Stratigraphy of the lower tectonic units

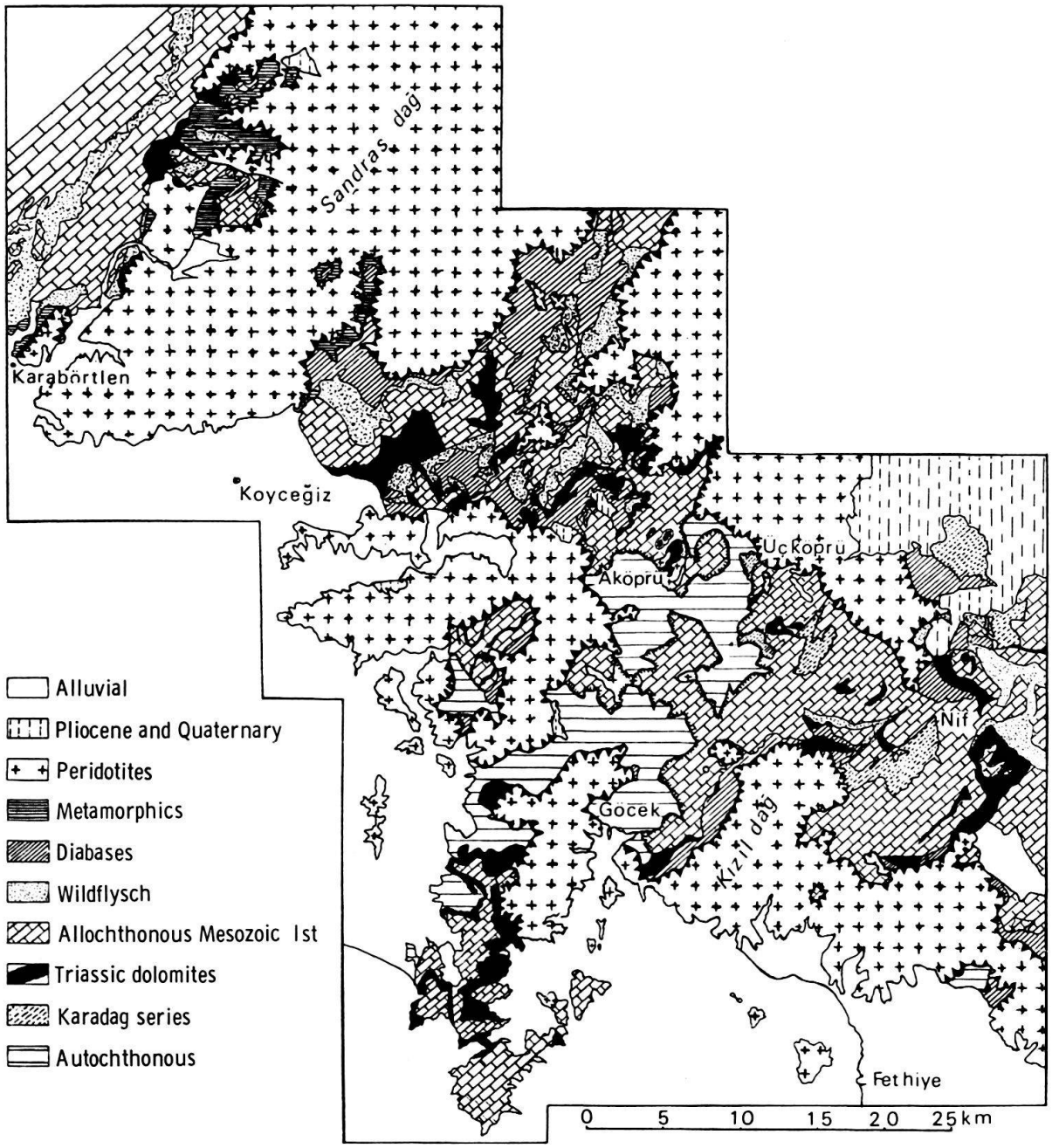

Fig. 2. Geologic map of the region between Fethiye and Karabörtlen by P. Ch. de Graciansky.

2. Stratigraphy of the lower tectonic units

2.1 *Southwestern Turkey*

In southwestern Turkey, the complex nappe pile of the Lycian Nappes is underlain by a probably autochthonous, originally more external sequence which comprises Middle Jurassic to Eocene limestones (Bey Dağlari, A. Poisson, personal communication) which in turn are disconformably overlain by Lower Miocene limestones and Lower to Middle Miocene clastics. Older sediments and the basement of this sequence are not known. The westernmost outcrops of this sequence occur in a

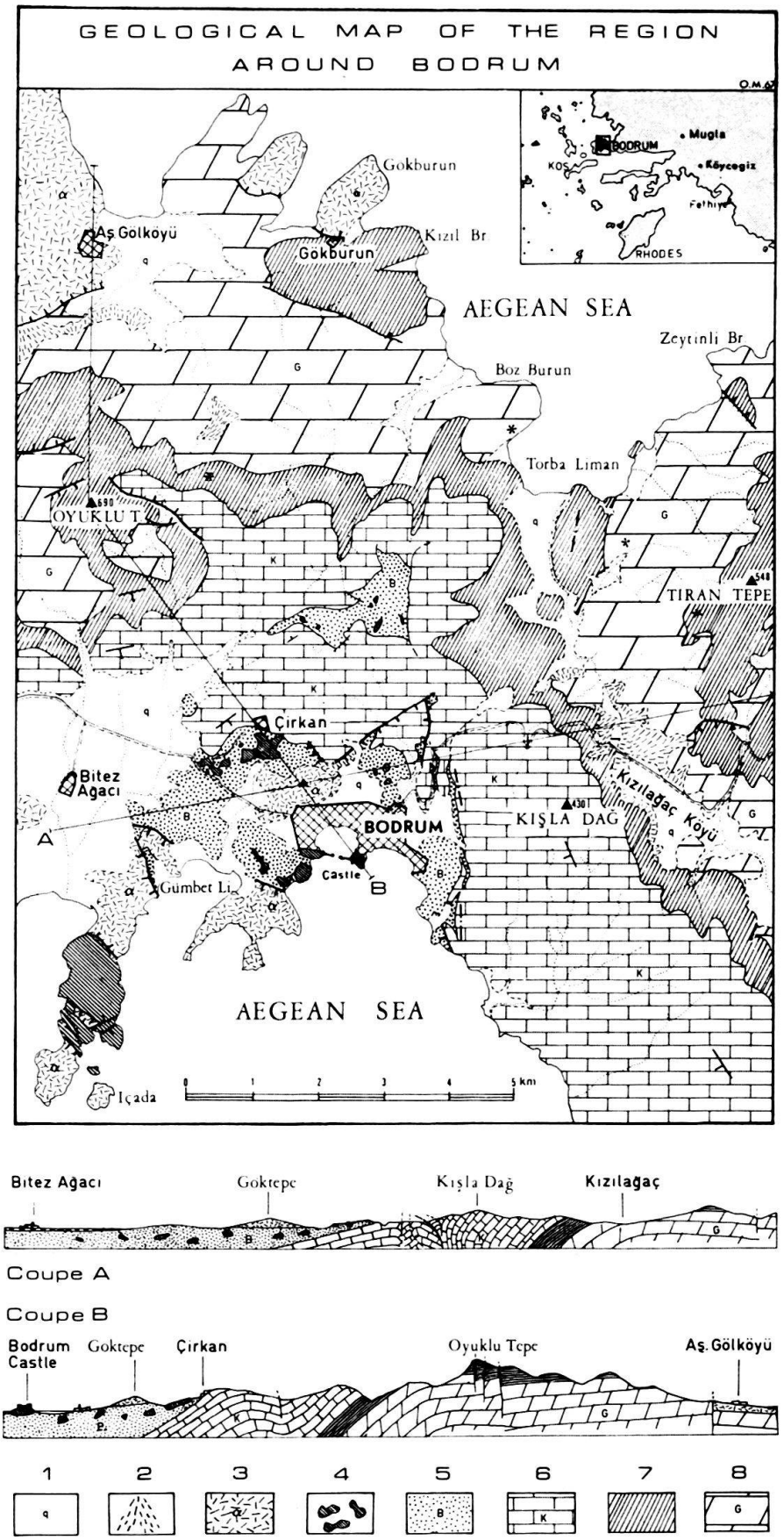

Fig. 3. Geologic map of the region of Bodrum by O. MONOD. *1* Alluvial deposits. *2* Scree. *3* Trachyandesites and tuffs, Miocene. *4* Exotic blocks in Karabörtlen Formation (Ages of the blocks vary from Upper Triassic to Upper Cretaceous). *5* Karabörtlen Formation (Bodrum Shales): black shales with exotic blocks, post-Cenomanian, probably Upper Cretaceous to ? lowermost Tertiary. *6.–7.* Çal Dağ Limestone, yellow silty limestones (*7.*): ? Upper Liassic to Cenomanian. *8* Gereme Formation, Upper Triassic to Middle Liassic.

number of tectonic windows situated to the north of the small town of Göcek (Pl. I and Fig. 2). Here the sequence comprises from bottom to top (Fig. 4, BRUNN et al. 1970; GRACIANSKY et al. 1970; GRACIANSKY 1972):

1. 200 meters of thick-bedded, mainly skeletal limestones of shallow-marine origin. At the base they contain rudists and larger foraminifera of Cenomanian age.
2. 80 to 90 meters of mainly pelagic limestones with planktonic foraminifera ranging from Upper Campanian to Lower Eocene. The limestones are relatively thick-bedded in the Upper Cretaceous and lowermost Paleocene. In the Paleocene to Lower Eocene fragments of larger foraminifera (*Discocyclina, Nummulites*) are found.

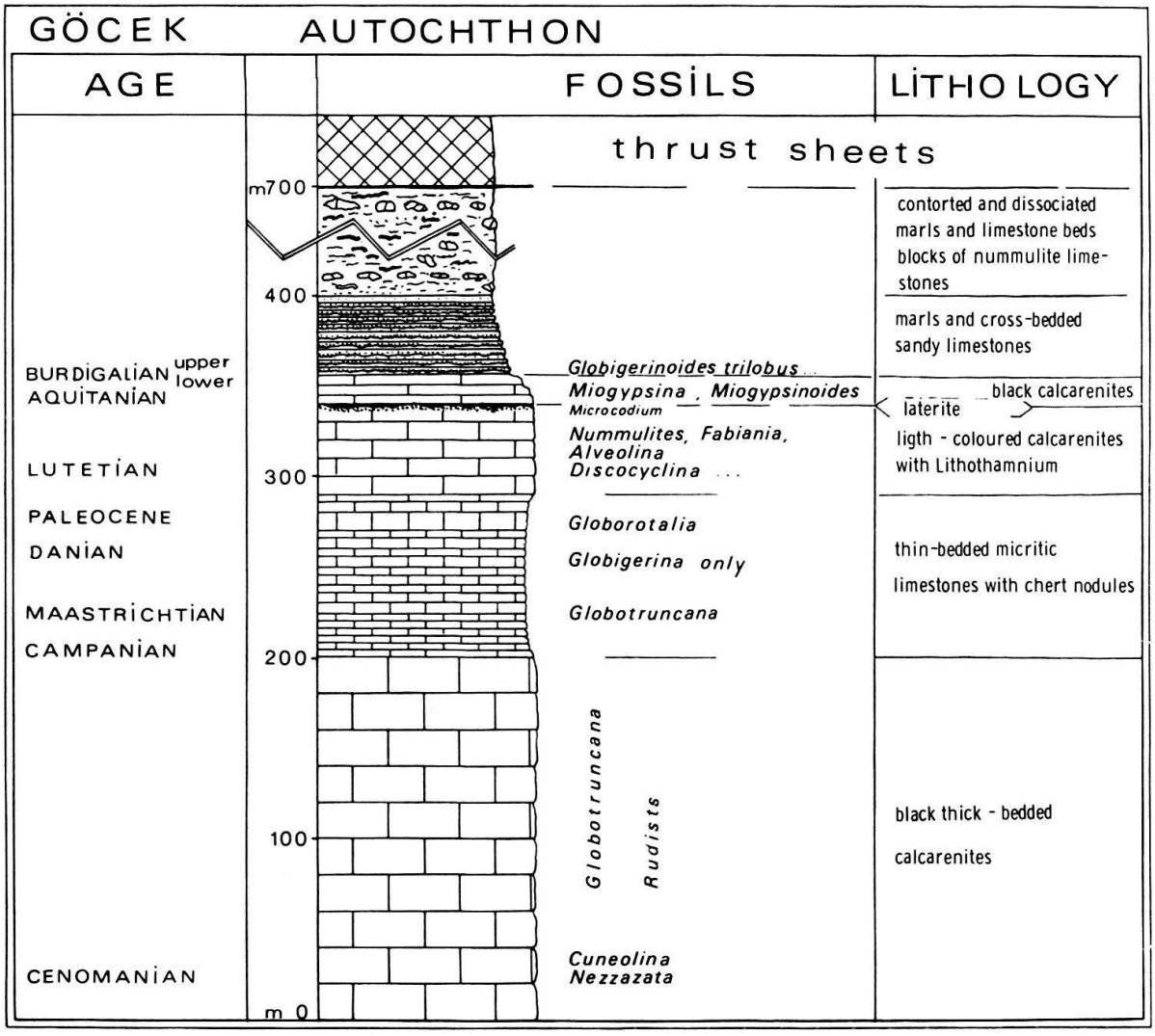

Fig. 4. Stratigraphic sequence of the "Autochthonous" at Göcek.

3. 50 meters of bioclastic limestones with larger foraminifera of Middle to possibly Late Eocene age. The upper part of this formation contains intercalations of coral and *Lithothamnium* limestone with a Late Lutetian or Early Priabonian fauna. At the top of the Eocene sequence the limestones are encrusted with *Microcodium* (RICHARD 1967a), and at its upper surface, pockets filled with lateritic material

indicate prolonged emersion during most of Late Eocene and Oligocene times (AYRTON et al. 1966).

4. 15–20 meters of uppermost Oligocene or lowermost Miocene to Lower Burdigalian shallow marine limestones that, aside reworked Eocene fossils, contain calcareous algae, bryozoa and corals and higher up some planktonic foraminifera. In the Göcek windows, rich associations of larger foraminifera at the base indicate a marine transgression prograding from south to north during the latest Oligocene to the Early Aquitanian (GRACIANSKY et al. 1970).
5. 200–300 meters of sandy limestones, marls and conglomerates. The lower 50 meters consist of a regular alternation of cross-bedded sandstones and marls that contain Lower Miocene faunas and, more specifically, Upper Burdigalian planktonic foraminifera (GRACIANSKY et al. 1970). The conglomerates are derived from the underlying Eocene and Miocene sequences and from the Lycian Nappes. The upper part of the sequence is composed of marls and argillaceous or calcareous sandstones with locally preserved small-scale current-laminations. The stratification of this part of the formation is highly disturbed; there are numerous large-scale slump complexes and olistostromes that contain large olistoliths of graded nummulite limestones of Middle to Late Eocene age emplaced during sedimentation of the formation.

A similar lithological succession which belongs to the same paleogeographic and tectonic unit (region of Kaş, PISONI 1967; POISSON 1967) is found in the southern Bey Dağlari; however, thicknesses are somewhat greater (BRUNN et al. 1970). The *Microcodium* limestone and the lateritic horizon are missing and the skeletal limestones of the Middle Eocene are overlain with a regional unconformity by the Lower Miocene clastics.

The main characteristics of the autochthonous sequence, underlying the Lycian nappe pile in southwestern Turkey, may be summarized as follows: The Middle Jurassic to Middle/Upper Eocene sequence is mainly composed of shallow water limestones with one major intercalation of pelagic, though not deep-water limestones from Upper Campanian to Lower Eocene. Part of the Upper Eocene and nearly all the Oligocene are missing and beginning first in the uppermost Oligocene to Lower Miocene the sea transgressed from the south, leading to the deposition of limestones and terrigenous clastics derived from the underlying sequence and the Intermediate Complex. On the eastern flanc of the Bey Dağlari, however, flysch deposits of Paleocene-Early Eocene age are intercalated in the sequence. They are closely associated with the emplacement of the Antalya Nappes and are not present in western Lycia (BRUNN et al. 1970).

2.2 *Aegean Islands*

Stratigraphic sequences which are most probably external and in a lower tectonic position to the Intermediate Complex of the Lycian Nappes are found in some of the small islands between Astypalia, Crete and Karpathos. Some of the sequences (island of Chamili) are very similar to those described from the Gavrovo Zone of continental Greece, whereas others show close affinity to the sequence observed on Astypalia, the tectonic position of which could not be established with certainty until now.

Chamili: On Chamili, a strongly faulted anticline is observed with a more complete sequence in the WSW. In the core of the anticline, skeletal limestones with rudists in growth position are present. Finer-grained skeletal lime grainstones contain rudist fragments and larger foraminifera including *Orbitoides media* (D'ARCHIAC), *Omphalocyclus macroporus* (LAMARCK) and *Siderolites calcitrapoides* LAMARCK (det. L. HOTTINGER). These forms indicate a Maastrichtian age. At places, the rudist limestones are heavily brecciated and it appears that dolomitization is following zones of brecciation and thus is, at least in part, of late diagenetic origin. The rudist limestones are overlain by some hundred meters of dolomites with occasional intercalations of rudist limestones. The dolomites are mostly fine-grained and at places they are finely laminated recalling stromatolitic laminations.

At one single place, the Cretaceous sequence of Chamili is overlain with a sharp discontinuity, accentuated by later stylolitization, by a small relict of Tertiary limestone. This rock is composed of skeletons of *Melobesieae* and closely packed, pressure-solved skeletal fragments, mainly larger foraminifera. L. HOTTINGER determined the following forms: *Nummulites* sp., *Assilina* sp., *Operculina* gr. *parva* DOUVILLÉ, *Pararotalia* sp., *Discocyclina* sp. and *Gypsina* sp. This association indicates an Early to Middle Eocene age.

Saforà: The main island of the small group of Saforà (Megalo Sofrano) is built up by a faulted sequence of Cretaceous limestones and some flysch sediments of probably Early Tertiary age. The oldest limestones, occurring in a fault block in the southern part of the island and along a fault in the central part, are light grey lime wackestones of Aptian to Albian age, with small primitive *Hedbergella* and some dasyclad algae (*Munieria baconica* HANTKEN and *Actinoporella* sp., det. E. FLÜGEL). On the eastern shore, there are skeletal lime wacke- to packstones with rudists (cf. DESIO 1931, p. 323–324) and a faunal/floral association of Senonian age including large specimens of *Thaumatoporella* sp., *Cuneolina* sp., *Dicyclina* sp. and *Accordiella conica* FARINACCI. These rudist limestones are overlain by well-bedded lime wackestones containing planktonic foraminifera and obviously redeposited shallow water fossils. The association includes double-keeled *Globotruncana* of the *G. linnei* group (det. H. LUTERBACHER) and some larger foraminifera (*Pseudosiderolites vidali* (DOUVILLÉ), *Navarella joaquini* CIRY and RAT, *Gavelinella* sp., det. L. HOTTINGER), indicating a Late Senonian age. In the Maastrichtian, skeletal limestones with rudist and inoceram fragments and larger foraminifera (*Orbitoides* sp., *Siderolites calcitrapoides* LAMARCK, det. L. HOTTINGER) occur. They are overlain by partly laminated dolostones with guttulinids, miliolids and thin-shelled ostracods. This facies corresponds closely to the so-called "Liburnian" facies of the uppermost Cretaceous, it is widespread in the Gavrovo Zone of the Hellenids and in the Dalmatian Zone of Yugoslavia (cf. FLEURY 1970).

The flysch is separated from the limestones by high angle-faults. It consists of graded lithic sandstones with interbedded shales and has not yielded any fossils, however, a Early Tertiary age is most likely. As a whole the sequence could be compared with sequences described by DERCOURT (1964) from internal parts of the Gavrovo Zone in the eastern Peloponnesus; however, in detail several rock types are identical with specimens from Astypalia (see below).

Di Adelphi: The larger (southeastern) of the two islands is composed of vertical rudist limestone and an overturned syncline in the Tertiary flysch. The island is not easily accessible, but a few relevant observations could be made. The Cretaceous limestone has been largely recrystallized but the rudist shells are still recognizable. The uppermost part of this sequence could not be observed and the contact towards the flysch syncline appears to be somewhat tectonized, however, the basal part of the flysch is well exposed in the southwestern part of the island. The flysch consists of an alternation of thick-bedded Nummulite breccias and shales that are followed by an alternation of shales and dirty sandstones. The core of the syncline is made up by coarse conglomerates with sub-ordinate intercalations of sandstones. In the Nummulite breccias the following fossils, indicating an Early to Middle Eocene age, have been found: *Nummulites* sp., *Operculina* sp., *Asterocyclina* sp., *Discocyclina* sp. (det. L. HOTTINGER). The conglomerate contains chiefly limestone pebbles that match very well with the facies of the Intermediate Complex. They include pelleted and skeletal lime grainstones with indeterminable dasyclad and codiacean algae that could be derived from the Gereme Limestone, lime wackestones with pelagic lamellibranchs and calcitized radiolaria of possible Upper Liassic to Middle Jurassic age and other lithologies rich in radiolaria (cf. Çal Dağ Limestone). In the arenites, quartz, plagioclase, biotite, glauconite and lithic fragments of diabase, radiolarite and limestone have been found.

The smaller, northwestern island of Di Adelphi is composed of strongly tectonized limestones. The following association, determined by L. HOTTINGER, indicates a Paleocene age: *Archaeolithothamnium* sp., *Miscellanea* sp., ? *Alveolina primaeva* REICHEL. This age is in good agreement with the Early to Middle Eocene age of the base of the flysch on the larger island of Di Adelphi.

The sequences of the islands described above compare very well with the sequence of an external zone of the Greek Hellenides, characterized by regular subsidence and mainly by carbonate platform deposits throughout the Cretaceous. The island of Chamili shows a development similar to the external Gavrovo Zone in western Greece, whereas the sequence of Saforà could be compared to the internal Gavrovo Zone in the Peloponnesus where pelagic intercalations also occur (DERCOURT 1964). Finally, the lithologic types of the sequence of Di Adelphi are comparable to the sedimentary sequence of the nearby island of Astypalia (cf. DESIO 1931; N. CREUTZBURG, personal communication, 1969).

In Astypalia, the Upper Cretaceous-Tertiary carbonate platform sequence is followed by flysch that apparently starts in the Middle to Upper Eocene. According to S. DÜRR (personal communication, 1970), the series of Astypalia is comparable to the one of Amorgos, that in turn is considered by DÜRR to be an equivalent of the Parnasse Zone; however, a more external position of Astypalia and Di Adelphi as similarly postulated for the Olympus window by some authors (AUBOUIN in GODFRIAUX 1964; BERNOULLI and LAUBSCHER 1972), cannot be excluded on paleogeographic grounds.

3. The Mesozoic sequences of the Lycian Nappes

In southwestern Turkey the Intermediate Complex includes several stratigraphic sequences that have been imbricated tectonically below the Peridotite Nappe and that often are characterized by a chaotic style of deformation.