

8

Central Greece

The term Central Greece is taken here to mean the Departments of Boeotia, Phocis and Euboea (Fig. 8.1). The area covered by this chapter spans four isopic zones and commences, in the east, with the rocks of the Attic-Cycladic metamorphic belt. These rocks underlie the southern, narrower part of Euboea, and adjacent parts of Attica. They closely resemble the rocks of the Cyclades, which are discussed in Chapter 15.

Further to the north and west lies the Pelagonian zone. Limestone is the dominant rock here, deposited in shallow seas during the Triassic and Jurassic periods. The Sub-Pelagonian zone further west was an ancient sea-floor (ophiolite), now composed of great masses of peridotite and serpentinite, as well as deep-water limestones and cherts. Further west lies the Parnassos zone, dominated by shallow-water limestone like the Pelagonian zone. Finally, in the west, the Pindos zone is here dominated by flysch sediments. The Alpine compressions stacked these zones onto each other: first the Pelagonian zone was thrust westwards onto the Sub-Pelagonian zone, then that package was thrust eastwards onto the Pindos and Parnassos zones.

During the Neogene volcanism was very limited, but important crustal extension began and is still taking place. The crust was stretched in a north-east/south-west direction, forming a series of parallel grabens. These are the Gulf of Corinth, the Kephissos valley (including the Copais basin) and the north and south Euboean gulfs. The faults defining the north-east coast of Euboea are also part of this system. The Spercheios valley cuts across this trend and connects two of the grabens, but is clearly part of the same system. Earthquake

activity is concentrated along the Gulf of Corinth, which is the most active graben in this region.

Boeotia and Thebes

The district of Boeotia is completely ringed with mountains except on the south-east (Fig. 8.1). It is composed of a group of plains whose soil is unusually fertile for Greece, and is good for cereals and livestock. There are two principal plains, separated by an east-west range (an outlier of Mt Helicon) on which the city of Thebes stands. To the north, the Plain of Orchomenos is watered by the Kephissos river, which flowed into Lake Copais, now a drained area. To the south, the Plain of Thebes is watered by the river Asopos. Boeotia was a prosperous area in the Bronze Age and later periods, and provided the material base for the dominant city of Thebes.

The two principal Boeotian plains constitute a graben, set within hills of Triassic-Jurassic limestone (Fig. 8.1). This graben is probably associated with the Kephissos graben to the north-west (see Lake Copais below), but has been recently somewhat less active; large parts of the basin are underlain by Miocene, Pliocene and Pleistocene sedimentary rocks that were formed in lakes in the basin, but now have been lifted up and are being eroded.

Thebes was as important as Mycenae during the Mycenaean period. Its most famous king, the probably legendary Oedipus, killed his father and married his mother. Traces of a magnificent palace and tombs of royalty and nobility, all of Mycenaean date, have been found. From about 700 BC Thebes was leader of

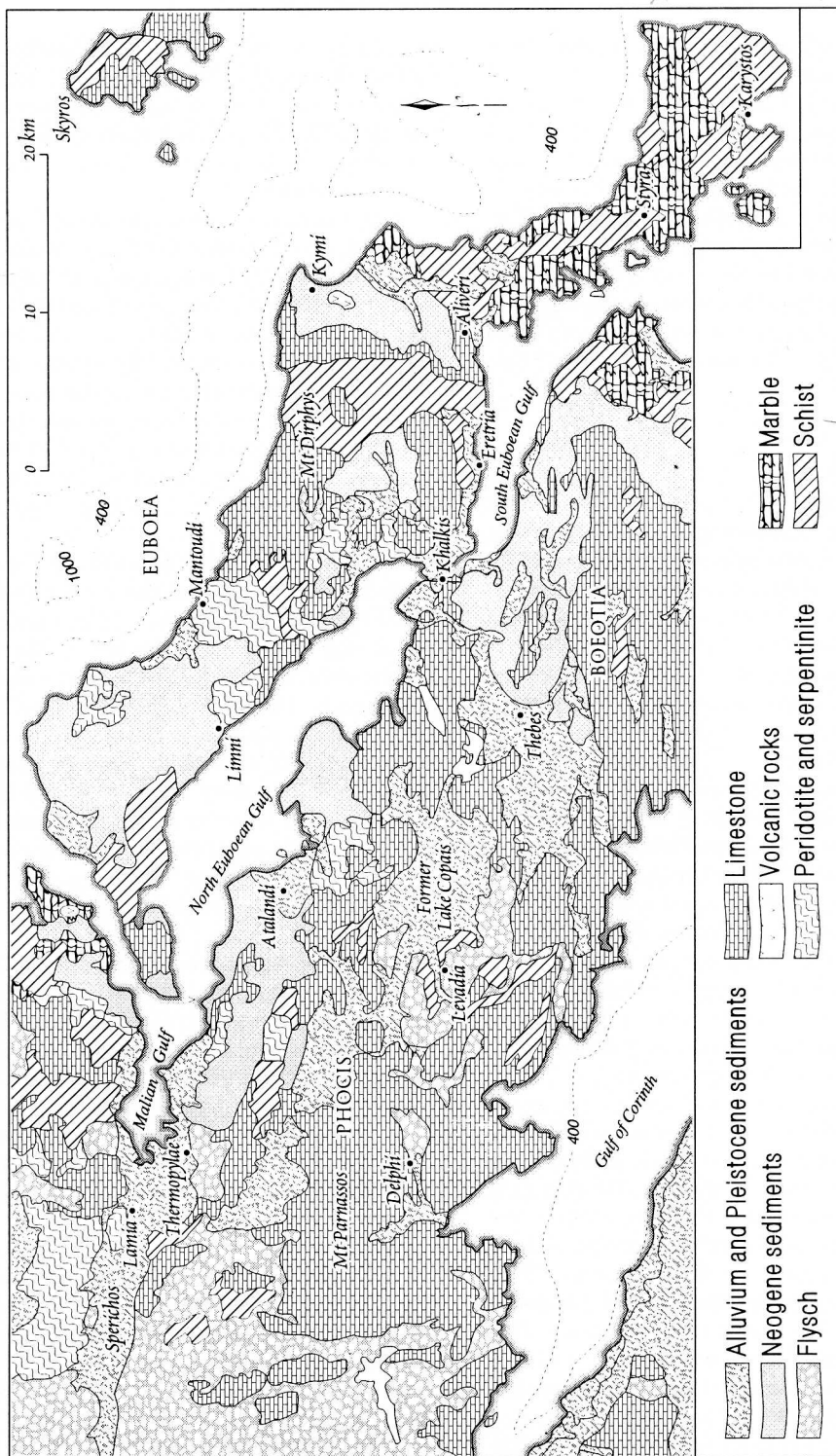


Fig. 8.1. Central Greece and Euboea.

a Boeotian Confederacy until its destruction in 336 BC by Alexander the Great.

The east-west line of hills on which the city of Thebes stands is composed of conglomerates and sandstones deposited in lakes on the floor of the graben during the Early Pliocene to Pleistocene, and subsequently uplifted (Fig. 8.1). Thebes was constructed on a small plateau 60 m above the plain and still dominates the flat landscape. One reason why this site was chosen in antiquity was the presence of the copious springs in the two valleys on either side of the plateau.²⁵⁹

Lake Copais

In classical times Lake Copais was the largest lake in Greece, measuring 24 by 13 km. It was entirely surrounded by mountains and was fed by the rivers Kephissos and Melas and a number of springs, with the only natural outlets being a number of sink-holes on the north-east and east sides (Figs. 8.1, 8.2). For most of the year it was a swamp, but in the summer much of it dried out, and in the rainy seasons it became a true lake.

There were several early attempts to drain the lake in order to create good farm land. The Mycenaeans enlarged two sink-holes between 1400 and 1200 BC; but after their downfall in about 1100 BC, nature again took over. Two more attempts at reclamation are recorded, in the late fourth century BC and in the second century AD. Finally, after many centuries of neglect, drainage works were completed in 1931. The Copais area is now very fertile and is devoted to pasture, rice and cotton.

The Copais basin is bounded to the north largely by Triassic to Cretaceous limestones of the Pelagonian zone, and flysch sediments of the Parnassos zone to the south (Fig. 8.2). It is one of a series of basins that stretch from the Boeotian plain in the south-east to those along the Kephissos river in the north-west. This broad valley is a graben formed by the foundering of a slice of the crust during tension. This process did not occur evenly, but has left bridges of bedrock separating the different basins. This graben is parallel to similar structures in the gulf of Corinth and the North-

ern Euboean Gulf. All these grabens were formed during the last ten million years in response to north-east/south-west tension in the crust. The floor of the Copais graben is still subsiding, which is why the basin is flooded by recent sediments.

Both vegetation and water levels have varied in the past: pollen studies indicate that before 3500-3000 BC oak trees were abundant in the region and Copais was a true lake.⁵ After this time the oaks declined and soil erosion increased, possibly caused by or linked with increases in human activity. At the same time the level of the lake declined, marshes became widespread and peat was deposited in the basin. Therefore, by the time of the Mycenaeans, Copais was a marsh rather than a perennial lake.

There are many sink-holes along the east-ern side of the basin, but the most important are those in the north-east, in Jurassic and Cretaceous limestone.¹³⁸ The Melas (Mavropotamus) river drains into the largest sink-hole, the Megali (Great) Katavothra. The water from all these sink-holes flows 2-4 km to the north and east, and feeds springs that discharge into the valley to the east and flow a short distance into the sea at Larimna (Fig. 8.2). Another group of sink-holes, to the south-east, feed springs that discharge into Lake Iliki. The bed-rock here is also mostly Jurassic limestone.

The Mycenaeans constructed a series of canals to drain the basin.¹³⁸ The canals terminated at the Binia sink-hole, north of Megali Katavothra, where a tunnel was excavated to augment the flow. Although over 2 km were dug, it was never completed. Another tunnel was started further south, to augment the flow into Lake Iliki, but was also never completed. However, it did anticipate the route of the modern drain, which passes under the National Highway.

Iron and nickel-rich laterite layers occur in the local limestones, both to the north and to the east of the Copais basin;²¹ see below for the origin of the laterites. Pliny mentions an occurrence of iron ore near Hyettos, about 8 km north of Lake Copais, but it is not clear if they were exploited. Recently, the laterites have

8. Central Greece

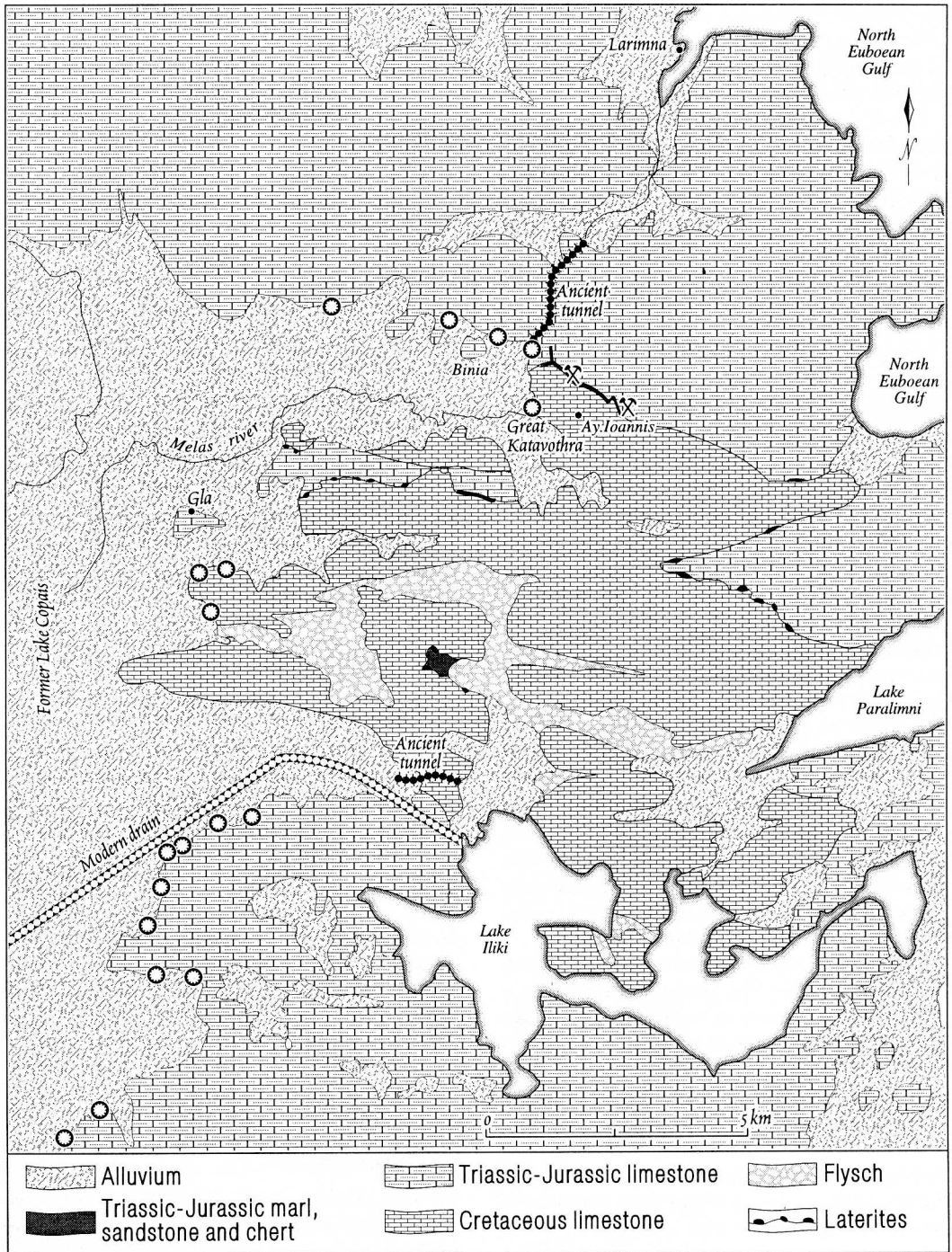


Fig. 8.2. The western part of the former Lake Copais basin (after 138 and other sources).

been exploited for nickel, especially around the village of Ayios Ioannis, near Megali Katavothra (Fig. 8.2). The ore was transported to Larimna where it was refined.

The Mycenaean stronghold of Gla lies in the north-east part of the Copais basin. Formerly an island, it is now a low, flat-topped hill. Ancient walls follow the edge of the cliffs for almost 3 km, and there is a Mycenaean palace at the highest point of the island. The hill is made of Cretaceous limestone, riddled with caves and abandoned sink-holes.

Levadia

Levadia was celebrated in antiquity for the Oracle of Trophonios, an institution second in importance only to Delphi. Trophonios was an old Boeotian god, later demoted to the status of hero. The oracular cave has recently been discovered on Mt Ayios Elias. In the deepest part of the cave were the Springs of Forgetfulness and Memory where the pilgrims bathed. Thanks to its strategic situation in the Erkina valley (ancient Herkyna), Levadia was of some importance in the Middle Ages, and today it is the capital of the Department of Boeotia.

Levadia is situated at the bottom of the gorge of the Kanellia river where it opens out into the plain of the former Lake Copais and joins the Erkina river (Fig. 8.3). The lower parts of the city are underlain by Palaeocene flysch, but the Kastro hill and the Kanellia gorge are faulted blocks of Late Cretaceous limestone. Further south flysch again reappears, this time above the limestone.

The gorge is a good example of a valley with incised meanders. The process starts with a slowly flowing stream meandering across relatively flat land. Rapid uplift causes the bed of the stream to cut down vertically into the bedrock, and it then incises the meanders.

Many springs feed the Kanellia river just above the Kastro walls turning it from a small stream into a significant river. On the east side of the stream a spring issues from the base of the cliff along a horizontal joint-plane, which has been enlarged into a small arch by the corrosive action of the water. The area above the spring contains many 'fossil' spring mouths

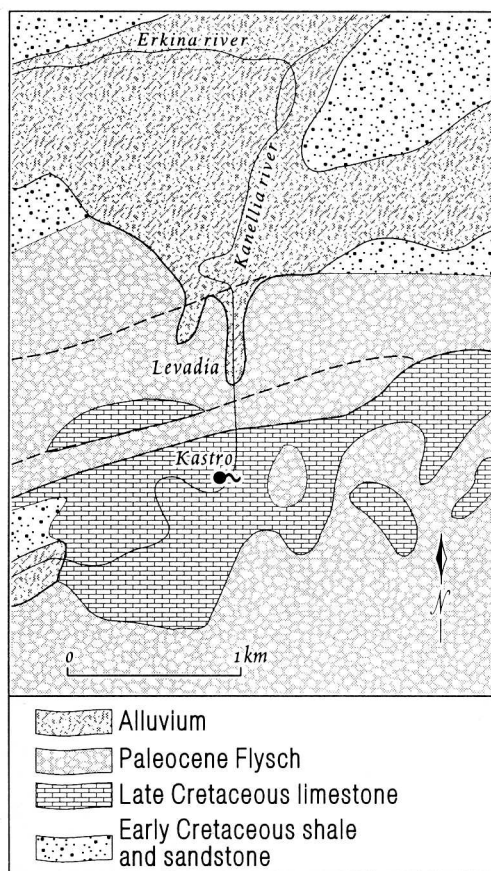


Fig. 8.3. Levadia.

which have a flat bottom and an arched top. Many of these have been further artificially enlarged into niches for religious offerings. The uppermost spring on the other side of the river feeds a reservoir for the city water-supply. Other springs issue directly into the bed of the river, some releasing streams of gas bubbles. These bubbles are air which comes out of solution in the water as the pressure is released.

Mt Parnassos

Mt Parnassos (2,457 m) has given its name to the Parnassos isopic zone, which crops out only in this area (Figs. 8.1, 8.4) and at Mt Olympos. The rocks here are a pile of shallow-water carbonates deposited from the Triassic to Pa-

laeocene. These massive limestones are very strong and were not much broken up by the Alpine compressional movements, in contrast to the rocks in the adjoining zones, which is why today Mt Parnassos has such strong relief.

Three times during the Jurassic and Late Cretaceous this area was lifted up above sea-level. At this time Greece had a tropical climate, and under these conditions extreme weathering of the rock removes almost all chemical elements, leaving behind a layer of loose material rich in aluminium called bauxite. Similar processes elsewhere acting on other rocks produced a material rich in iron and nickel called laterite (see below). At the end of each weathering cycle the rocks sank again below sea-level and another layer of limestone was deposited, sandwiching the bauxite between layers of limestone. Bauxite is the major source of aluminium, and these deposits have been extensively exploited in Greece.

Delphi

Delphi, site of the most famous oracle of antiquity, is even today a place of mystery, wildness and beauty, perched on the mountainside, looking up to Mt Parnassos and down to the port of Itea (Fig. 8.1). Immediately above it are the twin peaks, the Phaidriades, and below it is the river Pleistos. It was believed by the ancient Greeks to be the centre of the Earth, and it is indeed just about at the centre of Greece.

Delphi was a holy place, and probably an oracle, from a very early period. According to legend, and corroborated by archaeology, the first presiding deity was the Earth Goddess, Ge, served by Cretans from Knossos. A little Minoan and much Mycenaean material has been found here, dating between 1600 and 1100 BC. At the end of the Bronze Age the god Apollo became dominant. Under his protection the oracle was very active from the eighth to the sixth centuries BC, giving advice and foretelling the future for public and private clients, through the voice of his priestess, known as the Sibyl or Pythia. After 500 BC its oracular authority declined, but Delphi functioned for

another 900 years, until it was abolished by the Christians in about AD 400. Christians, barbarians and earthquakes reduced the oracular site to ruins and eventually a village grew up here.

The dramatic topography of Delphi was caused by rapid uplift associated with the Gulf of Corinth graben (see below) and by the preferential erosion of rocks adjacent to a fault that runs along the valley of the Pleistos river (Fig. 8.4). This fault is almost parallel to the graben faults, and was probably formed by the same tectonic forces. The local topography of the site is also controlled by the nature of the underlying

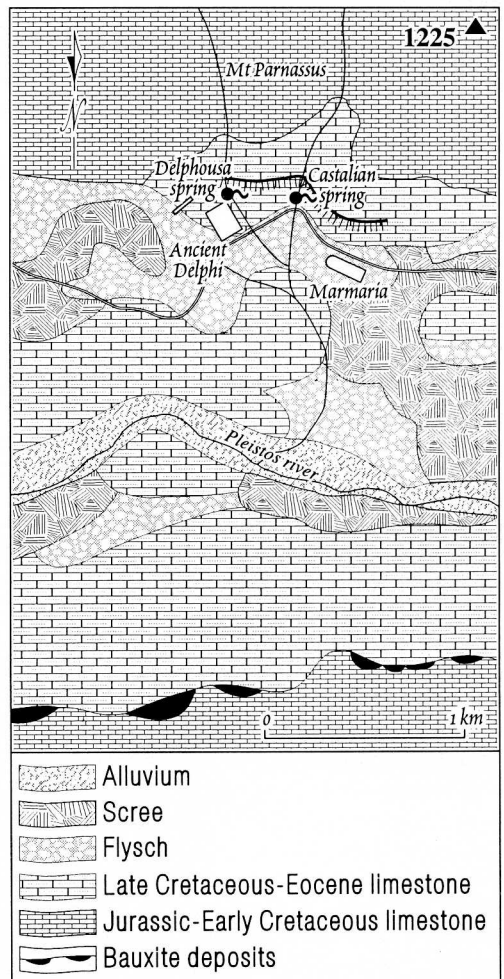


Fig. 8.4. Delphi.

ing rocks. Limestones are resistant to erosion and form steep cliffs, whereas shales erode easily and underlie the more gentle slopes.

Most of the rocks around Delphi have been turned upside-down by folding and faulting during the Alpine deformation of the area.²³¹ The oldest rocks are a series of dark Late Jurassic limestones and occur at the tops of the mountains. Below these rocks are a series of Middle Cretaceous pale limestones and slightly younger dark or black bitumen-bearing limestones. Finally, there is a thinly-bedded pale limestone, with layers of chert, of Cretaceous to Eocene age. The cliffs behind the ancient site of Delphi are made of the last three types of limestone. All these limestones are cut off by an almost horizontal thrust fault that runs just above the modern road. Most of the rocks below this fault are red shales of unknown age, as well as minor Cretaceous limestone and recent scree.

The south side of the valley has similar stratigraphy, but is offset by the steep fault that runs along the bottom of the Pleistos valley. On this side of the valley red-weathering bauxite deposits occur along some of the contacts of these limestones (see Parnassos).

The buildings of ancient Delphi were mostly constructed of local grey limestone.¹⁹⁴ Although some of this was cut from small quarries near the site, the supply was not sufficient and was supplemented by material from extensive quarries at Profitis Elias, about 5 km to the south-west. The quarries lie at an altitude of 210 m, in early Cretaceous limestones, with minor chert and calcite veins.

The Castalian spring was an important part of ancient Delphi. All who came here for religious reasons had to purify themselves in these waters. The spring issues from the eastern wall of the Papadia ravine, just above a thrust fault, where limestones overlie shales. The proximity of this fault is revealed by the well-developed cleavage of the rocks that dips 30° to the north. These waters originate as rain and snow which fall on Mt Parnassos and seep into the limestones. There the water descends until it reaches the less-permeable shale. Unable to descend further the water flows laterally until it reaches the surface as a spring. The flow rate

of the spring is rather low, and the water flows down the valley to join the Pleistos river far below.

The Kassotis fountain, immediately north-east of the Temple of Apollo, was also very important. The priestess drank from it before prophesying. This fountain was an artificial reservoir fed by waters from the Delphousa (Kerna) spring 70 m to the north-east, which issues from a cleft in the limestone. Small amounts of travertine have been deposited around the spring. Below the spring is a red limestone-breccia which is underlain by shale. This spring now supplies part of the water for the modern village of Delphi.

A greater deposit of travertine is present on the wall behind the temple of Apollo. Here up to 30 cm have been deposited since the site was cleared about 90 years ago. Traces of the travertine cone that once covered this whole area can be seen along the rear wall. This travertine probably comes from water channelled down from Delphousa spring or from a separate spring. The site must have been covered with abundant travertine deposits long before human habitation and these, now largely destroyed, may have first attracted people to this site.

The last temple of Apollo, whose ruins we see today, was built between 366 and 329 BC. Burnt in the first century BC, it was restored by the Romans and was finally closed in the fourth century AD. Subsequently earthquakes and human depredations took their toll.

The temple was built of local limestone, with columns of poros limestone covered with stucco. In the inner shrine, apparently an underground chamber, were the Omphalos (the navel of the earth) and the oracular chasm, over which the Pythia sat. Tradition holds that her utterings were induced by chewing laurel leaves and inhaling the emanations from the chasm. Of this chamber there is now no evidence and no emissions of gas are known today in this area. However, a sag in the middle of the temple floor suggests that it was constructed on artificial fill that has subsequently settled, perhaps into the chasm. Discharges of carbon dioxide are not uncommon in areas of limestone,¹⁸⁰ and such gas could perhaps induce a

trance. Earthquakes and construction activities can change the natural plumbing system, so the tradition of the vapours cannot be excluded on geological grounds.

A further spring or seepage appears below the temple of Apollo in the sanctuary of the goddess Ge (author's observation), adjacent to the Rock of Sibyl, where the first Sibyl was said to have prophesied.

All these springs have seasonal variations and also have been disturbed by earthquakes and construction activities. However, they all appear to fall along a straight line, which suggests that they are associated with a steep fault that runs about north-west/south-east.

Delphi is situated in an area much prone to earthquakes. Rockfalls associated with earthquakes have destroyed many of the monuments and have proved to be the decisive factors in several conflicts. The main reason for the frequency of earthquakes here is its proximity to the active Corinthian-Saronic graben. The walls of this graben have been uplifted and the floor has subsided to give at least 3 km of relative movement during the last 10 million years. Most of this movement has occurred during earthquakes.

The polygonal walls supporting the Sacred way were much better suited to withstand earthquakes than the square blocks of the temples, which needed reinforcing with clamps. Removal of these clamps during the Middle Ages led to the final disintegration of the temple of Apollo.

Thermopylae and the Malian Gulf

The only feasible route in antiquity along the east coast of Greece between Thessaly and Boeotia ran along the south shore of the Malian Gulf. The 6 km long pass between the cliffs of Mt Kallidromon and the sea was known as Thermopylae ('hot gates') from the hot mineral springs near the centre of the pass (see below). Here in 480 BC the Spartans earned immortal glory from their stand against the Persian invaders. A small force of 300 men held back the vastly more superior Persians for sufficient time for the bulk of the Greek forces to get away to the south. The Spartans were all killed, but

by their delaying action they made possible the ultimate defeat of the Persians. The balance between sedimentation by the Spercheios river and subsidence of the land has changed the topography of the pass considerably since antiquity until now it is a broad plain. These variations in geography will be explored below.

The Malian Gulf is part of a graben that stretches from the North Euboean Gulf deep into central Greece (Figs. 8.1, 8.5). This graben probably began to form about ten million years ago when tension in the crust behind the South Aegean volcanic arc produced many grabens in the Aegean region (see Chapter 2). The grabens of the Gulf of Corinth and the Boeotian plain are parallel to this graben and were formed at the same time and in the same way. The topography of the graben has been controlled by three factors: sedimentation, subsidence and sea-level changes.¹⁵³

The Spercheios river flows down the graben from the west, bringing large quantities of sediment formed by the erosion of the mountains. Other rivers also flow into the graben from the mountains to the north and the south. All these sediments are deposited when the river slows down as it enters the Malian Gulf. The deposits tend to fill up the bay and move the mouth of the river out into the Gulf. At least 800 m of sediments are present in the graben. Travertine formed around the hot springs has also contributed locally to the sediments in the gulf (see below).

The second factor, the subsidence of the floor of the Spercheios graben, began about 10 million years ago and still continues today. Movement is not generally continuous, but happens during earthquakes when movements of several metres may occur. Such events can drastically alter the coastline and the depth of the sea.

The third factor is the level of the sea: 18,000 years ago, near the end of the latest glaciation, sea-level was about 120 m below its present level. Rapidly rising sea-levels until 6,000 years ago exceeded sedimentation, flooding much of the former land that now lies beneath the Malian Gulf. It is possible that at this time the gulf extended right up to the cliffs on either side. After about 4000 BC sedimenta-

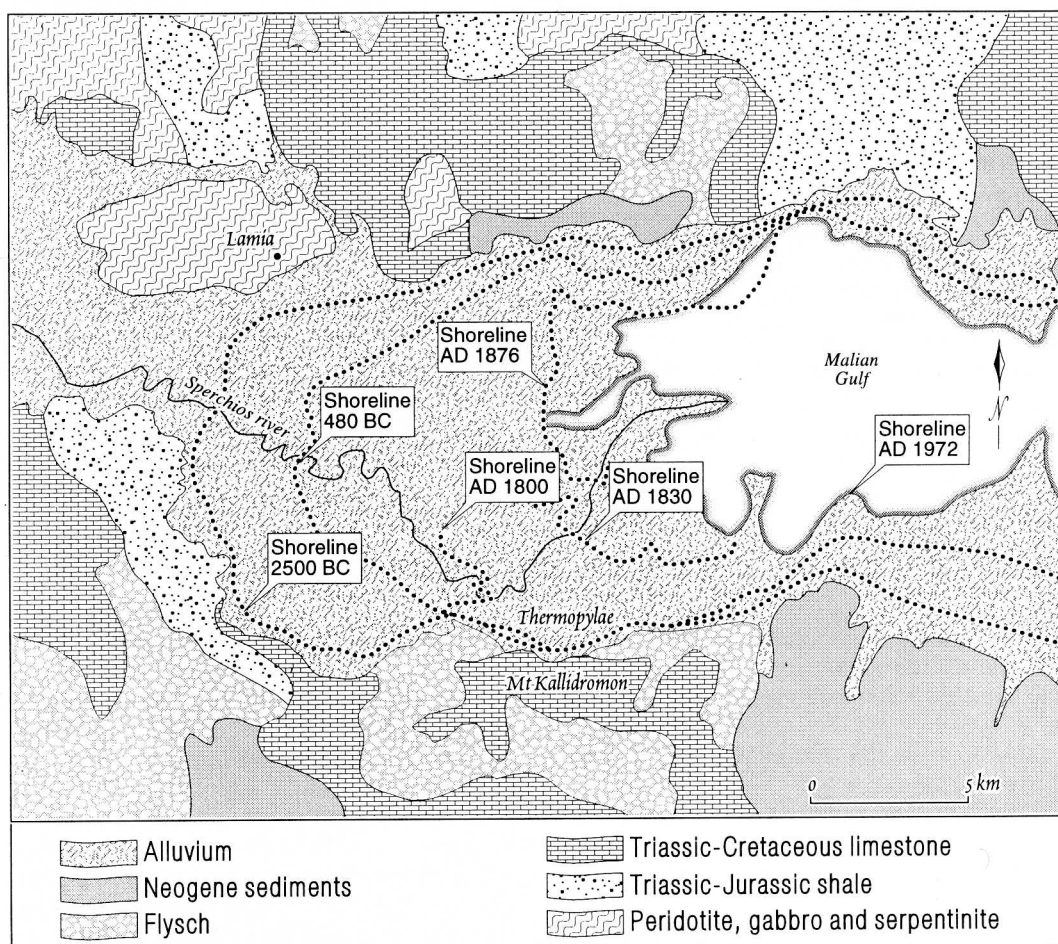


Fig. 8.5. Spercheios valley and the Malian Gulf (after 153 and other sources).

tion exceeded subsidence and rising sea-levels. This led to the formation of new land and the migration of the river delta into the gulf.

The Middle Gate appears to be the critical part of the pass (Fig. 8.6). At periods of high sea-level, possibly 1700 BC – 1300 BC and 300 BC – AD 1100, the sea lapped directly against the cliffs and the pass was effectively closed, while at other times it was open, but still very narrow. It was probably only 20-30 m wide at the time of the famous battle in 480 BC. During the nineteenth century the Spercheios river migrated or was diverted towards the southern shore, sedimentation increased and the pass began to broaden to its present width of 5 km.

Hot springs occur near both the Middle and West Gates, associated with the southern graben fault. The spring at the Middle Gate issues from beneath a boulder and scree at the foot of the cliff. The spring has a very high flow at a good bathing temperatures (40°C) but has been spoiled by the all too usual collection of decaying concrete, wire and pipes. The spring has deposited a large apron of travertine, on which the hotel and baths have been constructed. An appreciation of the rate of deposition can be seen near the parking lot, where a hot waterfall has deposited more than a metre of travertine. Travertine is limestone precipitated from the thermal waters as they

8. Central Greece

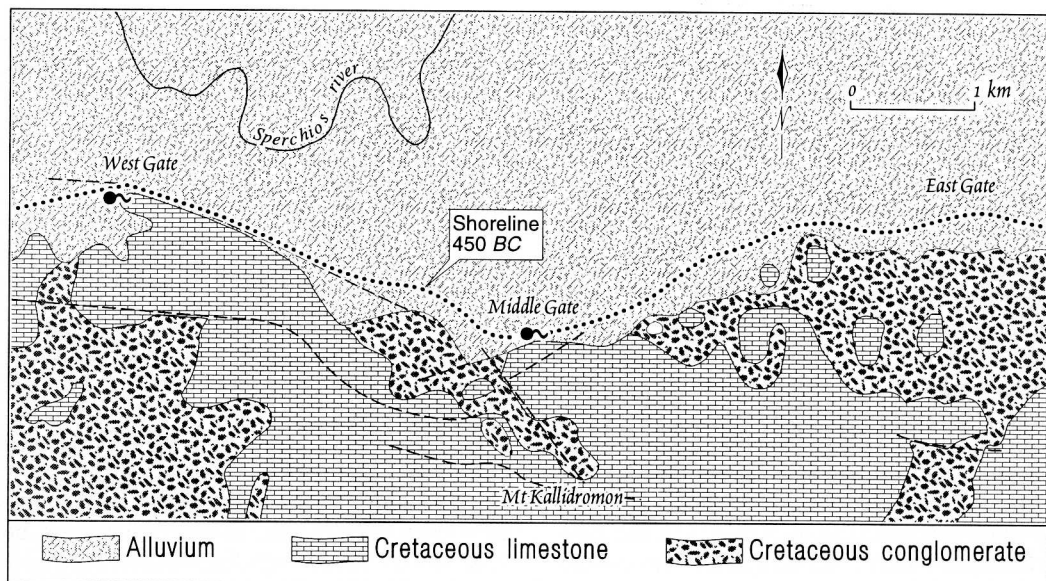


Fig. 8.6. Thermopylae (after 153 and other sources).

cool and lose carbon dioxide. The spring water is not very salty, which indicates that it originates as rainwater on the mountains to the south and is cycled along faults deep in the earth.¹⁸⁰

The spring at the West Gate also issues from a scree slope below a series of low cliffs of limestone breccia. The original limestone has been shattered in place and recemented by circulating, mineral-laden fluids. This type of rock is characteristic of major fault zones. The spring has been recently dammed to make an attractive swimming pool. The thermal water is very salty, in contrast to the spring at the Middle Gate, and probably originated as seawater. Cool, fresh water enters at the edges of the pool and floats on the warm, salty thermal water which is denser. Small amounts of travertine have been deposited at the exit of the pool and along an old aqueduct.

Euboea

Euboea, the largest Greek island after Crete, is 175 km long (Fig. 8.1). It runs parallel to the Greek mainland, separated from it by a narrow strait, which contracts to 80 metres at Khalkis,

where it is bridged. The west coast is well provided with ports, while the east coast, with its steep cliffs, is only accessible at Kymi.

It is a mountainous island – Mt Dirphys in the centre is 1,745 metres high – and many of the mountains are covered with forests of sweet chestnut, pine, fir and plane. The coastal plains are fertile; they produce corn, olives and figs in abundance, as they did in antiquity. The island is also rich in minerals, especially lignite, nickel, iron, asbestos, magnesite and marble.

Habitation on a considerable scale began before 3000 BC, and several prosperous settlements from the Mycenaean period (1600-1100 BC) have been located. In the Dark Ages (1100-800 BC) Euboea was exceptionally rich and started a colonising movement. It was well-placed geographically for contacts with the north and east and was probably now exploiting the local supplies of iron, which replaced bronze for many uses. The principal cities were Khalkis and Eretria. At about 700 BC this prosperity was brought to an end by the Lelantine War when these two cities fought for possession of the fertile Lelantine Plain, which left both in a state of exhaustion. Prosperity

returned about 300 BC and lasted throughout Hellenistic, Roman and Byzantine times.

The older rocks of Northern and Central Euboea belong to the Pelagonian zone and hence are linked with those of Thessaly, Boeotia, Corinthia and Laconia (Fig. 8.1). They comprise a series of older metamorphic rocks, currently exposed in a band north and west of Aliveri. During the Late Triassic to Early Cretaceous periods limestones were deposited in shallow water on these rocks. This activity came to an end when part of the Tethys Ocean closed and the ocean floor was thrust over these rocks to form ophiolites. Uplift of the rocks above sea-level was followed by tropical erosion and deep weathering, resulting in the formation of bauxites and laterites (see below). Another small ocean basin closed in the Late Cretaceous which resulted in the emplacement of more ophiolites.²³⁶

During the Neogene three basins developed in the northern and central parts of the island. The land in these areas subsided and sediments accumulated in shallow lakes in the basins. These sediments included marls, which have weathered to produce deep, fertile soils. Peat accumulated in swamps and was converted into lignite (see below).¹³⁵ The lower part of the sedimentary basin north of Aliveri is cut by minor andesite volcanic rocks that were erupted about 13 million years ago.⁹⁰

The basement of southern Euboea is quite different from that of the north. The lowest rocks are exposed in a tectonic window south of Aliveri. Here the phyllites and marbles are part of an underlying nappe that is also seen on Mt Ossa. Overlying these rocks, above a thrust fault, are the marbles and schists of the Attic-Cycladic metamorphic belt that comprise the rest of southern Euboea.

The most recent phase of volcanism in this area was part of the Volos volcanic field to the north. The small island of Likhades off the westernmost part of northern Euboea is made of andesite which was erupted about 500,000 years ago.⁹⁰ Minor eruption of andesites on the adjacent mainland at Kamena Vourla occurred rather earlier at 1.7 million years.

The North and South Euboean Gulfs that divide Euboea from the mainland are Neogene

grabens, in which most of the movement occurred during the last million years.²¹³ The South Euboean Gulf is separated from the Aegean sea by a sill only 55 m deep that runs from Ayia Marina to Stira island. At times of low sea-level, for example 25,000-18,000 years ago, this sill would have isolated the gulf and turned it into a lake.

Lignite and magnesite mines

Lignite is extracted from an open-pit mine at Aliveri and most of it is burned in the local power-station.¹³⁵ The lignite formed from decayed Sequoia trees that grew in a marshy area during the early Miocene period. Later on it was covered by limestones, marls, conglomerates and sandstones, which must now be removed to uncover the lignite seams. There are also deposits of lignite at Kymi on the east coast in the northern part of the basin.

Magnesite has been mined around Mantoudi and Limni in northern Euboea. It occurs as veins and irregular masses in serpentinites formed by the metamorphism of the peridotite parts of ophiolites. It is used to make refractory bricks.

Khalkis

The ancient city of Khalkis was situated west of Mt Vathrovounia (Greki), an isolated block of Triassic-Jurassic limestone, similar to the formations of the mountains to the east (Fig. 8.7). The acropolis was constructed on the south-west part of this hill. The low hills of the peninsula to the south-west of the ancient city are made of Late Cretaceous limestone. The plain on which the ancient city stood, and the modern city stands, is underlain by readily-eroded serpentinite. The Trokhos spring (in antiquity, Arethusa) east of the ancient harbour is brackish but drinkable. Seawater mixes with freshwater in the caves and fissures beneath the spring. The ancient water supply came from three freshwater springs on the northern edge of the mountain at Tris Kamares. The water for all these springs originates as rain on Mt Vathrovounia.

The Euripos or strait of Khalkis only opened

8. Central Greece

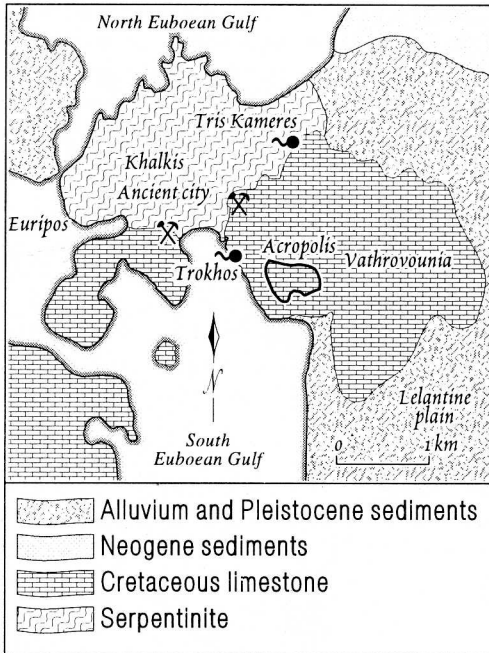


Fig. 8.7. Khalkis and environs (after 21 and other sources).

up about 6,000-5,000 years ago and is relatively shallow.¹³³ It is famous for the strong variable currents which reverse direction 6-14 times a day. Popular tradition holds that Aristotle, in despair at his failure to understand the phenomenon, threw himself into the Euripos. The currents originate in the interaction of tides in the North and South Euboean Gulfs. The tides in most parts of the Mediterranean are very small, such as in the South Euboean Gulf to the south of Khalkis which has a tidal range of 9 cm. However, in certain areas the configuration of the coastline combined with the depth of the water can cause a resonance which considerably increases the tidal range. The waters of the North Euboean Gulf to the north of Khalkis, where the tidal range is 42 cm, illustrate this phenomenon. Differences between the height and timing of the tides on either side of the strait at Khalkis produce the currents.¹³³ This phenomenon is a good example of a class of mechanical systems in which the interaction of periodic forces, in this case the tides, produce chaotic motions.

The Lelantine plain is a sub-aerial part of a long graben, mostly occupied by the South Euboean Gulf (see above), where less subsidence has taken place (Fig. 8.1). The plain is enclosed by mountains of Triassic-Jurassic limestones on the north and east. The ancient settlement of Lefkandi was situated on the southern part of this plain and was constructed on an eroding cliff of alluvium of the Lelas river.¹³³ Iron ore was smelted at Lefkandi around 900 BC.

Iron and nickel deposits

Euboea, and particularly Khalkis, was well-known in ancient times for its iron industry.²¹ The iron deposits occur in the mountains north-east of Khalkis, near the Aegean coast (the range that includes Mt Dirphys), and on the adjacent mainland, in north-east Boeotia, between Lake Copais and the North Euboean Gulf (Figs. 8.1, 8.2). They can be seen as long, thin, meandering lines of dark-red rock between paler limestones or greenish serpentinites.

The iron deposits are laterites, ancient deposits rich in the iron mineral haematite and were formed during the Early Cretaceous when a tropical climate prevailed in Greece. Intense weathering of serpentinite rock removed most of the chemical elements in solution, leaving behind a layer up to 10 m thick rich in iron and nickel. In some areas the laterites were eroded and redeposited on top of Jurassic limestones. At the end of the Cretaceous the sea invaded the area and limestone was deposited on top of the laterites. The laterites can be found now as a layer beneath the Cretaceous limestones, and on top of serpentinite or Jurassic limestone. Some of these laterites have been exploited recently, but for nickel instead of iron. The main nickel refinery is at Larimna, on the North Euboean Gulf.

Eretria

Three kilometres north of Eretria are quarries of a variegated red, violet and white marble known to the Romans as Marmor Chalcidicum and to Italian masons as Fior di Pesca (peach

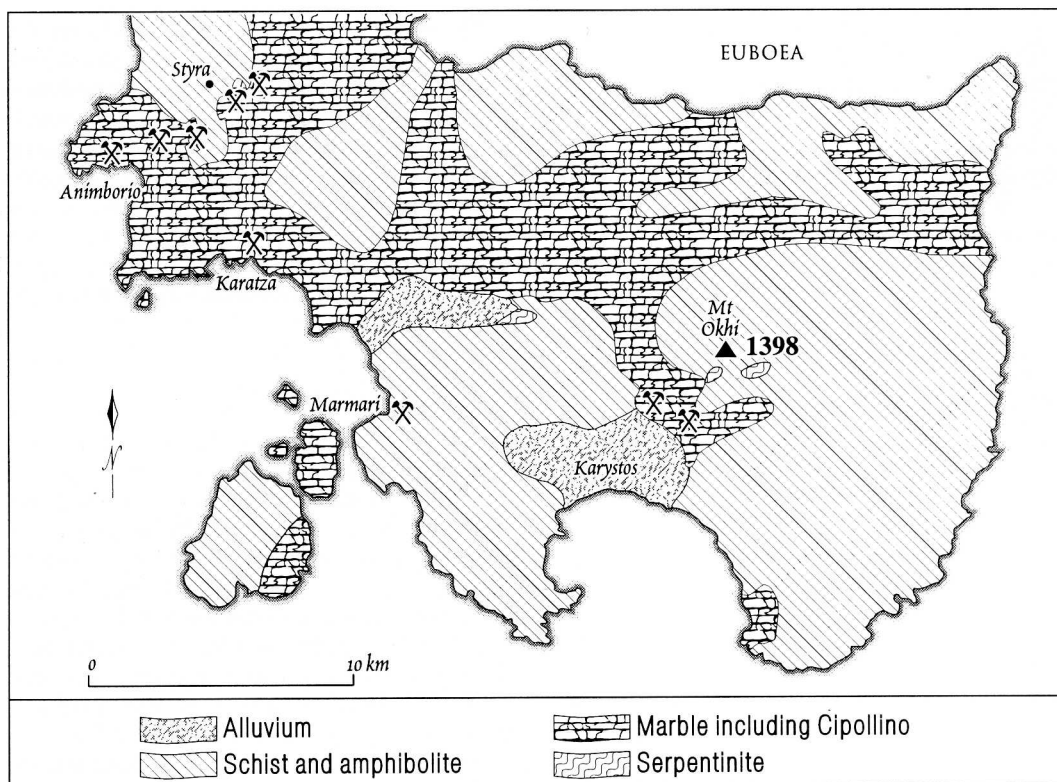


Fig. 8.8. Southern Euboea and the Cipollino quarries (after 159 and other sources).

blossom; Fig. 8.1). It was popular from the late first century BC into early Christian times, and was later used in Renaissance and Baroque architecture. This marble originated as Carboniferous limestone that was brecciated and infiltrated with iron-rich silts before it was metamorphosed and deformed.

Karystos and the Cipollino marble quarries

The area round Karystos was celebrated in antiquity for the veined green marble known to the Romans as Marmor Carystium and to us by its recent Italian name of Cipollino (onion). The name is apt, as a cut section of this marble looks very like an onion. It was used for monolithic columns, public fountains and wall-facings in Roman and Byzantine buildings from the first century BC to the seventh century AD. It was widely exported all around

the Mediterranean, and a piece has even been found in York.

There were five principal centres of exploitation (Fig. 8.8): Styra, Animborio, Karatza, Marmari, and Karystos.^{159, 147} By far the best preserved is the quarry north-east of Karystos and east of the village of Myli, at an altitude of about 650 m on the south-west slopes of Mt Okhi. Here one can see no less than 13 rough-hewn columns, many nearly 12 m in length, and one partly cut out of the rock face (Plates 7B, 8). It is hard to see how the monolithic columns were safely brought down for shipment.

Cipollino marble originated as Permian limestone, with layers of silt and clay. Metamorphism converted the clays into muscovite and chlorite, which gives both the green colour and the good cleavage of the marble. Quartz and feldspar are also present and stand out

8. *Central Greece*

from the other softer minerals after erosion.

Euboea was also known for its asbestos which was used in antiquity for making fire-proof cloth. Asbestos is a fibrous form of serpentine minerals that crystallises in veins up to 5 cm wide in massive serpentinite. The

crystals are generally lined up at right-angles to the direction of the vein, and form as the vein opens up. The ancient sources were veins in small patches of ophiolite on Mt Okhi north-east of Karystos.