

The Eastern Sporades and the Ionian Shore

This chapter covers the Greek islands of Lesbos (Mytilene), Chios and Samos, and the adjacent Turkish mainland (Fig. 13.1, Plate 11). The ancient Greek cities, on the western Turkish coast, which will be considered in conjunction with these islands are Pergamon, beside Lesbos; Izmir (formerly Smyrna), Teos and Sardis beside Chios; and Ephesus, Priene and Miletus, beside Samos.

Apart from a few Mycenaean settlements between 1400 and 1100 BC, the Greek presence in this region really starts about 1000 BC, when bands of refugees from the troubles in mainland Greece made their way eastwards across the Aegean. Some stopped off in the islands, while others moved on to the Asiatic coast. Thanks to the fertile soil, excellent climate, and excellent harbours, these settlements grew rich, but were never strong enough to withstand any powerful neighbour who might have designs on them. Consequently, between 550 and 525 BC, they fell to the Persians. Although freed by Athens after about fifty years, they were soon back under Persian control, and it was left to Alexander the Great to liberate them again in 333 BC. Henceforward they prospered. Rich in Hellenistic times, they were even richer under the Roman and Byzantine empires. The end came in the seventh century AD, caused by the silting up of the harbours, the onset of malaria, and attacks by pirates.

The bedrock of this region is divided into two parts: the Izmir-Ankara zone roughly to the north of the Gediz river and the Menderes massif to the south (Fig. 13.1). The Izmir-Ankara zone is made up of flysch sediments, limestones, volcanic rocks and serpentinite, mostly of Early Triassic to Late Cretaceous age.⁷⁸ The rocks of this zone have a chaotic

structure, with blocks of limestone up to 20 km long, set in a matrix of smaller blocks and flysch sediments. This structure was produced by tectonic movements during deposition of the flysch: the limestones were originally part of a shallow continental shelf that was broken up and slid into deeper water where the flysch was being deposited, during the Late Cretaceous. The whole unit was further disrupted when it was thrust southwards partly onto the Menderes massif, and perhaps beyond. The Izmir-Ankara zone may be equivalent to parts of the Pelagonian zone in Greece.

The Menderes massif is an area of older metamorphic and igneous rocks similar to the Attic-Cycladic metamorphic belt to the west, although the exact relationship between the two is not clear. The Menderes massif has a concentric structure, roughly decreasing in age and degree of metamorphism from core to edge. The core is made of gneisses metamorphosed during Late Precambrian to Cambrian time (more than 600 to 500 million years ago). Metamorphic rocks of this age are common throughout Africa (the Pan-African event) which suggests that this part of Turkey was originally part of that continent.²⁴⁶ The core is enveloped by a series of mica-schists and marbles, some with emery deposits of Palaeozoic age. Finally there is a series of Triassic to Early Tertiary marbles. The metamorphism that produced these rocks was probably related to the Alpine orogeny in Early Tertiary time. The three series of rocks of the massif were originally placed on top of each other by the Alpine compressions, but the core of the massif has suffered more erosion to reveal the underlying older rocks.

The geological history of western Turkey

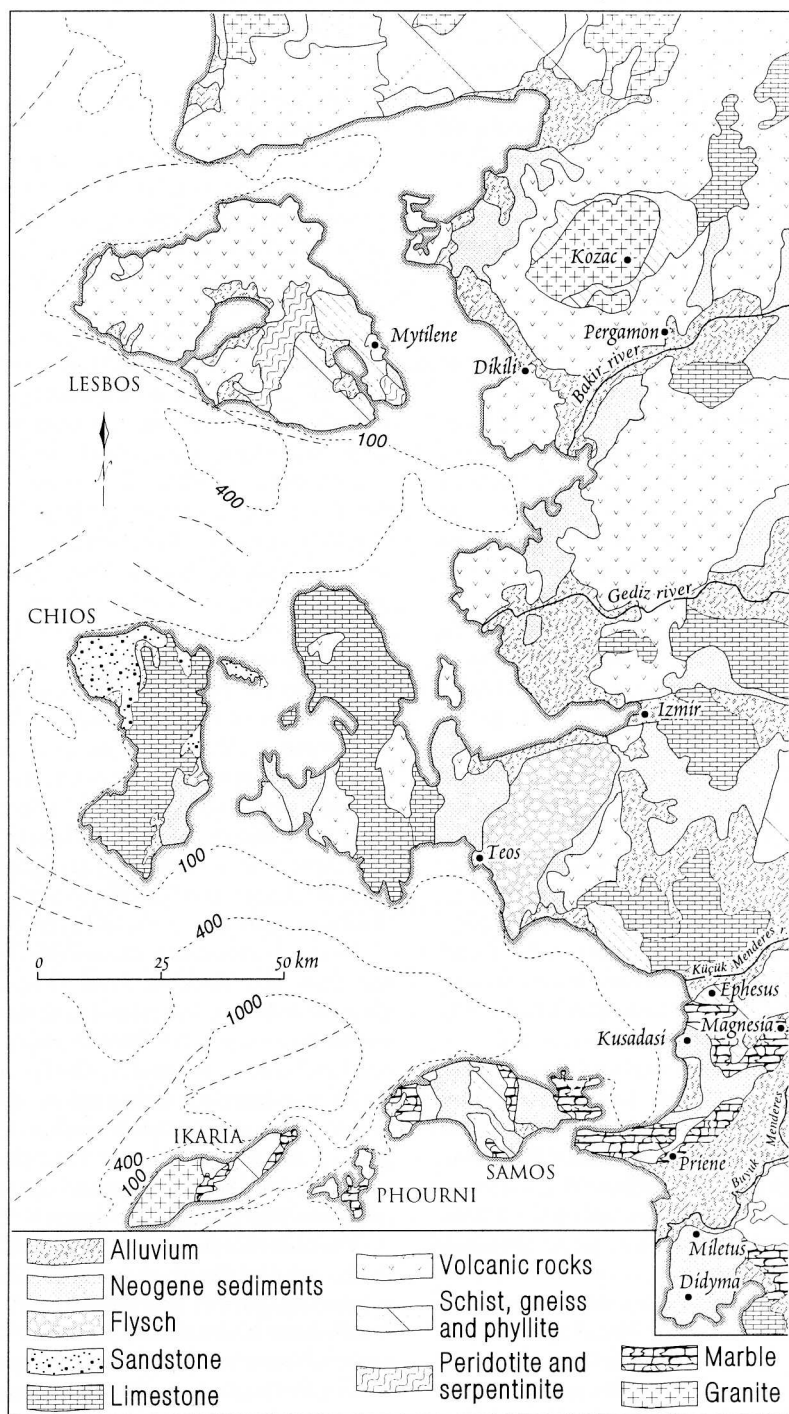


Fig. 13.1. The Eastern Sporades and the Ionian shore of Turkey. Sardis lies off the map, 94 km east of Izmir.

during the Neogene has been dominated by north/south stretching of the crust. This is part of the overall plate tectonic evolution of the Aegean region. The east/west faults produced by this extension have strongly controlled the topography of the region: almost all the major rivers in this area, the Bakir ('Copper river'), Gediz, Büyük Menderes and Küçük Menderes, flow along grabens. The floors of these valleys are still dropping today, which maintains the relief against the levelling effect of erosion. The rugged topography also leads to high rates of erosion and the resulting sediment is transported by the rivers to the sea, where it forms large deltas. One such graben is the valley of the Küçük Menderes river, which flows past the ancient city of Ephesus (Fig. 13.1). This graben continues underwater to the west as the gulf between the islands of Chios to the north and Samos and Icaria to the south.

Neogene sediments have been deposited in many of these grabens. Of particular importance are now the deposits of lignite around Soma, about 100 km north-east of Izmir.¹²¹ These rocks were formed from decayed vegetation in swamps during the Miocene period. Seams up to 20 m thick are mostly exploited for the generation of electricity.

Since the peak of the last glaciation about 20,000 years ago, sea-level has risen rapidly at least 100 m, greatly changing the topography. At the time of lower sea-level the valleys and their rivers extended further out to sea. Rivers drop their load of sediment (mud, silt and sand) when they meet the sea and slow down. In the past, therefore, the sediments of these rivers was deposited far out to sea. Initially, sea-level rose faster than the retreating valleys could be filled with sediments, and produced bays that cut deep into the continent. However, the large amount of sediments transported by the rivers quickly filled up these bays and today the process is almost complete.

Overall, this region has a low number of earthquakes, compared to the Aegean as a whole.³⁶ The Aegean Sea west of the islands is particularly low in earthquake activity, but this is compensated for by a higher activity near the channels east of the islands, especially Samos, and on the mainland.

Lesbos

Lesbos (or Mytilene), one of the largest of the Greek islands, lies close to the Turkish coast (Figs. 13.1, 13.2). The easternmost of the two large inlets, the Gulf of Geras, forms an excellent harbour. Behind the coastal plain is a mountainous interior, barren on the west side, but planted on the east with luxuriant olive trees and vines.

Lesbos was settled from nearby Asia Minor about 4000 BC (Late Neolithic). From 3000 to 2300 BC it enjoyed a flourishing civilization, revealed at Thermi on the east coast, which bears a striking resemblance to the first and second cities of Troy. Later the Mycenaean Greeks came; an event perhaps recorded by Homer's story that Agamemnon conquered the island during the Trojan War. Around 1000 BC Aeolian Greeks came from the Greek mainland and founded six cities, of which Mytilene and Mithimna were the most important. Thanks to the fertile soil and their excellent harbour, the Lesbians grew rich. Terpander, the father of Greek music, lived here as well as the poets Sappho and Alcaeus; the ruler, Pittacus, was counted one of the Seven Wise Men. We hear little of Lesbos in Roman and Byzantine times; but there was a revival in AD 1354 when the Genoese Francisco Gattilusio acquired the island and built the castle at Mytilene.

Lesbos is situated on a shallow shelf extending from the Turkish coast (Fig. 13.1). The channel between the island and the mainland would have been dry 20,000 years ago when sea-level was depressed by the Ice Age. To the south the sea-floor drops off rapidly into an underwater graben, an extension of the Bakir graben on the mainland. The graben originated about 10 million years ago during the Neogene stretching of the Aegean region.

The oldest rocks are exposed on Mt Olympos (1,055 m) and the surrounding plateau in the south-east part of the island, and in several small areas in the west (Fig. 13.2). These are a series of metamorphosed sediments of Carboniferous to Triassic age that were formed before the Alpine mountain-building event. This group of rocks includes schists, sandstones and conglomerates around the Gulf of Geras and

13. The Eastern Sporades and the Ionian Shore

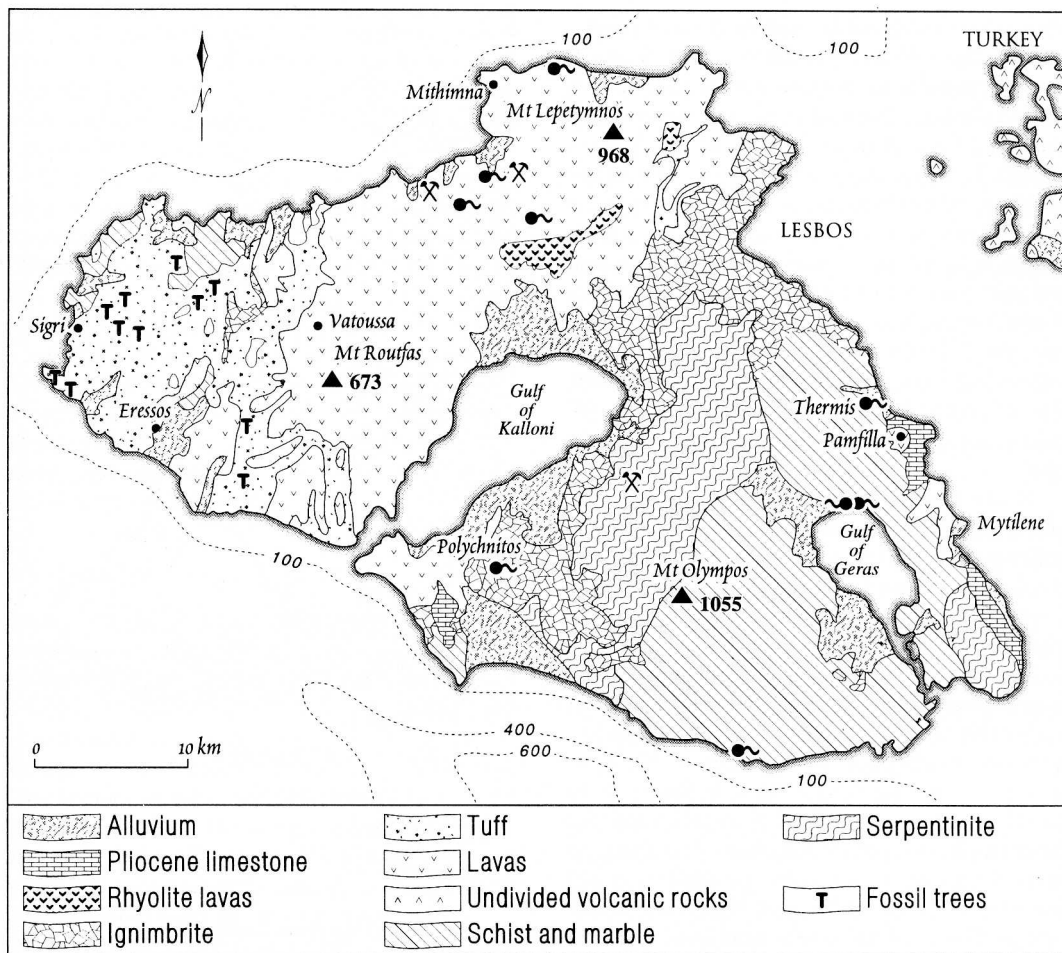


Fig. 13.2. Lesbos.

limestones north-west of the town of Mytilene. In some areas they are covered by Jurassic basalts, gabbros and peridotites, now commonly altered to serpentinite, which are members of the ophiolite suite. These rocks were originally part of the floor of an ocean to the north, which closed during the Alpine compressions, thrusting parts of the sea-floor onto the land along almost horizontal faults. Deposits of magnesite in the serpentinite have been exploited recently on the east side of the Gulf of Kalloni.

Volcanic rocks cover more than half of Lesbos and were emplaced over a short period of

time, mostly within 2 million years, synchronously with volcanism on the adjacent parts of Turkey.²⁰⁹ Volcanism started 22 million years ago with the eruption of lavas, now exposed in a small area east of Eressos. There was then a hiatus until 18 million years ago when the main volcanic episode started. Initially, basalt and andesite lavas were erupted around Vatooussa and south of Mithimna. Then followed a phase of more silica-rich, explosive volcanism. Volcanic ash (tuff) was deposited to the west, partly burying a forest (see below). In the east the ash was sufficiently hot that it welded together after it fell to form a sheet of ignim-

brite. The source of the ash may have been a caldera near Vatoussa. Domes and flows of rhyolite and dacite were emplaced north of the Gulf of Kalloni. Some of these rocks have been exploited for the manufacture of perlite (see Melos). The last major volcanic phase was the eruption of basalt, andesite and dacite lavas in the central part of the island. Great thicknesses of lavas accumulated to the north-east and south-west forming stratovolcanos whose eroded remains are Mt Routfas and Mt Lepeymnos. Volcanism continued in a very minor way in the east, near Mytilene, with the eruption of minor basalt and andesite lavas. All volcanism on Lesbos ceased 16 million years ago.

Minor faulting and subsidence of the land followed this period of volcanism and allowed sedimentary rocks to be deposited along the coast and around the gulfs of Kalloni and Geras. These movements may be a part of the overall Neogene stretching of the region.

Lesbos has many hot springs: most are rich in common salt and many debouche near or under the sea. The water in these springs is a mixture of rainwater and seawater. The most important spring issues from volcanic rocks about 1,500 m south-east of Polychnitos and feeds the Almiropotamos stream. It is the largest and hottest spring (87°C) on the island and one of the hottest in Europe. The composition of the dissolved minerals indicates that the water is not from the sea but is dominantly recycled rainwater. During its passage through the earth this water has dissolved calcite, which has been redeposited around the exit of the spring as travertine. Although this spring rises through volcanic rocks they are much too old to be the source of heat.

The town of Mytilene

Along the south-east coast of Lesbos there are a series of lowlands, underlain by Miocene lavas and tuffs, Pliocene freshwater limestones and Pleistocene sediments (Fig. 13.3). These rocks formed in a graben, isolated from the sea, whose eastern half has dropped down beneath sea-level in geologically recent time. The magmas that fed the volcanism rose up

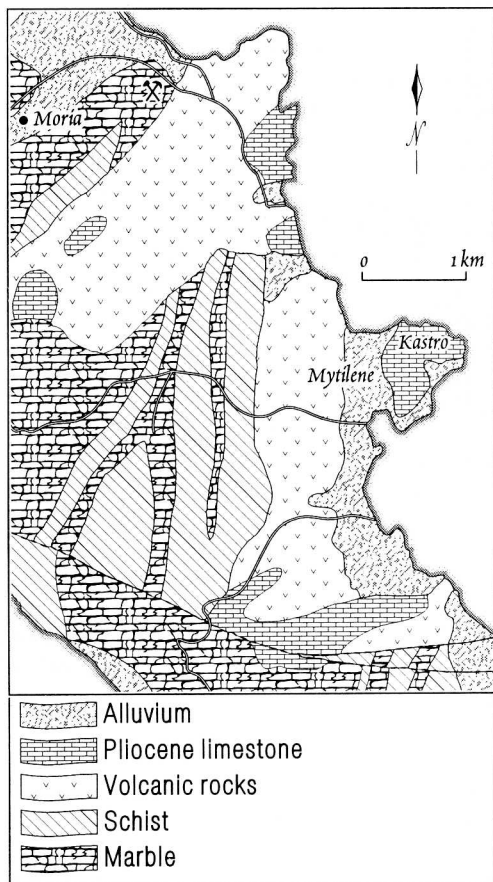


Fig. 13.3. Mytilene town, Lesbos.

from deeper chambers along the graben faults.

The town of Mytilene is built on one of these lowlands. The lowest part of the town is underlain by Pleistocene sediments and alluvium, but the low hills to the west are made of volcanic rocks. Behind rise the hills of Permian-Triassic marbles and schists that comprise the backbone of the peninsula. To the north-east of the town the peninsula of the Kastro is made of Pliocene freshwater limestone, isolated from the mainland by lowlands that conceal a north-south fault.

Marble was extracted from a large quarry near the coast, 1 km east of Moria and 3 km north of Mytilene (Fig. 13.3). This pale grey marble was formed by metamorphism of Triassic limestones. It was considered to be of lower

13. The Eastern Sporades and the Ionian Shore

quality than that extracted from quarries further north, near Thermis, which are still exploited. Volcanic cones also occur as small isolated hills around Pamfilla, 8 km to the north of Mytilene.

The ancient site of Thermi, 12 km north of Mytilene near (Loutra) Thermis, has been occupied from the Early Bronze Age, almost 5,000 years ago. The ancient attraction was the hot spring, which issues at 40°C. The saline nature of the water indicates that it is recycled seawater. The spring is associated with an important normal fault, running north-west/south-east, delineating a horst, which continues southward as the Mytilene Peninsula, and a graben to the north, now partly filled with volcanic rocks.

The 'petrified forest'

There are the remnants of a petrified forest in the far west of the island, mostly within 5 km of Sigri (Fig. 13.2). Over 200 fossilised sequoia trunks, together with roots and cones, and occasionally also palm trees, have been found at over 35 locations on land and underwater. The trunks, some of which are in their original growth positions, range up to 5 m long and 2.5 m in diameter. The Petrified Forest has been declared a Protected National Monument and the fossils should in no circumstances be removed. These trees were engulfed by ash from volcanic vents to the east about 18 million years ago. Rainwater circulating through the ash dissolved the finer particles and these dilute solutions then soaked into the tree trunks. The different chemical environment within the wood caused minute crystals of silica, pyrite and iron oxides to be deposited within the cells, replacing the wood and fossilising it.

Pergamon

Situated on the Turkish mainland some 30 km from the sea, the lofty site of Pergamon was for long too far inland to interest the Greeks, who seldom ventured far from the coasts (Fig. 13.1). It was, however, inhabited from about 700 BC by local Asiatics. It soon became part of the Persian Empire, to be conquered in 330 BC by

Alexander the Great. On his death the empire disintegrated: the fortress of Pergamon and its gold treasure passed to Philetairos who built a remarkable city, running down the hillside in a riot of Baroque town-planning. It was renowned, amongst other things, for a health-centre, the Asklepieion, in the lower ground south-west of the acropolis, where there were sacred springs. The Romans inherited the city in 133 BC and continued to beautify the city in the same flamboyant way. The Asklepieion was now reckoned the equal of Kos and Epidauros. Pergamon flourished for about a thousand years, but it had long been deserted when the Turks arrived in the fourteenth century AD and built their town Bergama, at the foot of the old acropolis.

The acropolis of Pergamon is situated on the northern edge of the Bakir valley (ancient Caicus), which stretches for 5 km to the south, and runs down to the sea at Dikili (Fig. 13.1). This valley is a graben, produced during Neogene north/south crustal stretching. A very large amount of volcanic rocks were produced

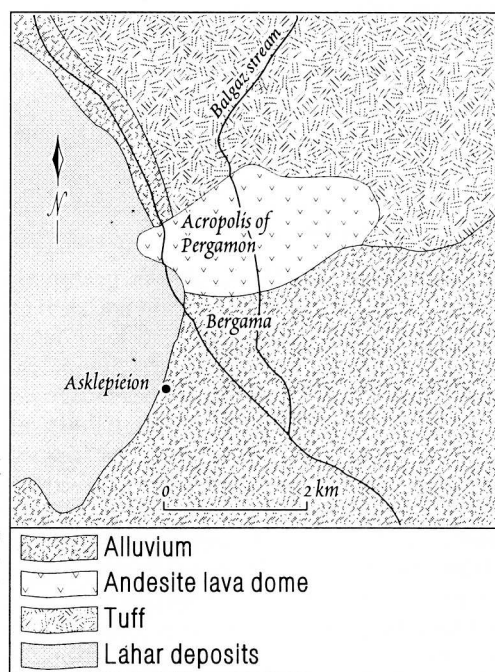


Fig. 13.4. Pergamon.

in Western Turkey at about the same time as the extension and were probably related to it. In this area these rocks are 18-16 million years old and they mostly consist of andesites and dacites. The hills to the north of Pergamon are made of such volcanic rocks. On the southern side of the graben the hills are also made of andesite with Permian limestones to the south-east and south-west.

The acropolis itself was constructed on a steep-sided hill that rises to about 450 m (Fig. 13.4). It is cut off to the south by the Bakir graben, and the east and west sides of the hill are defined by the valleys of the Selinus and Balgaz (ancient Cetius) streams, small tributaries that flow into the graben to join the Bakir river. Somewhat unusually for a classical site, the bedrock here is andesite, which contains phenocrysts of dark biotite and pale plagioclase up to 3 mm long. The acropolis hill is a lava dome, subsequently modified by erosion.^{4, 76} Similar domes occur along the graben towards Dikili. The magma probably rose up the graben faults. The hills on either side are made of volcanic ash and lahar (volcanic landslide) deposits.

The Asklepion is situated in the river valley below the acropolis. The springs are produced where the shallow water-table in the valley reaches the surface. The water originally fell on the surrounding hills.

Granite quarries

Although little used by the Greeks, granite (in the broad sense) was an important material for the Romans and was traded widely. There were two major sources of granite in the Aegean region: Marmo Misio (or Granito Bigio) from near Kozac, 15 km north-west of Bergama (Fig. 13.1) and Marmo Troadense (or Granito Violetto) from Mt Cigri, 10 km south-west of Ezine (Fig. 12.1).⁹⁹ Both rocks are grey, fine-grained and principally composed of quartz, feldspar and biotite. Marmo Misio is a true granite, but rather richer in quartz than most granites. Marmo Troadense is not quite a true granite as it has too much plagioclase feldspar in it, and it is more correctly termed a quartz-monzonite. Both intrusions are about the same

age as the volcanic rocks in the region, i.e. 18-16 million years old.

Chios

The large island of Chios lies close to the Turkish coast (Fig. 13.1). Its fertile plains are sheltered by a mountain range running from north to south which culminates in Mt Peli-naion. It produces the tree resin mastic (a Chian specialty); fruit, especially figs; and wine, for which it was famous in antiquity.

Chios has a long history, starting in the Neolithic (about 6000 BC). Mycenaean Greeks arrived here around 1400 and stayed until 1100 BC, when their settlements were destroyed. Then, shortly after 1000 BC, Ionian Greeks from Euboea settled at several places on the island and made their capital on the site of the present Chios town. The seventh and sixth centuries BC were the great days for Chios. Her citizens were famous as sculptors, bronze-workers and potters; even Homer was believed by some to have been a Chian. Thanks to their fertile soil, their mercantile skills and their productive marble quarries the Chians grew rich in Roman and Byzantine times. The once glorious monastery of Nea Moni is witness to their prosperity in the eleventh century AD. Then came Venetians, Genoese and Turks. The latter perpetrated a ghastly massacre in 1822, from which Chios never recovered, and a terrible earthquake in 1881 made a bad situation even worse.

Chios is geologically and geomorphologically an extension of the Aegean coast of Turkey, linked by a channel 8 km wide and only 75 m deep (Fig. 13.1). In all other directions the sea-floor slopes off gently, descending eventually to 800 m in a broad basin between Chios and the Cyclades, and to 1,000 m north of Ikaria.

The oldest rocks are Palaeozoic flysch sediments, predominantly sandstones and shales, and volcanic rocks, that crop out in the north-western part of the island and to the north of Chios town (Fig. 13.5).^{29, 197} Magmatic rocks of the same age are widespread in the Karakaya belt of north-west Turkey.²⁰⁸ The central part of the island, including the highest point Mt Peli-

13. The Eastern Sporades and the Ionian Shore

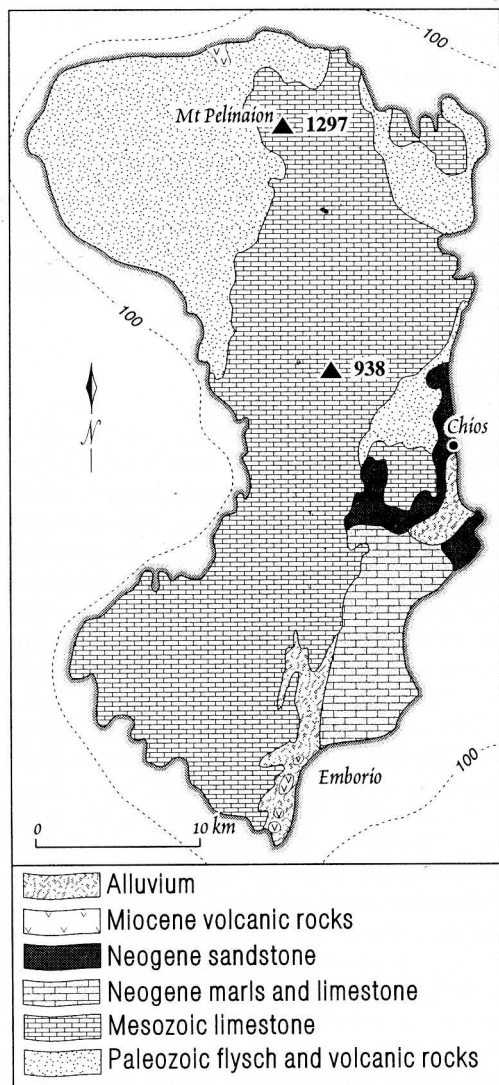


Fig. 13.5. Chios.

naion (1297 m), is made of Triassic and Jurassic limestones. Sedimentary rocks now exposed in the south-east part of the island were deposited in a graben from rivers and shallow lakes during the Miocene and Pliocene. Sandstones are more common in the north, around Chios town, but to the south marls and limestones predominate. These Neogene sediments, especially the marls, yield fertile soils.

Minor, but widespread, volcanism occurred on Chios 17-14 million years ago.²¹⁰ Tuffs were deposited in the Neogene sedimentary rocks south of Chios town. Near the southern tip of the island magma reached the surface quietly along the graben faults and formed a series of four plugs, domes and flows. The outcrop north of Emborio, Profitis Elias, is a rhyolite plug whereas that to the south is made of a series of columnar-jointed andesite flows.²¹⁰ There is also a small rhyolite dome on the north coast and many other smaller domes, flows and tuffs elsewhere on the island.

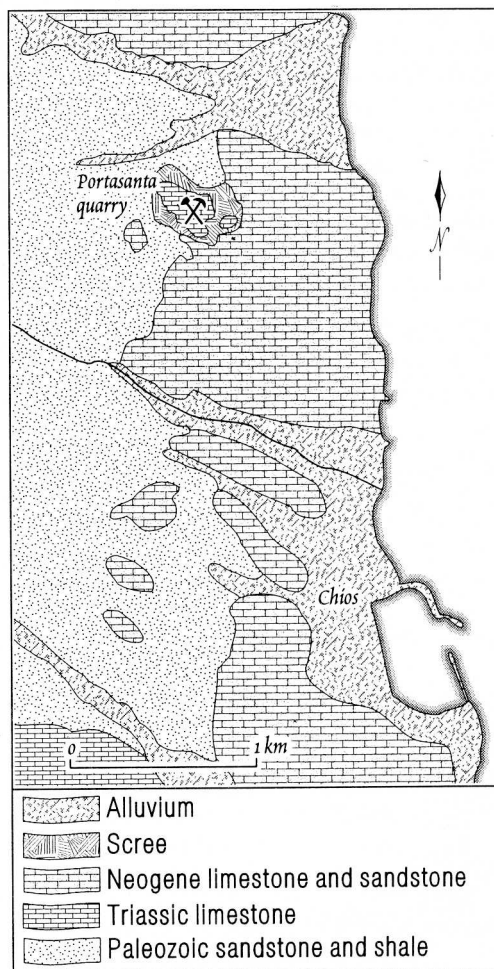


Fig. 13.6. Chios town.

Portasanta quarries

Chios also produced a salmon-pink marble known to the Romans as *Marmo Chium* and to the Italians as *Portasanta* from its use on church doors in Rome. It was particularly popular in Rome from the time of Augustus (late first century BC) to the fourth century, and was used for columns, wall panels and floor-decorations. It became popular again in the sixteenth century in the form of re-used stones from Roman buildings.

The *Portasanta* quarries are 2 km north of Chios town (Fig. 13.6). The rock is a recrystallised limestone, half-way to becoming a marble. It is commonly a breccia; mostly salmon-pink, with red and white inclusions, but the base is occasionally cream or grey. The pink colours reflect the abundance of iron, particularly haematite, in the rock. This block of rock is Triassic in age and similar to that of the hills to the north-west. It is probably part of a sheet of rock thrust over the surrounding Palaeozoic and Neogene sediments.

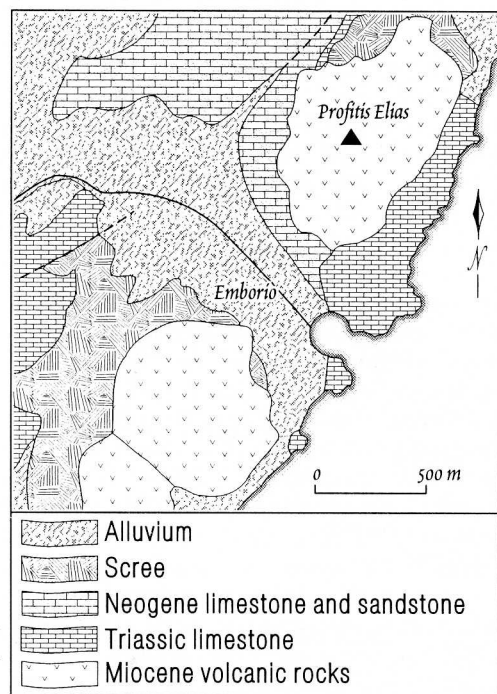


Fig. 13.7. Emborio, Chios.

Emborio

The village of Emborio lies on alluvial plains between two volcanic domes, both of Miocene age (Fig. 13.7). Along the coast there is a strip of Triassic limestones, which forms the headlands on either side of the bay, and has protected the volcanic rocks from erosion by the sea. The ancient settlement on Mt Profitis Elias, north of the village, was built on the rhyolite plug of Miocene age.

Izmir

The city of Izmir (formerly Smyrna) lies at the eastern end of the 24 km long Gulf of Izmir, near the mouth of the river Gediz (ancient Hermus; Figs. 13.1, 13.8). Spacious, sheltered and accessible, this has always been one of the best ports in the Mediterranean. In addition to possessing a very fertile soil, from earliest times Izmir has been the centre of export of the products, agricultural and mineral, of the interior, via the valley of the Gediz river.

The earliest settlement, dated at about 3000 BC, was on the low hill of Tepekula, near Bayrakli, about 5 km north of the present centre of Izmir. The acropolis was on a hill about 2 km to the north-west. The first Greeks arrived about 1000 BC, and the city rose in prominence until destroyed by the Lydians in 627 BC. About 330 BC it was refounded by Alexander the Great on the slopes of Mt Kadifekale (ancient Mt Pagus) and soon grew very rich as a mercantile and artistic centre. In AD 178 it was completely destroyed by an earthquake, but was soon rebuilt. In the seventh century AD Arab raids devastated the city, which was already impoverished by the silting up of the harbour; and in the fourteenth century, when the Knights of Rhodes came here to build a castle, they found it a ruin. Captured shortly afterwards by the Turks, it became a trading centre for European merchants in the seventeenth century. The old city was burnt down during the hostilities in 1922, and has been completely rebuilt.

Izmir lies at the head of a convoluted bay, part of the rather untidy Gediz river graben, which penetrates eastwards deep into the con-

13. The Eastern Sporades and the Ionian Shore

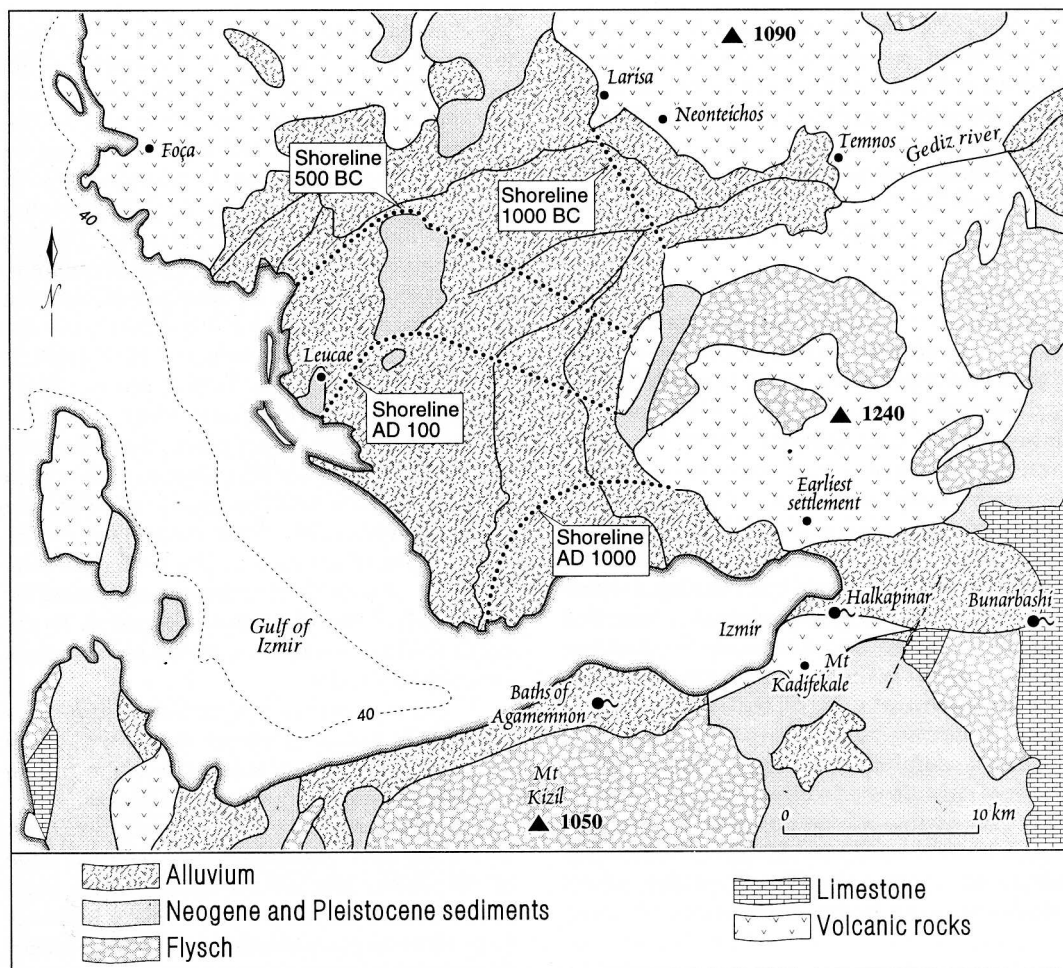


Fig. 13.8. The Gulf of Izmir (after 3, 139 and other sources).

continent (Figs. 13.1, 13.8). To the north of the city the hills are dominated by Miocene andesite lavas and tuffs. The hills to the south-east and south-west (Mt Kizil) are made of Cretaceous limestone and flysch respectively.

Both the earlier acropolis, north of the present city centre, and the later city, on Mt Kadifekale ('Velvet castle') were constructed on hills of andesite lavas, breccias and tuffs.^{122, 139} To the south of the city the volcanic rocks were covered by younger marls. Until recently andesite lava was extensively quarried for construction, both in Izmir and on the north side of the valley.¹³⁹ However, now Tertiary lime-

stones are used as aggregate in the concrete that has taken its place.

The Gediz is a major perennial river that drains a large area and transports 3-6 million tonnes of sediment each year, most of which is deposited in Izmir Bay.³ At the end of the last glacial period sea-level rose rapidly and the coastline retreated inland, covering at its maximum the whole of the current Gediz delta (Fig. 13.8). However, soon the deposition of sediments transported by the river began to fill in the bay and force the coastline back out. The ancient former ports of Temnos, Neonteichos and Larisa were isolated from the sea by 1000

BC. By 350 BC the island on which the port of Leucaea stood was transformed into a headland. The delta front continued to advance southwards, threatening to cut off the port of Izmir. In AD 1886 the Gediz river was diverted into the northernmost channel, almost completely cutting off flow in the southern branches, and the advance of the delta southwards was stopped.

The coastline at the far eastern end of the Gulf of Izmir has also advanced since ancient times. A number of small streams have transported sediment from the surrounding hills and dumped it into the bay. The advance is quite modest, a maximum of about 1 km, but sufficient to have turned the ancient site of Tepekule from a peninsula into a low hill.

A cool perennial spring, Halkapinar ('Diana's Bath') wells up near the present city centre, in the grounds of the municipal water company. This spring feeds a short stream that may be the river Meles of antiquity. Another important cool spring issues 10 km east of the city at Bunarbashi, fed by water that falls on the surrounding hills.³⁷

Warm, sulphurous springs known as the Baths of Agamemnon well up 10 km west of the city. The springs range up to 54°C and were well known in antiquity. However, nothing of any great age remains. These springs are related to the deep faults of the graben.

Sardis

The ancient city of Sardis (near the modern village of Sart) was built on the southern edge of the fertile plain of the Gediz river (ancient Hermus), 94 km east of Izmir. Here the Sart torrent (ancient Pactolus), rising on the Mt Boz range (ancient Tmolus) to the south, flows through the centre of Sardis on its way to join the Gediz river.

The site was inhabited continuously from at least 3000 BC, but is not known to history until about 700 BC, when it was the capital of Lydia, a kingdom situated inland from the Ionian coast. For some 250 years Sardis flourished, thanks chiefly to the plentiful gold and silver obtained from the Pactolus river. Herodotus relates that the precious metal was trapped on

sheepskins suspended in the river, a technique which gave rise no doubt to the legend of the Golden Fleece. Under such kings as Gyges and Croesus the Lydians were renowned as the inventors of coinage (about 600 BC), and as bankers, traders, horsemen and musicians. In 545 BC Sardis was taken by the Persians, following ambiguous advice from the Delphic oracle, and subsequently ruled from Pergamon and Rome. In AD 14 it was rebuilt after a terrible earthquake, and flourished until destroyed by the Sassanians in AD 616. Rebuilt, it was finally destroyed by Tamerlane in 1401.

The valley of the Gediz river, north of Sardis, is a major geographical feature of the region. It follows an east/west graben which penetrates deep into the continent, bisecting the Menderes massif in this region (see above). The Mt Boz range rises to the south reaching 2,159 m and is dominated by metamorphic rocks such as marble, schist and gneiss. To the north the hills are made of gneiss and Neogene sedimentary rocks.

The Gediz graben originated during early Neogene regional extension in a north/south direction. The earliest sediments in the graben are sandstones, conglomerates and freshwater limestones formed by the river and in lakes. These are most commonly seen near the edge of the graben, and around Sardis form a band about 3 km wide, south of the main highway (Fig. 13.9). In places large boulders, or patches of more resistant rock have protected the underlying conglomerates, giving steep-sided, conical hills, such as those that underlie the acropolis and necropolis. Part of the valley of the Sart torrent, between the two hills, follows a north/south fault, which has weakened the rock and allowed more rapid erosion.

The ancient city of Sardis covered the northern slopes of the acropolis hill and was built on alluvium and old landslide deposits. The imposing acropolis hill is made of weakly cemented conglomerates and sandstones. In antiquity at least 130 m of tunnels were excavated in the upper parts of the acropolis hill. They appear to have been excavated from below, near the base of the hill, and may have been constructed to augment the water supply of the city. Elsewhere on the site the water-

13. The Eastern Sporades and the Ionian Shore

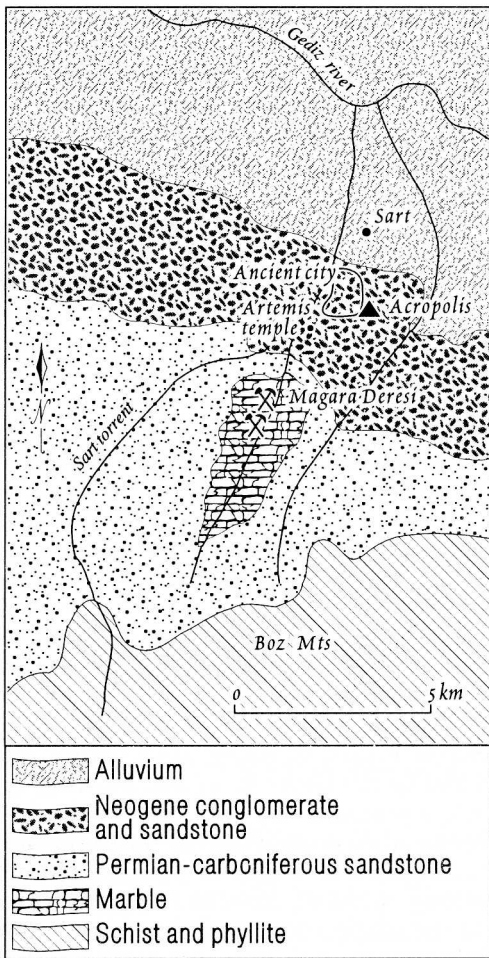


Fig. 13.9. Sardis.

table is low, necessitating the construction of wells up to 20 m deep.

The city was constructed of local Neogene sandstone and limestone, and a pale-grey to white coarse-grained marble. The latter was extracted from quarries at Magara Deresi, 4 km south of the city, on either side of a torrent flowing north into the Pactolus.¹⁸¹ These outcrops of marble are part of the Menderes massif to the south, and protrude through the overlying younger sediments. This lower level of erosion is due to the presence of weakened rock adjacent to a north/south fault, which continues northwards in the lower part of the Pactolus valley.

After it was abandoned the city was buried, commonly to a depth of 10 m, by sediments transported by the Sart torrent, and by landslides from the acropolis hill. Landslides are common here due a combination of weak, porous rocks, heavy winter rainfall and frequent earthquakes.

Ancient gold and silver deposits

At its zenith the wealth of Sardis was due to the placer gold deposits of the Pactolus river. The gold of these deposits started out in the metamorphic rocks of the Menderes massif to the south. During metamorphism high temperature water dissolved a number of elements from the rocks through which they passed, including gold. As the fluids ascended and cooled these elements were precipitated as new minerals in veins. One type of vein is dominated by quartz, but can contain small amounts of gold, in the form of the metal. Such veins are quite common, but only rarely attain sufficient size and richness for a mine.

The gold of the Pactolus was concentrated from the metamorphic rocks and their primary deposits by two cycles of weathering and erosion.²⁶² Initially the metamorphic rocks were broken down by weathering, liberating the gold particles. These sediments, including the gold, were transported by rivers and deposited in the Gediz graben. Gold is heavier and more resistant to weathering than the other minerals, and hence is concentrated by the action of the rivers. Subsequently these sediments were cemented to form the Neogene conglomerates and sandstones, such as those seen on the acropolis hill. These rocks were in turn weathered and the gold further concentrated in placer deposits in the river gravels of the Pactolus torrent.

In all probability all the rivers in this area provided small amounts of placer gold, but the Pactolus was richer than the others because the concentration process was repeated twice. The very nature of placer deposits makes it impossible to determine exactly where the gold came from after extraction. Even in antiquity placer gold mining was extremely easy and the Pactolus was exhausted by Strabo's time (first

century BC to first century AD).

The metal extracted from the rivers of this region always contains a proportion of silver, making the natural alloy called electrum. Initially, coinage was made directly from this alloy, but the variation in silver content from 36 to 53%, some of which was undoubtedly natural, may have shaken public confidence in the currency. Hence, during the reign of Croesus the metals were separated to produce pure gold and silver coins. Silver was also produced, together with lead, in the Balya mine, Balıkesir region.¹⁰⁸

Teos

Teos was a Greek city, whose ruins are situated 40 km south-west of Izmir, and 2 km south of the village of Sigacık (Fig. 13.1). It was settled by Ionians about 1000 BC. Thanks to its two good harbours it did well and founded colonies of its own. In 133 BC Teos fell to the rising power of Rome and almost passed out of history, but not entirely, as it supplied the Roman market with a desirable coloured marble.

This marble is a breccia with a dark, fine-grained matrix and inclusions of pink, yellow, blue-grey and white marble. It was known to the Romans as *Marmo Luculleum*; to the Italians it is *Marmo Africano*, apparently because the matrix is dark like the skin of an African. It was much used in Roman architecture in the first and second centuries AD, especially in Italy and North Africa. Its subsequent use in the churches and palaces of Rome consists of the recycling of Classical Roman material. The quarries are east of Sigacık, on the road to Seferihissar. The most important, which was worked out before AD 200, is now a lake known as Kara Gol. An unbrecciated, blue-grey marble is part of the same unit, and was also quarried in Roman times for decorating buildings. These marbles are a small block of the Menderes massif that protrudes through flysch and Neogene sedimentary rocks.

Ephesus

The city of Ephesus was founded about 1000 BC by Ionian Greeks, probably from Athens, at the

mouth of the Cayster river (now Küçük Menderes: Fig. 13.1). On the northern slopes of Mt Pion (now Mt Panayır) they found Carians and other native people living round a sanctuary of the Asiatic nature-goddess Cybele. They came to an arrangement with these people and established a joint city which was to last for over 400 years. They became very rich, thanks to their harbour at the mouth of the Cayster, which provided easy passage to the interior, to their Sanctuary of Artemis, and to the fertile flood-plain of the river. In 334 BC the city was conquered by Alexander the Great. Forty years later, badly affected by silting, the city was moved again to the spot where the ruins now stand, between Mt Panayır and Mt Bulbul (ancient Mt Koresos). Here it flourished for many centuries until replaced about AD 1000 by the town of Selçuk (formerly Ayasoluk).

The Temple of Artemis (Artemesion) was rebuilt many times over a period of 1,400 years and the last version, the largest in the Greek world, was numbered among the Seven Wonders of the Ancient World. It was the first monumental building to be constructed entirely of marble. It lasted intact until it was sacked by the Goths in AD 263. Partially rebuilt, it continued until the end of the fourth century when it was closed by the Christians. The marble was re-used to a large extent for building churches, and the remaining ruins were gradually covered by the silt of the Küçük Menderes river.

The wealth of the ancient city of Ephesus was controlled by the geography of its situation: at the head of a fertile valley that penetrates deep into the hinterland and on a deep bay that provided a good harbour (Fig. 13.1). The position and orientation of this valley, together with valleys to the north (see Pergamon and Izmir) and south (see Priene and Miletus) were controlled by the tectonics of the area during the last 20 million years. The deep bays, once so common on this coast, were related to the rapid rise of sea-level following the last glaciation. The loss of this bay, which figures so prominently in the demise of this city, was merely the correction of a temporary situation following the rise in sea-level.

The geography in antiquity was rather dif-

13. The Eastern Sporades and the Ionian Shore

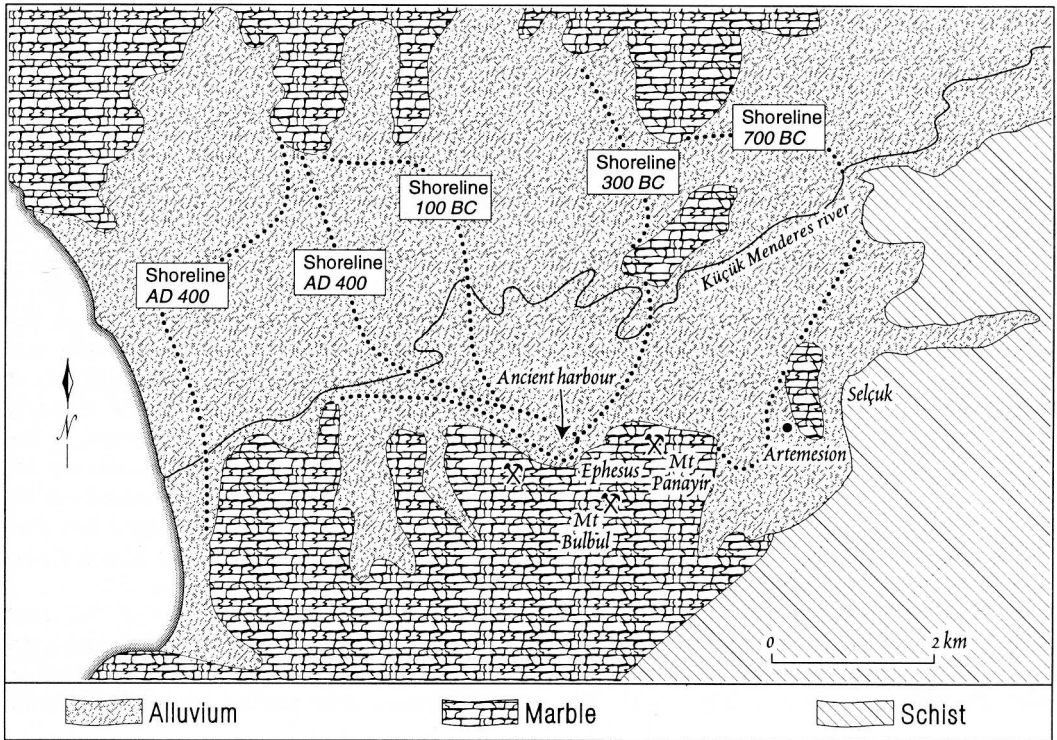


Fig. 13.10. Lower Küçük Menderes valley and Ephesus (after 152 and other sources).

ferent from that today (Fig. 13.10).¹⁵² During Hellenistic times the coast was about 10 km inland from its present position. The sea lapped up close to the Temple of Artemis, and Ephesus was constructed on a promontory of the south shore of the bay. The deep bay would have provided a safe harbour. By early Roman times the shoreline had advanced until it was opposite the city and started to engulf the harbour. Despite the efforts made to keep the harbour open by dredging, the shoreline advanced so rapidly that by late Roman times the harbour was lost and with it the prosperity of the city.

The effects of the advancing coastline are evident in the history of the Artemision. The first major temple was constructed in 550 BC above the flood level of the river. By 356 BC the level of the land, and also the water-table, had risen so much that the new temple had to be constructed on foundations three metres higher than those of the earlier temple. Now

even the foundations of this temple are often underwater.

The bedrock of this region is made of metamorphosed sedimentary rocks of the Menderes massif. The oldest rocks are schists and gneisses but marbles become more important in the upper parts of the series and eventually completely dominate. The steep slopes around Ephesus are made of this marble, which is at least 200 m thick. The marble of lower parts of the unit occurs in thick beds, and was extensively exploited in antiquity.

Ancient quarries can be seen on the northern and eastern slopes of Mt Panayır and on the slopes above the ancient harbour and channel (Fig. 13.10).²⁷⁵ Higher quality marble (paler and more uniform) for the great Temple of Artemis was quarried at Belevi, 15 km to the north-east. The column drums were shaped on site and rolled to Ephesus by inserting pivots in the ends, an unusual technique devised by the architect Chersiphron. Other blocks were

transported by water, as the estuary extended up to here in ancient times.⁷ In addition marble from Aliki on Thasos was used in the fourth century.

One of the cult images of the Artemesion may have been a meteorite, as St Paul, in the Acts of the Apostles, states that it fell from Jupiter. However, he may have been confusing it with a meteorite cult-image of Cybele at Pessinus, 400 km to the north-east. Cybele, the Anatolian mother goddess, was closely associated with and assimilated into Artemis. The attribution of the origin to Jupiter is fortuitously correct, as we now know that most meteorites come from the asteroid belt between the orbits of Mars and Jupiter.

Ikaria

The island of Ikaria is a horst between under-water grabens that are part of a system of faults that runs from the Küçük Menderes graben (see Ephesus) to Melos and originated about 10 million years ago (Fig. 13.1). The

eastern part of the island is made of gneisses and schists with minor marbles along the southern coast (Fig. 13.11). The western part of the island is almost entirely composed of Miocene granite.¹¹¹ Hot springs (33-58°C) on the south coast are produced by circulation of water deep into the crust along the horst faults.

Samos

The island of Samos is only 3 km from the Turkish coast, to which it is geologically and geographically related (Figs. 13.1, 13.12). A range of mountains, rising to a height of nearly 1,500 m, runs east to west, and continues the line of the Mt Samsun peninsula (ancient Mt Mykale) in western Turkey. Throughout its history this beautiful, fertile island has produced timber, olive oil and wine. Today it also grows oranges and tobacco.

In antiquity Samos was one of the most famous of all the Greek islands. Carians arrived in about 3000 BC and were followed by Mycenaeans, who settled in small numbers

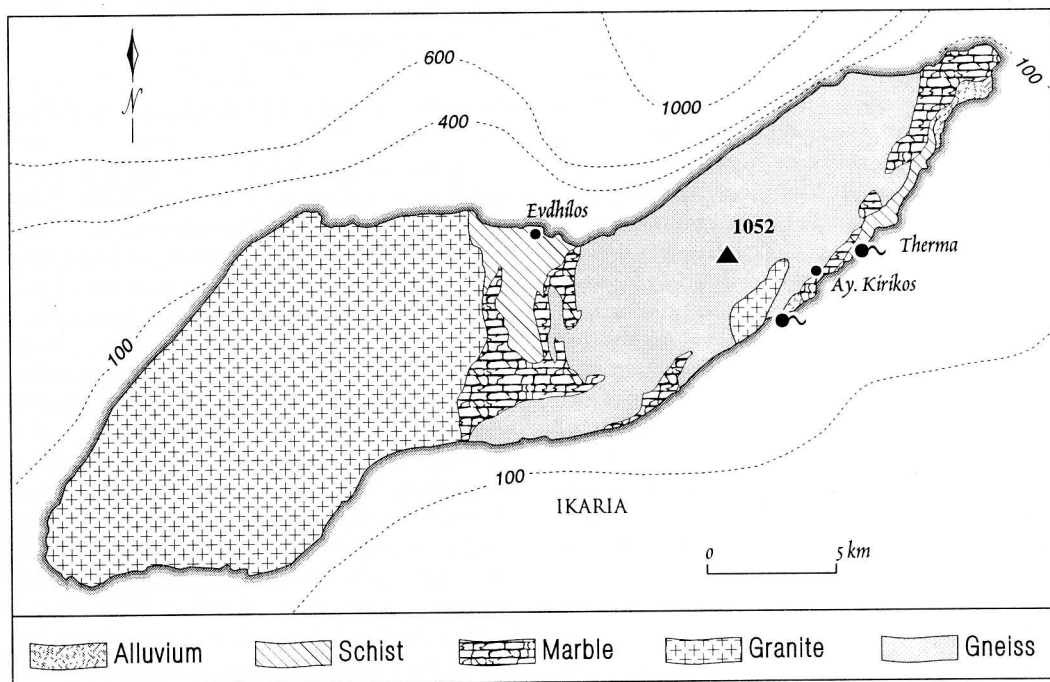


Fig. 13.11. Ikaria.

13. The Eastern Sporades and the Ionian Shore

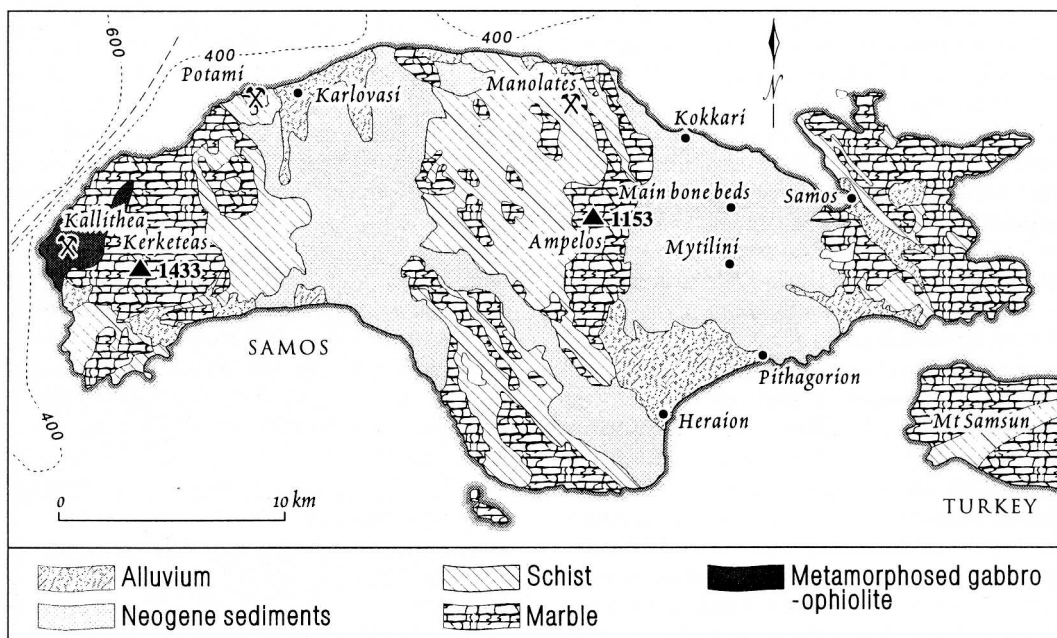


Fig. 13.12. Samos.

about 1400 BC. The first proper settlement by Greeks was about 1000 BC, when a body of Ionians arrived from Athens. They made their capital, also known as Samos, on the south-east coast, near modern Pythagorion. They prospered, thanks to the fertile soil, the excellent harbour, and their seamanship. They were also famous for their artists, who pioneered in Greece bronze-casting techniques learned in Egypt. In 538 BC Polycrates made himself ruler and established a brilliant court round him. Herodotus attributes to him the three greatest works of engineering in the Greek world: a 1,000 m long tunnel through the mountain; a 480 m long harbour mole at Pithagorion sunk up to 40 m into the water and the large Temple of Hera. Polycrates' rule, and Samos' greatness, were terminated by the Persian invasion of 522 BC.

Samos lies on a shallow plateau extending from the Mt Samsun peninsula (Fig. 13.1). The channel is less than 100 m deep, and the island was connected to the mainland during the Pliocene and much of the Pleistocene. The high cliffs and steep slopes of much of the north

coast of the island continue offshore where the sea-floor drops off rapidly. This area is probably an extension of the Küçük Menderes graben on the mainland (see Ephesus above). To the south the sea is relatively shallow, but similarly, it is probably an extension of the broad Büyük Menderes graben on the mainland (see Priene below). Hence the island of Samos is a horst, like Ikaria to the west.

The basement of the island of Samos is made of metamorphic rocks of the Attic-Cycladic metamorphic belt, or possibly the Menderes massif, which stick up through the younger rocks as three high massifs, in the west, centre and east of the island (Fig. 13.12). The basement has been divided into four nappes, piled on top of each other during the Alpine compressions. Marbles, schists and phyllites dominate, except for one nappe of metamorphosed basaltic volcanic rocks. Many of these rocks have been metamorphosed at high pressures to produce blueschists, but sometimes these have been converted to the lower pressure greenschists.¹⁸⁹ Both types of rock, easily distinguished by their colours, can sometimes

be seen in a single block of rock. Finally a thin nappe of unmetamorphosed Triassic-Jurassic ophiolites and limestones, exposed around Kallithea, was thrust over the metamorphic rocks. During the Late Miocene to Pliocene periods erosion and faulting produced two basins that were filled with lake and river sediments, including limestones and clays as well as volcanic ash. These rocks were folded and lifted up towards the end of the Neogene.

Between Mytilini and Kokkari, in eastern Samos, a rich collection of well-preserved fossil mammal bones has been found in limestones and marls deposited in lakes during the Late Miocene (8.5 to 7 million years ago).²⁸⁶ The fauna includes lions, mastodons, monkeys, rhinoceroses, early gazelles and an ancestral giraffe unique to Samos called a *Samotherium*. At that time Samos was connected to the mainland, and the animals migrated over a land-bridge. The animals lived around the lakes and their bones were washed there after death, to be preserved in the lake sediments. There is a collection of these fossils in the museum at Mytilini.

As usual the marbles are much more resistant to erosion than the other rocks and form the high peaks of Kerketeas and Ampelos, and the hills east of Samos town. These peaks are almost barren as marble does not produce good soil. Erosion of the schists has produced the lower hills and better soils. But the lowest topography and most fertile soils are in the areas of Neogene sediments.

Samos town

Samos town lies at the head of a deep inlet, Varthi Bay (Fig. 13.12). This bay is a small graben that continues inland almost across the island. To the north and south of Samos town are marbles and schists, but the south shore of the bay is made of Neogene sedimentary rocks.

Pithagorion and ancient Samos

North-west of the modern town of Pithagorion lies the acropolis of ancient Samos, which was built on a low hill of beige, moderately hard, Miocene limestones (Fig. 13.13). The valley to

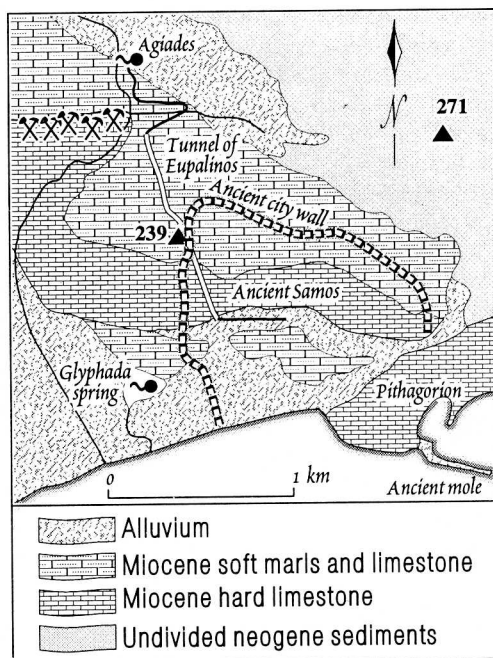


Fig. 13.13. Pithagorion and ancient Samos.

the north is underlain by Miocene marls and soft limestones, which have been eroded more deeply. The walls of the city, and many of the buildings, were constructed of the harder limestone, mostly from cave-like quarries on the south-east side of Agiades hill, 1,000 m to the north-west.²⁸³ Two types of limestone were extracted here: a porous, bitumen-bearing limestone that was easy to cut, and a silica-rich hard limestone that was more resistant to erosion.

The famous Tunnel of Eupalinos was cut through this hill of Miocene limestone and marl, to a valley behind the acropolis. What makes this achievement even more impressive is that it was excavated from both ends, the two operations meeting near the middle. Much of the tunnel is unreinforced, but faulting and cave formation led to the creation of weak breccias, so that parts of the tunnel were lined with masonry. Recent removal of an ancient rock-fall, and metal reinforcement of the roof have now made it possible to go right through the tunnel.

13. *The Eastern Sporades and the Ionian Shore*

The tunnel has two levels; an upper one for the movement of people, and a lower level for water. A spring near the chapels of Agiades (opposite the hill of the same name) fed a reservoir, and was then conducted via clay pipes in a narrow trench and tunnel along the contours to the entrance of the tunnel, 850 m away. Some water was also tapped within the tunnel, and these percolating waters have now formed stalagmites and flowstone up to 15 cm thick. At the other end of the tunnel, the water left the hill downhill from the main entrance, and was conducted to the east by clay pipes.

At the base of the hill there are two lagoons, fed by springs of water that fell on the acropolis hill and was forced to the surface by the high water-table of the alluvial plain.

The remains of the ancient harbour mole lie just south of the present breakwater in 3-4 m of water. Most of this submergence is due to erosion, but the level of some surviving harbour installations indicates that the level of the land has sunk about by about 50 cm during the last 2,500 years.¹⁸³

The Heraion

This place, located on one of the few coastal plains on Samos, was sacred for the Mycenaean from 1400 BC, and when the Ionians arrived in about 1000 BC they continued the tradition by the worship of Hera.

The first temple was constructed between 575 and 560 BC and was made of a mixture of local Neogene sedimentary rocks, some of which were very poorly cemented and readily eroded. It is not clear why construction stopped so suddenly, but it may have been when the builders realised the unsuitability of the rock or it may have followed an earthquake that partly destroyed the building and caused the land to sink – the area is now swampy and there is evidence at Pithagorion of subsidence of about 50 cm.¹⁸³

A new temple was started in 530 BC, at a level 1-5 m higher than the earlier temple. It was one of the largest in the Greek world, and was built in the Ionic style. It used columns and facings of more durable local streaky-white marble. This marble, and other construction

materials, were extracted from quarries at Poundes near Kallithea, Manolates and Potami (Fig. 13.12), and on the island of Phourni 5 km south-west of Samos (Fig. 13.1). The temple was never finished but lasted until AD 262, when it was badly damaged by an earthquake. It was subsequently sacked by the Goths and has now practically vanished from sight, except for one surviving column.

Priene

The Ionian Greek city of Priene was founded about 1000 BC, probably from Athens, somewhat to the east of the ruins which we see today. The exact site is lost, but it must have been on or near the mouth at the time of the river Meander (now Büyük Menderes). About 350 BC, thanks probably to the silting up of the river mouth, the city was moved to its present location on the south slope of Mt Samsun (ancient Mt Mykale), looking southwards over the former Latmian Gulf to the ancient city of Miletus. The constant silting of the river mouth has pushed the sea back some 30 km, and the Latmian Gulf is now the delta of the Büyük Menderes river.

Although on a steep slope, the new city was built on the gridiron plan associated with Hippodamus of Miletus. Priene proves one of the best examples of a small Greek city of some 5,000 inhabitants, with all the usual amenities. Alexander the Great freed Priene from the Persian yoke in 334 BC and paid for the completion of the Temple of Athena. Priene passed to the Romans in 133 BC who neglected it and it gradually sank into obscurity.

The bedrock geology of Priene is very similar to that of Ephesus; both lie in the belt of marbles that forms the outermost part of the Menderes massif (Fig. 13.14). These rocks crop out in the cliff behind the site and in the ancient streets, but they are most clearly seen in columns and building blocks. The original rock was a rather heterogeneous limestone with layers of purer material and breccias. Such breccias are common in limestones and form when caves collapse. Metamorphism, probably during the Alpine event, converted the limestone to a marble, closed up the holes in the

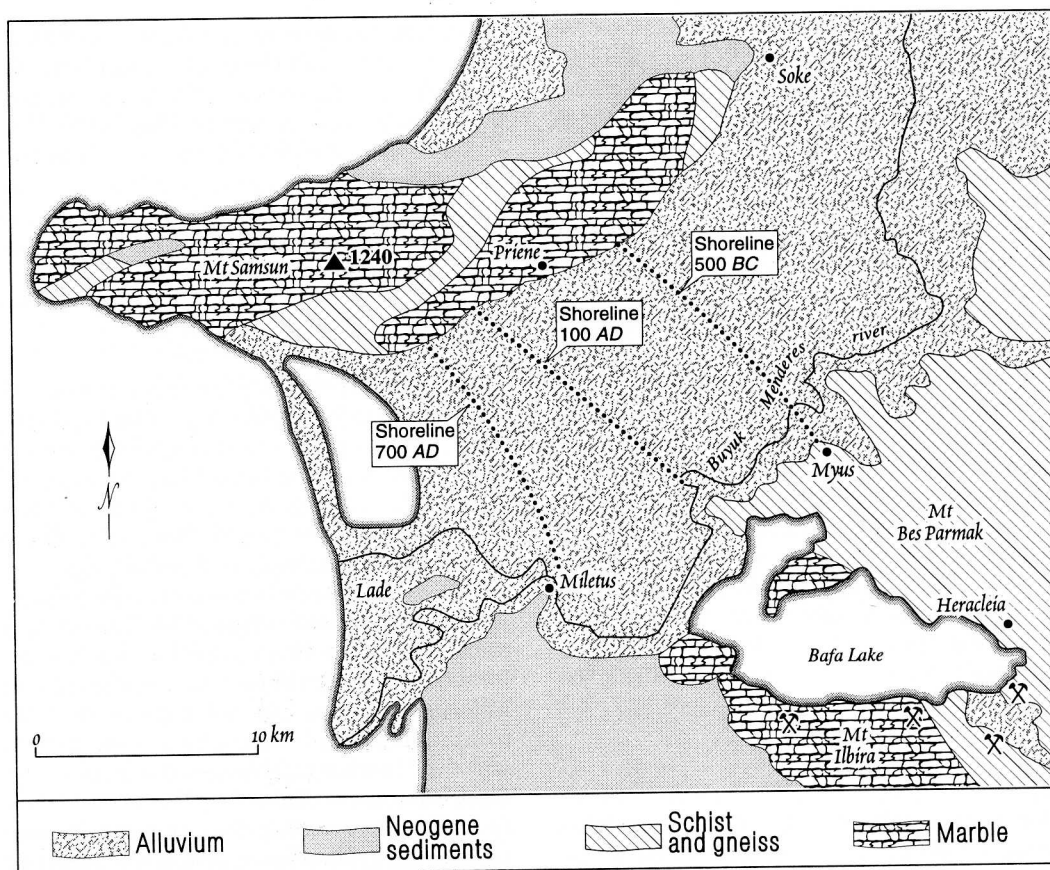


Fig. 13.14. The lower Büyük Menderes valley, Priene and Miletus (after 152 and other sources).

rocks and deformed the rock. Original structures in the limestone were not eliminated, but remain as colour differences, and the original blocks of the breccias can be seen clearly. The various shades of grey in the marble are due to variable amounts of graphite. The marble used to construct the city was obtained from quarries nearby.¹⁸¹ Metamorphism also produced a number of silver deposits in the hills 10 to 20 km north-east of Priene, some of which may have been exploited in ancient times.⁵⁵

Priene lies on the northern slopes of the valley of the Büyük Menderes river (ancient Meander). The river formerly wound its way across a broad valley and has given its name to this feature in other rivers. It has now been canalized in its lower reaches. This valley, like

that of the Küçük Menderes to the north (see Ephesus above), is a graben formed by tectonic stretching of the crust during the last 20 million years. It penetrates about 250 km eastward into the continent and brings down huge quantities of sediments. The northern fault of the graben passes close to Priene, and continual movement on this fault to this day maintains the steep relief against the levelling effects of erosion.

Rising sea-levels associated with the melting of ice at the end of the last glacial period caused the sea to penetrate deep into the continent, perhaps reaching the position of Magnesia, 12 km north-west of Söke (Figs. 13.1, 13.14). In Hellenistic times the coastline was about 35 km inland from its present posi-

13. The Eastern Sporades and the Ionian Shore

tion and Priene stood on a broad bay that stretched to Miletus, 15 km to the south.¹⁵² Since then the coast has advanced at an average of about 15 m each year, isolating Priene from the sea in late Roman times.

Miletus

Miletus was founded by Minoans from Milatos in east Crete in around 1700 BC on what was then the southern shore of the Latmian Gulf (Fig. 13.14). Originally bounded by the sea on three sides, it is now completely landlocked as a result of the silting up of the mouth of the Meander, and is a sad, desolate site. The Mycenaean arrived in about 1400 BC and were followed 400 years later by Ionian Greeks, who made it the largest and the most important of their cities of the Turkish coast. Destroyed by the Persians in 500 BC, the city was rebuilt soon afterwards by Hippodamus on the grid plan to which he gave his name; but it never regained its former stature. Nevertheless, in Hellenistic and Roman times it was again rich. But early in Byzantine times, from the eighth century AD, the silting up of the harbour and Arab raids greatly weakened the city. After many changes it was finally deserted in the fifteenth century.

Miletus lies on the southern side of the Büyük Menderes valley, opposite Priene, at the foot of low hills that make up the Milet sedimentary basin (Fig. 13.14). This block of crust was part of the ancestral Büyük Menderes graben, when the southern fault passed south of Didyma. In Miocene times limestones were deposited in shallow lakes, followed by a series of marls, sandstones and conglomerates.²⁴³ The youngest rocks are again freshwater limestones, the Milet limestone, deposited during the Early Pliocene. Next, the graben fault jumped to the northern side of this block, just to the north of Miletus. Simultaneous uplift and tilting of the basin formed a plateau rising up to 300 m in the north. Pleistocene erosion isolated blocks of the Milet limestone, and earthquakes triggered landslides. Blocks of limestone up to 2 km long slid up to 2 km into the valleys. Quaternary sea-level rises turned this region into a peninsula, with Miletus on a broad bay.

The limestones are more resistant to erosion and tend to form hills. They are also much more permeable than the underlying marls, hence water that falls on the limestone tends to appear along the base of the hills as springs. These springs partly controlled the location of the ancient settlements of Miletus and Didyma.

The city of Miletus was built on two low limestone hills and a spur of land jutting out from the hills to the south and east (Fig. 13.15). On the skyline to the north the highest part of the Milet basin is visible as a plateau at 300 m. In antiquity the flat alluvial plains to the north would have been a broad estuary. There has been little change in sea-level since antiquity here; the change in geography is entirely due to deposition of sediments by the river.

The city was constructed from a variety of different rocks. The local limestone was used, but for the most part it is too soft. There is a

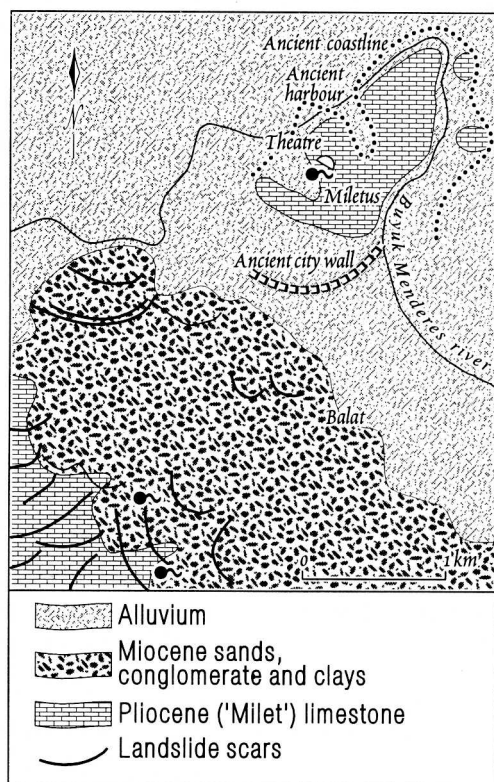


Fig. 13.15. Miletus and environs (after 243).

small quarry north of the Theatre, but most must have come from further inland. White and pale grey marble was used very extensively. It came from three areas of quarries, all along the southern shore of lake Bafa (Fig. 13.14), on the lower slopes of Mt Ilbira (formerly Mt Grion).²¹⁵ In antiquity lake Bafa was a bay of the sea, reducing transportation problems to Ephesus. A green-grey schist, with veins of quartz, was also used in some buildings. This rock occurs with the marble in some areas.

Didyma

Didyma is the site of one the great monuments of antiquity, the Temple of Apollo (Fig. 13.1). An oracle and sacred well were established here before the arrival of the Ionian Greeks.

They adopted the existing cult and completed the first temple in about 560 BC. The present building was started in 300 BC after Alexander the Great passed through the region. Construction continued for 500 years, but the temple was incomplete in AD 385 when the cult was abolished by the Christians.

Didyma, like Miletus, stands on a low hill of Milet limestone. The sacred spring or well is located where the limestone meets the underlying, less-permeable marls. The foundations of the temple were made of local soft limestone, but all exterior surfaces were made of white and grey marble. This marble was supplied from the same areas of quarries used by Miletus as well as another area was further east, near modern Bucak, which also supplied the ancient city of Herakleia to the north-west.²¹⁵