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Attica

Attica is currently the wealthiest and most densely populated part of Greece. It consists principally of a number of interconnected plains, floored by alluvium and Pleistocene sediments, and cut off to the north-west by the great mass of Mt Parnes (Fig. 3.1; Plate 3A). The Central Plain around Athens is bounded on the north by Mt Parnes, on the north-east by Mt Penteli, on the south-east by Mt Hymettos, and on the west by Mt Aigaleos. It connects with the smaller plains of Marathon on the north-east, Eleusis (the Thriasian Plain) on the north-west, and the Mesogeia on the south. The indented coastline provides a number of good harbours, of which Piraeus is by far the best. There are few rivers, apart from the Kephissos and the Ilissos, which run through Athens partly underground; all are dry in the summer.

The soil is generally poor. It is unsuited to stock breeding and, in general, to agriculture, except for olives, vines and figs. The territory is, however, rich in limestone and in the marble of Mts Penteli and Hymettos; in addition, there was formerly (until it was worked out) a copious source of silver and lead in the hills of Lavrion. Finally, Attica was (and is) blessed with generous supplies of potter's clay, to which the Athenians surely owed their pre-eminence in the craft of pottery. The best clay came from deposits near Athens, especially at the northern suburb of Amarousi (where it is still worked), and on Ayios Kosmas (ancient Cape Kolias), near the present airport.¹³⁰

In early times Attica was made up of a number of independent communities. There is probably an element of truth in the legend that they were brought under Athenian control by the hero Theseus at about 1300 BC; but the

process was probably not completed till the seventh century BC. Thereafter, the history of Attica is inextricably bound up with that of Athens.

The geological structure of Attica, as in much of Greece, is dominated by a series of nappes stacked up during Alpine compressional movements. The oldest rocks in the region occur in one of the higher nappes along the north-west borders of Attica, in the mountains of Aigaleos and Parnes. These mountains are dominantly made of Triassic limestones of the Pelagonian zone similar to those occurring as far north as Thessaly and western Macedonia.

The southern and eastern parts of Attica are underlain by schists and marbles of the Attic-Cycladic metamorphic belt similar to those in southern Euboea and the Cycladic islands. These marbles make up Mts Hymettos and Penteli, as well as the hills around Marathon and Lavrion.

The next highest nappe is made of schists, cherts and ophiolites, which is in turn overlain by lightly metamorphosed and unmetamorphosed limestones and flysch sediments of Cretaceous to Eocene age. The uppermost part of this series is called the Athens schist (see below).¹⁷³

During the Neogene period compressional forces associated with Alpine mountain-building ceased. Erosion and faulting produced a series of basins which were flooded by the sea and filled with sandstone, shale, clay and limestone. These rocks are still in their original places of deposition, except that they have been raised above sea-level by geologically recent tectonic movements.

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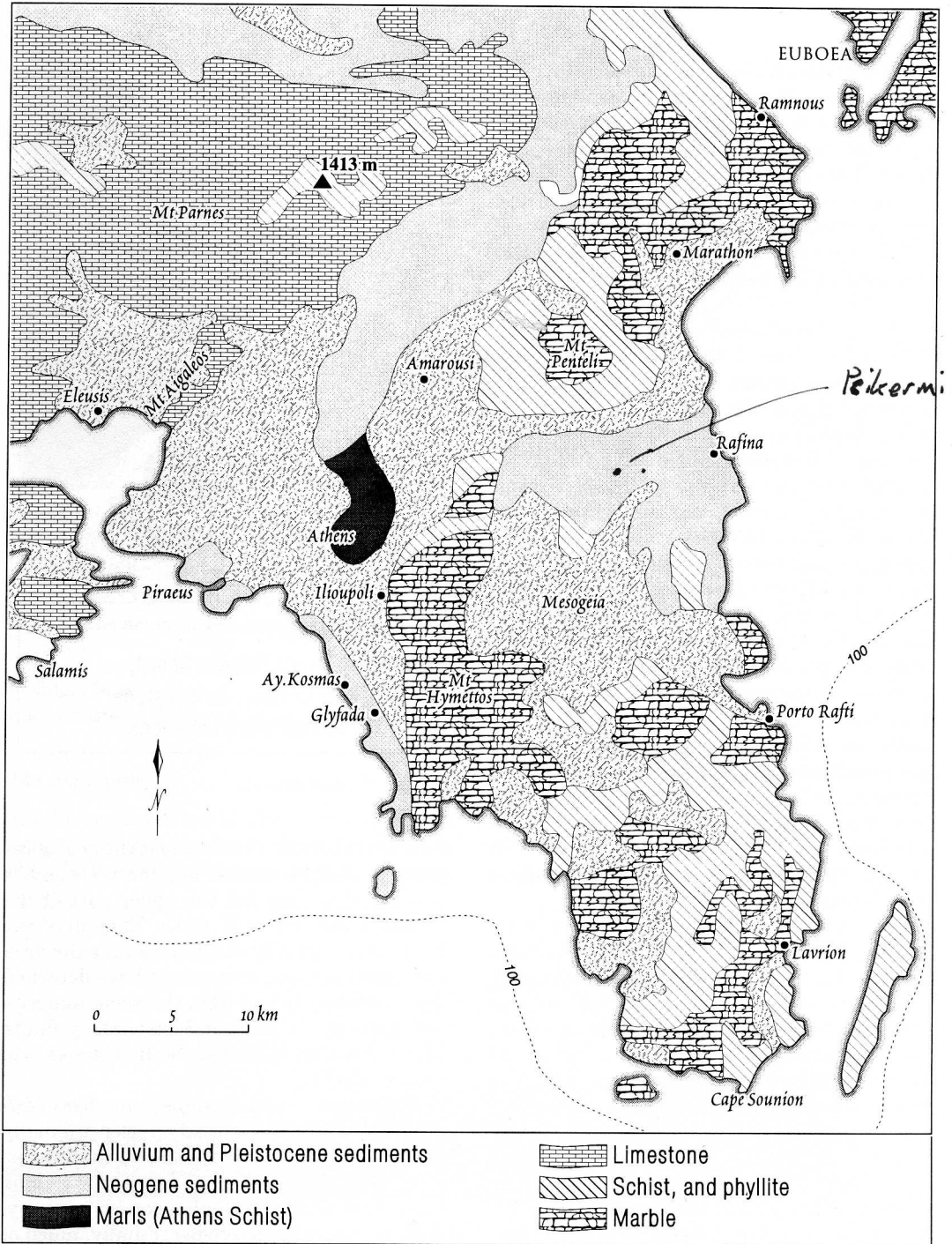


Fig. 3.1. Attica and Athens.

Athens

The site of Athens has been inhabited for approximately 8,000 years, and from at least the beginning of Mycenaean times, around 1600 BC, it has been one of the greatest cities of Greece. Like Mycenae and Tiryns, Mycenaean Athens possessed Cyclopean walls, a monumental entrance, a postern gate, a royal palace, and a secret water-supply. It is also to this period that the legends of the exploits of Theseus refer.

Around 1000 BC the Dark Ages were coming to an end in Athens, and the city became increasingly prosperous, reaching a climax between 600 and 500 BC. During much of this time Athenian pottery was the best in Greece and was widely exported for some 700 years. Another source of wealth was the silver from the mines at Lavrion, especially from about 500 BC. In 490 and 480 the Athenians defeated attacks by the Persians at Marathon and Salamis. Then followed fifty glorious years, which included the rule of the great statesman Pericles. But the Peloponnesian War, 431-404 BC, broke the power of Athens for ever. Henceforward, whether under Hellenistic or Roman rule, Athens, though artistically and intellectually pre-eminent, was politically reduced to the second rank. Neglected by the Byzantines, it regained a little authority under the Franks after the Fourth Crusade of 1204, but sank even lower when the Turks invaded in 1456. In 1834, however, Athens was designated capital of the newly liberated Greece.

The city of Athens stands in a great topographic basin surrounded by Mts Parnes, Aigaleos, Penteli and Hymettos (Figs. 3.1, 3.2). This basin was formed partly by faulting and partly by the erosion of the soft 'Athens schist', which outcrops or underlies the veneer of younger sediments in much of this area. The Athens schist is a slightly metamorphosed series of Cretaceous marls and shales, with lenses of sandstone and limestone. It is not a true schist by modern English usage.¹⁷³

Many of the hills in the eastern part of the Athens basin, such as Lykabettos hill, the Areopagus, the Acropolis and the Philopappos hill, are made of Late Cretaceous limestones (Fig.

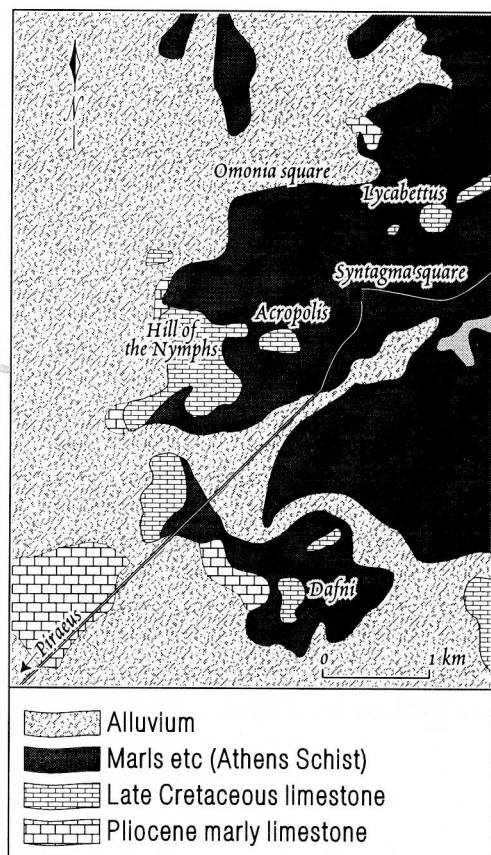


Fig. 3.2. Central Athens.

3.2). There is some debate about the geological position of these rocks, but most geologists consider that they are the upper part of the Athens schist series of rocks. They may not have been originally continuous over the area and minor tectonic movements have detached these stronger blocks from the weak underlying marls of the Athens Schist. Steep faults have since then dissected the limestones into smaller blocks.

The Athens basin contains a number of different Neogene sedimentary rocks originally formed in shallow lakes, such as limestones, marls and clays. The clay deposits were the basis of the ancient Athenian pottery industry, and are still exploited today. Finally, much of the central and western parts of the basin have been covered with a layer of alluvium up to 20

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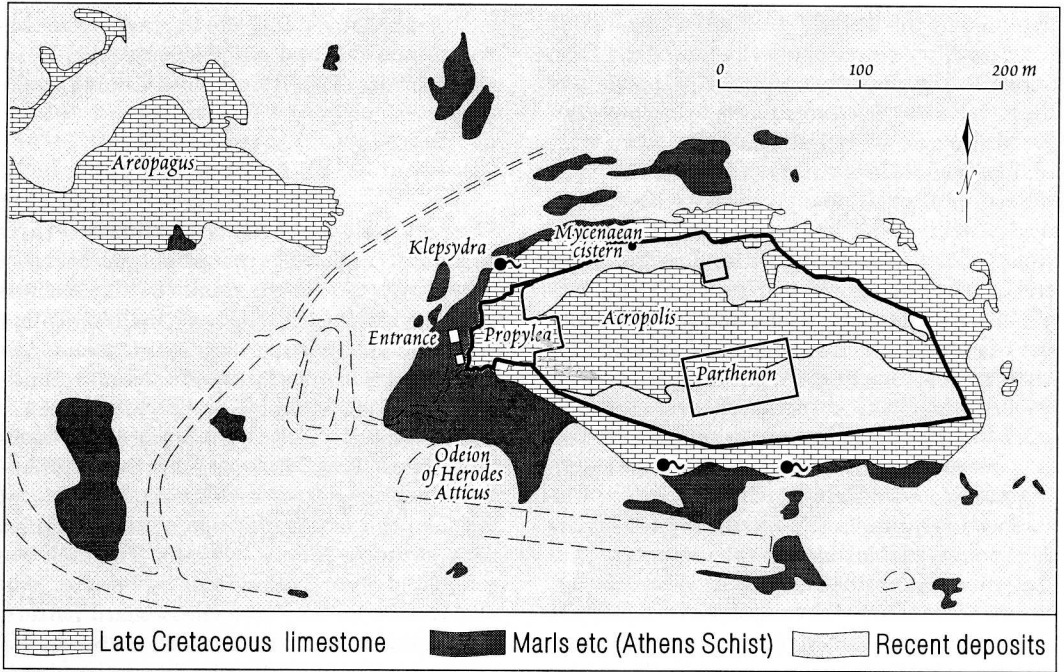


Fig. 3.3. The Acropolis and Areopagus (after 9).

m thick. Much of this deposition occurred during infrequent floods in the recent past.

The Acropolis

The Acropolis hill is a block of Late Cretaceous limestone resting on the marls and sandstones of the Athens schist rock series (Figs. 3.3, 3.4),

which can be seen on the approach to the main entrance to the site, and just beneath the Propylea.^{9, 10, 264} The grey limestone is well exposed on the top of the hill. It has closely spaced joints and some of the older fissures have been filled with red marl or coarse calcite crystals. The top of the Acropolis hill has been levelled with artificial fill up to 14 m thick which is

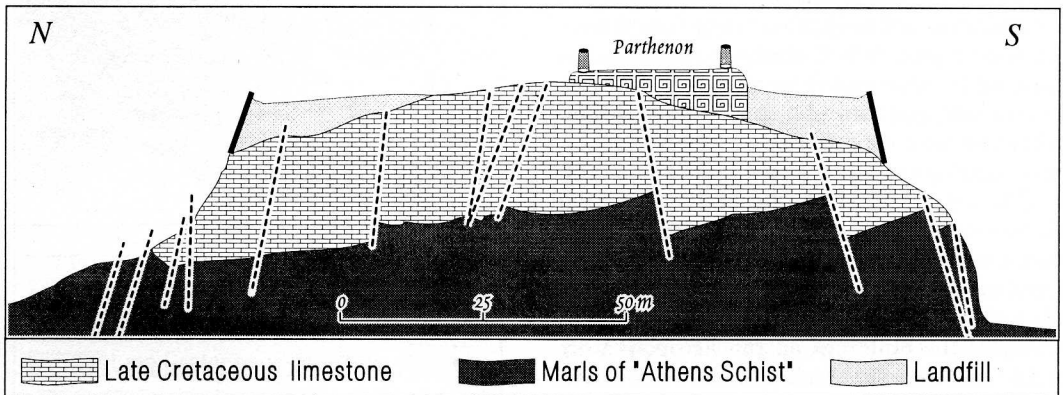


Fig. 3.4. Section through the acropolis (after 9).

retained by the walls.

Rainwater seeping into the faults and fractures on the upper part of the Acropolis has dissolved away the limestone to form caves and clefts. Such caves can be seen in the north-west and southern slopes of the hill (Plate 3B), but others, probably mostly choked with debris, undoubtedly exist in the interior of the hill. Much of this percolating water does not penetrate the underlying marls, which are less permeable, but reaches the surface at a number of springs around the base of the hill. One such spring, the Klepsydra, originally issued from a small cave in the north-west cliffs and attracted Neolithic settlers to the area. It was in constant use thereafter and has been subsequently considerably modified.

Towards the north-western part of the Acropolis percolating water has enlarged a fault in the limestone to produce a cave or cleft about 35 m deep. Percolating water fills the base of this cave to a depth of several metres, but the rate of inflow of water is low. The water level is about 4-5 m above that of the Klepsydra spring to the west. The Mycenaeans constructed a means of access to this water source but appear to have used it for only 25 years or so before it was abandoned. It is possible that the rate of inflow was too low to be useful.

Flow from these springs was probably stronger in antiquity. This may reflect climatic change, but is more strongly controlled by modifications to the geography of the hill. In the past the presence of plants, soil and loose materials on top of the bedrock would have retarded run-off so that the water could have time to be adsorbed. Recently, infiltration has been all but eliminated by sealing all the open cracks and fissures on the hill with cement. This has been done to reduce the rate of erosion, now enhanced by acid rain.

The sacred hill of the Acropolis was never defaced by quarries, but limestone for many of its buildings and the walls was quarried from several of the adjacent hills, including the Hill of the Nymphs.^{57, 290} The foundations of many of the buildings on the Acropolis were made of limestone from Piraeus (see below) and Aegina. Marble from Penteli was used for the construction of all the great buildings of the

fifth century, including the Parthenon (see below). Limestone and conglomerate from Kara, near the base of Mt Hymettos (see below), were also extensively used.

Piraeus

Piraeus, the port of Athens, comprises three harbours (Fig. 3.5): the principal harbour, Kantharos ('Goblet'); a small circular harbour to the south, Zea (formerly Pashalimani); and another small circular harbour east of Zea, Mikrolimano (in antiquity Munichia, recently Tourklimano). At first Piraeus was not used as a port, since the Athenians preferred to beach their ships along Phaleron Bay. But in 493 BC the Athenian statesman Themistocles started to make the whole of Piraeus into a fortified port, joined to Athens by walls. The task was completed a generation later by Pericles, who also rebuilt the city on a chess-board pattern. The walls were destroyed in 86 BC by the Romans, and the port lost its importance until comparatively recent times.

The town of Piraeus stands on a series of low hills south-west of Athens. Although Late Cretaceous limestone underlies two small hills to

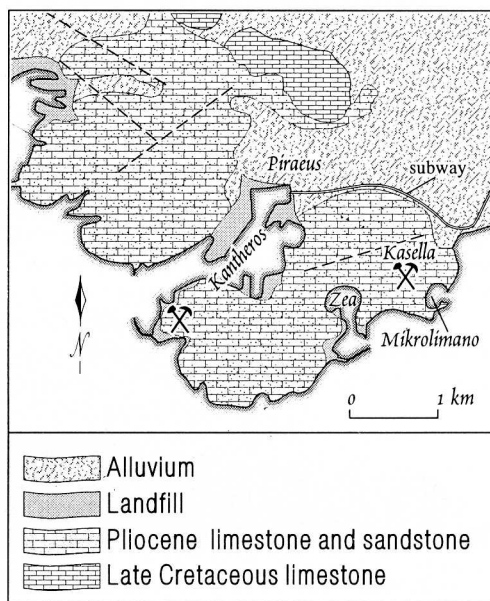


Fig. 3.5. Piraeus.

the north, the larger hills to the south are made of Pliocene marly limestone and sandstone. These rocks also occur along the coast to the north-west and south-east, past the airport. During the Pleistocene these rocks were uplifted about 80-100 m and eroded to form the present-day topography.

The soft Pliocene limestones, known as Ak-tites Lithos in antiquity, were quarried around the top of Kasella hill north-east of Mikrolimano harbour and also near the southern approaches to the main harbour. This rock is easily cut and hence was used extensively in Athens, especially in the sub-structures of the buildings of the Acropolis. It was also used in the Agora at the Stoa of Attalus, and indeed, the ancient quarries were reopened for the reconstruction of this building.

Eleusis

The present-day surroundings of Eleusis, polluted by industry, are far from prepossessing; but from 1500 BC to about AD 400 it was one of the great religious centres of Greece, second in importance only to Delphi. Here was the Sanctuary of Demeter, where the Eleusinian Mysteries were celebrated every September. The rites of initiation were kept secret, and we know nothing about them, except that the initiate was promised wealth in this world and

happiness in the next.

Eleusis is situated on the coast, in the southern part of a Neogene sedimentary basin that lies south of the Parnes range and west of Mt Aigaleos (Figs. 3.1, 3.6). Within this basin weathering and erosion of the sediments has produced fertile soils. In the western part of the basin there are a number of low hills of Late Cretaceous limestone that protrude through the Pleistocene sediments. Much of the ancient city of Eleusis was constructed on one such hill.

The acropolis hill rises to 63 m and runs parallel to the coast for about 1,500 m. It is composed of limestone and marl, variable in colour from pale yellow to grey. Some of the rainwater falling on the hill is adsorbed and reappears as springs and in shallow wells around the edge of the hill. One such water source is the sacred well called Kallichron, near the Greater Propylea.

Eleusis was also the source of a dark grey to black limestone used as a decorative element on some buildings in Athens. It was possibly extracted from a quarry on the north slope of the acropolis hill.⁷²

Mt Penteli and Mt Hymettos

Mt Penteli (1,106 m) is part of a 20-km-long sector of metamorphic rocks north-east of Athens, extending past Marathon to the coast opposite Euboea (see Fig. 3.1). Mt Hymettos (1,037 m) is part of another sector of metamorphic rocks to the south-east of Athens. Both these mountains are part of the Attic-Cycladic metamorphic belt (see Fig. 2.2 and Chapter 15). Both schists and marbles occur here, but the marbles are most resistant to erosion and stand up much higher as mountains.

In both mountains there are two main marble layers:¹⁶² the geologically upper layer is predominantly grey, while the lower is predominantly white (Fig. 3.7). Paradoxically the lower marble is exposed near the main summit of Penteli, and the upper marble is at lower elevations. The grey colour is produced by the presence of minute amounts of graphite, formed by metamorphism of plant remains in the original limestone. Some parts of the marble beds contain muscovite, which consid-

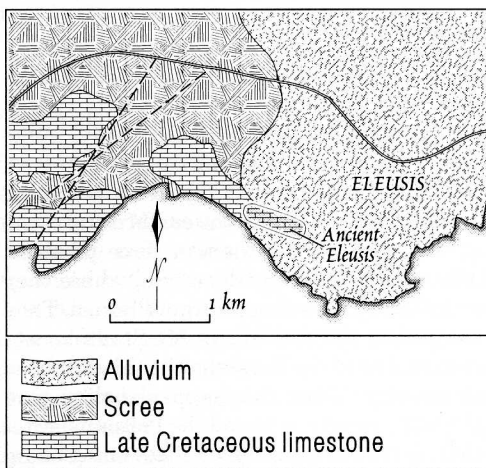


Fig. 3.6. Eleusis.

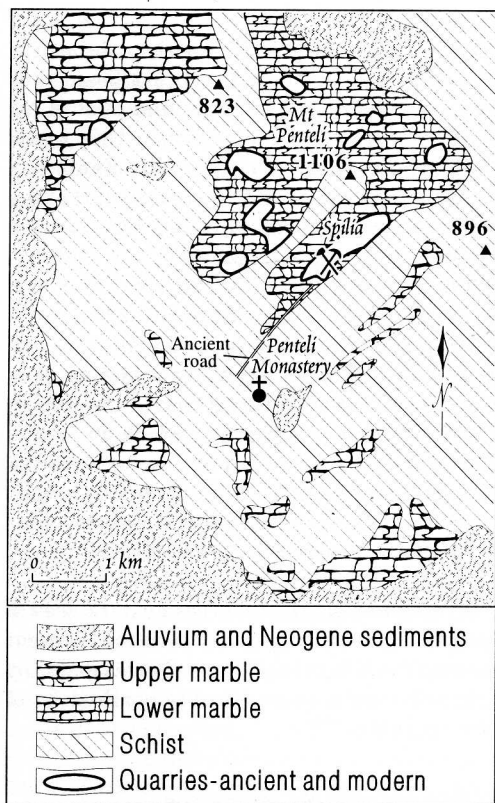


Fig. 3.7. Mt Penteli (after 162 and other sources).

erably reduces the resistance of the rock to weathering.

Although both white and grey marble occur on both mountains, in antiquity the best white marble was obtained from Penteli, and the best grey from Hymettos, a fact which has misled many modern scholars to refer (incorrectly) to the grey as 'Hymettan' and the white as 'Pentelic'.

The modern quarries are all around the main peak of Mt Penteli, and have partly obliterated the ancient quarries, which lie mostly to the south of the principal summit. About 25 of them have been found situated one above the other, many linked by an ancient, paved quarry road. One of the larger quarries, Spilia, about one third of the way up Penteli, is thought to have been the source of the marble for the Parthenon.

Although Pentelic marble can be very pure,

joints are relatively closely spaced, which restricts the maximum size of the blocks that could be extracted. This does not appear to have been a problem in classical times, but the Romans used other sources of marble for their larger pieces.

The ancient quarries for the grey marble on Hymettos are on the west side, near the former monastery of Karyes, below the Kakovevma gorge. It was not much used before the third century BC, but was quite popular in Roman times.

Two different rocks quarried near Ilioupoli (Kara), at the base of Mt Hymettos, were used for the foundations of many of the buildings in Athens.^{290, 57} A Pliocene yellowish-grey fresh-water limestone was mainly extracted during the sixth to fourth centuries BC.⁷² A second rock was conglomerate formed by cementation of pebbles in alluvial cones shed off Mt Hymettos.

On both Mts Penteli and Hymettos weathering of the marble has produced a thin red soil (terra rossa) that has mostly been removed by erosion and redeposited in the valleys. The paucity of the soil has been compounded by the porosity of the rock to produce very poor conditions for plant growth, unsuitable for trees and most crops. By way of exception, the highly aromatic shrubs on Hymettos produced, and still produce, some of the best honey in Greece.

Marathon

The Bay of Marathon lies 42 km north-east of Athens and is famous for the battle fought there in 490 BC. The Persian army, some 25,000 strong, disembarked in the Bay with the intention of marching on Athens; for safety, they moved their ships to the eastern end of the Bay. Meanwhile an Athenian force of about 10,000 men set out for Marathon, where they were joined by a contingent from Plataea. They encamped in the foothills of Mt Stavrokoraki and waited until the Persians should withdraw their cavalry. When this happened they gave battle and soundly defeated the Persians. Altogether, 6,400 Persians were killed, many being drowned in the Great Marsh while trying to reach their ships. The Athenians lost 192; they

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were buried in a mound on the battlefield which still exists.

The Marathon plain lies at the foot of mountains of schist and marble of the Attic-Cycladic metamorphic belt (see Fig. 3.1). They rise steeply from the plain, suggesting that subsidence is still occurring to maintain this sharp relief against erosion. The straits separating Euboea from the mainland, including the gulf to the south-east of Marathon, are active grabens (see Corinth in Chapter 5) and the Plain of Marathon is, therefore, probably an extension of these structures into the mainland.

The plain is typical of other coastal plains in Greece and consists of alluvial fans, formed by the transport of sediment in torrents from the mountains, descending into a marsh (now mostly drained) which is separated from the sea by a scrub-covered sand and gravel barrier.²⁰ The plain is divided by the Charadra river which formerly meandered across the plain, but has now been channelled. Flow of this river has been reduced by the creation of the Marathon Lake reservoir, and the diversion of the waters to Athens, but it is not likely to have been a significant river in antiquity. Sediment samples have shown that the plain has alternated between marine and estuary conditions. In 490 BC the coastline in the eastern part of the bay was located further inland by 500 m and the north-eastern part of the plain was a densely vegetated muddy marsh. This is the Great Marsh in which many of the invading Persians died.

Lavrion

Lavrion is one of the best-known mining areas in Greece. Although silver was extracted here as early as Mycenaean times (1600-1100 BC) the really rich veins were not discovered or exploited before the fifth century BC. Lavrion then became the principal source of silver for Greece. That produced in these mines was used in the minting of silver coins, which were the source of much of the wealth of ancient Athens, as well as for plate and statuary. The lead by-product was widely exported throughout the ancient Greek world, and has been found in western Turkey and Egypt.⁹⁷ Lead was used for

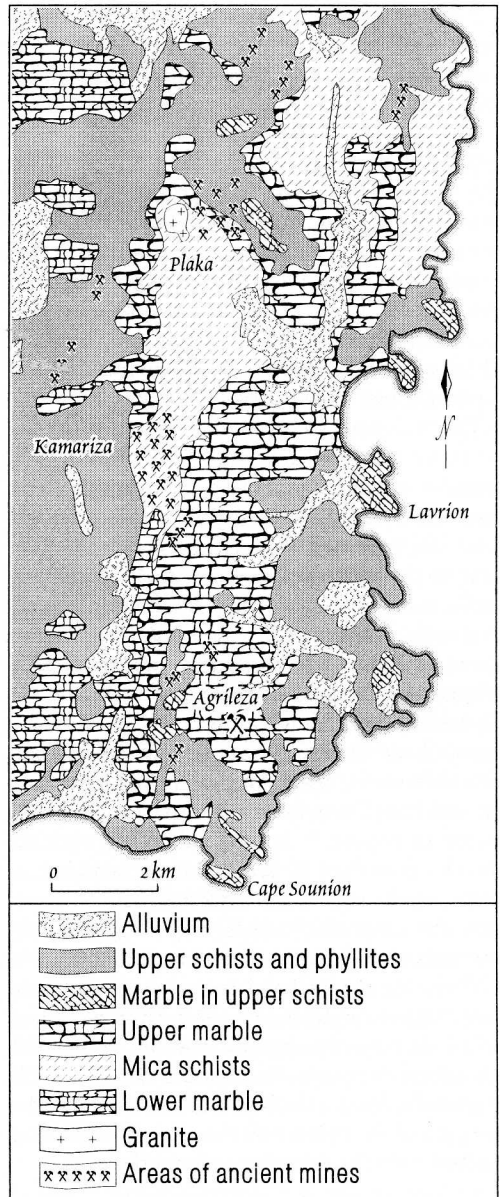


Fig. 3.8. Lavrion and Sounion (after 171).

anchoring iron clamps, covering the hulls of ships, and for making sinkers for fishing lines and standard weights. It was added to bronze to improve fluidity for casting and for the attractive patina that such alloys develop. In Roman times plumbing became its most impor-

tant use.¹⁸⁸ After this time mining activity declined and ceased altogether by the time of Christ. Activity recommenced at the end of the nineteenth century, but has now ceased.

The deposits were formed in two different series of metamorphic rocks (Fig. 3.8).^{171, 44, 95, 97} The sequence starts in the Attic-Cycladic metamorphic belt with the lower marble, exposed in the west. This is overlain by mica schists, that then pass into an upper marble unit. Over this package have been thrust Jurassic schists and phyllites, with some marble. All these rocks are cut by a Miocene intrusion of granite and its associated dykes.

The ore occurs as replacements of the marble near the contact with the schists and intrusions. The primary ore consists of galena (lead sulphide), which contains the silver as an impurity, together with sphalerite and pyrite. Near to the surface these minerals have been oxidised and hydrated to form oxide and carbonate minerals of the same metals. The ore mined in ancient times contained up to 50% galena, and the lead smelted from this ore had 0.1-0.4% silver. Minor amounts of other metals, such as arsenic and gold, are associated with these ores, and it has been suggested that Lavrion may have been an important ancient source of copper.⁹⁶ Among other by-products was the flue-dust of the smelters, which was occasionally used as a medicament.¹⁸⁸ However, the 'emeralds' reported by Pliny are only zinc carbonate, an alteration product of the ore.

The ores crystallised from low to medium temperature watery solutions that were expelled during the crystallisation of granite intrusions beneath the region. These fluids migrated along existing cracks, such as the margins of the dykes and the thrust faults, and reacted with the marbles to form the ores.

The ancient mines are very extensive and over 2,000 shafts have been found. Most of the ore appears to have been processed locally and the remains of the ore washing facilities have been excavated in the Agrileza valley. 'Washing' of the ore was the process of removing the associated minerals, which did not contain metal. These are generally lighter than the ore and so could be separated in a current of water (Plate 4). It has been estimated that 1-2 million tonnes of lead and 8,000 tonnes of silver were produced from these mines in antiquity.¹⁸⁸

The Lavrion mines have produced some fine mineral specimens, especially of secondary minerals such as smithsonite, adamite and annabergite, but this region is principally known by mineral collectors for its secondary lead slag products. In antiquity, slag from lead smelting was dumped in the sea, principally around the town of Lavrion, where it has reacted with seawater during the last 2,000 years. The most common new mineral is aragonite, but a large number of other products occur, principally as minute crystals in former gas bubbles in the slag, including laurionite, named after this region.¹⁴⁰

Cape Sounion

Cape Sounion looks out over the Aegean sea to the Cyclades and is part of the same geological unit. The bedrock here is marble, geologically similar to that of Mts Penteli and Hymettos to the north and the islands of Naxos and Paros to the south. The temple of Poseidon was constructed of a grey-veined white marble, which was quarried at Agrileza 3 km to the north, a place also famous for its silver mines (see Lavrion).

* Pikermi - Gorge rush - The first fossil hunters.
Neogene A. Mayor 2000
Voulagmani lake - geological interest