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GEOLOGY OF THE NON-METAMORPHIC FORMATIONS AROUND MILET/TURKEY

B.SCHRODER, U.YALCIN*

ABSTRACT

The sequence of Neogene sediments (some 400 m in thickness) can be subdivided into three formations and is similar to that of the island of Samos (comp. fig. 1, 4).

Late middle Miocene till early Pliocene age is highly probable. The gently dipping basin fill does not show internal dissection by faults.

In the N huge landslides in front of the crest of the cuesta landscape occurred prior to the late Pleistocene sea level rise.

The position of ancient Milet and Didyma is intimately connected with the Pleistocene evolution of landscape and ground water resources.

INTRODUCTION

The late Cenozoic sedimentary basins in SW Anatolia were examined for ligmite (1965-1969) and this resulted in lithostratigraphical divisions of the contained Mio-Pliocene fluvio-lacustrine and volcanic sequences (BECKER-PLATEN 1970).

The location map of fig. 1 shows the type localities of the four identified sequences. The associated palaeontological studies, particularly sporomorph assemblages, established a subdivision into six groups within the lithostratigraphical division (fig. 4).

The increase of radiometric dating of the related volcanic rocks gave rise to a modification of the time span of late Cenozoic basin formation (comp. fig. 4; SEYITOGLU & SCOTT 1991).

Concerning the paleogeographic evolution of the Aegean area during the late Cenezoic the reader is referred to SCHRÖDER (1986, fig. 78-87).

The Neogene to Pleistocene evolution is characterized by the high amplitude of vertical movements along the eastern rim of the Aegean basin (Anatolian coast) with eastward transgressive tendency of marine intercalations. The accentuated relief is deeply invaded by the rising late Pleistocene sea level (comp. SCHRÖDER 1986). Late Holocene delta accretion of the Menderes river induces the young coastal configuration.

* Prof. Dr. B. Schröder, Dr. U. Yalçin; Institut für Geologie, Ruhr-Universität Bochum, P.B. 102148, D-4630 Bochum

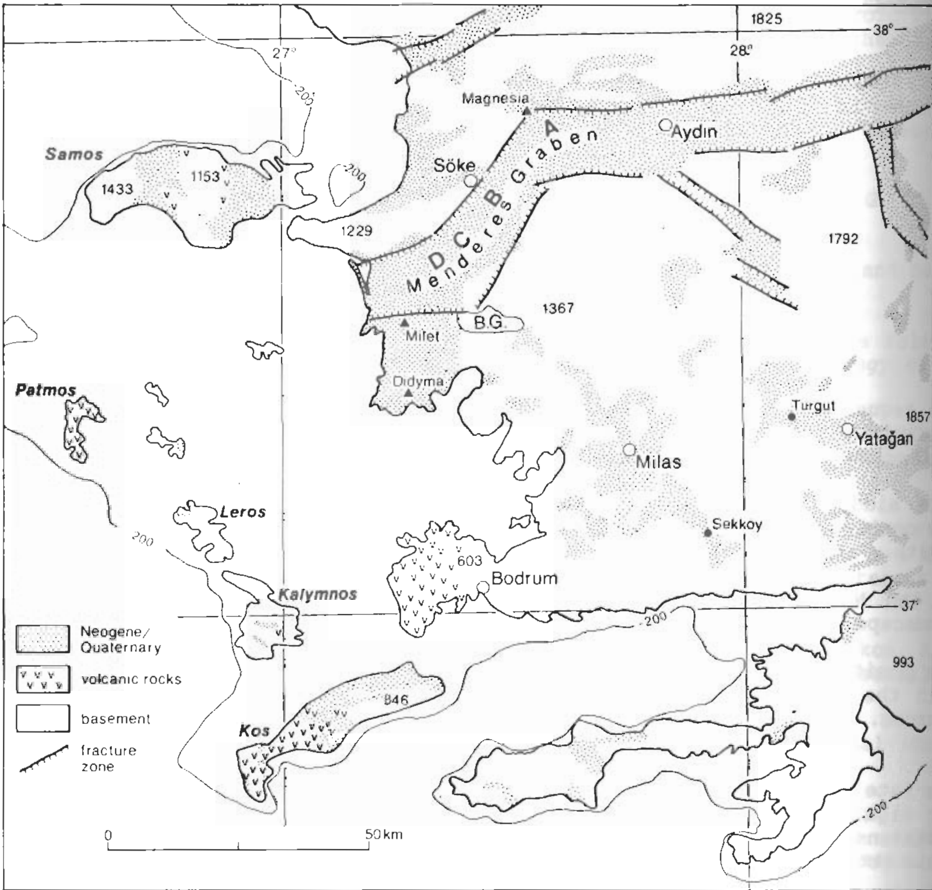

Figure 1 Geological sketch map of SW Anatolia (geol. detail after MEISSNER 1979). B.G. = Lake Bafa (Bafa Gölü) black triangles = ancient sites.
A-D = stages of delta progradation of Büjük Mender between Ionian settlement (A), late Archaic period (B), about 250 BC, and late Roman period (C and D)

BECKER-PLATEN (1970) described the basin fill of Milet and its regional lithostratigraphic correlation within SW Anatolia. MEISSNER (1976) started the attempt of mainly lithostratigraphic correlation between Samos and SW Anatolia which still suffered from problems of Neogene stratigraphic calibration at that time.

An outline of the basement areas of the surroundings has been published by DÜRR (1975, 1986) and YALÇIN (1987).

Field work in the Neogene basin of Milet has been carried out in interdisciplinary contact with archaeologists working at ancient Milet (comp. SCHRÖDER 1991, SCHRÖDER & YALÇIN, 1992).

STRATIGRAPHY OF THE MILET BASIN

The Neogene sequences in the areas around Milet consist of non-marine sediments. Within the basin, at least three lithostratigraphic units, different in origin and morphological behaviour, can be discerned (fig. 2, 3).

These units are represented by two lacustrine limestone sequences (each some 50-100 m in thickness) and an intercalated volcano-clastic one (about 300 m thick).

The Neogene sequence starts with the fresh-water limestone of the Nergiztepe formation. Its precise age is still unknown. A regional comparison (BECKER-PLATEN 1970) indicates similarities to the Seköy formation (position comp. fig. 1). The fossil content is restricted to ostracods and algal relics. Its thickness may reach up to 60 m (bore hole south of Balat; comp. fig. 2).

The lower part of the formation is made up by a 40 m thick freshwater limestone sequence with upward increasing thin-bedded marly intercalations at the top. The main outcrop area of these sediments coincides with the position of ancient Milet.

The transition into the fluvial Balat formation (some 300 m in thickness) is covered by Pleistocene sediments. After bore hole data (Balat) the lowermost 40 m consist of sandy marls, sands, conglomerates, volcanoclastics, and some lignite beds. The hanging wall sediments are poorly exposed in road cuts SW of Balat (some 60 m of sands, some conglomerates and an increasing amount of pyroclastic strata; - pink/violet, 0.5-2 m in thickness - and bentonitic clays).

The best exposed pyroclastic horizons occur in the lower half of the formation, a quarter of which is usually made up of tuff, bentonitic clay, and clay.

Increasing amounts of plastic bentonitic clays and marls, with a few interbedded pyroclastic horizons occur in the lower part of the upper half. They gave rise to spectacular sliding phenomena of the hanging wall sediments.

In the upper part of the upper half sandy-conglomeratic sediments with paleosols are prevailing. The best exposures occur where the road Söke-Milas crosses the crest (east of Yeniköy, comp. fig. 2).

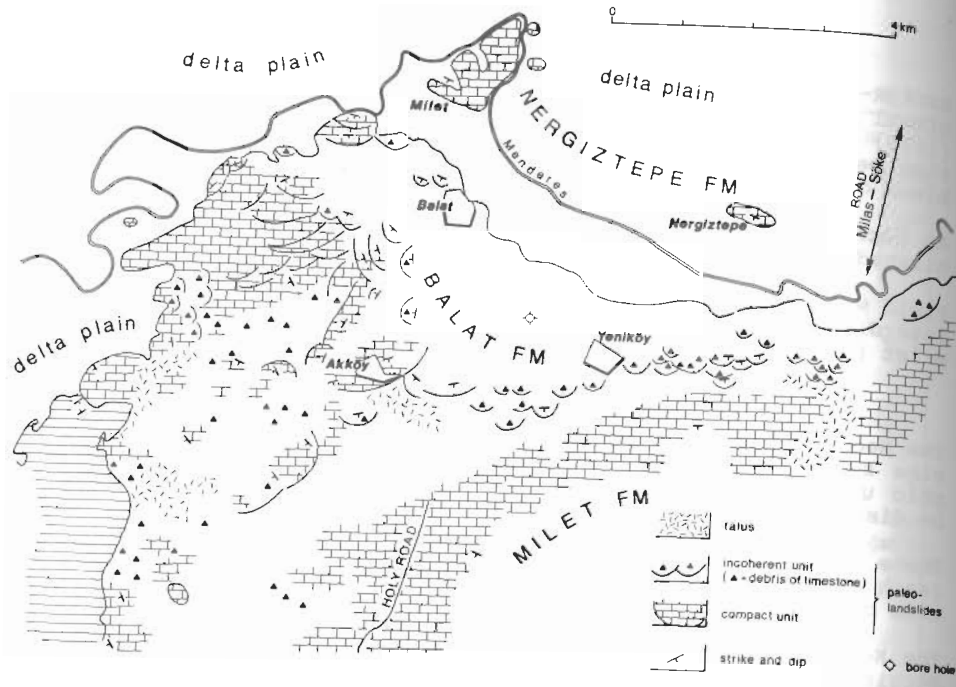

Figure 2 Map showing the distribution of Neogene to Pleistocene basin-fill units (mapping by SCHRÖDER, 1989, and SCHRÖDER & YALÇIN, 1990, 1991, unpub. data).

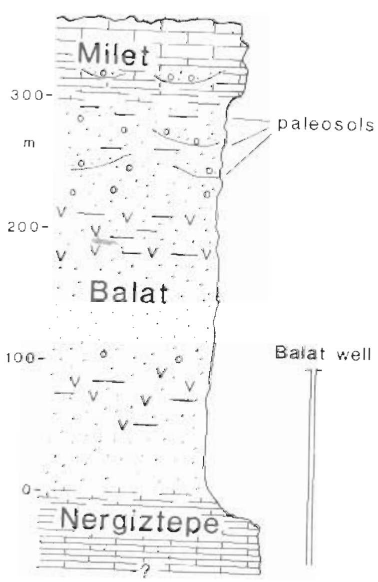

Figure 3 Stratigraphy of the continental formations of the Milet basin (position of Balat well comp. fig. 2).

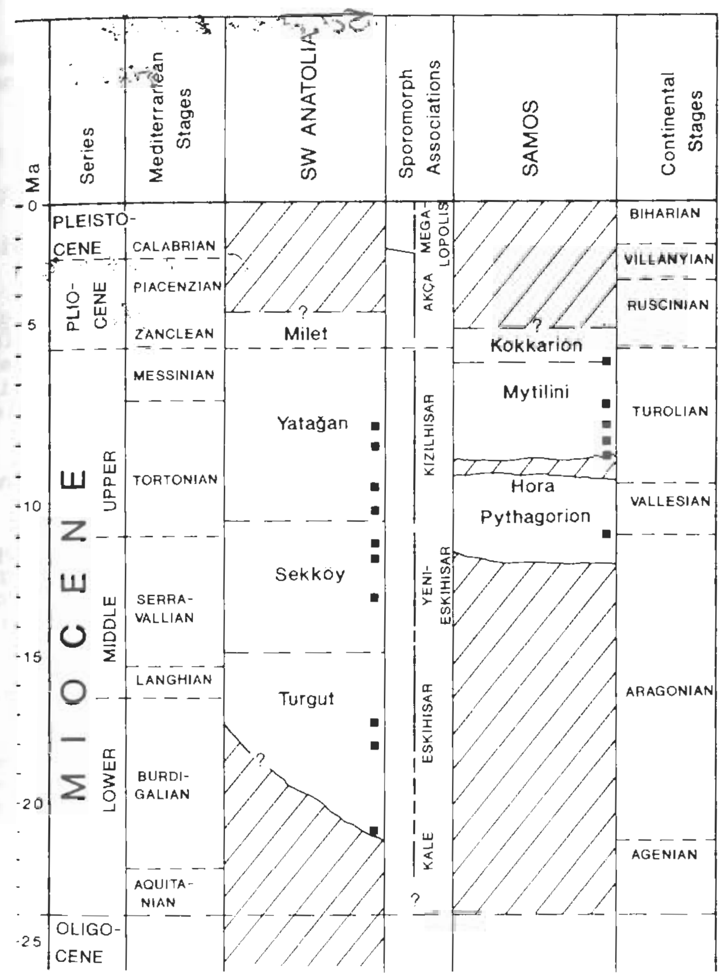

Figure 4 Correlation chart of sedimentary formations and gaps in SW Anatolia and in the eastern basin of Samosisland. Black squares = radiometric data. Correlation after BENDA & MEULENKAMP 1990, compiled after BECKER-PLATEN, 1970, BECKER-PLATEN et al. 1975, 1977, BESANG et al. 1977, MÄDLER & STEFFENS 1979, WEIDMANN et al. 1984.

The overlying Milet formation consists of fresh-water limestones with some thin marly and even conglomeratic intercalations. Its thickness reaches some 50-100 m.

Road cuts to the north of Didyma resp. to the northeast on the valley slopes near the Holy Road exhibit intercalations of matrix supported conglomerates (grain size of pebbles up to 5 cm).

The limestones of the Milet formation are resistant to erosion and form the crests of the hills.

Spectacular displacements of huge rock units originated sliding masses of Milet formation by gravity transport after tilting and erosive dissection and prior to the late quaternary sea level rise (SCHRÖDER 1991). They have probably developed due to a combination of weak stability of underlying water soaked Balat formation and seismic events.

In many cases the upper parts of the Balat formation are incorporated into the rock slide units.

Several allochthonous rock slide units occur along the slopes of the cuesta. They may reach up to 2 km in diameter and originally some 50-100 m in thickness. Sliding distances reached up to 2 km and even more (comp. fig. 2). Besides isolated sliding units, also composite ones occur of similar and/or variable tilt.

The distribution of lithostratigraphic formations (map comp. fig. 2) reflects the interference pattern of normal southern and westward tilt with Plio/Pleistocene erosion (and allochthonous sliding units), and with younger continental (fluvial conglomerates and alluvial debris) and marine/fluvial sediments (delta sediments of the Büjük Menderes) of the delta progradation during the late Holocene (comp. SCHRÖDER 1991, fig. 2).

REGIONAL STRATIGRAPHIC CONNECTION

The stratigraphy of the Neogene sediments has not been properly elucidated because fossils are uncommon and non-diagnostic.

Lithostratigraphic comparisons and few fossil findings give evidence that the paleogeographic evolution of the Milet basin is similar to the adjacent areas in the SE and to the isle of Samos as well (comp. fig. 4). According to regional similarities of the Balat formation with the Yatagan formation (BECKER-PLATEN 1970, locus typicus comp. fig. 1) and indications of Pikermi type vertebrate fauna in it (near Milas) its upper part might be equivalent to the uppermost Miocene (Messinian). Fig. 4 shows an attempt of probable to tentative stratigraphic calibration.

The stratigraphic sequences of the Neogene basins of Milet and the isle of Samos are strikingly similar (WEIDMANN et al. 1984).

STRUCTURAL EVOLUTION

SEYITAGLU & SCOTT (1991) examined the development of the late Cenozoic basins of west Turkey at a larger scale and in the light of published radiometric and other age data. They concluded that the north-south crustal extension and related sedimentary basin formation of this area commenced in the early Miocene.

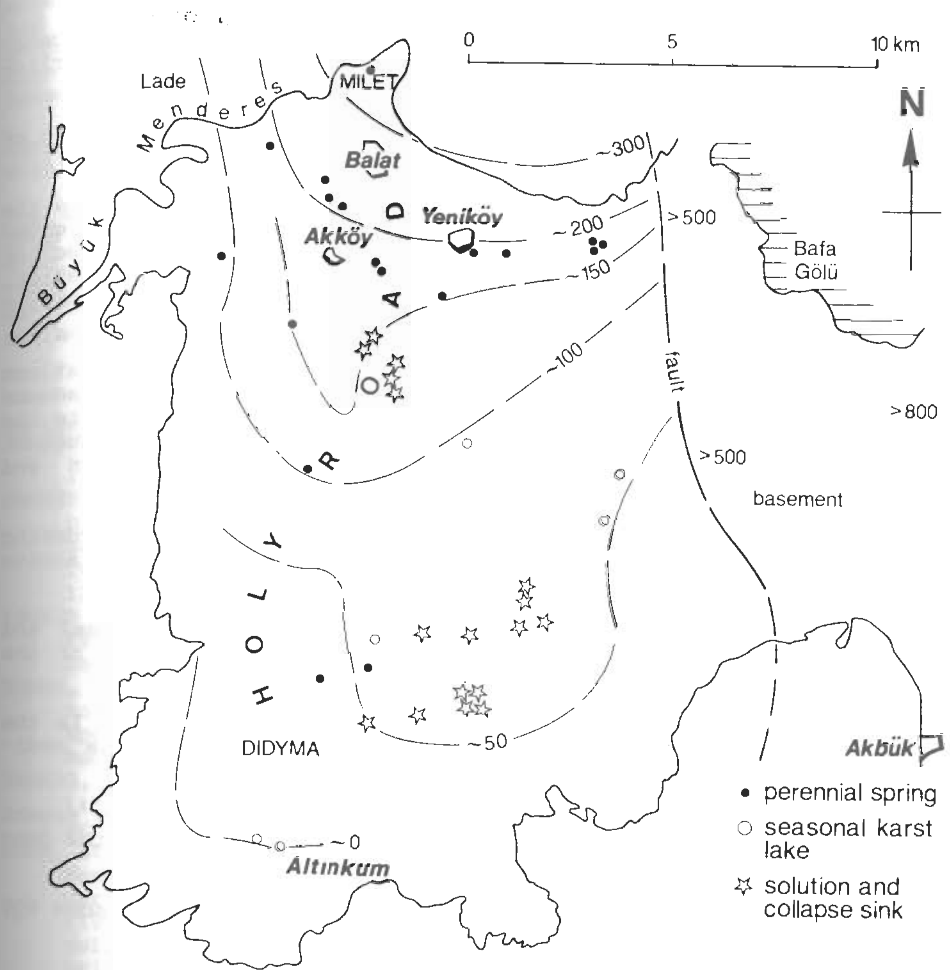

Figure 5 Contour map of the base of the Milet formation.

The age of formation of the Büyük Menderes Graben (early Miocene; indicated east of Aydin, SEYITOGLU & SCOTT 1992) is also earlier than priviously considered (Tortonian).

The Milet basin probably continuous in SW Anatolia to the basin of the Menderes Graben and seaward to those of Samos.

The Neogene sedimentary formations strike roughly parallel to the escarpment of "Stephania"-Akköy-Lade island; their dip is generally low to S and W (max. 5°). Basin internal fault dissection (assumed by PHILIPPSON 1936, BECKER-PLATEN 1970) does not exist. Higher dip only occurs within the units of large-scale to small-scale rock slides (comp. fig. 2).

The fresh-water limestones of the Nergiztepe and Milet formations developed in a shallow basin. The intercalated clastic-tuffaceous Balat formation shows a regional increase of marker pebbles to the southeast (diasporite, ophiolithe) and S (red chert) which suggest that important fluvial supply derived from southeastern and southern directions.

The eastern rim of the basin is partly exposed, the boardering fault can be followed for some 10 km and has probably been active from the late Miocene up to the present.

Basin development may have seized after the early Pliocene and gave rise to the development of a karstic surface on top of the Milet formation with some preserved relics of red soil.

The creation of the cuesta landscape between Milet-Didyma is the result of Plio-/Pleistocene uplift and tilting of Neogene sediments.

The severe earthquakes which have occurred in this area in recent years indicate that the faults which form the boundary of the Menderes Graben and adjacent areas are still active.

The structural relief of the tilted basin fill may reach some 500 m (comp. contour map of fig. 5).

GEOMORPHOLOGY, HYDROGEOLOGY, AND ENVIRONMENT OF MILET AREA

In the uplifted northern part of the basin the Pleistocene relief is northward increasingly incised into the structural relief. The rate of erosion prior to the late Pleistocene/Holocene may exceed 300 m in the area of the present Menderes valley fill. The exact dates of sliding processes of huge rock units are not known. On the one hand they depend on the relief cut into the tilted basin fill after the early Pliocene. On the other hand they came mainly into existence prior to the late Pleistocene rising sea level (comp. SCHRÖDER 1991).

The late Pleistocene marine transgression invaded deeply into the erosional configuration of the early Menderes valley. The late Holocene "Latmos Bay" may have reached the position of Magnesia as the easternmost Ionian settlement (BINGÖL, SCHRÖDER & YALÇIN, unpub.).

Accelerated delta progradation into the flat marine gulf originated from increasing inland settlements and human influence on erosional rates. Stages of it have been dated in an earlier publication (SCHRÖDER 1991). Fig. 1 summarizes the recent stage of knowledge of the historic evolution.

Early settlements within the basin area occured in locations within close proximity of springs.

The water supply of Milet during the late Roman period derived from several springs in front of the escarpment of Milet formation, mainly from the catchment areas of larger sliding units (comp. fig. 2; SCHRÖDER & YALÇIN 1992 and unpub.) down to the settlement of Milet (max. 40.000-70.000 inhabitants according to estimations).

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