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STRATIGRAPHY AND SEDIMENTARY EVOLUTION OF THE NE ANTALYA COMPLEX: ISPARTA PROVINCE, TURKEY

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ABSTRACT. — The Antalya Complex (Antalya Nappes) is an allochthonous assemblage of mainly Mesozoic rocks located in the «Isparta angle» of the western Taurides. Two groups are defined in the northeast segment of the Complex, east of Lake Eğridir. The Pazarköy Group comprises ten formations, including mafic lavas, radiolarites, mudstones, turbiditic sandstones, turbiditic limestones, and pelagic limestones. The Yuvalı Group includes two formations, consisting entirely of shallow-water carbonates. Harzburgite and extensive melange/megabreccia terrains also occur in the area studied. The northeast Antalya Complex represents an area of complicated paleogeography on a Mesozoic continental margin; persistent carbonate banks (Yuvalı Group) were surrounded by deeper water areas (Pazarköy Group). The region was deformed by northeastward thrusting in late Cretaceous time. Effects of Tertiary deformation are also seen.

INTRODUCTION

The Antalya Complex, an allochthonous assemblage of deformed sedimentary, igneous, and minor metamorphic rocks, crops out in the provinces of Antalya and Isparta in southwest Turkey. In this paper, a stratigraphic scheme is proposed for the relatively little known northeastern segment of the Complex, lying to the east of Eğridir, in Isparta province (Fig. 1).

GEOLOGICAL SETTING

The northeastern segment of the Antalya Complex is well exposed over an area of approximately 600 km^2. It includes a variety of sedimentary rocks, mainly interbedded mudstones, sandstones, radiolarites and limestones, but also several isolated massifs composed entirely of shallow-water carbonates. Harzburgite and basaltic lavas occur in separate tectonic slices; gabbro and cumulate peridotites are found as boulders and blocks in «melange». Metamorphic rocks, mainly chlorite schists and metacherts, are found at a few localities. The sedimentary rocks are mainly of Upper Triassic to Upper Cretaceous age; Permian limestones occur extensively in adjacent areas of the Complex to the west and south (Gutnic, 1977; Dumont and Kerey, 1975) but only very locally within the area of this study.

To the north, east, and south the northeastern segment of the Antalya Complex is surrounded by Mesozoic limestones and dolomites of the Anamas Dağ, Karacahisar, and Bey Dağları massifs (see Figure 1). These carbonates appear to represent continuous shallow-water sedimentation from Late Triassic to Cretaceous times (Dumont, 1976a). The Antalya Complex is generally regarded as allochthonous with respect to these units; it rests with a low-angle tectonic contact upon Upper Cretaceous limestones and detrital sediments occurring at the top of the Bey Dağları and Karacahisar sequences (Allasinaz et al., 1974; Dumont, 1976a). The relationship with the Anamas Dağ massif to the northeast is less clear. Dumont (1976b) and Monod (1976) interpreted this boundary as a major strike-slip fault, but the present author found the SW edge of the Anamas Dağ to be overthrust onto the Antalya Complex (Waldron, in press).

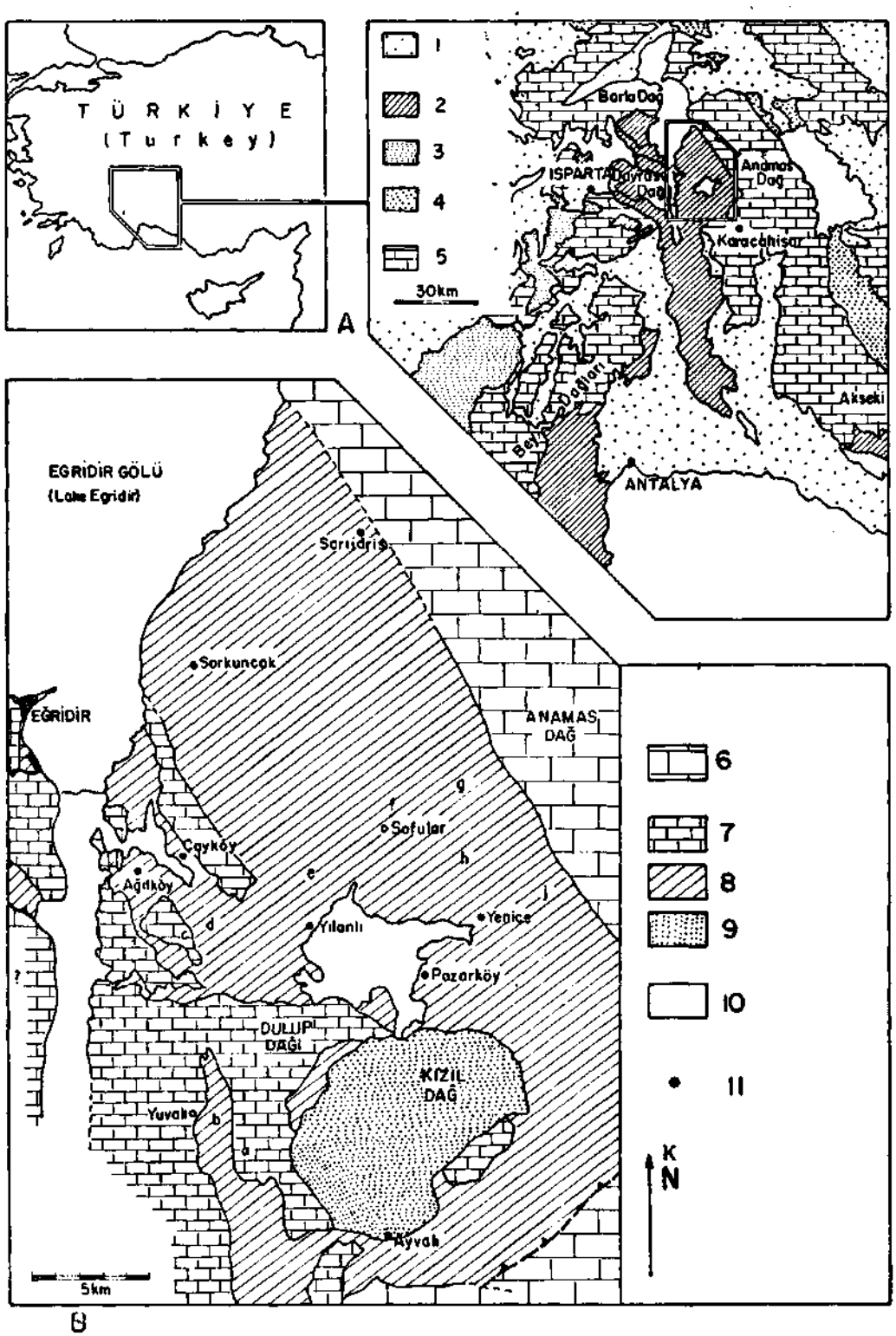

Fig. 1 - Area maps.

A - Outline tectonic map of Antalya-Isparta region.

B - Simplified geological map of NE Antalya Complex (area boxed in upper map).

1 - Post tectonic formations; 2 - Antalya Complex; 3 - Lycian or Teke nappes; 4 - Beyşehir-Hoyran-Hadim nappes; 5 - Relatively autochthonous Tauride platform units; 6 - Tauride platform units of Anamas Dag and Karacahisar; 7 - Antalya Complex, Yuvalı Group; 8 - Antalya Complex, Pazarköy Group; 9 - Antalya Complex, Eğridir Kızıl Dağ Harzburgite; 10 - Alluvium; 11 - Villages. Letters a - j indicate location of sections (Fig. 2).

The Complex is internally highly deformed by folding and faulting. Cleavage is only very locally developed. The style of deformation is strongly dependent on rock-type. Thus the massive carbonates of the Yuvalı Group (see below) form a number of large overthrust sheets, within which the rocks are deformed into open folds. The sediments of the Pazarköy Group are mainly thinly bedded, and include abundant mudstones; these rocks are characteristically deformed by asymmetric folding and thrusting, to produce multiple tectonic slices. In some areas, these slices are organized in imbricated zones (duplexes). Where the deformation is less well organised, chaotic tectonic slice terrains and even tectonic melanges result (Waldron, in press).

The complex is unconformably overlain by lacustrine limestones and sandstones of unknown (probably Neogene) age, and by recent alluvium. Cemented limestone screes occur on certain steep slopes, these are also probably of recent origin.

STRATIGRAPHY

The stratigraphic scheme here proposed conforms as far as possible to the principles laid down by Hedberg (1976) in the International Stratigraphic Guide. Each formation is a mappable unit, and where possible has a precisely defined type section, shown in Figure 3. Previously used names, such as those defined by Juteau (1975), Dumont and Kerey (1975), and Dumont et al. (1980), are retained wherever possible.

The Antalya Complex was initially described as the Antalya Nappes, in the area west of Antalya (Lefevre, 1967). The Antalya Nappes were identified in the Eğridir region by Brunn et al. (1970, 1971); previous studies (Ortynski, 1941) had failed to recognize their allochthonous nature. Brunn et al. divided the Antalya Nappes into three tectonic units, known as the Lower, Middle and Upper Nappes, but in the region east of Eğridir these units were identified only on the basis of similarities in sedimentary fades; the structural continuity of the three «nappes» has never been confirmed. Recent structural work (Waldron, in press) has indicated a more complex pattern involving at least two interfering phases of deformation, while to the west of Antalya, Woodcock and Robertson (1982) have described a dominantly strike-slip tectonic regime in parts of the area previously mapped as «Antalya Nappes». For these reasons, the term Antalya Complex is here used, following Woodcock and Robertson (1977), to refer to the assemblage of rocks formerly known as the Antalya Nappes.

Thirteen formations and two groups are defined within the northeast segment of the Antalya Complex. Figure 2 indicates the relationships of the formations as observed in a number of measured sequences. Most formations have been identified in several tectonic slices, often without direct evidence of original continuity; certain of the formations probably represent deposits laid down in several separated regions, rather than a single continuous layer.

The Pazarköy Group includes a variety of sedimentary formations, mostly showing pelagic and redeposited facies; it is roughly equivalent to the Lower and Middle «Nappes» as mapped by Brunn et al. (1971). The Yuvalı Group consists entirely of «platform» carbonates, and corresponds to the Eğridir Unit and Upper Antalya Nappe of Brunn et al. (1971) and Gutnic et al. (1979). The Eğridir Kızıl dağ harzburgite of Juteau (1975) is not included in either group.

PAZARKÖY GROUP

Definition. — New Group, comprising the following ten formations: Sofular Formation, Yılanlı Formation, Bucak Lava, Akpınar Tepe Limestone, Yassıviran Limestone (part), Zindan

Formation, Gavurçalı Tepe Limestone, Kocakent Tepe Formation, Havutlu Lava Formation, Göynük Formation. The Sofular and Yılanlı Formations crop out over the largest area.

Name and type area. — The Group is named after the village of Pazarköy on the eastern edge of Yılanlı Ovası, around which all the formations are exposed.

Synonymy. — The Pazarköy Group is roughly equivalent to the «Formation Schisto-Radiolaritique (F.S.R.)» of Blumenthal (1956), and to the Lower and Middle Antalya Nappes as mapped by Brunn et al. (1971).

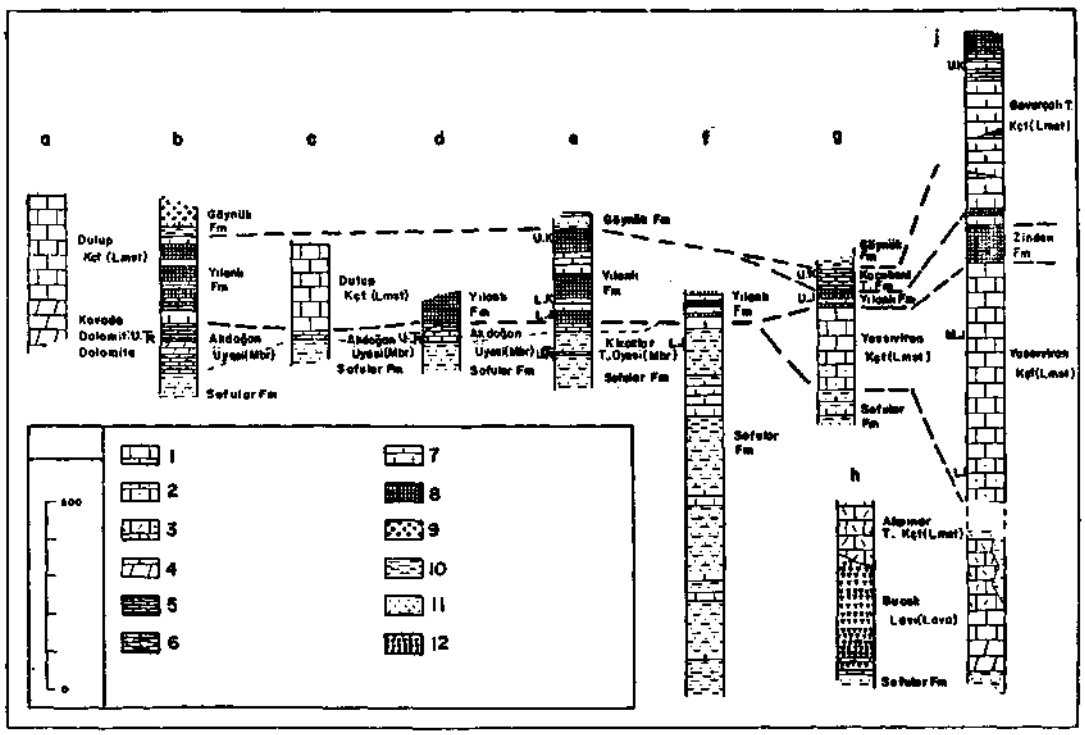

Fig. 2 - Typical sections in northeast Antalya Complex. Location of sections shown in Figure 1.
1 - Shallow-water limestone; 2 - Sandy limestone; 3 - Reef limestone; 4 - Dolomite, dolomitic limestone; 5 - Grey hemipelagic limestone; 6 - Pink nodular limestone; 7 - Redeposited (turbiditic) limestone; 8 - Radiolarian chert and shale; 9 - Ophiolite-derived conglomerate; 10 - Shale, mudstone; 11 - Sandstone; 12 - Basalt; Fm - Formation; Mbr - Member; Lmst - Limestone; Tr - Triassic; J - Jurassic; K - Cretaceous; U - Upper; M - Middle; L - Lower.
Column j in part after Dumont et al. (1980).

Sofular Formation

Definition. — New Formation; an assemblage of late Triassic to early Jurassic hemipelagic and turbiditic sedimentary rocks, including mudstones, sandstones calcarenites and *Halobia-bearing* limestones.

Name. — The Formation is named after the village of Sofular, 27 km by road northeast of Eğridir.

Type section.— The type section lies immediately northeast of Sofular (Fig. 3); the sequence is summarized in Figure 2 (lower part of column f). The lowest 200 m of the Formation is overturned, but thereafter the beds pass through vertical and then dip and young southwestwards.

The lowermost 350 m are dominated by dark grey mudstones with thin (3-10 cm) bands of sandstone rich in plant debris, which locally forms very thin (1 cm) coal seams. Grey impure limestones and orange-weathering ferruginous siltstone bands and concretions also occur. Above this, graded sandstone beds show turbidite sedimentary structures and bioturbated basal surfaces. Black, locally pyritous limestones occur in occasional beds and larger lenticular masses up to 10 m thick. Grey thickly bedded calcarenites and calcirudites form several distinct packets in the upper 500 m of the section. The top of the Formation is placed at the top of the highest interbedded sandstone, adjacent to Sofular village graveyard; the overlying sequence is assigned to the Yılanlı Formation. The total thickness is approximately 1050 m.

Regional characteristics. — The Sofular Formation in most areas is dominated by lithologies similar to those in the type section, but several other facies form important intercalations; two of these are distinguished as members (see below). Briefly, the additional facies are:

i) *Halobia-bezring* limestone. Thin to medium bedded grey fine-grained limestones and minor mudstones. The limestones contain calcified Radiolaria and fragments of thin-shelled bivalves such as Halobia.

ii) Red mudstones and limestones. Dark red mudstones occur interbedded with turbiditic sandstones and also in sandstone-free intervals, where they characteristically contain horizons marked by concretions of pink micritic limestone.

iii) Pink nodular limestones, intra-formational conglomerates, and laminated calcilutites; confined to the Akdoğan and Kirazlar Tepe Members (see below).

iv) Volcanic rocks. Poorly exposed mafic lava flows up to 3 m thick occur within a sequence of Sofular Formation sandstones and mudstones 2 km southwest of Yenice.

The Sofular Formation is exposed in almost every tectonic unit of the Antalya Complex in the area studied. Its base is never seen, and it is assumed to have undergone decollement from its original basement. As shown in Figure 2, it is overlain variously by the Yassıviran Limestone, the Yılanlı Formation, and the Dulup Limestone. The boundary with the Yassıviran Limestone is placed at the point where pelletoidal and oolitic limestones become predominant. At the transition to the Yılanlı Formation, the boundary is placed at the top of the highest sandstone bed, or at the top of the Akdoğan or Kirazlar Tepe Member (see below), if there is no higher sandstone. The boundary with the Dulup Limestone is always at the top of the Akdoğan Member.

Age. — *Palaeodasydadus mediterraneus* Pia (identification: J.-P. Bassoulet) near the top of the type section indicates a Lower Jurassic (Pliensbachian) age for the upper part of the Formation. The Triassic (Carnian-Norian) bivalve *Halobia* is locally abundant. Siliceous tubular fossils are provisionally identified as *Torkssia mackayi* Bather, recorded from the Upper Triassic of New Zealand and the Lower Lias of Alaska (Bather, 1905; Jaworski, 1915). The majority of the Sofular Formation is believed to be of Middle Triassic to Lowest Jurassic age, but earlier Triassic stages may be represented in the poorly fossiliferous lower parts of the Formation.

Kirazlar Tepe Member of the Sofular. Formation

Status. — New Member; a thin but conspicuous interval of pink to grey thinly bedded calcilutites at or very near the top of the Sofular Formation.

Name. — The Member is named after Kirazlar Tepe, a hill 1 km west of Yılanlı (Fig. 3).

Synonymy.. — None.

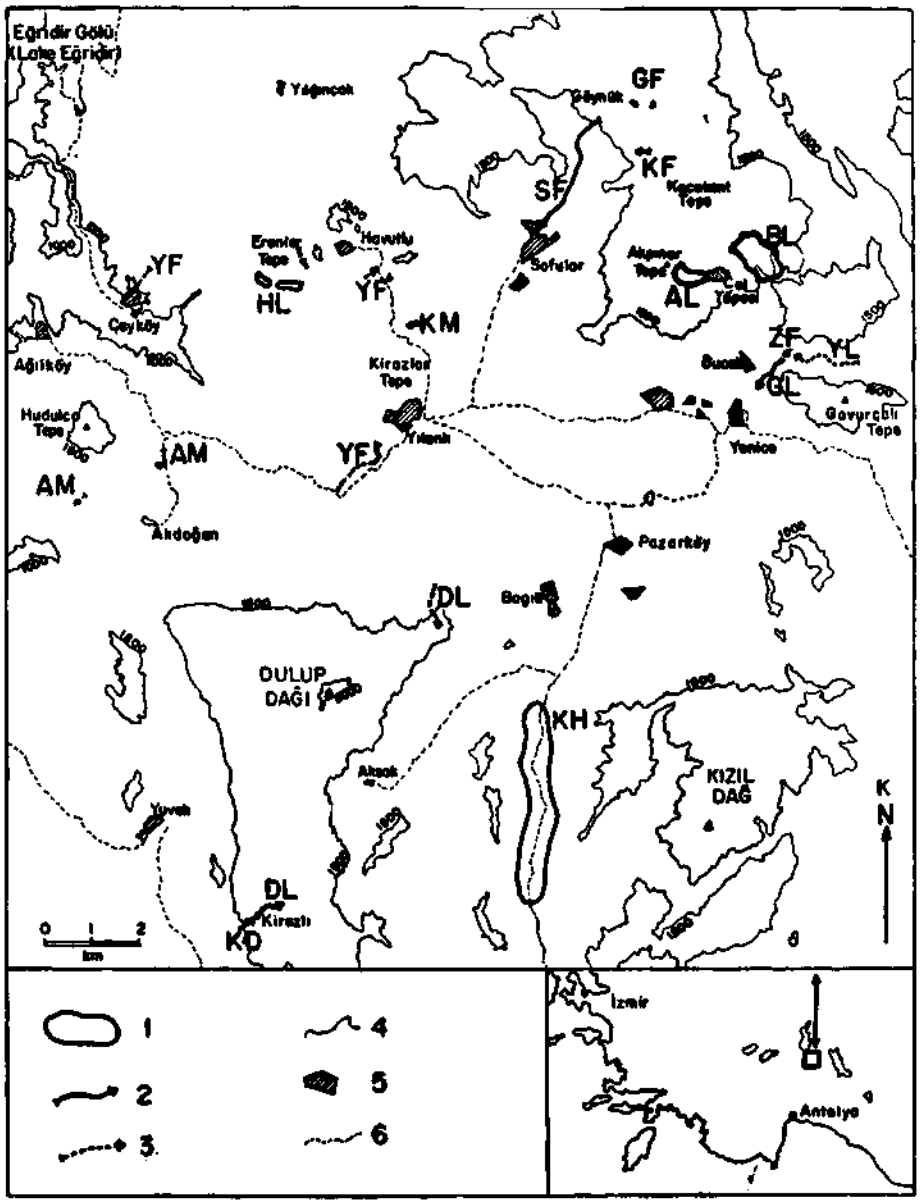

Fig. 3 - Location of type localities and sections.
1 - Type area; 2 - Type section (arrowhead at top); 3 - Reference section; 4 - Contours in metres; 5 - Village; 6 - Road; AL-Akpınar Tepe limestone; AM-Akdoğan Member; BL-Bucak Lava; DL-Dulup Limestone; GF-Göynük Formation; GL-Gavurçalı Tepe Limestone; HL-Havutlu Lava; KF-Kocakent Tepe Formation; KH-Eğridir Kızıl dağ Harzburgite; KM-Kirazlar Tepe Member; SF-Sofular Formation; YF-Yılanlı Formation; YL-Yassıviran Limestone; ZF-Zindan Formation.

Type Section. — The type section is in the shallow gorge 500 m east of the Yılanlı-Havutlu road, at the foot of Kirazlar Tepe. The base of the Member is the transition from brown Sofular Formation mudstones to pink calcilutites. The Kirazlar Tepe Member consists of thinly to very thinly bedded pink and grey calcilutites containing calcified Radiolaria. The calcilutites are com-

monly finely laminated, but locally heavily stylolitized. Occasional beds of fine graded calcarenite, red mudstone, and fine sandstone occur. The top of the Member is marked by the transition from predominant pink calcilutite to predominant red mudstone and radiolarite of the Yılanlı Formation. The thickness of the type section is 13 m.

Regional characteristics. — The lithology of the Kirazlar Tepe Member is always similar to that of the type section, although the Member varies from zero to 30 m in thickness. The Member may be overlain directly by the Yılanlı Formation, or there may be up to five metres of Sofular Formation sandstones and mudstones below the base of the Yılanlı Formation. The Member passes laterally into the Akdoğan Member of the Sofular Formation.

Age. — Direct palaeontological evidence for the age of the Member is lacking. At Yılanlı, calcilutites 70 cm below the base of the Member yielded the Triassic bivalve *Halobia*. Radiolarites 9 m above the Member at the same locality yielded Lower Jurassic (U. Pliensbachian to Toarcian) Radiolaria. The Kirazlar Tepe Member is therefore of Upper Triassic and/or Lower Jurassic age.

Akdoğan Member of the Sofular Formation

Status. — New Member; micritic *Halobia-bearing* limestones, pink nodular limestones, and pink intraformational carbonate conglomerates, at the top of the Sofular Formation.

Name. — The Member is named after the village of Akdoğan, 18 km by road southeast of Eğridir.

Synonymy. — Calcaire a Halobies (Brunn et al. 1970) - in part.

Type section. — The type section is defined in the shallow road cutting and on the adjacent hillside 1.3 km north of the village of Akdoğan (Fig. 3). At the base of the Member brown-weathering mudstones pass upwards into grey thin to medium-bedded micritic limestones. The lower 35 m of the section consist of thin to medium-bedded and nodular grey micritic limestones with subordinate mudstones and saccharoidal calcarenite. The limestones contain abundant calcitized Radiolaria and fragments of thin-shelled bivalves. The upper 13 m of the Member consists of mottled pink and grey nodular micritic limestones with red chert nodules. Calcitized Radiolaria are still abundant but bivalve fragments become less common. The top of the Member is placed at the top of the highest bed of pink micritic limestone; it is overlain by red radiolarites of the Yılanlı Formation.

Regional aspects. — In addition to the lithologies seen in the type section, the Akdoğan Member locally shows a conglomeratic facies of pink micritic limestone; this probably formed by synsedimentary break-up of nodular beds similar to those of the type section. A section 1 km west of Akdoğan displays this facies well (Fig. 3). Laminated calcilutites similar to those of the Kirazlar Tepe Member are also present; the Akdoğan Member is believed to pass laterally into the Kirazlar Tepe Member.

The Akdoğan Member locally consists entirely of grey or entirely of pink limestones; typically, however, a lower grey interval and an upper pink interval are present.

The Member is always underlain by mudstones and sandstones of the Sofular Formation. It may be overlain either by the Yılanlı Formation, as at the type section, or by the Dulup Limestone, in which caserne pink facies are normally absent, and the boundary is placed at the transition from thinly bedded micritic limestones with Radiolaria to massive dolomitic or algal Dulup Limestone (see Fig. 2).

Age. — The lower, grey part of the Member is dated as Triassic by the presence of the bivalve Halobia at many localities. The upper part of the Member may extend into the Lower Jurassic.

Yılanlı Formation

Status. — New formation; bedded cherts, mudstones, and redeposited limestones.

Name. — The Formation is named after the village of Yılanlı, 22 km by road east of Eğridir.

Synonymy. — None.

Type section. — The type section of the Yılanlı Formation is in the water channel cutting 1 km southwest of Yılanlı (Fig. 3). The base of the Formation is the top of the Sofular Formation, the boundary being placed at the top of the highest bed of calcareous sandstone. The lower part of the section consists of red (locally grey) mudstones and cherty mudstones, interbedded with grey-green and grey thinly bedded cherts. 37 m above the base of the Formation is a sudden change to grey thin to thick-bedded calcarenites and calcirudites. These limestones form a packet 92 m thick; they are overlain by grey thin-bedded cherts and orange-weathering mudstones which become increasingly deformed up section. Continuity of exposure is lost 175 m above the base of the section although further excellent exposures occur to the southwest along the channel for 1 km.

Higher parts of the Formation are well seen in a reference section defined in a gully immediately north of the northern extremity of the village of Çayköy (Fig. 3). The sequence of lithologies is similar to the type section but thinly bedded cherts and mudstones alternate with pink to grey cherty calcilutites at the top of the section.

The top of the Formation is exposed west of the Yılanlı-Havutlu Road, 4 km north of the type locality (Fig. 3). Red radiolarian cherts of the Yılanlı Formation are directly overlain by Göynük Formation calcarenites containing green lithic fragments.

Regional characteristics. — The Yılanlı Formation is everywhere dominated by bedded cherts and redeposited limestones; the proportion of limestone varies between 5% and 80%. Sequences with little calcarenite are commonly largely composed of red cherts, often manganiferous, whereas limestone-dominated sequences usually contain predominantly grey-green and mottled cherts. Nodular and banded replacement chert is common in the limestones. The base of the Formation is equivalent to the top of the Sofular Formation, except when the two are separated by the Yassıviran Limestone, in which case the base of the Formation is taken at the lowest bedded chert. The top of the Formation, never well exposed, is the transition to splintery calcareous mudstones or lithic arenites of the Göynük Formation.

Age. — Radiolaria from the base of the type section *(Trillus elkhornensis* Pessagno and Blome, *Canoptum rugosum* Pessagno and Poisson) indicate a Lower Jurassic (Upper Pliensbachian to Toarcian) age. A section on Kirazlar Tepe, 1 km north of Yılanlı, yielded varied faunas ranging from Jurassic (Oxfordian-Kimmeridgian) to Upper Cretaceous (Turonian) in age. *Thanarla conica* (Aliev). *Xitus* sp. and *Tunis* sp. in the upper part of the reference section at (Çayköy (see above) also indicate a Cretaceous (Hauterivian to Aptian) age. (Radiolarian faunas determined by E.A. Pessagno.)

Foraminifera and algae have been identified in a number of Yılanlı Formation calcarenites. 3 km north of Yılanlı, an assemblage including *Pseudocyclammina* cf. *lituus* Yok., *Trocholina* cf *alpina-elongata* (Leopold), and *Clypeina jurassica* Favre indicates an Upper Jurassic (Kimmeridgian-Tithonian) age. (Identifications: J.-P. Bassoulet.)

The Yılanlı Formation therefore ranges in age from Lower Jurassic (Pliensbachian) to Upper Cretaceous (Turonian or younger).

Yassıviran Limestone

Status. — Formation defined by Gutnic (1977); well bedded limestones extensively exposed in the Anamas Dağ region northeast of the Antalya Complex (Fig. 1), but extending into the Complex along its north-eastern edge.

Name. — The Yassıviran Limestone is named after the village of Yassıviran, 4 km east of Senirkent and 34 km northwest of Eğridir.

Synonymy. — Calcaires de Yassıviran (Gutnic, 1977).

Type section. — The type section described by Gutnic (1977) is located on the south side of Demir Tepe, 9 km south of Yassıviran.

Regional characteristics. — Gutnic (1977) traced the Limestone from its type area as far as the Anamas Dağ (Fig. 1). Dumont et al. (1980) subsequently identified it within the Complex, in the sequence cut by Zindan gorge, east of Yenice (Fig. 3). In the course of the present investigation similar limestones, though less thickly developed, have been identified elsewhere in the northeastern part of the Complex; these too are assigned to the Yassıviran Limestone.

The Yassıviran Limestone consists of grey and dark grey pelletoidal grainstones and packstones, with occasional coarse intraformational conglomerates which include oncolites and coral debris. Towards the base, the Limestone becomes sandy, locally pinkish in colour, and includes beds of yellow siltstone; it passes down into sandstones of the Sofular Formation. The Yassıviran Limestone is overlain by cherts of the Zindan and Yılanlı Formations.

Age. — According to Dumont et al. (1980) the Yassıviran Limestone is of Lower to Middle Jurassic age in the Zindan gorge section. No characteristic fossils have so far been recovered elsewhere in the Limestone.

Zindan Formation

Status. — Formation defined by Dumont et al. (1980). Black bedded cherts and grey cherty calcilutites overlying the Yassıviran Limestone in the Zindan sequence (Fig. 2).

Name. — The formation is named after the cave known as Zindan, of the right bank of Aksu Çayı, 1.5 km northeast of Yenice (Fig. 3).

Synonymy. — None.

Type section. — Dumont et al. (1980) define the type section of the Zindan Formation in the slope on the right bank of Aksu Çayı 200 m west of Zindan Cave (Fig. 3). The Formation consists of dark grey to black thinly-bedded chert, which becomes interbedded towards the top of the section with cherty cream-coloured calcilutites. The top of the Formation is marked by the incoming of breccias and calcarenites of the Gavurçalı Tepe Limestone. The thickness of the Formation is roughly 100 m, although complex folding makes measurement inaccurate.

Regional characteristics. — The Formation can be traced laterally for 2 to 4 km north and south of the type section. Elsewhere in the Complex cherts and calcarenites occurring in an equivalent position are assigned to the Yılanlı Formation (see Fig. 2 g and 2 j).

Age. — The age of the Zindan Formation is probably Upper Jurassic to Lower Cretaceous (Dumont et al. 1980).

Gavurçalı Tepe Limestone

Status. — Formation defined by Dumont et al. (.1980). Massive redeposited limestones, with minor bedded cherts and pink micritic limestones.

Name. —The Limestone is named after Gavurçalı Tepe, 2 km east of Yenice.

Synonymy. — None.

Type section. — The type section described by Dumont et al. (1980) is in the valley of Aksu Çayı (Zindan gorge), northeast of Yenice (Fig. 3). The Limestone overlies the Zindan Formation. It consists of massive coarse calcarenites and limestone breccia with interbeds of radiolarian chert and pink micritic limestone with pelagic fossils. The top of the Gavurçalı Tepe Limestone is truncated by a thrust fault; the visible section is approximately 450 m thick.

Regional characteristics. — The Gavurçalı Tepe Limestone is confined to the massifs of Gavurçalı Tepe and Karaçam Tepe, north and south of Zindan gorge. It always overlies the Zindan Formation, and probably originally passed laterally into the Kocakent Tepe and Yılanlı Formations (Fig. 2 g and 2 j).

Age. — The Gavurçalı Tepe Limestone ranges in age from Lower to Upper Cretaceous (Albian to U. Senonian) according to Dumont et al. (1980).

Kocakent Tepe Formation

Status. — New Formation; thinly bedded pink pelagic limestones and occasional redeposited calcarenites extensively developed near the northeastern edge of the Antalya Complex.

Name. — The Formation is named after Kocakent Tepe, a hill 3.5 km northeast of Sofular (Fig. 3).

Synonymy. — None.

Type section. — The type section follows the crest of the ridge to the west of Kocakent Tepe summit (Fig. 3). The base of the Formation is at the top of a sequence of brownish black cherts which are assigned to the Yılanlı Formation. The Kocakent Tepe Formation consists of thinly bedded pink to white micritic limestones which contain planktonic foraminifera including *Globotruncana* sp. Beds up to 1 m thick of white calcarenite also occur, making up approximately 20% of the total thickness of 50 m. Dark greybrown chert nodules are confined to the lowest 10 m of the Formation.

The top of the Formation is not exposed in the type section; the boundary with the overlying Göynük Formation is exposed 1 km to the north.

Regional characteristics. — The Kocakent Tepe Formation outcrops extensively near the northeastern edge of the Antalya Complex. It is usually deformed, and its boundaries are commonly faulted. Laterally, the Kocakent Tepe Formation probably originally passed with an increase in the proportion of calcarenite into the Gavurçalı Tepe Limestone (Fig. 2 g).

Age. — *Globotruncana* cf. *marginata* or *linnet* (identification: J. Sigal) from the lower part of the Formation indicates an Upper Cretaceous (Turonian-Senonian) age. Higher in the Formation faunas suggesting Upper Maestrichtian, or possibly even Lowest Paleocene (Danian) age were found.

Bucak Lava

Status. — Formation defined by Juteau (1975); mafic lavas exposed on the plateau north of Bucak.

Name. — The Bucak Lava is named after the village of Bucak, 1 km north of Yenice, and 29 km by road east of Eğridir.

Synonymy. — Lavas du Bucak (Juteau, 1975).

Type area. — The type area of the Bucak lavas is on the plateau 2 km north of Bucak, on the northwest side of the path from Bucak to Sorkun Yayla. Juteau (1975) distinguished aphanitic, porphyro-ankaramitic, and porphyro-labradoritic types in pillowed and unpillowed flows. Interbeds of pink micritic limestone occur rarely. The lavas dip southwards, and are probably around 300 m thick. They rest on deformed Sofular Formation sandstones, shales and limestones; they are overlain by the Akpınar Tepe Limestone.

Regional characteristics. — The Bucak Lava is exposed only in the vicinity of the type area.

Age. — The overlying Akpınar Tepe Limestone is of Triassic age according to Juteau, suggesting that the lavas are Triassic also.

Akpınar Tepe Formation

Status.— Formation defined by Juteau (1975); massive white limestones overlying the Bucak Lava.

Name. — The Akpınar Tepe Limestone is named after Akpınar Tepe, 2.5 km northwest of Bucak (Fig. 3).

Synonymy. — Calcaires d'Akpınar Tepe (Juteau, 1975).

Type area. — The Akpınar Tepe Limestone is not clearly stratified; a type section is not therefore defined. The type area comprises the summits of Akpınar Tepe and Çal Tepe (Fig. 3).

The Akpınar Tepe Limestone is white and recrystallized. It locally shows fenestral fabrics, algal lamination, and algal binding; a number of poorly preserved corals have also been found.

Regional characteristics. — The type area is within the largest outcrop of the Limestone, occupying approximately 2 km^2; several other small massifs probably assignable to this formation occur in the northeastern part of the area studied.

Age. — Juteau (1975) quotes a Triassic age for ammonites from the base of the Limestone in the type area.

Havutlu Lava Formation

Status. — New Formation; mafic aphanitic pillow lavas and associated sediments.

Name. — The Formation is named after the village of Havutlu, 4 km north of Yılanlı (Fig. 3).

Synonymy. — None.

Type area. — No complete section through the Formation is known. The type area is 1½ km southwest of Havutlu, where several good exposures occur on the banks of a small stream (Fig. 3).

The Formation consists mainly of greenish grey to black aphanitic mafic lavas. Pillows are locally well developed, but are often largely obscured by deformation. The lavas are interbedded and overlain by red to black manganiferous radiolarian cherts and pink recrystallized fine-grained limestone. The upper surface of the lava is often highly uneven. A conglomerate composed of lava, chert, and pink limestone fragments occurs at the top of the exposed sequence in the type area. The boundaries of the Formation are tectonic.

Regional characteristics. — Many small slices of the Havutlu Lava Formation occur elsewhere in the Complex; the most notable is exposed in the«high valley north and south of Aksak (Fig. 3), where deformed Havutlu Lava is very locally metamorphosed to green chlorite schist.

Age. — A radiolarian fauna extracted by E.A. Pessagno from cherts in the upper part of the sequence exposed in the type area indicates an-Upper Jurassic or Lower Cretaceous (U. Kimmeridgian to L. Hauterivian) age.

Göynük Formation

Status. — New Formation; Late Cretaceous mudstones, chalks, and ophiolite-derived sediments.

Name. — The Formation is named after Göynük, a high s.lope 3.5 km northeast of Sofular.

Synonymy. — None.

Type section. — No complete section of the Göynük Formation is known; the type area includes two short sections which illustrate the basal boundary and general characteristics of the Formation.

The first occurs in a small crag 50 m south of the cliff of Kocakır Tepe. It shows a transition from deformed pink limestones of the Kocakent Tepe Formation, through approximately 5 m of resistant grey calcarenite, into 5 m of splintery impure chalks. The base of the Formation is at the boundary between calcarenite and chalk; the sequence is overturned at this point.

The second section is in the gully 400 m to the southwest of the first section. It shows a sequence of calcareous and siliceous splintery mudstones, interbedded with greenish chert, and, at the top of the section, calcareous sandstone containing ophiolite-derived debris.

Regional characteristics. — The Göynük Formation includes a variety of ophiolite-derived sediments in addition to those seen in the type area. Coarse, poorly sorted conglomerates are well developed around the edges of Dulup Dağı. The Formation is usually deformed, and its relationships with the underlying Yılanlı and Kocakent Tepe Formations are often difficult to demonstrate; the Göynük Formation overlies both the Kocakent Tepe Formation and the Yılanlı Formation. Its top is always tectonic.

Age. — *Globotruncana* cf. *area* and *Globotrnncana* cf. *elevata* or *stuartiformis* in the type area, near the base of the formation, indicate a Campanian or Maestrichtian age. (Identification: J. Sigal.)

YUVALI GROUP

Definition of Group

Status. — New group, including two existing formations: the Kovada Dolomite and the Dulup Limestone. Permian limestones occurring locally below the Kovada Dolomite are also included in the group, although not formally defined as a formation.

Name arid type area. — The Group is named after the village of Yuvalı (old name: Direskene) 25 km by road southwest of Eğridir (Fig. 3). Both formations are extensively exposed in the hills surrounding the village.

Synonymy. — The Yuvalı Group is approximately equivalent to the «Upper Antalya Nappe» as mapped by Brunn et al. (1971) in the northeastern segment of the Complex, and to part of the Limestone Series of Ortynski (1941).

Kovada Dolomite

Status. — Formation defined by Dumont and Kerey (1975).

Name. — The Kovada Dolomite is named after the region «Kovada», surrounding a lake of the same name (Kovada Gölü), 20 km south of Lake Eğridir.

Synonymy. — None.

Type section. — No type section is defined in the type area by Dumont and Kerey. A local reference section is here defined 3 km southeast of Yuvalı on the western slope of the Dulup Dağı massif (Fig. 3). At the base of the section, the Dolomite rests with tectonic contact on the Göynük formation. The Dolomite is off white, poorly bedded, and locally highly fractured. Dolomitic limestone and limestone become more abundant up section. The transition to the overlying Dulup Limestone occurs at the centre of the small depression known as Kirazlı. The section is 250 m thick approximately.

Regional characteristics. — Where visible, the base of the Kovada Dolomite is usually tectonic. 1½ km north of Yuvalı, however, a few metres of dark grey Permian limestones occur below the Dolomite. It is not clear whether the sequence here is unbroken; Dumont and Kerey (1975) record similar Permian limestones only in separate tectonic slices at the base of their «Dulup Unit». In addition to the lithologies seen in the reference section, the Kovada Dolomite locally includes algal-laminated dolomitic limestone (well seen 2 km south-of Aksak) and dark-grey highly bituminous dolomitic limestones: The Dolomite is probably up to 200 m thick, and is always overlain by the Dulup Limestone.

Age. — No fossils have been found in the Kovada Dolomite. Upper Jurassic fossils from the immediately overlying Dulup Limestone imply that the Dolomite is Jurassic or older.

Dulup Limestone

Status. — Formation, defined by Dumont and Kerey (1975).

Name. — The Dulup Limestone is named after Dulup Dağı, a 2049 m peak situated 18 km ESE of Eğridir. Following existing usage, the abbreviated name is here used where «Dulup Dağı Limestone» would follow standard stratigraphic procedure (Hedberg, 1976).

Synonymy. — None.

Type area. — The type area comprises the high karstic terrain between Yuvalı and Aksak, including the summit of Dulup Dağı. No continuous section through the Limestone is known. The base is at the centre of the depression known as Kirazlı, 3 km southeast of Yuvalı, where pinkish grey pelletoidal limestones overlie the Kovada Dolomite (Fig. 3). Higher parts of the Limestone are well exposed on the northern slopes of Dulup Dağı. The top of the Limestone is not seen. In the type area, the Dulup Limestone is dominated by pelletoidal packstones and wackestones although grainstones become more abundant upwards. Several dolomitic bands occur in the lower part. The Dulup Limestone is probably approximately 500 m thick in the type area.

Regional characteristics. — The Dulup Limestone outcrops over a large area between Dulup Dağı and Çandır, 40 km to the south. Dumont and.Kerey record Dolomitic, Oolitic, Reefal, and Algal members, although these cannot be clearly recognized in the type area. The limestones of several small massifs (Fig. 1), to the north of the Dulup Dağı Massif, are here also assigned to the Dulup Limestone, although it is not certain whether these were originally continuous with the main part of the formation. On Hudulca Tepe, the Limestone includes dolomitic, algal and locally reefal facies. The Dulup Limestone overlies the Kovada Dolomite in the type areas of both formations, but on Hudulca Tepe and in the Çandır region (Akbulut, 1977), it overlies *Halobia-bearing* limestones which are here assigned to the Sofular Formation.

Shallow-water limestones which form the prominent ridge north of Çayköy (Fig. 1) are here also assigned to the Dulup Limestone. Close to Lake Eğridir they pass'up into pelagic *Globotruncana-bearing* facies, and then into mudstones and sandy calcarenites of the Göynük Formation. The same unit re-appears west of Lake Eğridir at Bark, Eğridir, and in the Davras Dağ massif (Fig. 1, Gutnic et al., 1979). Brunn et al. (1971) regarded these limestones as an autochthonous unit below the Antalya Complex. They are here interpreted as an allochthonous part of the Complex (Waldron, in press) and are believed to represent a separate carbonate bank from the Dulup Limestone of the type area.

Age. — Dumont and Kerey (1975) record Upper Jurassic to Lower Cretaceous microfossils from the Dulup Limestone. To the south of the area of this study, Akbulut (1977) reports ages ranging from Triassic to Upper Cretaceous.

OTHER UNITS

Eğridir Kızıldağ Harzburgite

Status. — Formation defined by Juteau (1975); ultrabasic rocks outcropping between Bağıllı and Ayvalı (Fig. 1).

Name. — The Harzburgite is named after Kızıldağ, a peak 4 km southeast of Bağıllı. The peak is identified as Eğridir Kızıl Dağ, to distinguish it from several other peridotite massifs in SW Turkey which bear the same name (Juteau, 1975).

Synonymy. — Harzburgite du Kızıldağ d'Eğridir (Juteau, 1975).

Type area. — The road from Pazarköy to Ayvalı (Fig. 3) offers excellent exposures of the Harzburgite, in cuttings and in the adjacent river bed.

Harzburgite with tectonite fabric is the dominant lithology, but dykes and lenses of pyroxenite, dunite, and chromite occur. The Harzburgite is variably serpentinized. Juteau (1975) gives a full description.

Age. — Unknown.

Metamorphic rocks

Several small outcrops of metamorphic rocks occur approximately 1 km south of Aksak. The rocks are fissile greenish chlorite schists with occasional bands of red metacherts and finely banded marble. They appear to represent deformed and metamorphosed equivalents of the Havutlu Lava Formation, into which they pass transitionally.

Melange and megabreccia

The northeastern segment of the Antalya Complex includes extensive «melanges», in which blocks of numerous lithologies are supported in a shaley matrix. Some of these melanges are sedimentary olistostromes, deposited by debris flow, and are included in the Göynük Formation. Others may be tectonic in origin, and pass transitionally into regions of intense tectonic slicing which are nevertheless not true melanges since they do not have a matrix. When poorly exposed, such regions cannot be subdivided into formations; they are mapped simply as «melange and megabreccia».

CORRELATION WITH OTHER AREAS

The stratigraphy of other parts of the Antalya Complex has been documented by a number of authors, notably Akbulut (1977), Allasinaz et al. (1974), Kalafatçıoğlu (1973), Marcoux (in Delaune-Mayere et al., 1977), Monod (1977), Poisson (1977) and Robertson and Woodcock (1981a, 1981b, 1981c).

In general, the sediments of the Complex are divisible into «basin» and «platform» assemblages, corresponding to the Pazarköy and Yuvalı Groups. Figure 4 shows a number of «basin» sequences from various parts of the Complex. In most cases a Triassic sandstone-dominated sequence is overlain by Jurassic to Cretaceous bedded cherts and redeposited limestones, although the thickness of the chert-limestone sequence varies greatly. «Platform» sequences similar to the Yuvalı Group are recorded in the southwestern segment of the Complex (Tahtalı Dağ; Delaune-Mayere et al., 1977) and in the region 20-50 km south of Eğridir (Sütçüler Unit; Akbulut, 1977).

The Antalya Complex in the area studied also shows similarities with some of the Tauride platform units (Fig. 1). The «Zindan Series» (sequence j of Fig. 2) is compared sequences in the Barla Dağ (Fig. 1), west of Lake Eğridir, by Dumont et al. (1980). East of the area studied, turbiditic sandstones and mudstones (Kırkkavak and Kasımlar Formations) resembling those of the Sofular Formation occur extensively in the Triassic of the Karacahisar and adjacent massifs. The Jurassic Yassıviran Limestone occurs both in the Antalya Complex and in the adjacent Anamas Dağ (Fig. 1), while the underlying Çayır Formation of the Anamas Dağ is probably represented by yellow siltstones and pink sandy calcarenites which occur within the Complex at the base of the Yassıviran Limestone. These similarities suggest that the sediments of the northeastern segment of the Antalya Complex were deposited in a region adjacent to the Anamas Dağ platform carbonates.

INTERPRETATION

Figure 5 shows schematically a possible palinspastic reconstruction of the Pazarköy and Yuvalı Groups in Late Cretaceous times. It is based on the stratigraphic relationships shown in Figure 2, combined with a preliminary analysis of structural and sedimentological data. Lateral transitions, such as that between the Yılanlı Formation and Dulup Limestone are mostly inferred from comparisons of vertical sections; lateral transitions often cannot be directly observed because thrust faults have exploited the major changes of lithology. Where possible, the effects of deformation have been removed by «unstacking» superimposed thrust sheets; structurally high units appear towards the left of Figure 5. However, the polyphase history of deformation (see below) leads to uncertainties in the order of stacking; Figure 5 is therefore only one of a number of possible reconstructions (Waldron, in press).

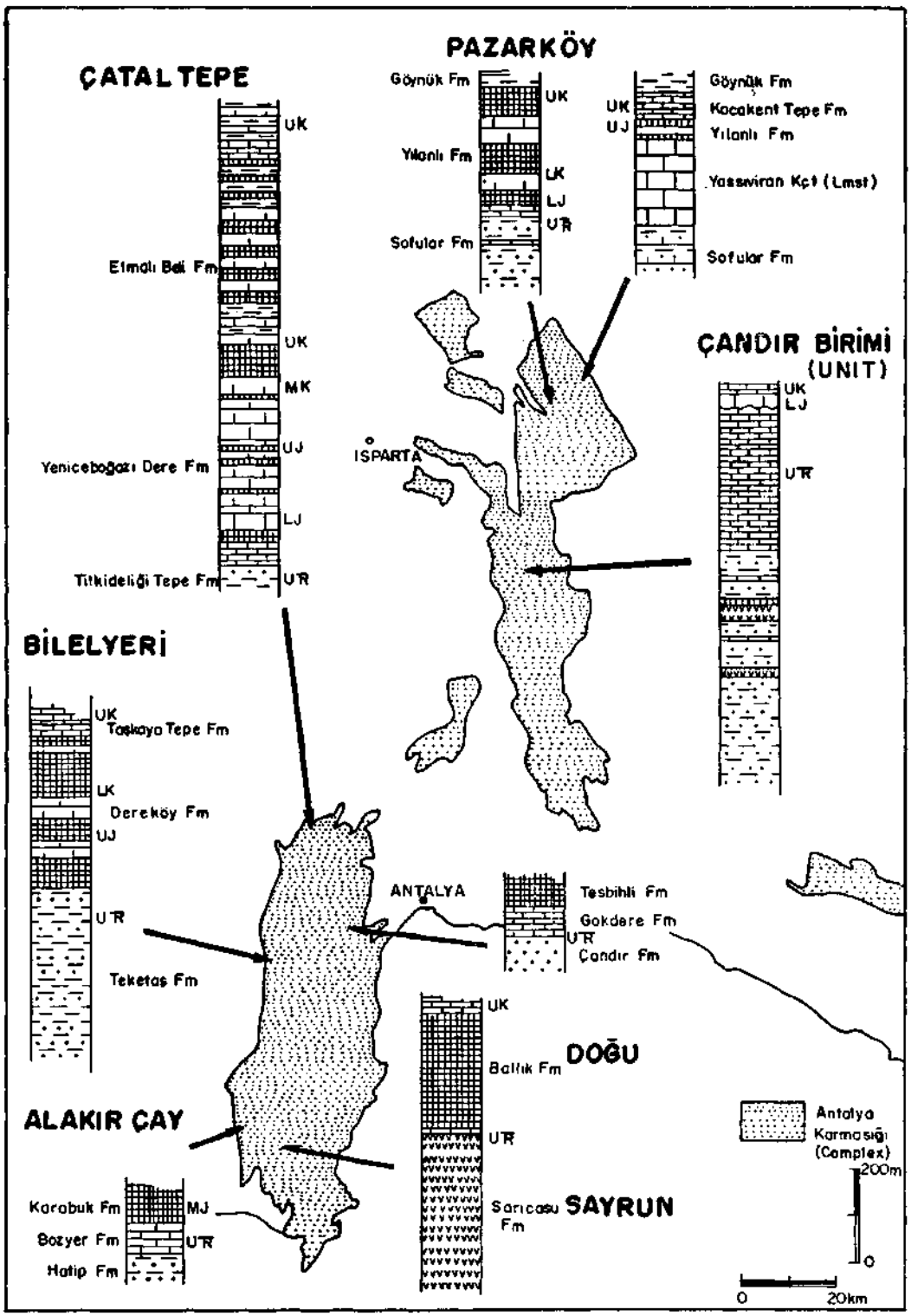

Fig. 4 – Comparison of Pazarköy Group with basin sequences elsewhere in Antalya Complex. Symbols as Figure 2. Sources: Çatal Tepe Unit: Poisson (1977); Çandır Unit: Akbulut (1977); Bilelyeri Group: Robertson and Woodcock (1981*b*); Antalya: Kalafatçıoğlu (1973); Doğu and Sayrun Groups: Robertson and Woodcock (1981*c*); Alakır Çay Group: Robertson and Woodcock (1981*a*).

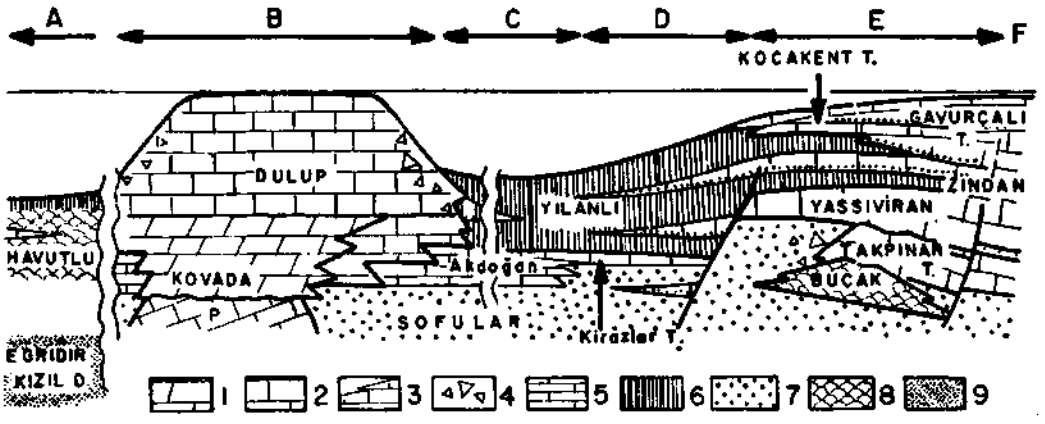

Fig. 5 - Cartoon showing generalized palinspastic reconstruction of northeast Antalya Complex. Not to scale. A-Oceanic zone; B-Offshore carbonate bank; C-Basin; D-Basin slope; E-Platform; 1 - Dolomite; 2 - Shallow-water and reef limestones; 3 - Redeposited (turbiditic) limestone; 4 - Coarse carbonate debris; 5 - Hemipelagic limestone; 6 - Radiolarian chert and mudstone; 7 - Sandstone and shale; 8 - Lava; 9 - Peridotite. Upper case names are formations; lower case names are members.

The oldest rocks in the area are the Permian limestones exposed locally at the base of the Yuvalı Group. The overlying Yuvalı Group carbonates represent shallow-water «platform» environments which probably persisted from Upper Triassic to Upper Cretaceous times.

In contrast, the Pazarköy Group is dominated by deep-water and slope sedimentation. The oldest rocks are the sandstones and mudstones of the Sofular Formation. Carbonate debris, including blocks up to 1 m in diameter, was derived from a nearby shallow-water environment; the majority of the sands had a more distant, metamorphic source area. Micritic *Halobia-beanng* limestones (Akdoğan member) represent peri-platform oozes, derived from adjacent carbonate platforms, and deposited in relatively uplifted areas free of terrigneous sand. In late Triassic or early Jurassic times, certain of these areas became shallow enough for the establishment of carbonate platforms; in such areas the Sofular Formation is overlain by the Dulup Limestone (Yuvalı Group). Elsewhere, input of terrigneous sand was cut off abruptly in Lower Jurassic times. The overlying Yılanlı Formation formed in relatively deep water (below carbonate compensation depth); deposition of mudstones and radiolarian oozes was interrupted occasionally by influxes of coarse platform-derived carbonate debris.

Basaltic lavas were erupted in the Pazarköy Group in Triassic (Bucak Lava) and Upper Jurassic or Lower Cretaceous times (Havutlu Lava Formation). The Bucak Lava caused a shallowing sufficient for the establishment of a Triassic carbonate build-up or reef (Akpınar Tepe Limestone).

This marginal area of the sedimentary basin is marked by the presence of pelletoidal and oncolitic grainstones (Yassıviran Limestone) in Jurassic times. In the Upper Cretaceous, pink pelagic limestone occurs in this area instead of radiolarite, indicating depths shallower than carbonate compensation depth. The marginal sequences show dramatic variations in thickness (compare sequences g and j in Fig. 2) suggesting that active faults were controlling deposition throughout the Mesozoic.

Deformation of the Complex associated with ophiolite emplacement began in latest Cretaceous times; the onset of deformation is marked by an influx of ophiolite-derived sediments (Göynük Formation). This deformation event effectively ended sedimentation in the Antalya Complex, and resulted in its emplacement as an allochthonous sheet of complex structure above the Upper Cre-

taceous limestones of Davras Dağ and Karacahisar. Correlation with the southwestern edge of the Anamas Dağ (see above), and the facing directions of structures within the Complex suggest that the direction of emplacement was from southwest to northeast (Waldron, in press).

A second phase of deformation, well known in the Anamas Dağ and Aksely regions (Fig. 1), occurred in Late Eocene times (Monod, 1977). This, episode mainly affected the northeastern part of the area of this study, where earlier structures were deformed by southwest-verging folds and thrusts. The area may also have been deformed in the late Miocene «Aksu phase» (Poisson, 1977; Akbulut, 1977).

CONCLUSIONS

The Mesozoic sediments of the northeast segment of the Antalya Complex are comparable to those of modern passive continental margins (Bernoulli and Jenkyns, 1974). They record an area of complex paleogeography involving isolated carbonate banks (Yuvalı Group) separated by areas of deeper water (Pazarköy Group), into which bank-derived detritus was deposited by sediment gravity flows. Differential vertical movements within the basins appear to have continued throughout Mesozoic era.

Alpine deformation began in Latest Cretaceous times, and resulted in the emplacement of the Complex as a stack of thrust sheets into its present position. Further deformation in Tertiary times affected both the Complex and its «autochthon», producing a complicated pattern of interfering structures.

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