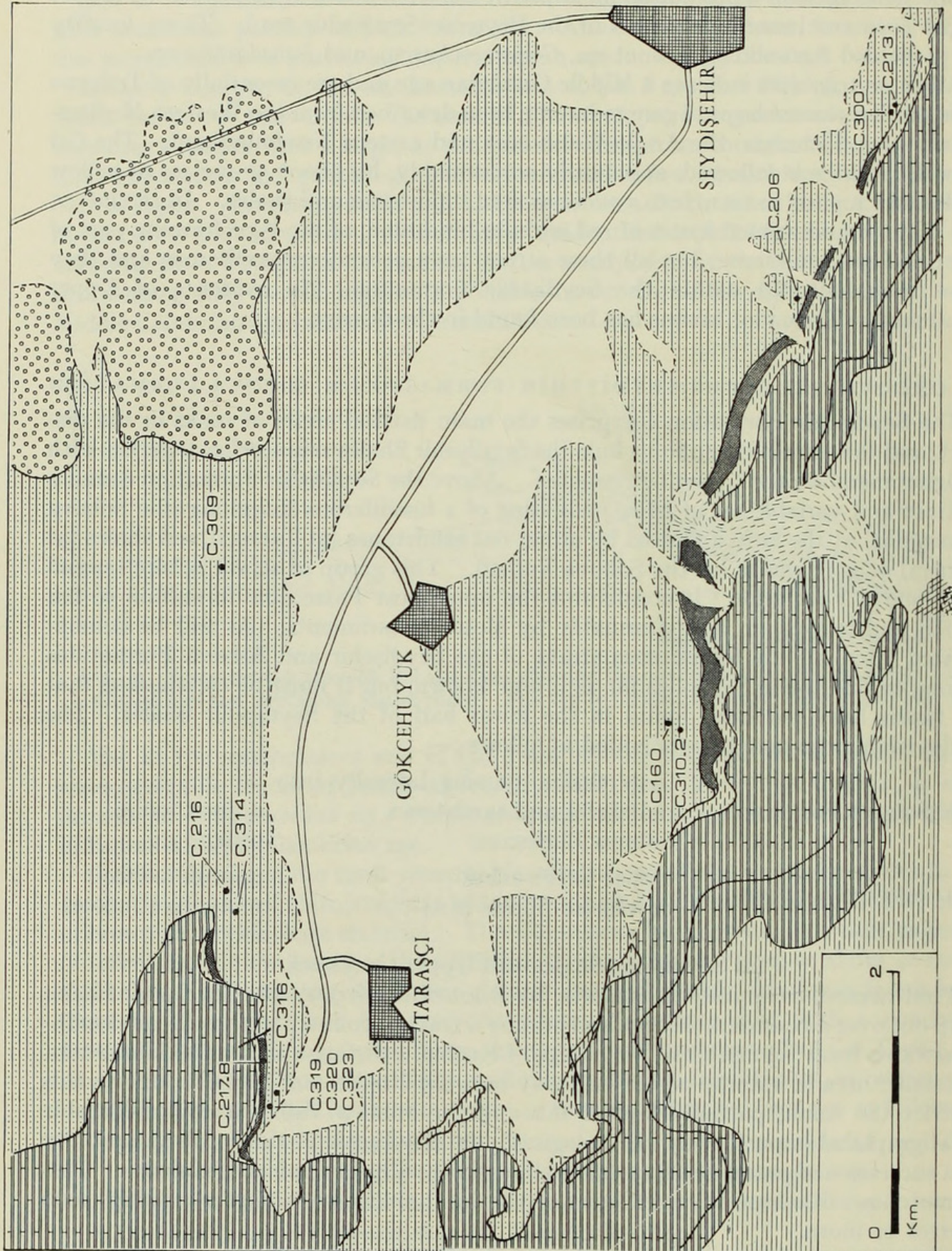


FIG. 5. Fossil localities in the Ordovician rocks near Seydişehir. Key as for Fig. 2 with the following additions :—the Sobova Formation overlying the Seydişehir Formation is indicated by the closely-dotted outcrop ; the shading of discontinuous lines of the overlying strata denotes the lowest Trias (Anisian Stage).

Fossils have now been found at several localities, all of which, for the sake of completeness, are shown on the accompanying maps (see Figs. 5, 6). Few places, however, have yielded identifiable faunas and most of the fossils, though locally abundant comprise poorly-preserved asaphid trilobites, dalmanellid brachiopods, gastropods (*Lesueurilla* sp.) and bivalves (*Redonia* cf. *prisca* Thoral). The shales are generally slickensided and almost invariably barren, and virtually all the fossils were collected from a peculiar, brown-weathering, sandy limestone facies which occurs only in small, thin lenses within the sandstones.

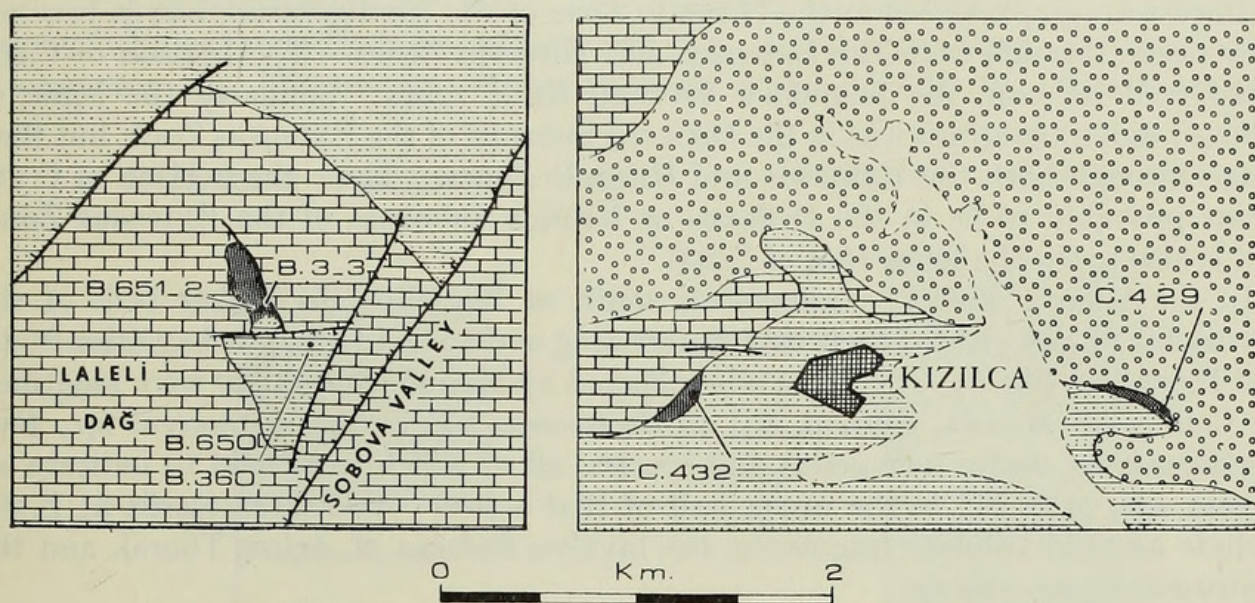


FIG. 6. Fossil localities in the Seydişehir Formation and Sobova Formation in the Sobova Valley and near Kızılca. For key, see Fig. 2, with the addition of the closely-dotted outcrop, which denotes the Sobova Formation, as in Fig. 5. Geological boundaries by O. Monod.

The majority of fossil localities were found west and southwest of Seydişehir, but several occur both at and near the important section to the north of Taraşçı. The latter section (Fig. 7) shows the Seydişehir Shales *sensu stricto* passing conformably upwards into a group of coarser beds, here termed the Upper Greywackes, some 15 metres thick, which are in turn overlain, apparently conformably, by the Sobova Limestone, described later in this paper.

Provisional faunal lists for the Seydişehir Shales (excluding the Sobova Valley outcrop—see later) are as follows :—

- Locality C.160. Trilobites—cheirurid ? gen. et sp. indet., *Paramegaspis* ? sp.
Brachiopods—*Cyrtonotella* ? sp., *Panderina* ? sp.
- Locality C.216. Trilobites—*Megistaspis* ? sp., *Neseuretus* sp. Brachiopods—*Eodalmanella* sp.
- Locality C.310. *Megistaspis* sp., asaphid gen. et sp. undetermined.
- Locality C.312. *Megistaspis* sp., asaphid gen. et sp. undetermined.
- Locality C.312a. *Megistaspis* ? sp., *Paramegaspis* ? sp.
- Locality C.314. *Megistaspis* ? sp., *Paramegaspis* ? sp.

In addition to the above shelly fossils, graptolites were collected from localities C.206 and C.310, and we are indebted to Dr. P. Toghil for the following identifications and comments.

" C.206. Numerous fragmentary tetragraptid stipes, all referable to *Tetragraptus* cf. *reclinatus* Elles & Wood, but no complete specimens occur.

C.310. Numerous didymograptid fragments and a few complete examples of *Didymograptus deflexus* Elles & Wood and *D.* cf. *nitidus* Hall.

Although the faunas of these two localities are distinct, they probably represent broadly similar horizons. According to Jackson (1962, p. 308) the acme of reclined tetragraptids was in the Hirundo Zone of the Arenig Series, but in practice they range through both the Extensus and Hirundo Zones. The horizon of C.206 could well be near the boundary between these zones. Similarly the acme of reflexed didymograptids was in the Deflexus Subzone of the Extensus Zone, but they range through both the Extensus and Hirundo Zones. Thus, the horizon of C.310 seems probably to be in the Deflexus or Nitidus Subzones of the Extensus Zone, and is also probably below that of C.206".

In the Sobova Valley, 7 kilometres south of Beyşehir, the higher beds of the Seydişehir Shales yielded their most interesting and varied faunas at localities B.360 and B.650 (see Fig. 6). Cephalopods collected by Monod from B.360 were identified by Collins (*in* Monod, 1967, p. 83) as *Bactroceras* sp., *Proterovaginoceras* sp., *Protocycloceras* sp. and a new genus and species, all of which were held to indicate an Arenig age, probably in the upper half of that series. Associated fossils at B.360 include asaphid trilobite fragments, the bivalve *Redonia* cf. *prisca* Thor, and the gastropod *Lesueurilla* sp.

At locality B.650 the fauna includes the following trilobites :—*Colpocoryphe* sp., *Geragnostus* sp., *Megistaspis* sp., *Paramegastaspis* ? sp. and *Symphysurus* sp.

The terms "calymenid-trinucleid province" (Whittington, 1966) or "Tethyan province" (Dean, 1967) have been employed in previous publications to describe Ordovician faunas of a certain composition in and around the Mediterranean and Western Europe, and it is clear that the faunas of the Seydişehir Shales, with their asaphids, agnostids and calymenaceids, together with *Redonia*, belong in this category. *Symphysurus* is perhaps more indicative of Baltic and Scandinavian faunas, but it has been described from the Montagne Noire, southwestern France, in strata traditionally supposed to be Tremadoc in age, but more probably Lower Arenig. In the present instance the sporadic appearance of *Symphysurus* foreshadows its abundance in the succeeding Sobova Limestone, in which stratum trilobites of Baltic-Scandinavian type predominate.

(b) Sobova Limestone and overlying strata

In the hills about 7 kilometres south of Beyşehir the Sobova Valley contains a small inlier of Seydişehir Shales, roughly triangular in plan with apex directed southwards (see Fig. 6). The southwestern side shows the Ordovician shales overlain unconformably by Jurassic limestones, but the other sides mark the position of faults. The inlier is surrounded by Mesozoic limestones, but a narrow, neck-like outcrop of Ordovician strata extends northwestwards for about 600 metres. In this

outcrop the Seydişehir Shales are succeeded stratigraphically by a group of well-bedded, often massive, jointed, grey and pink detrital limestones, here termed the Sobova Limestone. Most of the beds are unfossiliferous, but many contain unrecognizable crinoid or cystoid ossicles, some contain large concentrations of small brachiopods (*Eodolmanella* sp.), and a few yield what has proved to be the most prolific Ordovician trilobite fauna in the district. With the exception of a single enrolled individual of *Symphysurus*, all the trilobites are represented by isolated fragments, mostly cranidia and pygidia. The strata are available for collecting at only one place on the hill-side, shown on the map as locality B.651 (see Fig. 6). The fauna will be described in detail at a later date, but the provisional list of determinations includes the following:—*Agerina* sp. nov., *Apatokephalus* sp., *Carolinites* sp., *Geragnostus* sp., *Iliaenus* sp., *Neseuretus*? sp. indet., *Niobe* sp., *Ampyx* sp. and

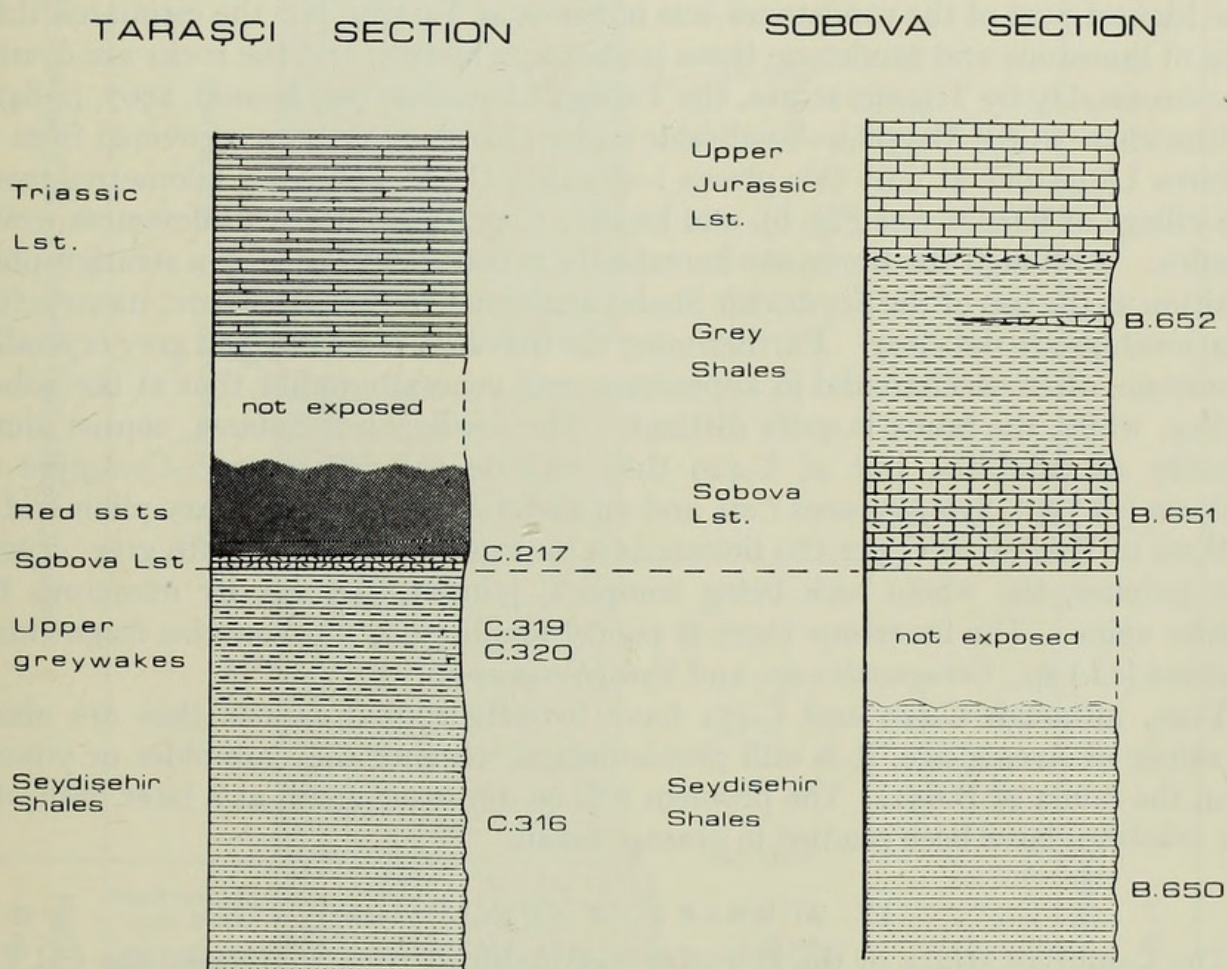


FIG. 7. Sections showing the relationship of the highest Ordovician strata in the Sobova Valley and at Taraşçı. The numbers indicate fossil localities.

Symphysurus sp. The precise dating of this assemblage must await its detailed description, but there is nothing to suggest that it is later than Arenig Series, that is to say not significantly younger than the Seydişehir Shales, so that the junction of the two groups of strata, though not exposed here, is probably conformable, as in the section north of Taraşçı (Fig. 7).

The highest beds of the Sobova Limestone in the Sobova Valley are followed with apparent conformity by a group of grey shales some 20 metres thick. These proved unfossiliferous for the most part, but a thin band of argillaceous limestone at the base of the topmost third yielded a few fragmentary brachiopods and the trilobite *Symphysurus*. The latter genus, present already in the Sobova Limestone and highest Seydişehir Shales, suggests a broadly similar age, i.e. Arenig Series, for the grey shale subdivision which, at this locality, is overlain transgressively by Upper Jurassic limestones.

The section in the Sobova Valley shows the thickest development of the Sobova Limestone, but the thickness diminishes southwards to Tıraşçı, where it is only about 2 metres thick at the section northwest of the village (see Fig. 5). There the attenuated development of limestone is succeeded by red sandstones which, from their stratigraphical position, are equivalent to the grey shales of the Sobova Valley. The highest part of the sandstones was not seen at Tıraşçı, but the estimated thickness of limestone and sandstone there is about 20 metres, and the rocks are overlain unconformably by Triassic strata, the Tıraşçı Limestone (see Monod, 1967, p. 84).

Elsewhere in the Beyşehir–Seydişehir region, fossils have been recovered from the Sobova Limestone at only two places :—locality C.429, about 1.5 kilometres east of the village of Kızılca (see Fig. 6), and locality C.432, just over 0.5 kilometres west of Kızılca. Although the limestone hereabouts is believed to occupy a stratigraphical position at the top of the Seydişehir Shales analogous to that elsewhere, its structural relationships are not clear. Furthermore, the lithology is a white and grey crystalline limestone, often saccharoidal in appearance and generally unlike that at the Sobova Valley, whilst the fauna is quite distinct. The fossils, as at Sobova, consist almost entirely of trilobites, but at C.429 they include the following :—*Cyclopyge* sp., *Euloma* (s.l.) sp., *Symphysurus* ? sp. and an undetermined fragmentary pliomereid.

West of Kızılca, at C.432, the limestone is pink or liver-coloured with grey, crystalline patches, the whole rock being compact, jointed, and cut by numerous thin calcite veins. The limestone there is poorly fossiliferous but contains fragments of *Euloma* (s.l.) sp., *Geragnostus* sp. and *Symphysurus* sp.

Thus, although C.429 and C.432 have broadly similar faunas that are almost certainly of Arenig age, it is still problematical whether they are older or younger than the fauna of B.651. The problem will be discussed again at a later date when the trilobites have been studied in greater detail.

IV. SUMMARY OF CONCLUSIONS

The Cambrian strata of the Beyşehir–Seydişehir district are termed the Çal Tepe Formation and total more than 130 metres in thickness. The lower subdivision, the Çal Tepe Dolomite, is unfossiliferous and the base is not exposed. The higher subdivision, the Çal Tepe Limestone, is itself divisible and has yielded trilobites which suggest a possible Lower Cambrian age for the lower beds and a definite Middle Cambrian age for the higher beds, which contain a Tethyan fauna comprising, *inter al.*, *Paradoxides*, *Conocoryphe* and *Ctenocephalus*.

The Çal Tepe Formation is followed by shales of the Seydişehir Formation, which contains Lower Ordovician fossils in its upper half, and at the hill called Çal Tepe

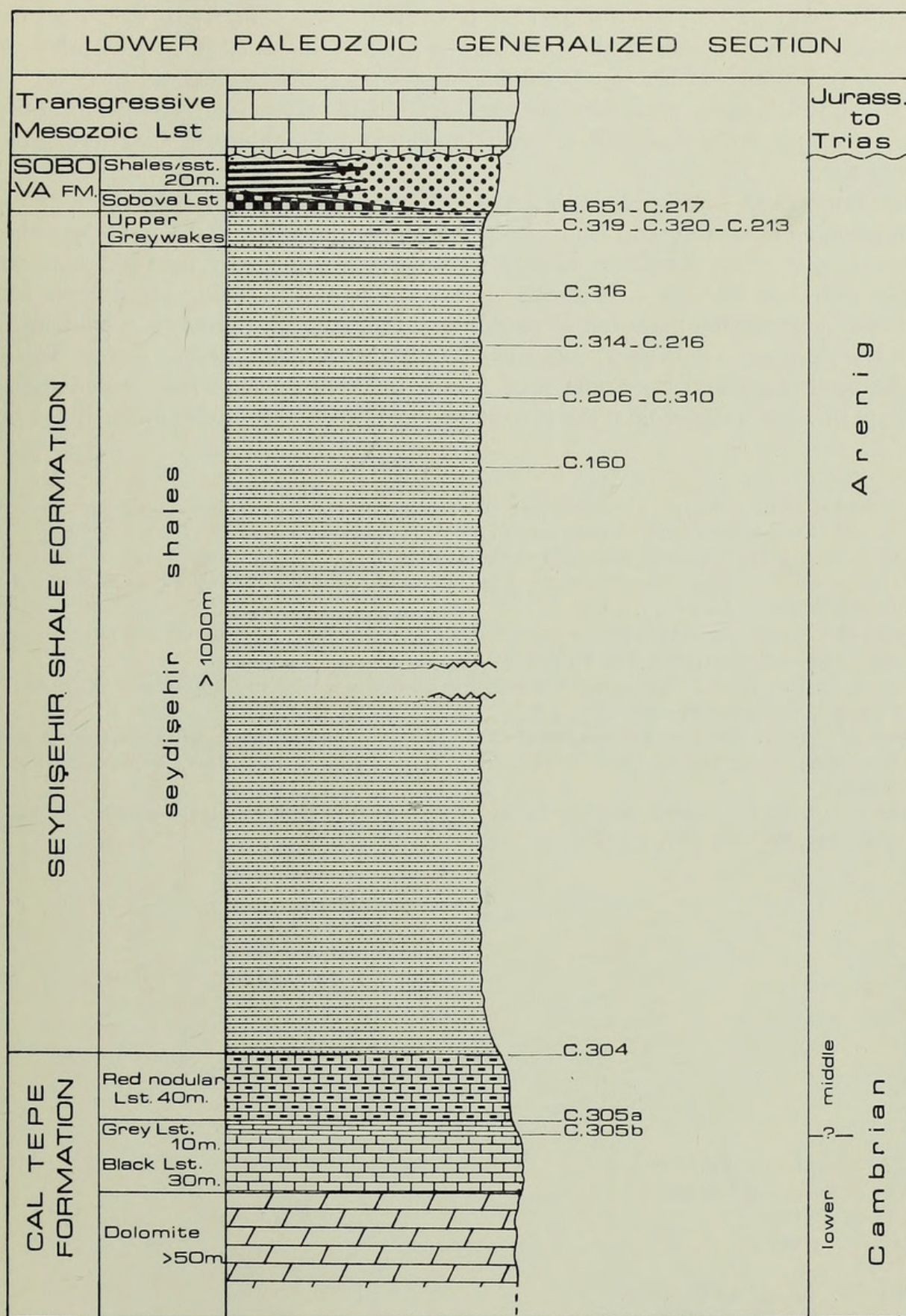


FIG. 8. General stratigraphical succession of the Lower Palaeozoic rocks in the Beyşehir-Seydişehir district.

the succession of the two formations is overturned. The Seydişehir Formation comprises the Seydişehir Shales, a group of silty shales and quartzites more than 1000 metres thick, with a small thickness of Upper Greywackes at the top. The few shelly fossils in the shales are mostly asaphid and calymenid trilobites of Tethyan type, together with graptolites, cephalopods and brachiopods that indicate an Arenig age.

The uppermost Palaeozoic strata, the Sobova Formation, succeed the Seydişehir Formation conformably and comprise the Sobova Limestone (0 to 10 metres thick), followed by a small thickness of shales which passes laterally into red sandstones southwards near Taraşçı. At its type locality, south of Beyşehir, the Sobova Limestone contains a trilobite fauna of predominantly Baltic-Scandinavian affinities that includes *Agerina*, *Carolinites*, *Illænus*, *Niobe* and *Symphysurus*. A few Tethyan genera occur also, and the fauna is of Arenig age. Over the whole region the substratum of older Palaeozoic rocks is overlain unconformably by Mesozoic limestones.

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