1. Introduction

1.1 *Generalities*

During the last few years, our knowledge of the structure of the Hellenides of the Greek mainland and of the Tauride mountain chains of Anatolia has increased considerably and several attempts to reconstruct their sedimentary and structural evolution have been undertaken. Evidently, both mountain systems are composed of a pile of basement and sedimentary cover nappes with a general southwestern to southeastern vergence (cf. AUBOUIN et al. 1963 for Greece; and BRUNN et al. 1970, for southwestern Turkey), though antinappist views are still maintained by several authors (e.g. MARINOS 1957; BRINKMANN 1967). As the youngest structural trends of both mountain systems can be followed from the Peloponnesus through the islands of Crete, Karpathos and Rhodes to southwestern Turkey, the two mountain systems obviously are somehow connected. However, even a rapid comparison between the well-documented picture of Greece, as it results from the recent work of AUBOUIN, BRUNN, and their co-workers in Greece (AUBOUIN 1959; AUBOUIN et al. 1963, 1970; BRUNN 1956, 1959; CELET 1962; DERCOURT 1964; GODFRIAUX 1968; MERCIER 1966), and the synthetic outline of the western Taurides depicted by the Laboratoire de Géologie Historique at Orsay (BRUNN et al. 1970, 1971) clearly shows that there are definite limitations for purely cylindristic reconstructions and that considerable changes along the strike of the orogen must take place. More specifically, the correlation of the Mesozoic and Lower Tertiary sequences and the reconstructions of paleotectonic trends across the Aegean Sea are still ambiguous, though some major features such as the basement complexes of the Pelagonian and Menderes "massifs" and the Ophiolite Nappe may be well compared.

In this paper we attempt a comparison of some Mesozoic sequences of southwestern Turkey with corresponding sequences in the Aegean islands, in order to evaluate their possible place in a paleogeographic and paleotectonic frame. Of particular interest are the sequences of the so-called "Intermediate Complex", a pile of nappes and imbrics, intercalated between the Ophiolite Nappe and the "autochthonous" sequence in southwestern Turkey. The Mesozoic sequence of the main

tectonic unit of this complex could be clearly followed into the small Aegean islands situated between Astypalia, Crete and Karpathos and we believe that somewhat comparable sequences may occur as far to the northwest as the Argolis Peninsula in the eastern Peloponnesus.

The present study is based on extensive field work carried out by Graciansky in the Lycian Taurus (GRACIANSKY 1972), on an unpublished study undertaken by Monod in 1967 in the region of Bodrum and on a geological reconnaissance by Bernoulli on the small islands between Astypalia, Crete and Karpathos in 1967 (Plate I). Comparisons with continental Greece are based on literature studies and personal observations by the authors.

1.2 *Extension of the Hellenide tectonic units in the southern Aegean Islands*

The tectonic units of continental Greece have been established and discussed by many workers and the reader is referred to the work of AUBOUIN et al. (1970), BRUNN (1956) and others. In this context the interpretation of the ophiolites is of primary importance; earlier concepts by AUBOUIN (1959, 1965) and BRUNN (1956) included their emplacement by a giant extrusion during the Jurassic along the Pelagonian margins (BRUNN 1956, AUBOUIN 1959, 1965) but a *tectonic* emplacement during the latest Jurassic (AUBOUIN 1973a–c) or Early Cretaceous (BERNOULLI and LAUBSCHER 1972; HYNES et al. 1972) seems now generally accepted. This interpretation implies Tertiary deformation of a pre-existing nappe edifice and the existence of composite thrust-sheets. The different tectonic units of the Hellenides are, in fact, not all of the same order (cf. BERNOULLI and LAUBSCHER 1972), and Alpine tectonic boundaries may run obliquely or even at right angles to the older paleogeographic units and paleotectonic trends. As a consequence a straight-forward correlation of Greek and Anatolian Mesozoic paleogeography seems hardly possible.

The extension of the different tectonic units of the Greek mainland in the Aegean islands still presents major difficulties, as most of the Alpine nappe edifice has been affected by post-orogenic block-faulting and was drowned during the Pleistocene. As a consequence the attribution of an isolated island to one or another facies zone or tectonic unit is often conjectural and in some cases may never be established with certainty. However, the following trends can be recognized (cf. Plate I):

The sequences of the Tripolitza Zone of the southeastern Peloponnesus and the underlying metamorphic units can be followed to Crete and (?) Kasos, where they are involved in a complicated, Alpine nappe structure. In the southeastern Peloponnesus (H. LAUBSCHER, personal communication 1973) and in Crete (EPTING et al. 1972a, 1972b) it appears that the Tripolitza Zone is detached from its basement and overthrusted on a metamorphic Upper Paleozoic to *Mesozoic* ("Plattenkalke", etc.) and *Early Tertiary* (O. RENZ 1932; FYTROLAKIS 1972; cf. FLORIDIA 1932, for Kasos) sequence which possibly corresponds to the Ionian Zone. Further east, possible equivalents of the Ionian and Gavrovo Zones occur on Rhodes (MUTTI et al. 1970).

The Pindos Nappe, characterized by Upper Triassic *Halobia* limestones and Cenomanian-Turonian flysch, has been recognized on Crete (CAYEUX 1903a, b; BONNEAU 1970; SEIDEL 1968, 1971), Gavdos (CREUTZBURG 1928; VICENTE 1970), Karpathos and Rhodes (OROMBELLI and POZZI 1967), but internally of the outer arc of the

Aegean islands no remnants of this nappe have been recognized with certainty. The uppermost unit of the nappe pile in Crete is represented by remnants of the Ophiolite Nappe (mainly ultramafics) with slivers of metamorphics along its base (VICENTE 1970, BONNEAU 1972a, 1972b).

In Crete, the nappe movements have been dated as pre-Tortonian by postorogenic sediments (MEULENKAMP 1969); on Rhodes the nappe edifice is, according to MUTTI et al. (1970), older than the onset of sedimentation of the Middle to Late Oligocene neoautochthonous or mesoautochthonous Vati Group.

The continuation of the Parnasse Zone south of the Gulf of Korinth has been discussed by various authors. On the Argolis Peninsula the Pindos Zone is bordered internally by a zone characterized by alternation and interfingering of carbonate platform and pelagic facies. DERCOURT (1962, 1964) has interpreted this as an expression of a paleogeographic termination of the Parnasse platform. In general, the Mesozoic sequence of the eastern Argolis is very similar to that underlying the Cretaceous ophiolite nappe in central Greece. The sequence is characterized by the sinking of the former shallow water sites during the Liassic (Ammonitico Rosso), a thick sequence of radiolarites, volcanic sandstones and basic extrusives (Diabas-Hornstein Formation, "série détritique infra-ophiolitique", AUBOUIN et al. 1970), Upper Cretaceous pelagic limestones and Lower Tertiary flysch. In the Argolis, the main mass of ophiolites with its overlying Cretaceous shallow-water limestones seems to have been emplaced during the Early Tertiary (personal observation by D. BERNOULLI and H. LAUBSCHER 1973), the paleotectonic situation of the Argolis is thus somewhat comparable to the Paleogene front of the Ophiolite Nappe in the northern Pindos ranges.

Equivalents of the Pelagonian basement and its cover are found in Attica, on Euboea and several of the Cycladic islands. In Attica the situation is obscured by Alpine nappe structure and metamorphism (ARGYRIADIS 1967). Non-metamorphic Permian and Triassic overlying granites and metamorphics are reported from Mykonos (PAPASTAMATIOU 1963 and references therein) and Naxos (MARKS and SCHUILING 1965, cf. C. RENZ 1955). Small remnants of the Cretaceous ophiolite nappe, overlain by Barremian skeletal limestones are found on the island of Paros (PAPAGEORGAKIS 1969a). Lower Tertiary "flysch" sediments are reported from Naxos (NEGRIS 1915) and remnants of the postorogenic "Sillon Mésohellénique" could be present on the island of Paros (PAPAGEORGAKIS 1969b).

The paleographic and tectonic position of many of the islands of the southeastern Aegean Sea is still enigmatic. According to S. DÜRR (personal communication) Amorgos presents many analogies to the Parnasse zone, e.g. the absence of a Cretaceous ophiolite nappe, and the presence of Cretaceous bauxites and Lower Tertiary flysch.

The stratigraphy of the smaller islands of the southeastern Aegean Sea is only poorly known. Most of them are composed of metamorphics (Samos, Leros, Kalymnos) or of Upper Cretaceous-Lower Tertiary shallow-water carbonates and flysch. Some of these sequences seem to overlie unconformably the old basement complexes (Kalymnos, Pserimos, DESIO 1931) while others may belong to a more external zone (?Astypalia). The paleotectonic position of Kos is still uncertain. The sequences corresponding to the Intermediate Complex in southwestern Turkey will be discussed in section 5.

1.3 *The tectonic units of the Lycian Taurus*

The Lycian Taurus constitutes the eastern end of the arc that connects the Dinarides through the Hellenides, Crete and Rhodes with southwestern Turkey.

In the Lycian Taurus the following tectonic units, appearing on the map as NE–SW-trending belts, can be distinguished (Pl. I and Fig. 1–3):

1. An "autochthonous", external sequence, occurring along the Mediterranean coast and culminating in the calcareous massif of the Bey Dağlari (BRUNN et al. 1970). This sequence also occurs in a number of tectonic windows below the pile of the Lycian nappes to the north of the small town of Göcek. There the sequence is composed of Cenomanian to Lower Burdigalian carbonate rocks, and Upper Burdigalian and possibly somewhat younger clastics.
2. The western Lycian Nappes (BRUNN et al. 1971), composed of a lower series of complex thrust-sheets and imbrics (Intermediate Complex) that comprise essentially four different stratigraphic sequences, each derived from a different paleogeographic realm, and a large nappe of peridotites representing the uppermost unit of the nappe pile. Within the Intermediate Complex, the Köyceğiz series and its equivalents are of particular interest as they appear to be the most extensive series.
3. The belt of the Lycian Nappes is bordered to the northwest by the Menderes "massif", an old basement complex. The core of this massif is composed of "Augengneiss", enveloped by different layers of micaschists and marbles with emery. Most probably the Augengneiss represent an old deformed and granitized core, overlain by detrital and, later, by carbonate sediments with emery deposits (GRACIANSKY 1966). Based on scanty fossils, these marbles were considered young Paleozoic in age, but recently typical sections of *Hippurites* have been discovered by S. DÜRR (personal communication, 1972) in crystalline limestones overlying the emery near Milas. This, of course, implies an Alpine remobilization of the core of the Menderes "massif" and an Alpine metamorphism of its Late Paleozoic to Cretaceous cover (cf. Pelagonian basement, GODFRIAUX 1964, 1968).

Wherever the contact between the Menderes "massif" and the Lycian Nappes has been investigated thoroughly, the Menderes "massif" and its metamorphic cover dip below the pile of the Lycian nappes (GRACIANSKY 1972), which therefore rest tectonically on two apparently different sequences along their internal and external margins. Over large distances the tectonic contact between the Menderes "massif" and the Lycian Nappes is unconformably overlain by the Oligo-Miocene clastics of the Kale-Tavas basin. This basin therefore occupies a position similar to that of the "Sillon Mésohéllenique" as stated by BRUNN (1960). The structural situation here may be compared to the one in continental Greece where the Ophiolite Nappe and its underlying mélange rest internally on the Pelagonian "massif" and externally on the flysch of a more external zone (Pindos zone). Similarly the Menderes "massif" might represent a sort of "paleoautochthon" for the Lycian Nappes, which has later been thrust together with its Lycian cover as a composite nappe on the "autochthonous" foreland (cf. BERNOULLI and LAUBSCHER 1972, Fig. 3, for the Pelagonian composite nappe).

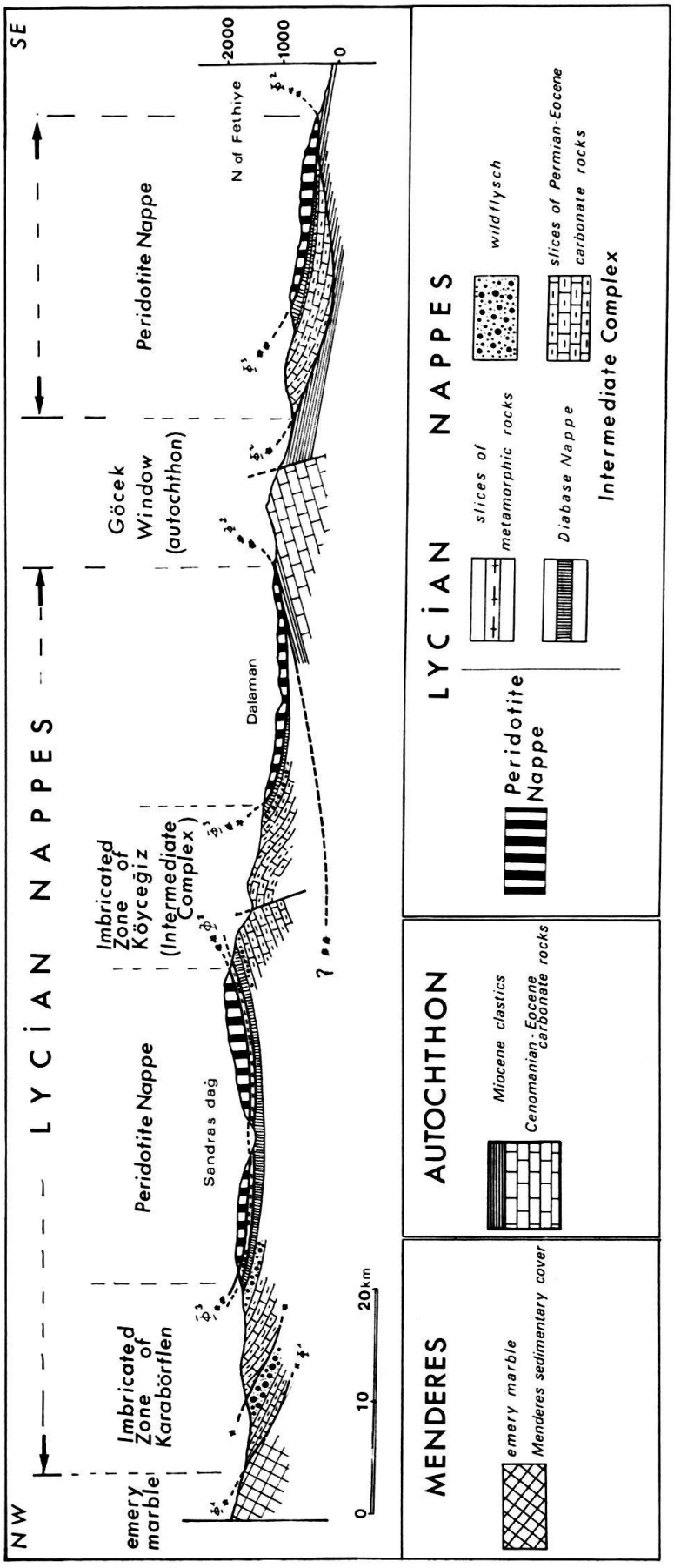

Fig. 1. Tectonic cross-section of the Lycian nappe system in southwestern Turkey by P. Ch. de Graciansky.

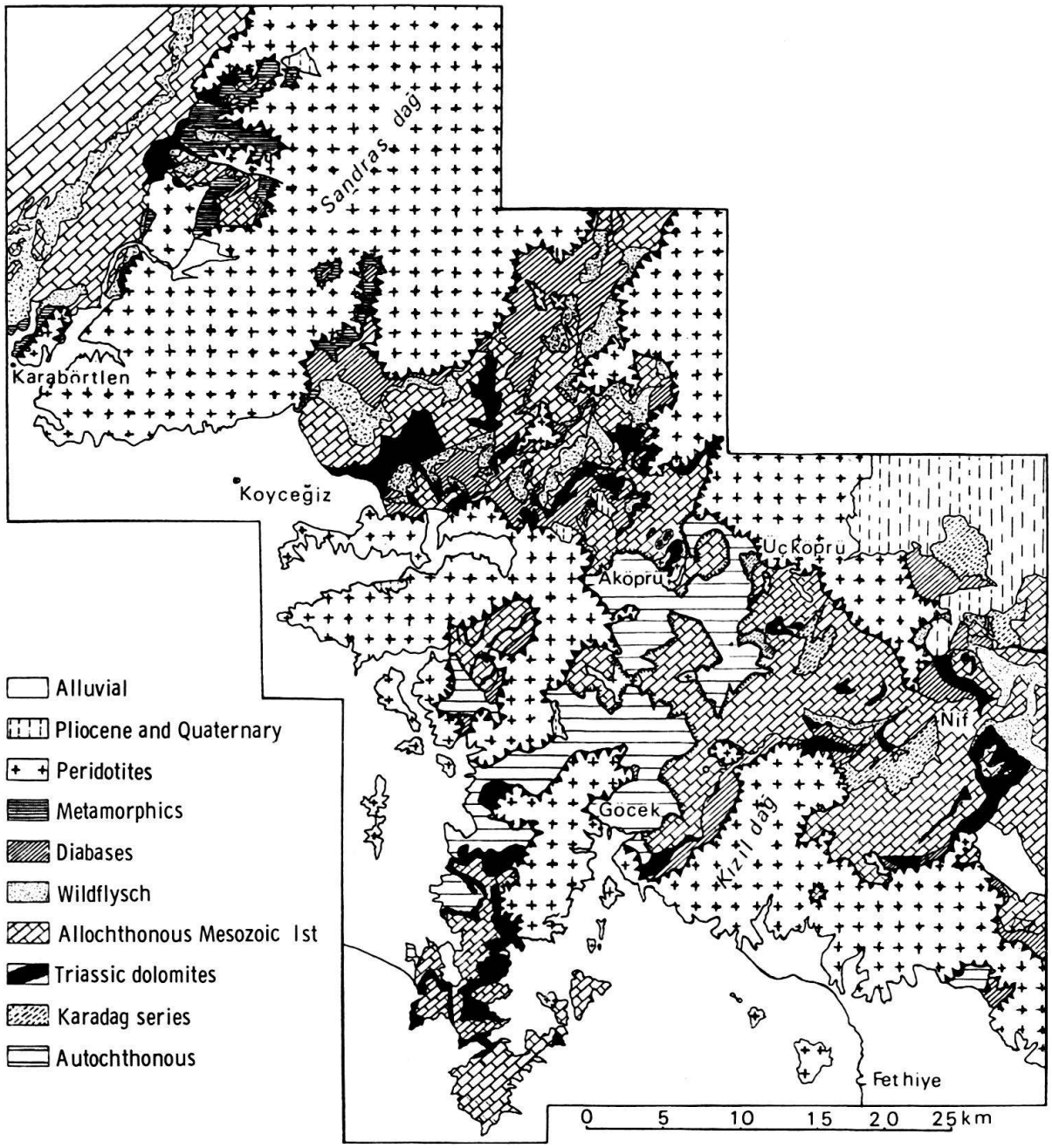

Fig. 2. Geologic map of the region between Fethiye and Karabörtlen by P. Ch. de Graciansky.

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