LIBRARY OF ART

PUBLISHER - DIRECTOR: GEORGE RAYAS

FROM PENTELICON TO THE PARTHENON

Texts, drawings and lay-out: MANOLIS KORRES
English translation of Part I and Appendix 1: D. TURNER
English translation of Part II and Appendix 2: W. PHELPS
Editorial Supervisor: LAMBRINI VAYENA-PAPAIOANNOU
Artistic Advisor: RACHEL MISDRACHI-KAPON

~~Artistic Advisor: RACHEL MISDRACHI-KAPON~~

ISBN 978 960 204 017 1

MANOLIS KORRES

FROM PENTELICON TO THE PARTHENON

The ancient quarries and the story
of a half-worked column capital
of the first marble Parthenon

MELISSA Publishing House

CONTENTS

PROLOGUE
7

PART I
NARRATIVE AND PICTORIAL RECONSTRUCTION
9

PART II
EXPLANATION OF THE PLATES
61

APPENDIX 1
Testimonies
116

APPENDIX 2
The *Quarry of the Nymphs* on Paros
120

Table of contents
122

List of Figures
123

Select Bibliography
124

Indexes, Glossary, Greek pronunciation, etc.
127

PROLOGUE

There are few visitors to the Acropolis who have not paused to ponder how the large masses of marble used for the monuments were originally hauled up the sacred rock. Those somewhat more familiar with the subject may regard such speculation as superfluous, scoffing at times at the visitor's perplexed questions which appear to betray a failure to understand that the Acropolis monuments are much more important as achievements of art and of the intellect, rather than simply as products of manual labour. Nevertheless, the detractors are equally mistaken in insisting that attention should be paid only to the purely immaterial and intellectual part of the achievement, and in almost overlooking the manual as of little import. But it would appear that whether admirers of manual labour or not both groups have one thing in common. They perceive only a few, and indeed the most easily comprehensible, of the technical questions involved in ancient architecture. They ignore that certain other stages of the work such as quarrying and transport were much more demanding than that of raising the marbles into position, and that an even greater accomplishment, and the most difficult of tasks, involved the final smoothing and joining of the blocks.

These ever spiralling technological achievements, however, do not end with the assembly of the blocks. Even more important feats were evinced in the field of metal workmanship involved in the manufacture of stone-cutting implements. Judging from the quality of the marks left by these tools on the marble they must have been of a quality much higher than that of their modern counterparts. It would appear that in antiquity certain craftsmen had, after much systematic experimental research, discovered unsurpassed metallurgical processes. Knowledge of the contents of these processes is denied to us today along with so many other secrets that were lost with the decline of the ancient world. With modem day stone-cutting implements, construction of the Parthenon by the same stone masons and sculptors would require at least double the time, and the quality of the surfaces would not approach the level of perfection left by the ancient tools. Work, indeed, would evidently have remained unfinished due to the intervention of the Peloponnesian War, and the Propylaea may never have been built, since the Parthenon's completion was a basic prerequisite for its construction! Using the unique quality of ancient stone masonry and the structural bulk of the Parthenon as a measure, it is a simple matter to prove that it would be impossible today to complete construction in so perfect a manner in the astounding time of eight years. And this even were we to allow for the employment of the same number of experienced craftsmen, and even if petrol-driven vehicles replaced waggons, or electric cranes were used instead of manually operated ones. However strange this conclusion may sound, it is well documented: for when the greatest possible demands of refinement and constructional accuracy are made for a building such as the Parthenon, the final stages in the preparation of each block, of each column, of each sculptured figure and so on, demand far greater work than that involved in the first stages where quarrying, transport and hoisting of the blocks constitute simply one part of the process. Therefore, it has been calculated that in the case of the Parthenon, the use of an ancient wooden crane instead of a modem electric one would constitute a disadvantage of economy not greater than 3%, while the use of waggons instead of petrol-driven vehicles a disadvantage of between 10 and 20%. However, the ancient tools' unique metallurgical quality combined with the incredible technical prowess of the ancient stone masons constitute, when compared to present methods and standards, an advantage which quantitatively exceeds 100% and qualitatively remains incalculable.

All these technical means, however, were not taken for granted by the ancient architects and sculptors in the same way that draughtsmen's equipment, manufactured mechanisms, commercial building and other material, not to mention the mediocre abilities of present day construction workers are taken as a matter of course today by modem architects. An ancient architect was quite often responsible for the planning of the mechanical means used by his craftsmen, as well for establishing standards of manual labour for them. A good quarryman would quite often bear in mind a few of the problems faced by the sculptor or the architect, and made calculations which demanded considerable thought. He had to observe, evaluate, and handle a very difficult material. He had to comprehend complex combinations of geological, geometrical, artistic and mechanical factors. A worthy craftsman had, generally speaking, a broad range of theoretical interests and when these combined with exceptional talent a career as an architect was by no means impossible. Finally, all these factors had to operate within a perfectly organised system of work and production which in itself represented an exceptional intellectual undertaking. Unfortunately, this achievement has till today remained almost ignored since it is perceived as being neither artistic nor imbued with ideals. On the other hand, now more than at any time in the past, analogous questions arising from how a group, workshop, or even an entire society operates have given rise to specialised studies and serious political speculation and action on such matters. Why, therefore, should a great project be arbitrarily divided into higher intellectual and lower manual or "managerial" components? Why should those who in their own field were gifted with all those characteristics that go to make up a creative artist —even a minor one—be considered ordinary labourers?

The following pages are devoted to precisely these minor but important craftsmen and to that combination of boldness and imagination that manifested itself in the physical exertion of their bodies. Although this exertion may have corrupted their mortal selves, the task came to be rewarded not simply with a day's wage but with that eternity which only the natural immortality of Pentelic marble can secure.

The first part of this book constitutes a freely written account reconstructing the process whereby an eleven tonne Doric column capital was quarried and transported to Athens, relating its adventures as they interweave themselves with those of the people and the city in general. The second part contains analytical scientific documentation of the first part, and constitutes the most extensive archaeological study on the Pentelicon quarries yet published.

Sadly, modern exploitation of Pentelic marble, beginning slowly (1834-1940) and reaching a feverish pitch in the post-War reconstruction period, has taken place for the most part at the site of the ancient quarries, resulting in about 90% destruction. Amongst the extant remains of the ancient quarries are many—often huge—cuttings, rock faces and pits, carefully formed dumps for chips and flakes, ancient roads and so on. All these are mostly situated in a continuous zone almost three kilometres long along the south side of the central mass of the Pentelicon, as mount Pentele (modern Penteli) is also known. The second half of the book reconstructs this zone as it would have appeared in antiquity, describes phases of its development, how production was organised, how the marble was moved, the nature of tools and the means of transport, along with the terrain along the road from the Pentelicon to Athens.

The story of the half-finished column capital, as presented here, came about as a result of a consecutive series of external factors. Nevertheless, I feel satisfied that it fulfills a long standing desire of mine. Therefore, I would like to thank firstly those who encouraged me in this undertaking: D. Kalapothakis, D. Korres, M. Spyratou, K. Chatziaslani and especially my wife K. Korre. I also owe thanks to T. Biles and M. Magnisali for the invaluable help provided by their studies on the reconstruction of the ancient quarries, to K. Koveos for useful linguistic suggestions, and to professors C. Bouras and G. Gruben for the discussions on the subject they were kind enough to have with me.

For the Munich Glyptothek exhibition of the original drawings which appear in the first part of this book and the publication of the catalogue Vom Pentele zum Parthenon *(April–December 1992), I warmly thank the Board of Directors of the Glyptothek and the Collection of Antiquities, in particular K. Vierneisel, B. Vierneisel and U. Moll for the preparation of the exhibition and the German edition.*

Likewise I warmly thank professor L. Marangou, the Board of Directors of the Museum of Cycladic Art, Athens, and especially its president Mrs. Dolly Goulandri for presenting a slightly revised version of the exhibition in Athens (December 1993–May 1994). This consisted of two parts, of which only the first corresponded to the original. The old title was, nevertheless, retained: From Pentelicon to the Parthenon.

I greatly thank the following persons who contributed to the realisation of the present publication: Mr. W. Phelps and D. R. Turner for the English translation, the philologist L. Papaioannou for editorial supervision, prof. D. Philippides for generously reading the manuscript and for his suggestions, Mr. G. Karianakis for checking the galleys, Mr. A. Tsourinakis for the computer processing of the texts, Mrs. R. Misdrachi-Kapon for her valuable editorial advice, and especially the director of Melissa Publications, Mr. G. Rayas.

Finally, I should like to take the opportunity to thank A. Galanopoulos, E. Protonotariou-Deilaki, I. Dekoulakou, M. Doris, H. Kapsoulis, B. Petrakos, S. Tarantou, D. Tsiouvaras, and T. Chatzitheodorou, with whom I was fortunate to work in an attempt to save the ancient quarries from destniction and ransacking. These dangers make the present publication all the more urgent, in particular the analysis in Part Two which, without being exhaustive, responds to the need for an initial presentation and interpretation of the subject. New and more detailed studies to be undertaken by others are thus now a desirable objective. At the same time, I hope this book helps to underline the ancient quarries' immense value as historical monuments to the technology of this land's most enlightened age.

M. Korres, Athens, July 1993

PART I

NARRATIVE AND PICTORIAL RECONSTRUCTION

Only five years have elapsed since the unforgettable battle of Marathon. The changes are clearly visible in the heart of Athens on the Acropolis, and can be discerned even from as far away as Aegina. The oldest of the poros stone temples of Athena can no longer be seen; giant scaffolding rises up high around three of its sides. The Athenians are replacing it now with another much larger temple which likewise will be in the Doric order, as tradition has prescribed for all the other temples in Athens. Nevertheless, poros stone, Doric architecture's material par excellence, will not be used for this new structure. Instead, another material commonly used for Ionic buildings in the Cyclades and on the other side of the Aegean will be employed—marble! For the first time marble will be used for the entire superstructure of a building and, indeed, on so large a scale. Its solid base and foundations, made of very large finely cut blocks from the quarries of the Piraic coast, are 260 feet long and 40 feet high. The scaffolding rises along almost all the foundations' length, hinting at the new temple's bulk. Slightly to the north stands the newer and larger poros stone temple of Athena which, while always visible from any location in the Attic basin, appears suddenly quite small next to the marble temple's gigantic scaffolding.[1] But there is another change in the landscape, this time outside the city, which is visible from every direction. South of the crest of the Pentelicon, about half way down the mountain, a massive quarry of considerable depth grows larger by the day. Despite its size, this quarry is also quite new, having been created only to provide marble for the new temple.

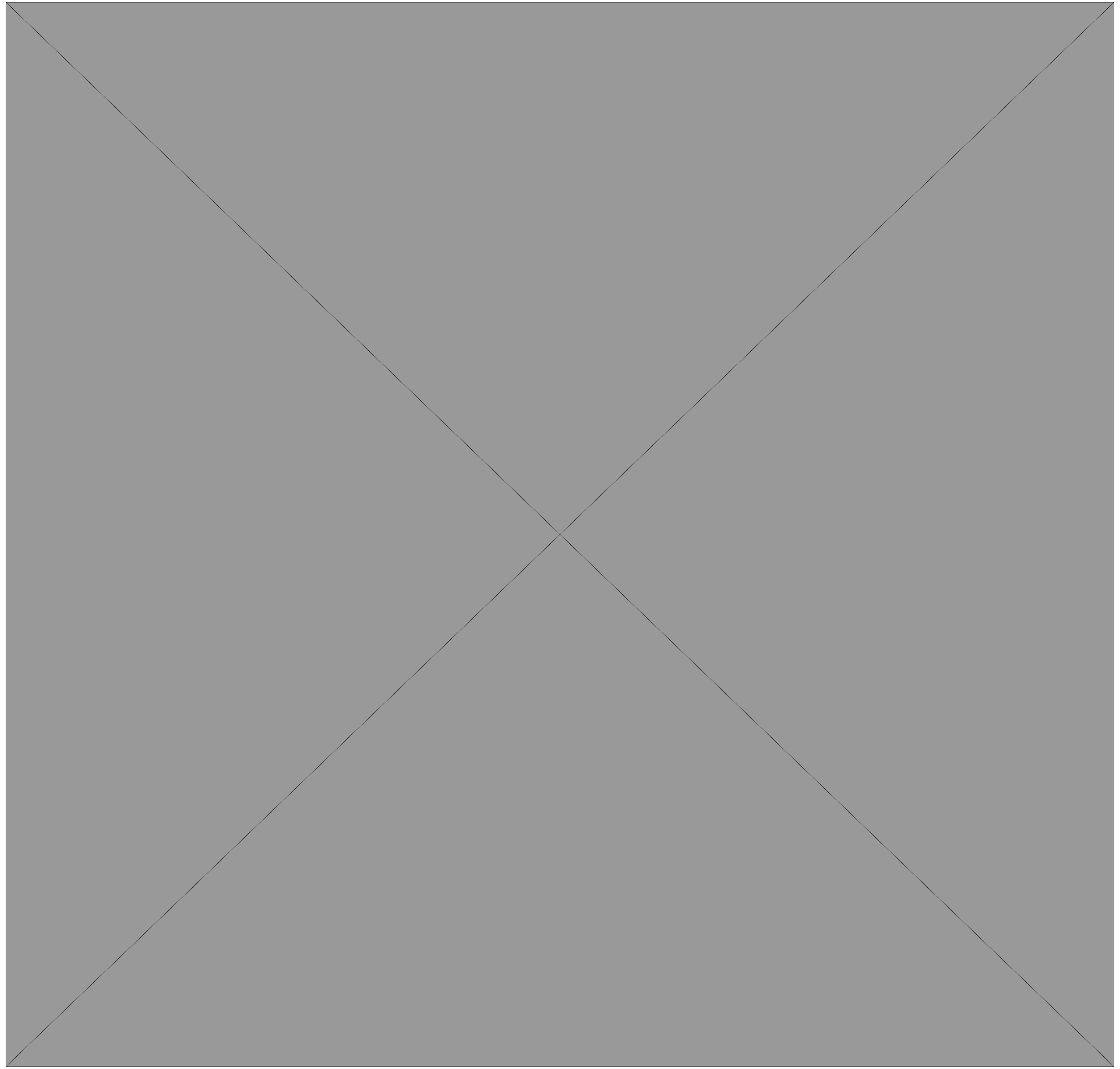
Prior to this quarry, only a small area on the surface had been exploited for statues and small architectural members. Objects such as these do not need large quantities of marble, although the highest possible quality is demanded. This and various other reasons meant that from the time of Peisistratus, and especially of his sons, imported marble, usually Parian, had been preferred. At an even earlier date, marble was imported from Naxos. The best Hymettus marble was also used in small quantities, again mostly during Peisistratus' time; but despite being carefully chosen it was always inferior to the Cycladic marble. Till that time, then, no marble quarry had ever been so large and so deep as to be a clearly discernible feature within the natural landscape. The hard stone quarries in the city hills were much larger, the famous Barathron for example, and even more so the poros stone quarries on the Piraic coast. Of the structures made from this material, the largest now is the half-finished temple of Olympian Zeus, 370 feet long and with columns eight and a half feet in diametre. This was the most ambitious architectural project undertaken by the state towards the end of the Tyranny and all are aware that work on it had been halted with the advent of the Democracy. Located to the east of the city it still stands out impressively and, as with the Acropolis, is visible from afar despite being built on low ground. Nevertheless, it remains a forgotten monument. Now the ambitions of the state are concentrated on the Acropolis. The building surrounded by scaffolding, which will honour Athena for the victory and salvation of the homeland, progresses rapidly. Thus even as the lower column drums are being positioned, the builders must begin to prepare the column capitals so that they may be ready when the last drums of the columns are put into place.

2. *The Pentelicon quarry*

Extraction has already reached a depth of 60 feet in the middle of the large marble quarry. The deposit extends clearly along all sides, although natural fissures, some vertical and others diagonal, break the continuity. Although these fissures set the size limits for the masses of extractable usable marble, at the same time they help make quarrying easier. The distances between fissures are not constant. In some places they are small, rendering the marble useless. At others, they are very large and necessitate the carving of deep channels to separate the stone into required sizes. The marble's most important quality, however, involves the ease or difficulty with which regular scission can be made in either one or the other direction. Knowledge of how to exploit this quality remains one of the basic "secrets" of the mason's art. In wood, one quickly becomes experienced in recognising the same phenomenon since the directions in which scission can or cannot be made are clearly discernible. In marble, however, these directions are sometimes quite invisible to the naked eye. Another of the stonecutter's secrets involves knowledge of his material's invisible internal lithological faults, such as discontinuity. The quarryman must therefore carefully select the quarriable masses of marble, not only on the basis of simply calculating the distances between fissures, but also with regard to the more complex criterion of quality which involves not only the marble's resilience, but also its purity and responsiveness to precision workmanship.

Our experienced Athenian and foreign quarrymen are happy with the stone. Almost half of it is quarriable, but of this amount, of course, only a third ultimately will be utilised. The rest will be sacrificed at various stages of the work. The quarrymen should, however, still feel content since they could never hope for a better result, the original natural formation of the quarriable masses for the most part being very irregular and the scission surfaces uncertain. The same applies to all marble quarries when the demand is for masses of great size, regular shape and highly workable texture. The more experienced quarrymen, who have learnt their craft in the Cyclades and Ionia, speak about these and many other things. Naturally, the temple's architects are aware of the same problems, and probably visit the quarry regularly to inspect the stone and the work's progress.

Till now, about 150,000 cubic feet of marble have been extracted for the production of about 50,000 cubic feet of material that will actually be utilised. At least half of this has been transported to the work site and has been either positioned or awaits positioning.



3. *The marble for the column capital*

Down in the middle and deepest part of the quarry, a large mass of marble has attracted the attention of the experienced quarry foreman. For days now he has been calculating whether this potential block of marble will suffice for the production of yet another capital for the temple’s exterior colonnade.

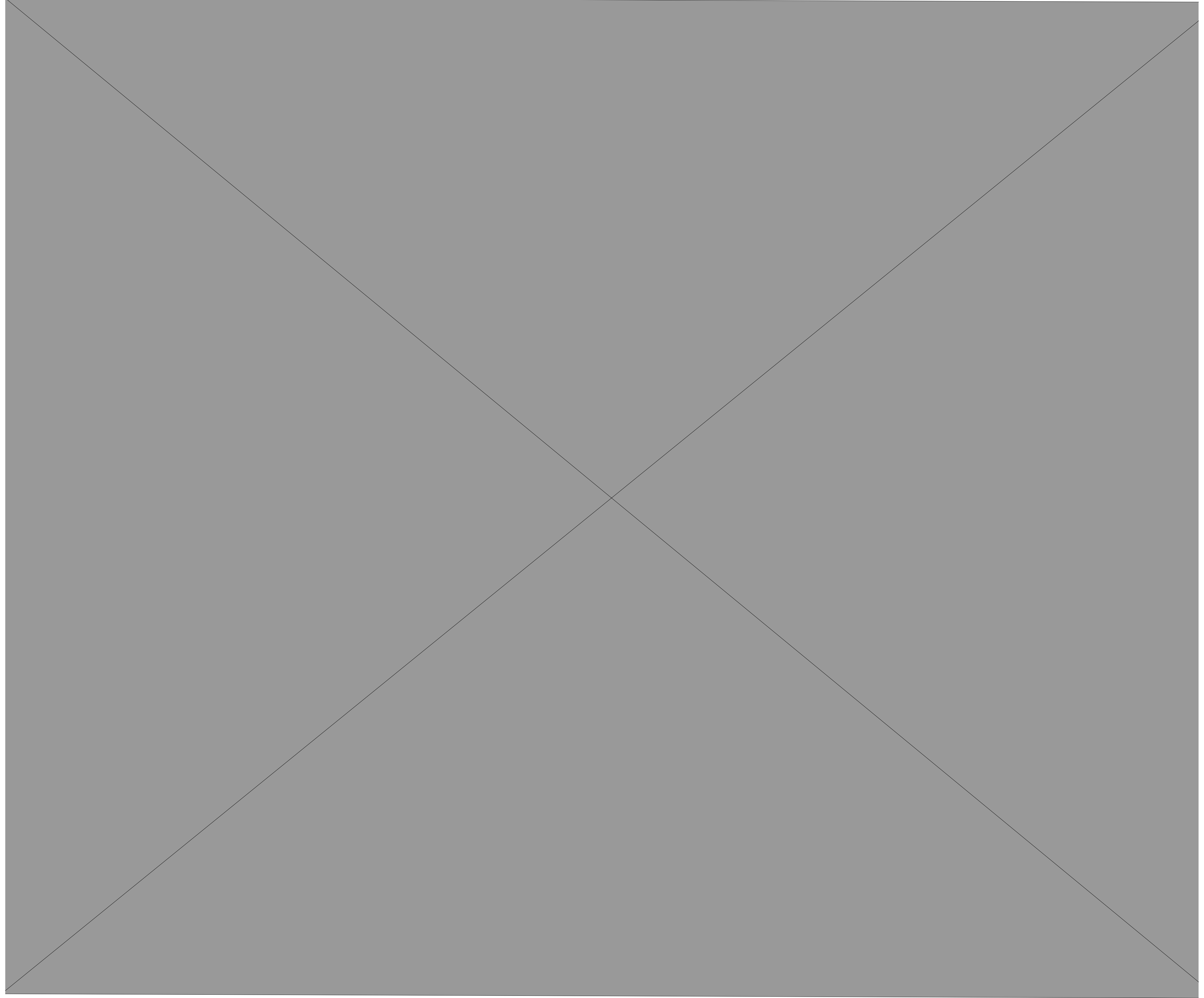
The quarry foreman observes that the block is clearly divided from its parent rock. Two sides are exposed and the others are defined by natural fissures.

The crack dividing the block from the vast subjacent mass of rock protrudes slightly, while its visible extremities indicate that it is quite regular.

The foreman, trusting in his experience and highly developed skills of observation, hopes that the work of splitting and extracting the block from the parent rock will not prove as difficult as it has been in a few other instances of marble blocks of this size.

4. Sockets for wedges and levels

After at last taking a decision, the foreman gives directions to the specialist masons and they, in turn, begin preparations for the first and most difficult task: splitting the massive block from the parent rock. Appropriate locations for the insertion of wedges and large levers are selected along the length of the natural fissures and cracks that define the block. Here the masons cut deep sockets into the rock, carefully trying to ensure with precision that the distances between the sockets are correct, and in particular that the surfaces to be cut converge exactly. Many days are needed for this particular task.



5. *Splitting the block from the parent rock*

Now the most difficult task is to be undertaken. Firstly, however, the iron wedges have to be tested to ensure that they fit neatly in their sockets where they will be sandwiched between iron splints. Then weighty iron levers[2] capable of multiplying the applied pressure of a work team by up to thirty times are placed in position.

With perfectly regulated rhythm, the quarrymen begin pounding the wedges, slowly at first with sporadic short blows. The wedges initially enter the rock without much difficulty, but then hammering becomes more difficult and finally progress is almost imperceptible as the wedge is driven between the iron splints. Slowly but steadily, the reverberations of metal clashing upon metal rise from low, muted tones to a shrill ear-piercing pitch. Following a short pause to inspect the depth to which the wedges have been driven, and after a few more blows are given to some, the most experienced of the quarrymen gives the order for the next stage of the work to begin.

Now four *baries*, heavy metal mallets weighing all together some four talants of iron, all swing in an arc through the air and, all together, pound the wedges. With complete control, the quarrymen wield their mallets with admirable coordination for quite some time, and the regular repetition of the hammering becomes almost unbearable. Now the climax approaches in the struggle between man and rock. The sound of deep human breathing rivals that of the stormy hammering while sweat covers the quarrymen's muscular bodies.

After hundreds of heavy blows on the wedges[3] from the heaviest of the *baries* and much superhuman pressure applied on the levers, muffled creaking announces to the tenacious quarrymen that the mass of marble is ready to part from the parent rock.

The experienced quarryman's ear is trained to recognise the changes in the creaking sounds which emanate as the block begins to split away, sounds with hidden messages of great importance for the work's success.

The sound of the creaking becomes clearer, lifting the quarrymen's spirits. Resistance has begun to lessen. Gradually, but steadily, the fissures begin to loosen their hermetic hold as clouds of exceptionally fine dust rise with every new blow of the mallets.

A brief pause, then the attempt continues with greater patience in a calmer atmosphere. Slowly but surely, the fissures open up, so much so, that some of the wedges fall into the ensuing gap, whereupon wedges with a larger base take their place.

6. *Preparation for cutting away excess marble*

After the large block has been pried away and its fissures have begun to loosen up, work continues with an ever greater reliance on the large levers. With each small increase in the gap left between the block and the parent rock, slabs of rock are inserted to provide a constant base for the application of force using the levers. After many hours of exhausting work, the gap, so small to begin with, has become wide enough to allow the quarrymen to stand inside it, for now they must work behind the block. A basic requirement for the extraction of this specific mass of marble is that before any attempt can be made to remove the superfluous upper surface, the rough block itself has to be accessible from all sides. The quarry foreman knows that in cases where the excess marble of a such a block is quite extensive,[4] it is preferable to remove the first rough layer by cutting away individual pieces, rather than removing it in one piece. He is also aware that these pieces should be as large as possible to economize on labour time, but also because large fragments can themselves be used for the carving of other architectural members. The foreman wants the excess marble to be used in the most profitable way, and thus the back of the block has to be pried free with the use of wedges on all four sides.

After carefully inspecting the surfaces on the back of the block, the foreman incises a few lines to act as markers for the next stage: the cutting away of the superfluous mass in pieces of the greatest possible size. The shape and incline of the veins in the marble appear to promise that almost the entire upper part of the block can be removed.

Later on, four of the most experienced quarrymen take on the task of executing this new stage. For five days they prepare recesses, deep grooves and 21 sockets for wedges. This work is very tiring and rather monotonous. But opportunities for some distraction are not lacking, even in the depths of the quarry. Jibes are exchanged now and then, and friendly competitions of dexterity held. Then there are the short but frequent visits to the quarry's iron workshop where worn tools are being constantly replaced with repaired ones; breaks are taken for a very frugal meal, and the men may be needed briefly for other jobs which demand a large group effort. At midday, a short but refreshing sleep boosts the spirits, but not before chats about the latest events, the weather, the meaning of dreams and much more.

Finally, everything is ready for the scission of the first large piece of excess marble. The wedges are positioned and the incessant repetitive hammering immediately begins. The work continues with great care, since all the wedges must be packed into their splints at approximately the same rate to ensure an even distribution of applied force.

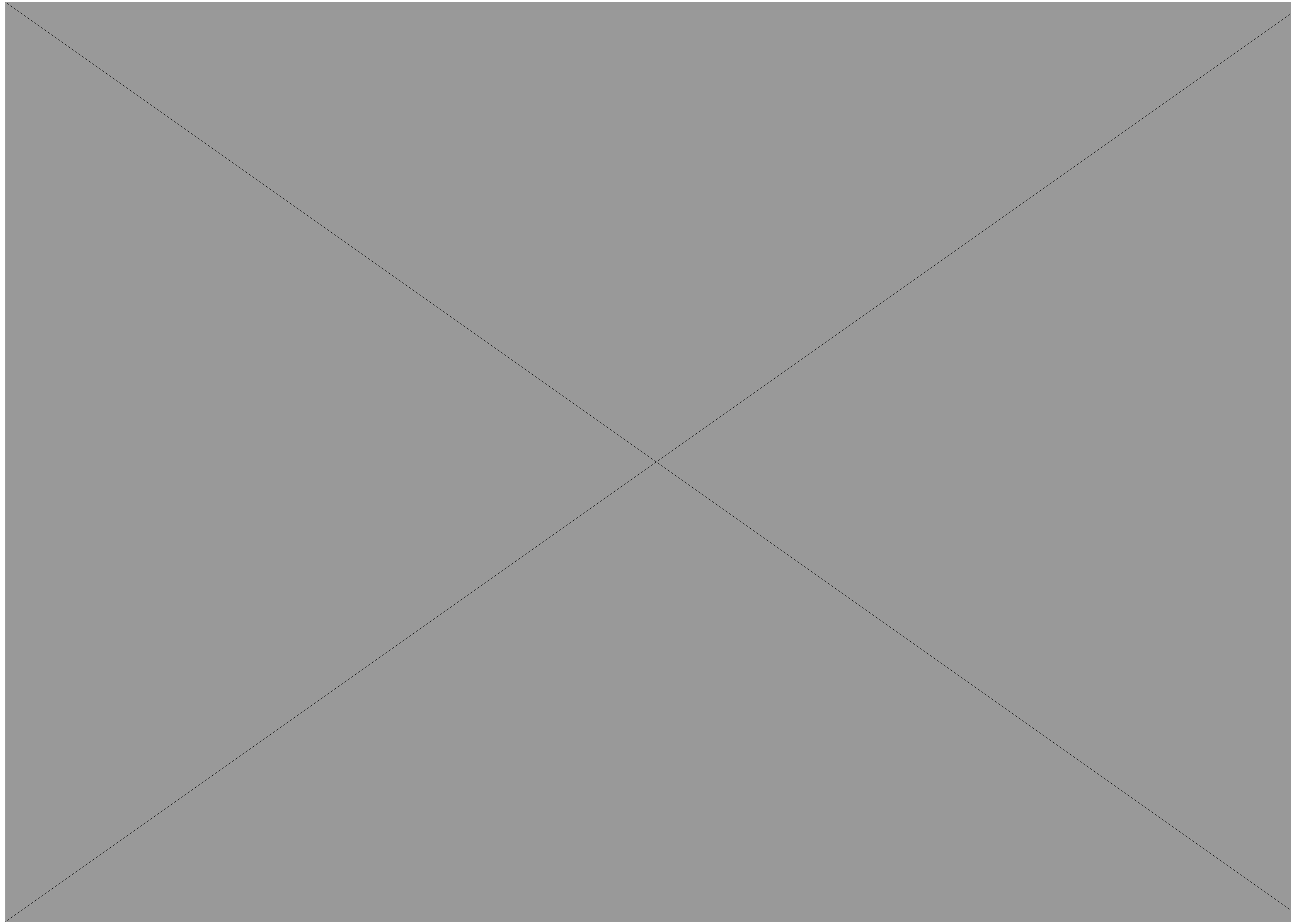
7. *Removal of more excess marble*

Following the initial removal of excess marble, other larger sections are cut away using wedges and grooves incised along the line where the stone is to be cut. The position of these incisions is calculated with the utmost care by the master mason so that the conceptual shape of the large column capital can be more closely achieved in that position within the block where the marble's exterior features show it to be most compact, regular and, most importantly, free of harmful fissures, internal faults or interruptions of its crystalline texture.

While the excess marble is roughly removed from around the future column capital, fissures and other natural imperfections must be identified in time so that skillful changes can be made in the direction of the cutting so that none of these imperfections should appear in the final product. The master mason learnt much about this problem from his old teacher, a truly worthy—albeit unlucky—craftsman from the islands with whom he had worked closely for a few years at Delphi and on Delos. This man had lost his life in unknown circumstances—which still baffle those who knew him—but his teaching lives on. Many a time he would say, "the best thing to do is to arrange the work at the quarry in such a way as to ensure that faults appear only in the excess marble and not in the main mass", and he would add: "Should this not be possible, the faults should at least appear in the least susceptible, exposed or stressed points of the final product, they should never appear in the exposed protrusions of the final shape."

The master mason calmly examines the excess fragments, and is almost certain that they can be used in some capacity on account of their size, the incline of their geological texture and their quality. He probably thinks that the fragment to the right of the block could be better used for a section of the east pediment cornice, and that the piece to the left would suffice, if carefully fashioned, for the production of two regular *primores*, or large sima tiles.

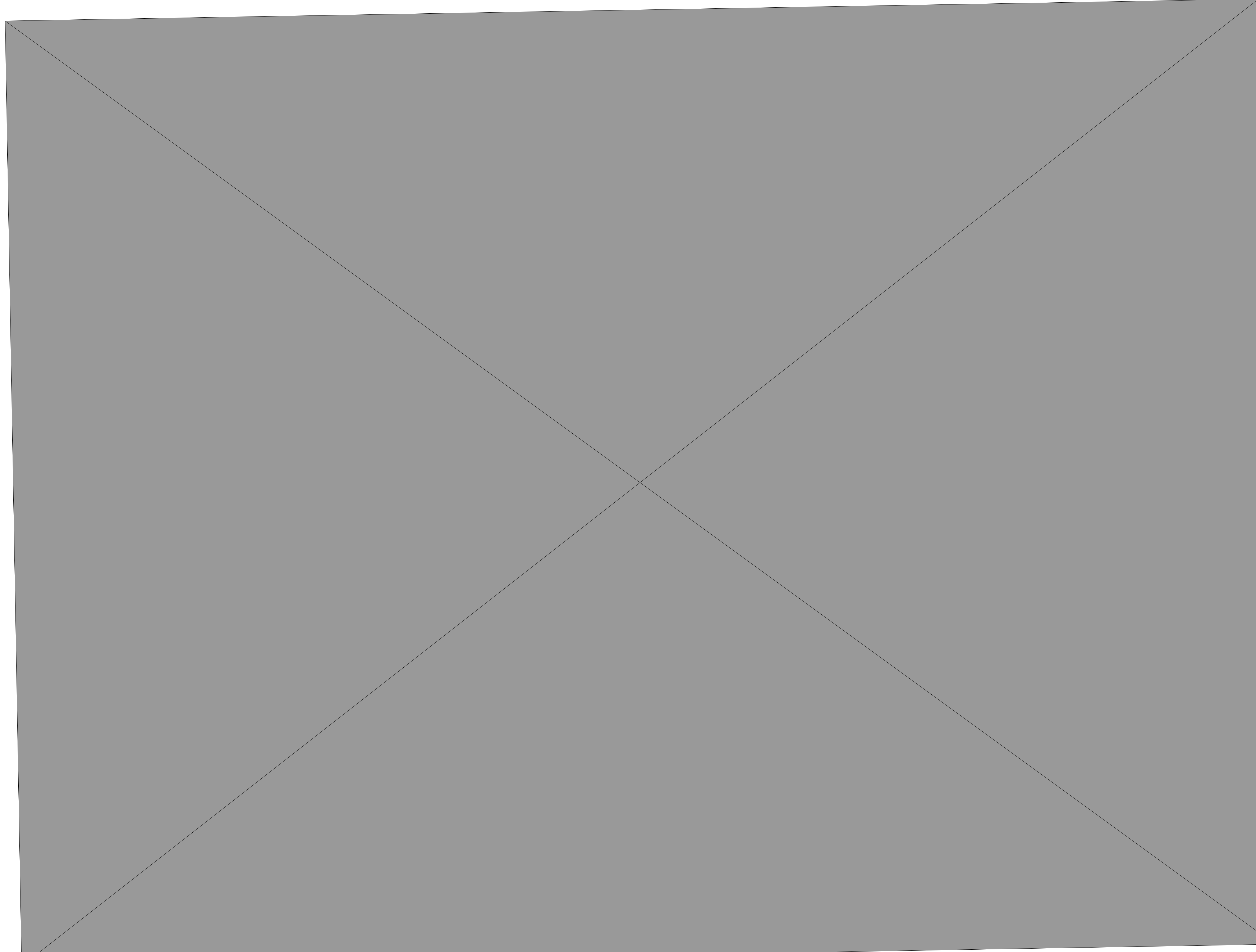
With great care and a certain general anxiety, he examines the main mass of marble.



8. *Squaring of the block*

On the next day the large pieces of marble that were cut away from the block are removed so as not to hinder work. Immediately after this, a new stage in the work begins: all sides of the block now have to be carved to arrive at a relatively smooth surface. The block is still irregular in shape and the thickness of the superfluous layer to be removed varies from place to place. New, more precise measurements and geometrical estimates are now made. This work was entrusted to two very good craftsmen who had come to the quarry only a few months ago having been highly recommended by a Parian merchant acquainted with the quarry foreman. The foreman, however, wanting to make up his own mind about the newcomers, assigns various tasks to test them over a period of a few days. Now he is in no doubt as to their professional acumen, having seen the skill with which they handled the tools of their trade. On the other hand, they are not very well acquainted with the geological peculiarities of Pentelic marble, being far better acquainted with Cycladic marble. But this seems to be much less of a problem than that presented by the newcomers' character. One of them is rather haughty and aggressive, and does not appear to be popular in his new working environment. The other gives the impression of being shy, even though he attempts to inspire respect by stressing at every available opportunity that he is the nephew of the architect who erected the largest temple in the Cyclades. His uncle had transported and positioned the four marble blocks for the temple doorway. "Those monoliths were amazingly heavy, a thousand talants each!" The others listen carefully without always being able to hide their admiration, or jealousy. In order to avoid possible conflict between the newcomers and the others, the foreman prefers to have them working by themselves. Their colleagues, however, often approach them with feigned indifference that sometimes fails to hide their deeper curiosity as to what professional secrets the newcomers may know.

Their self-confidence clearly discernible, the two craftsmen prepare for work by first making some careful measurements. Immediately after this they carve channels on the block's upper surface to act as guidelines for further cutting. Then they carve vertical guidelines at the four corners which help in levelling the sides and also serve to establish the exact boundaries for the underside.



9. ***Overturning the block to work on the underside***

The preparation of a block’s upper surface and the carving markers indicating the eventual position of the corners is usually followed by turning the block over to facilitate rough preparation work on the underside. The same process is necessary during the preparation of the column capitals.

After inspecting the block again, the craftsmen use powerful levers to lift the block momentarily, placing a few cylindrical iron rollers underneath it to help move it, even though the lower surface’s natural anomalies make the rollers less than fully effective. Resistance, at times moderate and at others great, is eventually overcome by the superior power of a few levers and two winches.

The block is then dragged to the edge of the subjacent parent rock shelf where the applied force of winches, not to mention its own massive weight, cause it to fall upside-down with a great crash onto the surface below, sending clouds of dust into the air. The surface where the block falls has been prepared to cushion the impact with strong timber beams and a pile of marble chippings. The beams will facilitate the block’s future horizontal movement.

10. ***Stages in the formation of the column capital***

The future column capital is now much lighter, not weighing more than 25 large bulls(!), and lies upside-down some distance from where it was extracted. Work will now proceed to provide it with as perfect a geometric shape as possible.

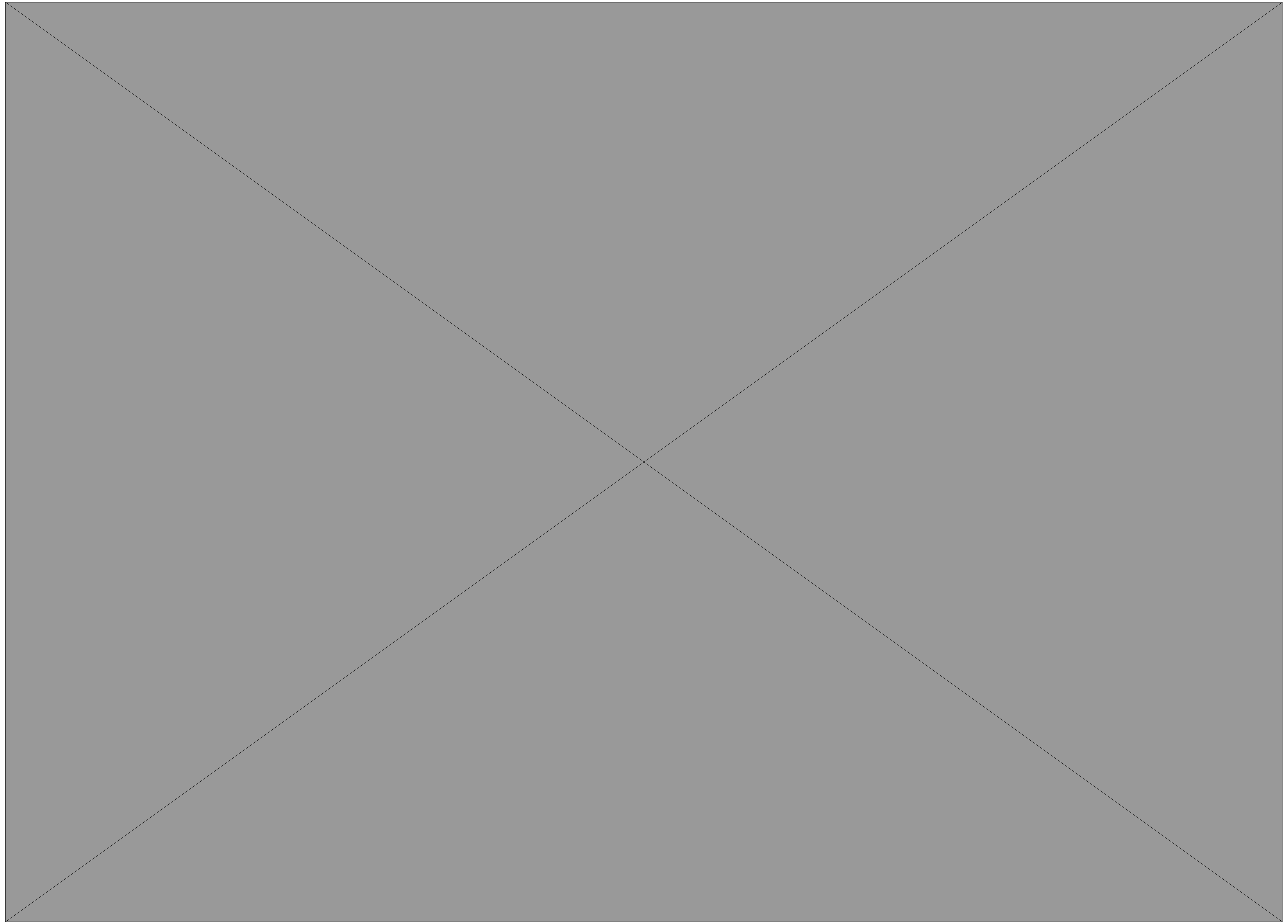
As with any geometric construction many stages are involved here, beginning with defining the basic reference surface, then continuing with locating a centre and two basic drafted margins, establishing the vertical central axis and so on.

Rulers, callipers and various squares and angles[5] are indispensable tools constantly used in the patient work of roughly cutting the marble. Removal of the excess surface always involves use of the *tykos*, a heavy pick with a long sharply edged stylet. The *kopeus*, or pointed chisel, is always used for carving the drafted margins along which the excess marble will be cut.

The column capitals made for the first marble Parthenon were larger than those of the newer Parthenon.[6] A half-finished column capital, as transported from the quarry, weighed almost 500 talants (twelve tonnes). The block’s weight was naturally much greater in the earlier stages, from quarrying up till the carving of the half-finished shape.

As far as this column capital is concerned, the initial mass of marble, which gave so much trouble to the quarry foreman, must have weighed not less than 1,600 talants (40 tonnes). If we detract the 500 talants of the column capital and the 100 to 200 talants from the large fragments initially cut away, we are left with a further quantity of useless material and chippings[7] which, if loosely piled up together, take up almost as much space as the initial amount of compact marble.

The time required in the quarry for this impressive work of extracting and carving marble blocks into a half-finished column capital must have been about two months. Four to five days were needed for the sockets of the original wedges, the same amount of time for the grooves and other wedge sockets, a few days more for splitting the block from the parent rock and moving it for the first time, another five for removing the large fragments of excess marble and many other smaller pieces, a few days to move it here and there and many more for the repetitive stages of fashioning the capital itself.

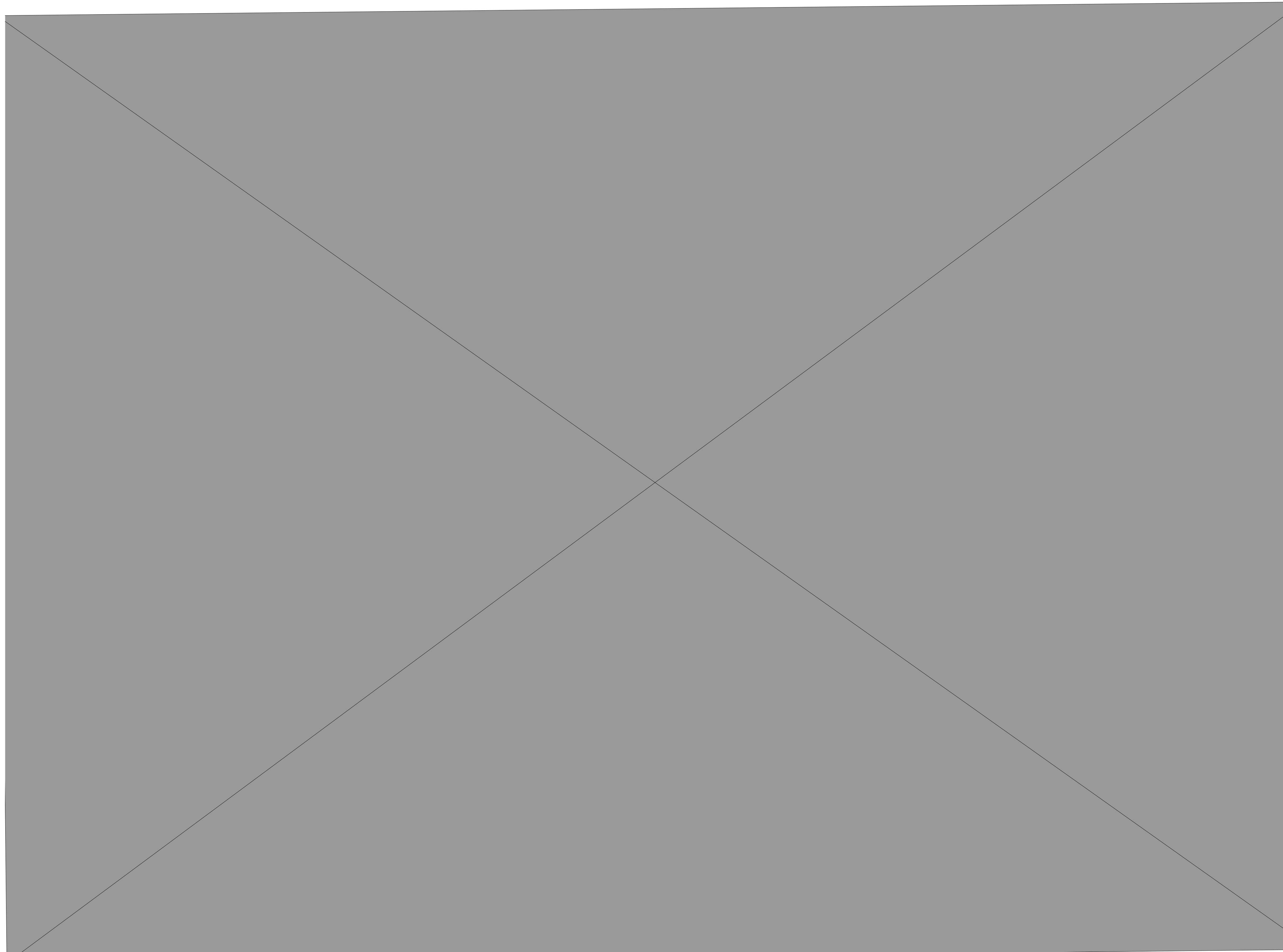


11. *The assembly of a timber sledge for the half-finished column capital*

The number of quarrymen needed at any one time obviously depends on the nature of the work to be done. Three to five are sufficient for the various tasks involved in cutting sockets. Many more are needed, however, to break the block away from the parent rock, not to mention moving it to and fro afterwards, work which demands rope, pulleys, winches, a variety of levers, wooden beams, rollers and other implements. At last the day arrives when the half-finished capital is ready to be transported to the Parthenon work site.

Once again, the tireless quarry foreman inspects it closely. The marble is impressively pure, as is the quality of the finish. The smile, that only the contented craftsman knows, begins to rise to his lips. But all the same, something still troubles him, and not for the first time. Almost from the outset, his experienced eye had discerned an extensive fissure passing through the original block. This means that he needs to be extremely careful in selecting the capital's position within the original marble mass. Since the capital cannot fit completely on either side of the fissure, the latter has to run through its centre and nowhere near the exposed edges. He thus believes that the fissure should not obstruct the capital from bearing the heavy loads that it will have to support. The foreman's final decision, however, is influenced by the marble's otherwise excellent appearance. After thinking once again for some time, he gives orders that preparations should be made immediately for its transport.[8]

Early in the morning of the next day, the quarrymen, equipped with massive wooden levers of great strength, gradually begin to lift the capital. Bit by bit, they assemble large and small wooden beams underneath it to form a sledge, essential in the first stage of pulling the load from the quarry depths—a task which requires great effort—and then for the relatively simple procedure of moving it down to the base of the mountain.



12. *Hoisting the block to the quarry entrance*

A number of quarrymen complete a task begun the previous day. They flatten out or remove marble chippings and lay long timber planks along the corridor through which the sledge will be hoisted to the quarry entrance. Other quarrymen lay out two long and extremely powerful ropes. One end is fastened to the sledge, the other is wrapped in three or four loops around the sturdy wooden axles of two massive winches located slightly further up at the quarry entrance.

Both winches were made by the finest engineers of the day out of extremely sturdy and resilient wood. Being much more powerful than those used in boat building, they arouse awe in all who see them in action. But the ropes are also the pride of their makers, known as *kalostrophoi*, or rope weavers. They can withstand both the pull of the winches and the enormous combined weight of waggon and capital.

Everything being ready, the strongest of the quarrymen now take hold of the winch levers and, moving slowly, turn the axles till the rope becomes taut. Then they pause for a while for now the *phalanges*, very hard cylindrical oak rollers, must be placed properly underneath the sledge and a brake must be connected at the rear. The brake stops the sledge from backsliding.

The value of such detailed preparation is well appreciated by all in the quarry. The older hands often tell a story, amongst the many they never tire of reciting, where the sudden backward slide of a loaded sledge caused by a rope snapping resulted in the tragic death of a quarryman. No doubt, this led to the idea of applying a brake.

This accident is very much in the mind of one of the quarrymen entrusted with the task of constantly moving the *phalanges* from the rear to the front of the sledge, when suddenly the foreman in charge, an experienced man from Holargos, gives the final order that work should begin. The great mass of marble finally begins its journey.

The powerful winch axles slowly turn three times, creaking encouragingly. Sweat covers the winch operators who are already breathing rapidly. The sturdy ropes are now taut, like the strings of two enormous bows capable of shooting an arrow as big as a tree. But even so the load remains still. The winch operators apply even greater force till suddenly, before the fourth turn is completed, the great load, protesting with spasms and creaks, unwillingly begins to move to the quarry entrance, defeated at last by sheer human determination.

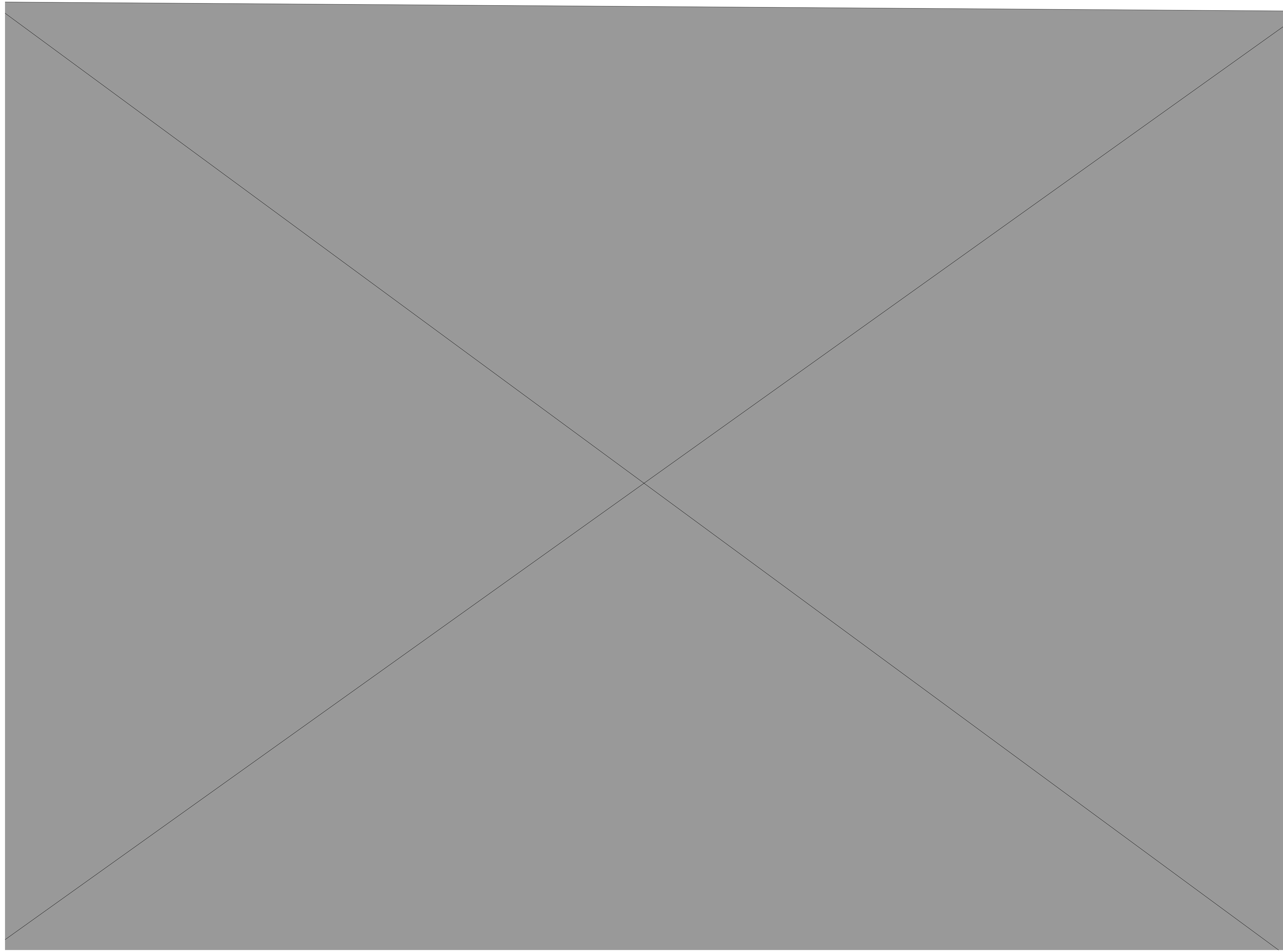
13. *Descent to the loading platform*

It has taken the quarrymen quite a while to take turns at the arduous work of operating the winches, but the great load at last reaches the apex of its ascent, whence the descent towards Athens now begins.

For tens of millions of years this mass of marble had gestated in the mountain depths. Now, seeing the light of day and being fashioned by beings more shortlived even than the surrounding shrubs, it bestows something of eternity to mankind.

By evening of the same day, the load has descended the straight and narrow, but quite steep, flagstone road to arrive at the point where it will be loaded onto a waggon.

The forces of weight and friction which have made the capital's ascent to the quarry mouth so difficult are precisely those which now facilitate its descent to the loading platform. The friction, acting against the sledge sliding on the steep flagstone road[9] and controlled slightly by greasing the flagstones with animal fat, is no greater than the weight's downward pull. Thus the descent can be made simply with wooden levers guiding the sledge while, in order to reduce acceleration, ropes attached thereon are slowly tied and untied around stakes secured at intervals in the rock.[10]



14. *Loading the capital onto the large waggon*

The sledge is no longer needed after reaching the loading platform. Since it is constantly being used, however, it must be returned to the quarry. Although we may hypothesise that the first such sledges were solid devices, they would not have been practical since many animals or winches would have been needed to drag them up to the quarry again. Naturally, such a task would either seriously reduce the amount of time available for work on the road, or would have necessitated a second such road.

We may suppose, then, that the sledge could be dismantled. The individual components, along with the ropes, could thus have been carried back to the quarry with greater ease, each of them loaded onto a few pack animals driven on paths a little beyond the flagstone road.

These mundane tasks take place a little before sunset at the same time as another work team undertakes to load the capital onto a large waggon which had arrived a few hours earlier. This very heavy waggon, known as *tetrakykle*,[11] is the pride of a renowned waggon-builder from Phlya, the Halandri of later centuries. It is perhaps the largest and sturdiest to have ever traversed the approximately 94 stades[12] from Athens to Pentelicon. The speed at which it travels is not much less than that of other, somewhat smaller waggons used for the blocks of the temple walls. This waggon, however, demands a well-built road that can endure heavy loads; also, it is far from flexible since many teams of pack animals are needed to draw it. Square and round masses are loaded from one side, while narrow or long blocks such as architraves are loaded from behind.

Loading the column capital proves relatively effortless thanks to the specially developed loading platform at the end of the road and the amazing skill of the quarrymen. Two sturdy beams, a few oak rollers and three or four levers are enough to move the great mass of marble onto the wagon.

15. *On the road to Athens*

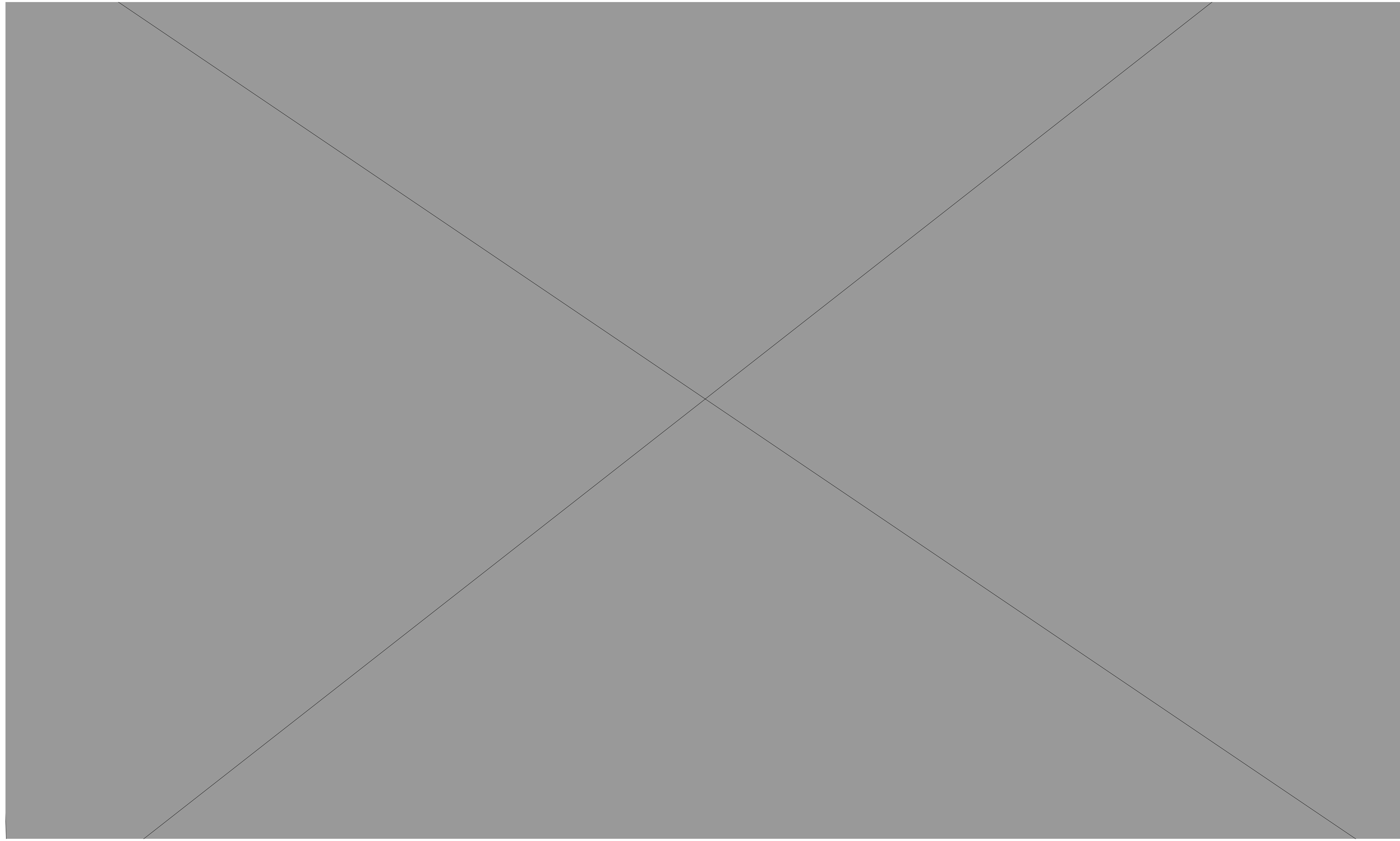
On the next day, early in the morning, the waggon starts for Athens. The mules were left to graze all the afternoon of the previous day and to rest. The prospects for the journey, the so-called *lithagogia*, bode well; the driver has inspected the road carefully to be certain that it is in good condition. Generally speaking, the Athenians always transported heavy loads quite some time after the rainy season. Then the roads were dry and hard and the longer days meant that the journey could be made without haste. Certain other possible obstacles and difficulties, often unforseen, were thus also avoided.

During the summer months the loads of marble coming back and forth from the quarry are a regular occurrence. If one were to make a calculation on the basis of the amount of marble used for the Parthenon[13] and the short period in which the temple was built, at least fifteen different waggons must have gone to and fro every day on the road between Pentelicon and Athens in the summer months.

But the waggon which now carries our half-finished capital, is perhaps the largest and most impressive to behold. At every point on the way, people leave their everyday chores and cares to devote a little time to gaze at the spectacle, some out of simple curiosity, others with awe and admiration, some with uneasiness and others still with scepticism. No one, however, remains indifferent when faced with the mechanical achievement of the waggon builders' art, not to mention the gigantic load of marble it now hauls.

Just before mid-day, while steady and almost effortless progress is being made thanks to the slope in the road, the hill of Lykabettos already looms on the right. The Acropolis, which for most of the journey has been hidden by this small mountain's pleasant aspect, now begins to appear in its entirety together with the rest of the city. In the background of this wonderful landscape shines the blue sea, its colours vying with the often praised clarity of the Attic sky.

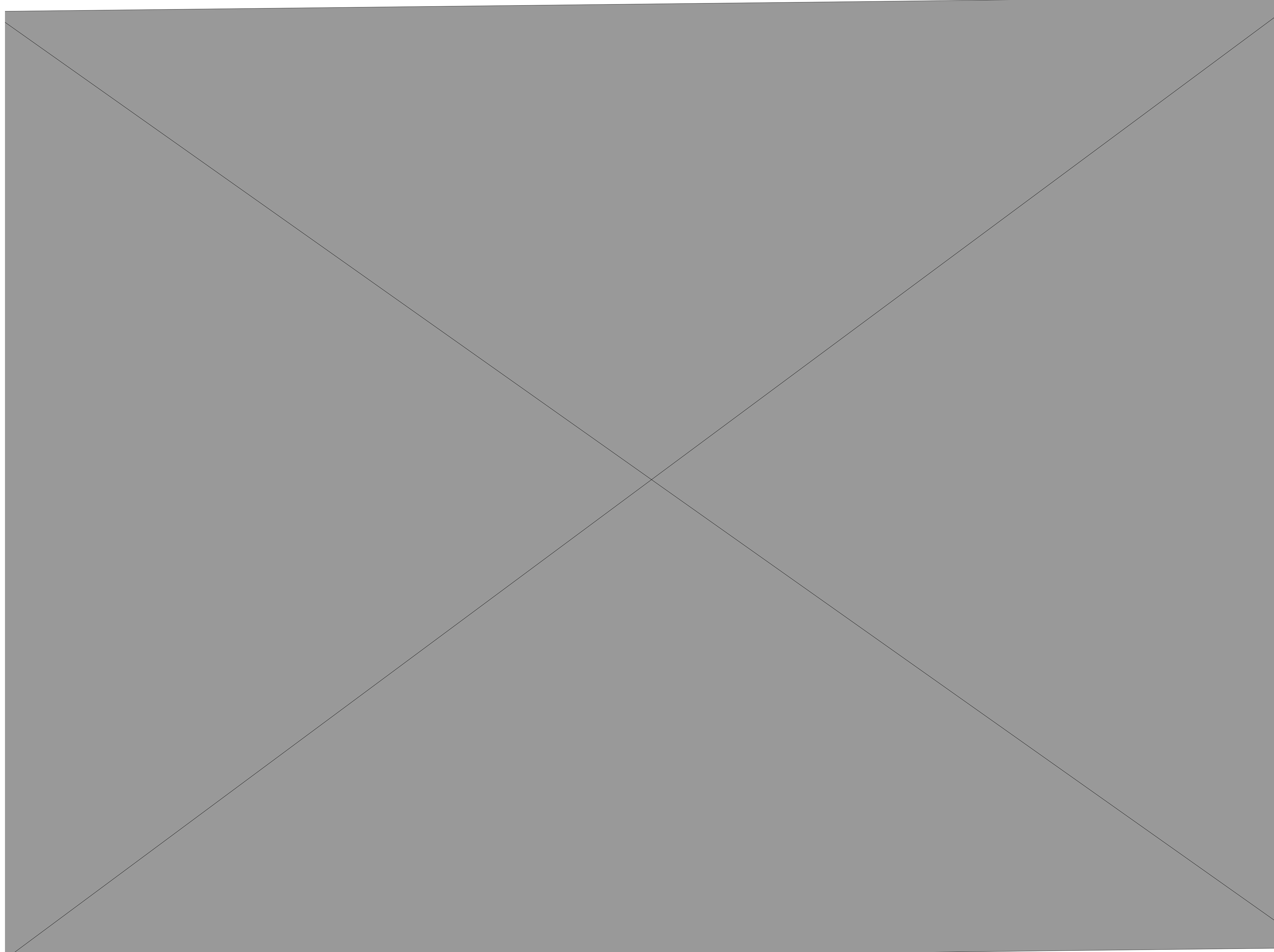
Despite the heat of the mid-day sun, many farmers stand to admire yet again the *pentelethen lithagogia*, the "marble transport from Pentele". Naturally their emotions are ones of happiness, not only for the splendid building programme being executed on the Acropolis, but also on account of the good harvest reaped during the last few days and the recent fine crop of well-ripened grapes from the vineyards on the slope of Lykabettos.[14]



16. *On the eastern outskirts of the city*

A distance of some ten stades remains to be covered till the waggon reaches the Acropolis. Thanks to the careful work of the road builders and the condition of the waggons, animals and men, the journey has been free of undue difficulties. Amongst the most serious of these in the past in terms of expense in time and money was the collapse of sections of the road surface, or the splitting of a waggon axle which could halt traffic for two entire days. Setbacks such as these, however, provided a valuable lesson for builders of road and waggon alike.

Twelve stades on and the road slopes down more steeply, but not enough to necessitate the use of the brake. The driver, the rein-holder and their assistants[15] now cast a melancholy glance to their left at the low but striking bulk of the half-finished but nevertheless gigantic Olympieion.[16] They know how that temple’s exceptionally heavy column drums were transported, not only from the stories told to them by their elders, but also from their own childhood memories. For the project had come to a halt only 25 years previously, and yet in their eyes it seems unbelievable that these blocks from the quarries of the Piraic coast,[17] of an even greater size and weight than our column capital, had been transported such a distance.



17. *Passing the south slope of the Acropolis*

The road continues its downward course for two stades. Now the waggon is within the city and trundles its way between the houses of the Athenians. A single stop is made, outside the shrine of Dionysos Eleuthereus[18] where fresh mules are harnessed onto those at the front that have pulled the waggon till now. They are needed now since the road begins to rise. Fortunately, the distance to be covered using the mules alone is very small: two and a half stades up to the great bend where the mules are unharnessed from the waggon and where the last and most difficult part of the ascent to the Acropolis will begin. The most awkward section of the road for the animals is the distance between the sanctuary of the Nymph[19] and the great bend, a length measuring some one hundred paces. A plan to reduce the problems encountered here has been worked out, and involves the filling in and levelling out of the small declivity to the south with firmly packed material for which a sturdy retaining wall must be built. The many houses in the vicinity, however, mean that the project has been constantly postponed, although it would finally be implemented at a somewhat later period.[20] It is thus difficult to imagine how the waggon traversed this particular spot.

While the waggon passes the south slope of the Acropolis, the driver and his companions ecstatically behold the first courses of the great temple's colonnades rising above them on the crest of the rock. How strange this fabric of heterogeneous shapes appears.

On the one hand, there is the simple and austere geometric form of the new temple's foundations,[21] on the other the winding snake-like body of the ancient cyclopean wall[22] alternating with the irregular and uneven surface of the exposed rock under and above it. Who ordained that the building programme on the rock should continue? Who foresaw what the Acropolis might finally look like? Who had even the slightest idea that new broader structures would one day be built on the southern slope?

The distance from the great bend to the site of the ancient gate, where a new marble propylon[23] is also being erected, is only one stade, but the latter is more than 120 feet above the former! Thus the power needed to drag the capital is much greater than what twenty beasts of burden could apply.

But even four times this number would still not suffice to haul such a load on such a slope. Furthermore, the road space available is not sufficient for such a host of animals. Once again it is necessary to resort to the use of simple mechanisms such as those used to pull blocks of marble from the deeply cut quarries. This problem had been overcome about four decades ago when the architraves and other large blocks were needed for the poros stone temple of Athena, the so-called Old Temple, and four decades before that when similar blocks were hauled up for the other poros stone temple of Athena, the so-called Hekatompedon. The blocks used for the Hekatompedon's large pedimental sculptures extended back into the wall to act as structural supports, and at times weighed more than seven tonnes. But winches were not enough to haul such

weights onto the Acropolis, especially if they had to be pulled over the irregular surface of the slopes or the serpentine paths of more ancient times. Thus a ramp was essential, and such an inclined surface appears to have been used even in the Mycenaean period to transport the great blocks of the Cyclopean wall.

The western approach to the Acropolis consisted of an impressive ramp, 10 metres wide and 80 long, built in the Archaic period. Large sections of its retaining wall can still be seen today.[24] Even during the years when the first marble temple was constructed, this approach was already quite ancient and in a way had itself become associated with the shrine's architectural character. Nevertheless, those who knew something of the work undertaken on the Acropolis up to that time realised that the main, if not the only reason for its construction was purely practical: to facilitate the ascent of the massive Piraic blocks for the Old Temple. There may have been other reasons of an architectural nature, but they could not have been of fundamental importance.

Thoughts such as these must have lingered in the minds of the labourers each time they conveyed marble blocks for the large temple via the tried and true ramp.

Such specialised knowledge in the drawing of heavy loads on inclined surfaces has resulted from long experience in the quarries of Pentelicon and Paros. On the Acropolis, this culmination of experience can be utilised and perfected: while in the quarries the marble blocks are ideally loaded onto sledges, those below the Acropolis are loaded onto waggons that are much easier and far quicker to pull. These waggons are used to convey the marble to the propylon, there evidently being no other effective way.[25] Understandably, this method requires, first and foremost, a sound brake system to protect both men and waggon. But a much more efficient and quicker traction system is employed here than that in the quarry depths: we may call it the "balanced waggon" method. Huge pulleys, flexibly attached by ropes to stakes in the ground, are needed at the upper point of each straight section of the route. That all the ropes have to be particularly strong goes without saying. The system is as simple as it is effective: the tractive force needed to haul a loaded waggon up the ramp is provided, via the pulley, by the applied force of another, empty waggon at the top of the ramp which, having gone up beforehand and delivered its load, now has to descend safely to the ramp's lower platform.[26] The mules are harnessed to this empty waggon and thus instead of wasting almost all their strength in ascending the ramp they simply have to drag the empty waggon to the bottom of the ramp, their horse-power being supplemented to a large degree by their own physical weight. This system is highly effective since it automatically transforms the disadvantage of a dead weight into an advantage. As the animals descend the ramp, their effort is transformed from being futile into being doubly effective. The problem of the confined space at the top of the ramp is eliminated, while at the same time both the ascent of a loaded waggon and the safe descent of an empty one is facilitated.

No doubt the builders of the Parthenon valued this system from the project's very outset since it ensures that a great deal of marble can be brought up each day.

One of our labourers must have turned all this over in his mind before asking his companions:

"I wonder how many huge marble blocks have been hauled up here in the five years that they've been building the temple?"

"Pentelic? Or Piraic as well?" asked the driver.

"Everything, naturally!"

"That's a difficult one, but I'd say about ten to eleven thousand."

“That’s my estimate as well, more than ten waggon loads daily,[27] if we leave out the days when rain and mud made transport impossible. But without the method of balancing the weight of the waggons we wouldn’t have been able to get even half the amount of marble up there, even if we were twice the number of men!”

These men and their fellows know that all these important mechanical matters were addressed by the architects when they decided which methods would prove the best and least time-consuming. They may not know, however, exactly how many of these new ideas are indeed the architects’, and how many have been borrowed. But the waggon driver is certain of one thing: that quite apart from the inspiration of architects and specialists, the main prerequisite for the safe and effective operation of any mechanism is, above all else, the care, knowledge and prudence of all those participating in the work. Thus, while waiting for his turn to take his waggon up the ramp, he devotes much of his time to a painstaking inspection not only of the waggon part—the pole in particular—but also of the machines and pulleys, of the ropes and the stakes to which they are attached, and even of the ramp’s very surface. Finally, he himself adjusts the distance between the brake and the waggon wheels.

Twenty mules are then harnessed to the empty waggon and its descent begins. The immensely resistant *kalos*, the largest and best of the ropes used here, becomes encouragingly taut and begins to drag the loaded waggon up the ramp. The undertaking must be divided into two stages, however, for as the ramp ascends it takes a turn to the right. Thus the waggon must stop for a while.

The second stage of the ascent takes place just as the first, with the ropes being passed through a large pulley secured outside the gates to the Acropolis. Now the excellent organisation of the entire operation pays off and the great column capital stands on the platform in front of the propylon just as dusk begins to spread its rosy mantle over Aigaleo and Parnes.

19. *At the work site to the east of the Parthenon*

On the next day, before the stars have even left the morning sky, the massive but now empty waggon sets off once again for the quarry. A Naxian stone mason claims that this time the waggon would return with the first of the marble blocks for the temple's architrave: "If all goes well, in a few months, when the first column capitals are in place, we can set up the architrave immediately." However, an Aphidnian, once a companion in arms of Callimachus, voices concern as to certain developments in far-off lands. "If what is said about Darius' serious illness is true, then no one knows if in ten months we shall be able to continue work on erecting the architrave!"

These troubling thoughts are dispelled by the foreman's salutation. He has come to give instructions as to how the capital should be moved to the Parthenon. Once again, as in the quarry, a system employing a sledge and *phalanges* is used, this time pulled on a permanent wooden track running from the propylon to the temple. The marble is hauled by two winches, and finally arrives at a platform to the east of the Parthenon just before the Agora opens to fill with the jostling morning crowd. Joining the newcomer here are dozens of half-worked column drums and a few other likewise partly finished column capitals.[28] Here, skilled stone masons finish only the drums' lower surface. The upper surface is carefully completed by other masons immediately after being positioned on their places.[29] Thus the columns are erected in the quickest possible way. The column capitals, however, have to be completely finished prior to being hoisted into position, necessitating that work begins on them even as the first row of column drums are set in position. Two of the column capitals are already in an advanced stage of completion and begin to take on their final shape. They differ little from those of the most recent poros stone temple,[30] being of the same size with a slightly lower echinus and a thicker neck. These variations are mostly due to the greater height of the new temple's columns, to the nature of the construction material and to new architectural concepts.

20. *A dilemma: greater economy or greater security?*

On the next day, one of the architects must inspect the newly brought half-finished column capital. He has already been informed of the presence of the fissure and must ponder the seriousness of the problem. It would seem, however, that he arrives at much the same conclusions as did the quarry foreman three days earlier since he orders that carving should proceed and that two of the finest stone masons on the work site should be entrusted with the task.

Firstly, the masons carefully examine the dimensions and the corners of the half-finished capital, work which demands expert knowledge of geometry. Secondly, they begin to prepare the first drafted margins for the carving of the capital's resting surface. This enables them to examine the fissure more closely and in the process to estimate the extent of the handicap, especially with regard to carving at those points where the fissure would meet the delicately chiselled *imantes*[31] (necking mouldings) and the fluted edges of the column's *hypotrachelium*[32] (neck). Then they ask the architect for his professional view.

Much discussion ensues. All the evidence seems to indicate that the capital should be put to one side and that work should continue on the other column capitals. After new half-finished column capitals have been received, a better opinion can be formed as to the relative quality of our capital with its fissure.

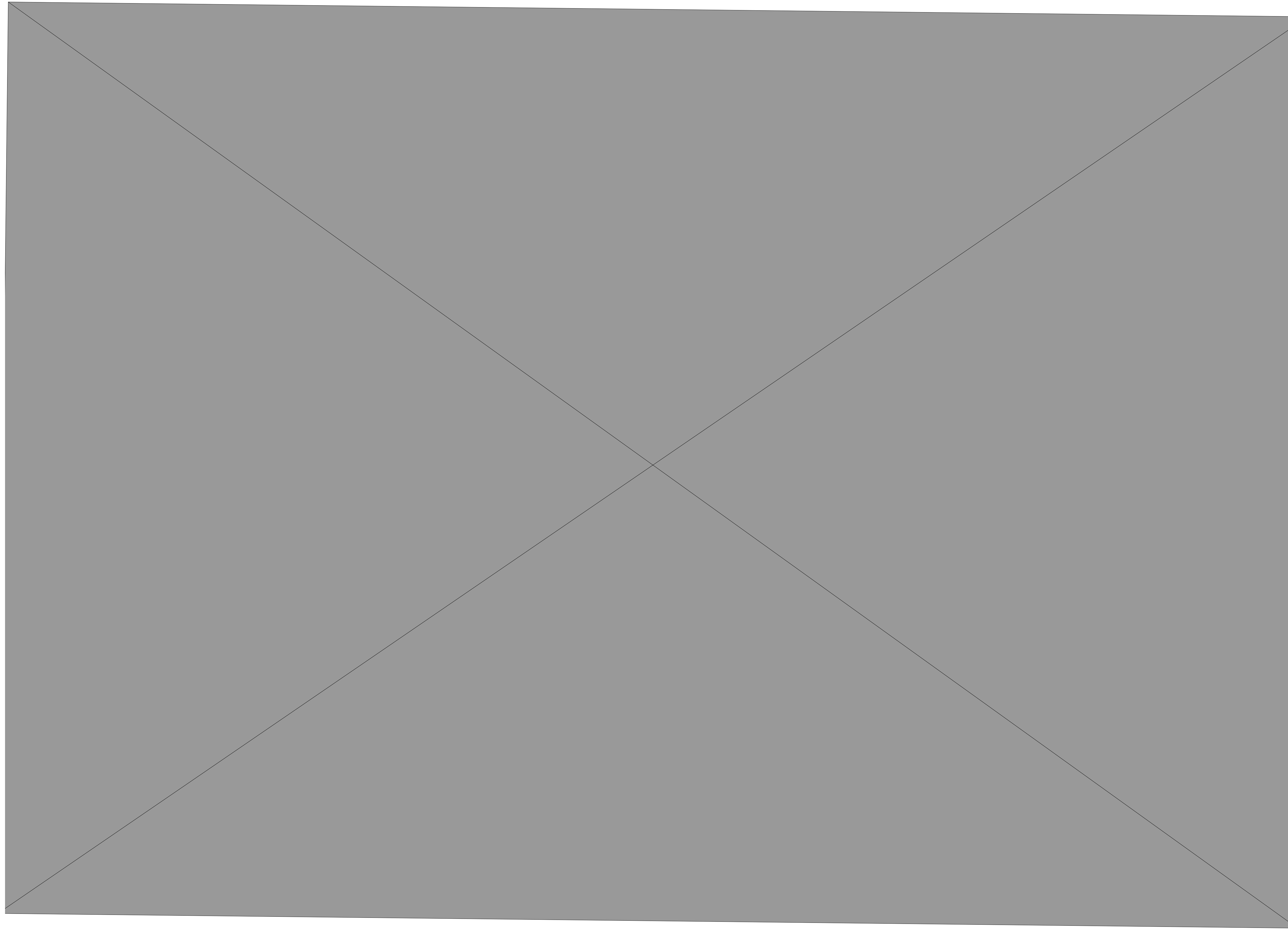
"If, in the end, it is deemed suitable, it must be reinforced with quite a number of hidden iron clamps on both its surfaces", says the architect with a trace of weariness.[33]

"Let us hope that it can be saved!" comes the passionate answer of the oldest of all the craftsmen, while the youngest looks on anxiously. How thrilled he has been over the last few days that he should be included in such an important part of the work. The architect, ever sensitive to the feelings of the aspiring craftsman, adds a few words of soothing optimism: "There are still quite a few possibilities, so don't give up. Your thirst may yet be quenched." But deep inside, he is almost certain that the column capital must in the end be deemed unsuitable.

Nevertheless, he ends the discussion by saying, "for the time being, we shall put off a decision and think a little more about the matter".

Thus many days pass and no other work is undertaken on the capital.

This unlucky turn, which seemed so serious at the time, pales in comparison to the misfortunes that now would befall the Athenian state. Unfortunately, King Darius in distant Persia breathes his last and his successor, Xerxes, younger and more energetic, begins to prepare a new campaign against Greece.



21. *The work site after the Persian attack*

The governing regime in Athens changes abruptly as a shift in policy is needed to meet the new threat. Themistocles, who now leads the Athenians, cannot afford to indulge in the luxuries of temple building. All the state's efforts[34] are now devoted to ship building and the preparation of a new and strong navy, to fortifying the Piraeus, and to the manufacture of a sufficient supply of weapons.

Thus the great building project on the Acropolis grinds to a halt. The brilliant artists, architects and craftsmen undertake duties of a different kind, but never lose hope that they will one day continue work on the Acropolis. Forty years were to pass[35] before their hopes could materialise, and when they had, the glorious half-finished temple lay ruined, consumed by the flames of the Persians.

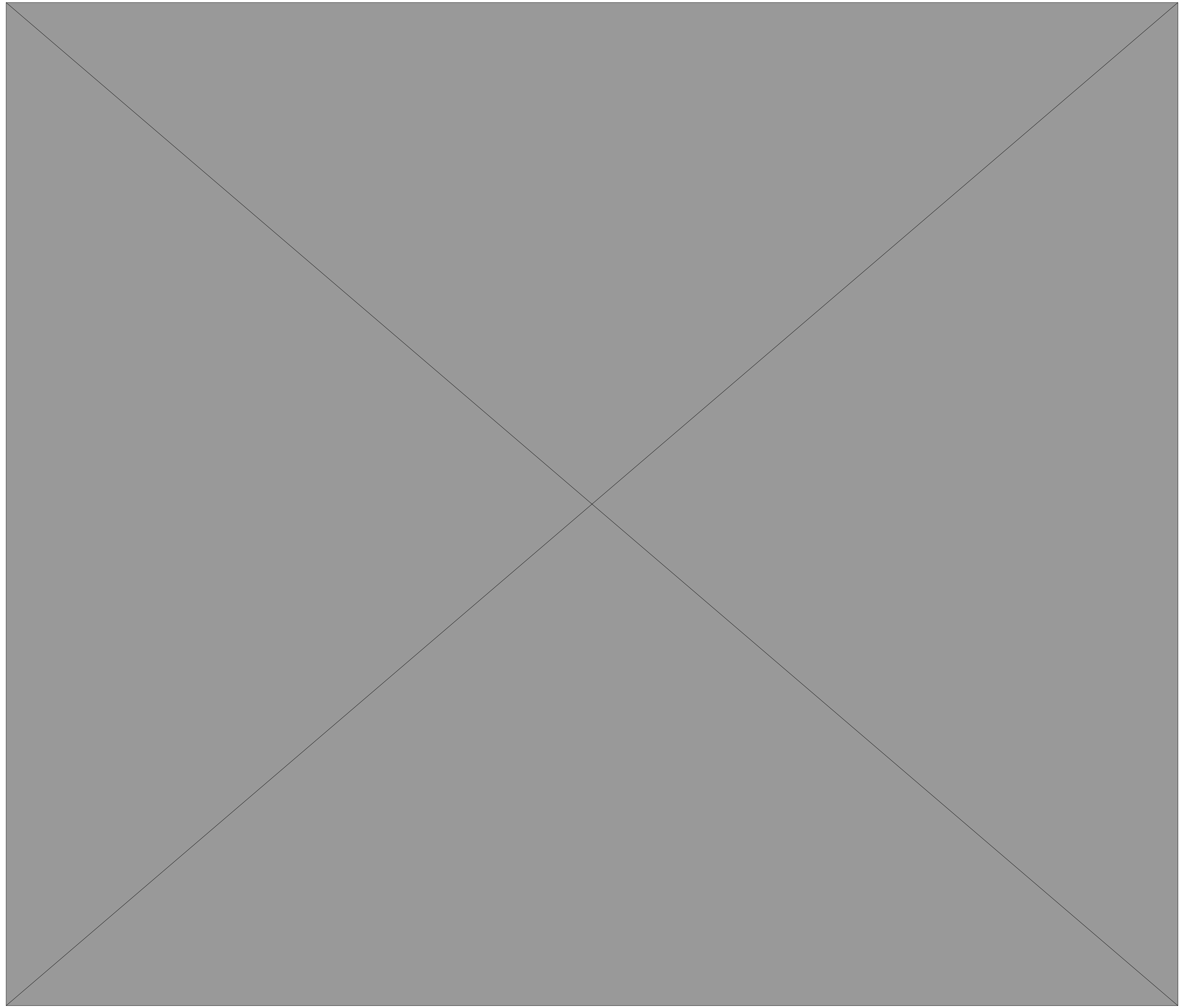
22. The same site fifty years on

One of the craftsmen who had worked on the column capital met a hero’s death at Plataea. The other, younger member of the work team is now a venerable old man and still practices his wonderful craft. For decades following the great war, opportunities for stone masons were few due to the postponement of the temple building programmes. Our worthy craftsman, along with his contemporaries, saw the best years of his life pass by, first in brick making and then in ship building. Twice more did he offer his military services and on even more occasions was he obliged to serve abroad. But he is, nevertheless, lucky to have survived. He is also fortunate to have lived to see the day when, following the signing of the peace accords some ten years earlier, the state would decide to continue the temple building programme. And so once more we find him working on the Acropolis. For ten years he has worked with admirable resilience, helping in the carving of the threshold, the cornices and the impost capitals of the *antae*. By a coincidence of fate he now finds himself at exactly the same spot where he had sat 50 years ago, when just 18 years old and full of so many dreams. Now, he feels his last days at the work site pass rapidly. Sometimes he finds himself unwillingly lost in deep thoughts and reminiscences of things past. Today, indeed, while lifting his gaze to the pediment, he caught sight of the column capitals, and for a moment tears well in his eyes.

But life, as always, continues around him. The Parthenon, the most illustrious building ever erected by the state, and the greatest accomplishment in the technology of stone, is almost finished.

The Periclean programme[36] has no precedent. Each of the old buildings is to be rebuilt, and the surface area is to be almost completely transformed. Both architects and sculptors think in new ways. Almost nothing has remained of the plans for the first marble temple; only the diameter of the columns are the same.[37] Although the columns are even taller than those initially planned,[38] the column capitals are clearly smaller.[39] Indeed, a few of these have been carved from the older capitals. Very few people, however, know which these capitals are, and amongst them is our old mason. He knows which of the forty-six column capitals of the colonnade have been fashioned out of the handful of old half-finished capitals, carved in such a way as to match the new dimensions. He is also aware that the capital with the fissure was never used, even though he cannot locate it now. At one instance he thought he saw it used as a pedestal, but for what he cannot remember exactly.[40]

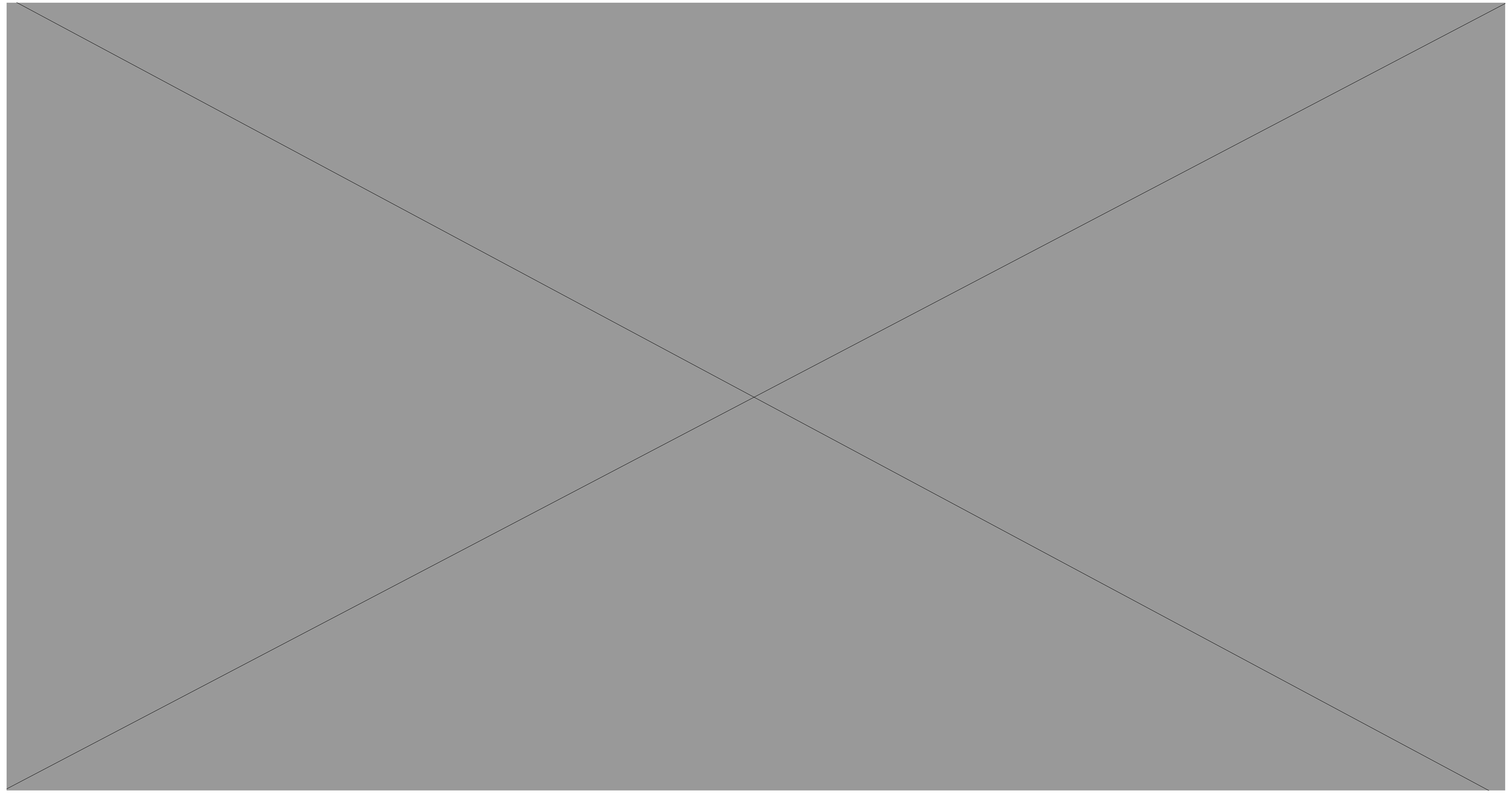
“That’s what time has in store for us all!” he murmurs with a degree of melancholy every time his thoughts return to wars and work.



23. *Time future*

The adventures of the half-worked column capital were to continue during the centuries that followed and continue to this day. But its story will remain incomplete, just like the marble itself, unless, of course, we were able to journey back in time. The modern thirst for knowledge is such that many would give all for such a journey, considering the ancients privileged for having lived in such a brilliant epoch. Just over 2500 years have passed, almost one hundred generations have come and gone since the last appearance of our column capital. Following generations could never even contemplate the luxury of modern scientific curiosity—the struggle for survival was enough. Recording history was a rare and often distorting occurrence, and a hazy oral tradition was often deemed sufficient to pass on the legacy of generations. Athens for centuries was little more than a village, a fraction of its ancient size with houses that more resembled huts. The great distance between quarries and the building site no longer existed, for the ancient monuments themselves had become quarries. Many later generations managed to transform one hundred thousand tonnes of sculpture and hewn marble, that had once belonged to the buildings of antiquity, into ten million shapeless pieces of one million times less value than the works destroyed in the process—one might use the analogy of the Mona Lisa cut into strips to be used as soles for the shoes of the blind. On the Acropolis, all the ancillary buildings and thousands of small monuments were destroyed. And let it not escape us that what is now left of the Parthenon is only a skeleton. Excavations in the last century, lasting three times as long as the golden age of Pericles itself, uncovered innumerable fragments of stone statues but nothing in bronze which would have been a more popular and important material. Then there are the hundreds of fractured inscriptions, thousands of sherds, and the foundations of some smaller structures. Tens of thousands of smaller marble fragments have also been found, originating not only from the Acropolis but also from buildings all over Athens. One of the hundreds of larger fractured blocks from the Acropolis monuments now lies some 40 metres east of the Erechtheion. It is all that remains of the principal actor of this book. At some point, it was split into two along the length of the fissure and only the smaller part is preserved today. The necking band and all the edges and corners were destroyed at a later date when large chunks were cut away, possibly to procure small pieces for building use. The flat side seems at some stage to have been used as a threshold.[41] But this, together with its fate in antiquity after its rejection, must remain the stuff of conjecture.

“That’s what time has in store for us all...”, one might say with a degree of melancholy.



Endnotes

1. *Preparthenon, Older Parthenon, Elder Parthenon, Parthenon II* etc. are the conventional names used from the beginning of the 19th century onwards for the marble temple that preceded the Parthenon. The half-worked drums of this building, visible on the north wall of the Acropolis, where they have been reused, were recognised and studied for the first time (1806) by W. M. Leake. In 1835 Ludwig Ross determined that the foundations and the solid base of the Periclean Parthenon belonged to the older temple (see also Explanation of Pl. 19).

2. On the size and shape of the levers we only have scanty indications. Fragments of a large heavy iron lever from a later period were found on Proconnesos, N. Asgari, Steinbrüche von Prokonesos, *Ist.Mitt.* 39, 1989, 48. The metallurgical capabilities of the classical era for rather bulky iron objects are documented by buildings which preserve sockets for iron reinforcements or supports, W. B. Dinsmoor, Structural Iron in Greek Architecture, *AJA* 26, 1922; G. Gruben, Weitgespannte Marmordecken in der griechischen Architektur, *Architectura*, 1985,10, 112.

3. W. Koenigs, Beobachtungen zur Steintechnik am Apollon-Tempel von Naxos, *AA* 1972, 380-385.

4. M. Korres, The Geological Factor in Ancient Greek Architecture, *The Engineering Geology of Ancient Works, Monuments and Historical Sites* (P.G. Marinos, G.C. Koukis, eds.), Rotterdam 1988, 1779-1793.

5. A. Ὀρλάνδος, I. Τραυλός, *Λεξικόν αρχαίων αρχιτεκτονικών όρων*, Athens 1986, 64, 65, 69, 139-140, 221.

6. See Explanation of Pl. 23.

7. M. Korres, op. cit., 1782-83.

8. A. Ὀρλάνδος, I. Τραυλός, op. cit. , 167, and see Explanation of pls. 13,15.

9. A. Ὀρλάνδος, *Τά ʽΥλικά καί οἱ τρόποι δομῆς τῶν ʼΑρχαίων ʽΕλλήνων*, Athens 1959-60, 90, figs. 31, 33.

10. Ibid., fig. 32.

11. A. Ὀρλάνδος, *Ἡ Ἀρχιτεκτονική τοῦ Παρθενῶνος*, Athens 1977, 95.

12. The distance traversed by the waggon was some 17,400 metres. The ancient *stade*, equalling 600 feet, differed from place to place. In Olympia, it was 192.27 metres, while in Athens 185 metres (see Explanation of Pl. 1).

13. M. Κορρές, Χ. Μπούρας, *Μελέτη Ἀποκαταστάσεως τοῦ Παρθενῶνος*, Athens 1983, 212-232 (Charts indicating all the marble blocks of the Parthenon arranged according to type, size, and quantity).

14. N. Καλτσάς, Τό ἀρχαῖο ἀττικό τοπίο, Μυθολογία καί πηγές, *Ἀττικό τοπίο καί περιβάλλον*, Catalogue of an exhibition of the Ministry of Culture, Athens 1989,142-153.

15. The so-called Zeugetrophoi. It was not yet possible for the work of many teams of animals to be controlled by the driver alone. The *zeugetrophoi* had to accompany the animals on foot to force the animals to work, the mules with a whip and the oxen with a goad. The same persons had naturally to ensure that the animals were well cared for. Their daily wage was one drachma, as for other labourers, but an additional two drachma per yoke, or some times per animal, was provided for upkeep. This system was maintained till modern times, *Il Marmo, ieri e oggi*, Societa Editrice Apuana, 1978, figs. pp. 90-94, 134, 50-51.

16. G. Welter, Das Olympieion in Athen, *AM* 47, 1922, 62-71.

17. The distance of this quarry from the Olympieion was about 12 kilometres. The temple is 81 metres above sea level. The largest half-finished column drums have a diametre of 2.56 metres and a weight of 13 tonnes. Work was halted about twenty years prior to the beginning of the first marble Parthenon.

18. W. Judeich, *Topographie von Athen*[2], München 1931, 316-319.

19. Χ. Παπαδοπούλου-Κανελλοπούλου, Ἀνασκαφή “νοτίως Ἀκροπόλεως”, Μελανόμορφη κεραμεική, *ΑΔ* 27, 1972, A, 185-302. From the same excavation ΑΔ 28, 1973, Α΄, 1-63 (Σ. Χαριτωνίδης) and 29, 1974, Α’, 109-142 (Α. Μαντζώρου).

20. The remains of houses behind the sturdy retaining wall south of the Herodeion have been dated by Meliades to the middle of the fifth century B.C. (see *Explanation of Pl. 18*).

21. See *Explanation of Pl. 19*.

22. See *Explanation of Pl. 18*.

23. Ibid.

24. J. Travlos, *Pictorial Dictionaiy of Ancient Athens*, London 1971, figs. 608, 609.

25. See *Explanation of Pl. 18*.

26. The traction animals are capable of hauling a load even on a downward slope. Suffice it to note that sloping fields may at times be ploughed with mules or horses from upper to lower levels.

27. Up till 1940, the largest blocks of marble for the restoration works were lifted onto the Acropolis using an iron waggon moving on iron rails, and pulled from the Propylaea by an iron hand-operated winch. Work was tiresome and time-consuming. However, the recent (1986) ascent of a new marble block weighing some 13,5 tonnes with a powerful electric crane at the south-east corner of the Acropolis, and then moving it by rail to the Parthenon was a very difficult and time-consuming task lasting five hours and demanding the labour of an average of ten persons.

28. On the open-air work site, excavated in 1835, see L. Ross, Archäologische Aufsätze I, Leipzig 1855, 129. Twelve half-finished column drums were uncovered. Their locations appear on the ground plan of the Acropolis published by F. C. Penrose, *An Investigation of the Principles of the Athenian Architecture*, London 1851, pl. 3. Amongst these column drums a few implements were found, along with vases containing fine red ochre, used as a colouring agent by the stone masons, Penrose, op. cit., 3.

29. M. Κορρές, *Συμβολή στήν οἰκοδομική μελέτη ἀρχαίων κιόνων*, Athens 1991, 45-47.

30. W. Dörpfeld, Der Peisistratische Peripteralbau, in Th. Wiegand, *Die archaische Poros-Architektur der Akropolis zu Athen*, Cassel/Leipzig, 1904, figs. 118, 119.

31. The fine horizontal carved lines between the necking band and the *echinus*.

32. The “neck” of the column capital, where the extremities of the column flutes are also located.

33. On the classical use of clamps to reinforce architectural members in the places of natural fissures or cracks, M. Κορρές, Χ. Μπούρας, *Μελέτη Ἀποκαταστάσεως τοῦ Παρθενῶνος*, Athens 1983, 116. Such reinforcements have been observed on the upper surface of the capital of the 7th column of the Parthenon’s east colonnade during structural restoration work in 1990. These reinforcements provide an idea of the manner in which the half-finished column capital may have been reinforced (see Explanation of Pl. 20).

34. Herodotus **7**,144; Thucydides **1**, 14, 2 and 93, 4.

35. Work on the Periclean Parthenon began in 447 B. C. with the dismantling of a section of a part of the crepidoma of the Older Parthenon, the transport of blocks from Piraeus for the widening of the foundation by almost five metres and a corresponding widening of the crepis, and finally with the new carving of the *euthynteria* due to a reinforcement of the original curvature (which was made for the Older Parhenon, see Explanation of Pl. 21). Work on the new crepis must have taken place in the following year and on the columns in 446/5 up to 442 B.C. In 440 B.C., the temple was roofed and in 438 it was ready, including the colossal chryselephantine statue of Athena Parthenos.

36. G. S. Boersma, *Athenian Building Policy*, *from 561/0 to 405/4 B.C.*, Groningen 1970. G. Gruben, *Die Tempel der Griechen*[3], München 1980, 152-205.

37. 1.91 m, but the shape of the fluting in cross-section changes from being simply round before to false-elliptical after.

38. ~10.43 m instead of ~9.55 m (see Explanation of Pl. 19).

39. See Explanation of Pl. 23.

40. See Explanation of Pl. 23. At the lower part of the capital exists a part of a large rectangular cutting with restored dimensions: length 87cm, width 40cm, depth 50cm or more, which in all probability points to the capital’s secondary use, placed upside down as a heavy base for a large wooden post.

41. In 1990, using powerful machines, the block was moved and positioned on a small base so that its flat, upper surface could be made visible.

PART II

EXPLANATION OF PLATES

Analytical Scientific Documentation and Archaeological Study of the Pentelicon Quarries

Explanation of Plate 1.

(see Figs. 1-6 and 20-21)

Plate 1 is an *orthographic projection* of an oblong section of the terrain of the Athens basin, extending from *Phaleron* and the Piraeus *Akte*, where the limestone quarries were, to *Mt Pentelicon*, the source of the marble. This stretch of terrain, the geographical setting for the quarrying and transport of the building material for the Parthenon, will henceforth be called the *lithagogia landscape*. Pl. 1 was drawn on the basis of measurements (coordinates and altitudes) taken from the plans and maps of Athens and Attica, and on evidence of Athenian historical topography.

A better understanding of Plate 1 and this explanation will be gained from Figs. 1-6 and 20-21.

Fig. 1 is a precise drawing of Pl. 1 with the reference numbers marked. Fig. 2, a general view of Attica, shows the exact position of the *lithagogia landscape* and the form of its orthographic projection, on the basis of which Pl. 1 and Fig. 1 were drawn. Figs. 3-6 are more analytical maps of the *lithagogia landscape* and contain reference numbers marking every important point in the landscape, coinciding with those of Fig. 1.

The reference numbers are the actual altitudes of the points above sea level; this was found to be both serviceable and practical, because the points all happen to be at different altitudes.

Plate 1 and Figs. 1-6 and 20-21 and the information accompanying them are an aid to understanding the basic geophysical conditions of ancient quarrying and especially ancient stone transport. Additional information is contained in the explanations of the other plates and the notes. Below is an explanation of the important points in Figs. 1-6.

E marks the position of an observer in relation to the plates as follows:

E1 → Pls. 2 and 12,
E2 → Pl. 13,
E3 → Pl. 14,
E4 → Pl. 15,
E5 → Pl. 16,
E6 → Pl. 17,
E7 → Pl. 18,
E8 → Pls. 19 and 23.

A,Π. Ancient quarries of actites (hard marly limestone) and *poros* (soft marly limestone) at Piraeus.

AA. Ancient quarries of *Acropolis Stone* (a very hard, thick, tabular limestone found on the tops of the hills of the Acropolis, Lykabettos, Philopappos, the Nymphs, and others).

λA. Modern quarries of *Acropolis Stone* (chiefly on the hills of Philopappos, the Nymphs, Lykabettos, Strephi).

Λ. Ancient quarries of white marble.

49. Hill of *Akte* at Piraeus.

54. The *Barathron*, a very ancient natural chasm, a place of penal execution and a quarry (*AA*), west of the Hill of the *Nymphs*; it has now vanished after intensive quarrying (*λA*) during the 19th c.

64. The most northwesterly spur of the Hill of the *Nymphs*, beyond the *Barathron*; it no longer exists after intensive quarrying (*λA*) in the 19th c.

65. The most southwesterly spur of the Hill of the *Nymphs*, which has partially disappeared after intensive quarrying (*λA*) during the 19th c. and recent building activity.

75-79. Hill of *Sikelia*. The greater part of it has disappeared after intensive quarrying (*λA*) during the 19th and 20th c. and recent building activity.

78. (Fig. 3) Lowest point between the *Olympieion* and the Theatre of Dionysus.

80, 97. Western heights of the Hill of the *Nymphs*.

81. Huge unfinished temple of the *Olympieion*, built of poros stone.

85. Hill of *Munichia*, the most easterly and the highest part of what is now Kastella, at Piraeus.

88. (Fig. 3) Valley of the *Stadium*.

91. (Fig. 3) Sanctuary of *Dionysus*.

96. (Fig. 3) *Sanctuary* of the *Nymph*.

97-99. *Koile*, one of the quarters of the ancient city.

99. Site of the *Dipylon*, the gate of entry for the road from Piraeus to the Acropolis.

104. Saddle between the *Acropolis* and the *Areopagus*.

105-110. Ridge running along the north side of the Hill of the *Nymphs*.

110. *Pnyx*.

115. *Areopagus*.

125. (Fig. 3) Hill of the Stadium.

138. (Fig. 3) *Ardettos*.

143. *Propylaea*.

156. *Acropolis*.

165. “Strephi Hill”. Most of it has disappeared after intensive quarrying (*λA*) in the 19th and 20th c. and recent building activity.

171. The “Schiste Petra”.

277. *Lykabettos*. Small ancient and large modern quarries (*AA* & *λA*, and cf. explanation of Pl. 15).

370. *Boulismene* or *Thalassi* or *Limne* (old forgotten names), karstic doline, casually filled in and turned into the *Communal Gymnasium of Nea Penteli* (see Fig. 6). Formerly it used to be flooded by subterranean and rain water. The following was written about Boulismene (Κ. Σ. Χασάπης, *Εγκ. Ηλίου*, vol. 13, 436): “There are considerable and sufficient indications that there could also have been a meteoric crater at Nea Penteli...”

388. “Koupho Vouno”.

430. Site of Moni Pentelis.

505. Hill of the Pentelis Observatory.

700. *A1*, ancient quarry and cave. *A2*, large trench-like quarry (north of *A1*).

~800. Sanctuary of the *Nymphs* in the ancient quarries.

948. South saddle of the crest of Mt Pentelicon.

1108. Highest peak of Mt Pentelicon.

31, 122, 128, 172, 179, 188, 200, 240, 280, 285, 438, 466, 469, 470, 473, 544, 930, 990, 1000. Various other heights and peaks.

140, 127, 48. The *Ilisos*.

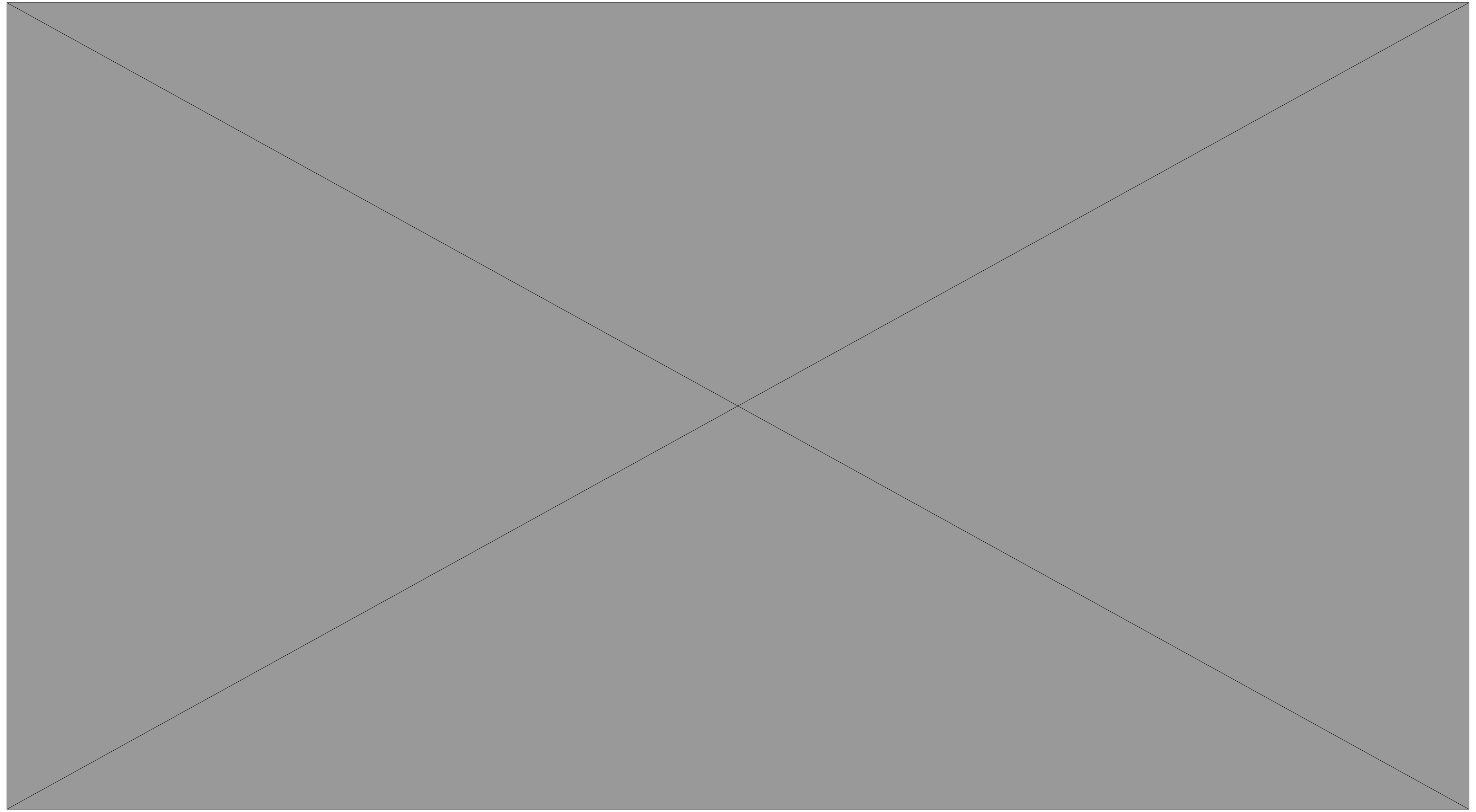
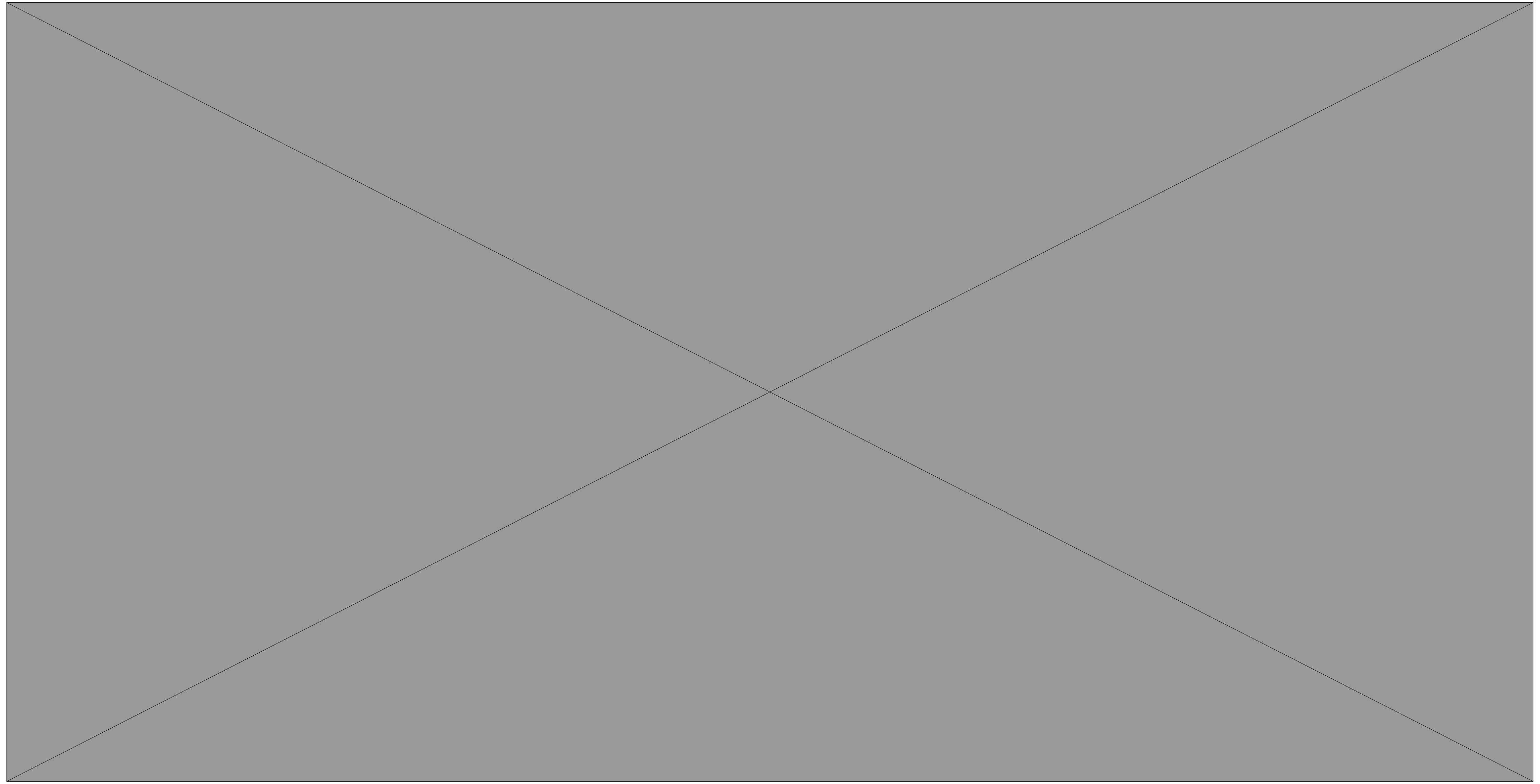


Fig. 1 The shore, Athens, Mt Pentelicon and the *lithagogia*.
Orthographic projection on a scale of 1:5000.
Printed here on a scale of 1:8000.



92, 100. (Figs. 3, 4 and 6). The torrent of *Kyklovoros* (it joins the *Kephissos*).
187, 175, 161 and 400, 160 (Fig. 3). The southern tributary of the *Kephissos* (torrents of Pentelicon → *Halandri Gully* → "Podoniftis" and the torrents of Hymettus). During the 20th c. the greater part of these very ancient natural formations caused by the perpetual action of water has been destroyed by modern technical works consequent on the thoughtless influx of new inhabitants into Athens.
104-147-81-277-141-240-285-...-280-181-200-...(Fig. 3). *Kephissos-Ilissos* watershed boundary.
950-1108-948-1000-910-990-887-930. Crest line of Pentelicon, *Kephissos* watershed boundary.
Different broken lines represent the principal roads of the ancient *lithagogia*:
(---) From Pentelicon to Athens.
(---) From Pentelicon to Eleusis (Fig. 2).
(-·-·-) From Piraeus to Athens (Fig. 2).
(··········, -·-·-) From the Piraeus Akte to the Olympieion and Acropolis via Phaleron (Fig. 2).
The line (---), 162-182-175 (Fig. 3, and see Figs. 4, 6), represents the ancient road connecting the Mesogeia (127-162-187) road with the Penteles road, beneath which, centuries later, the so-called Hadrian Aqueduct ran.

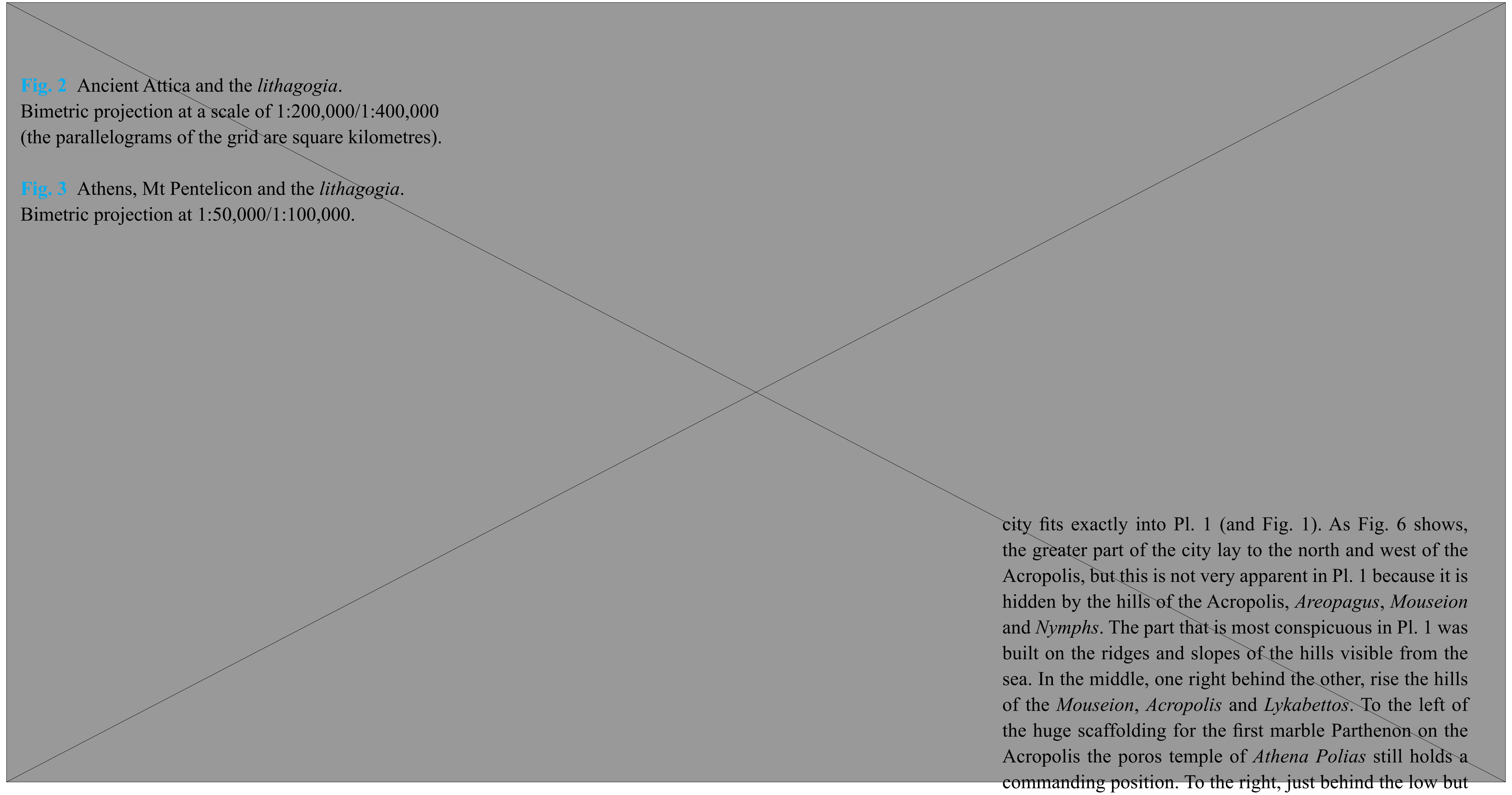


Fig. 2 Ancient Attica and the *lithagogia*.
Bimetric projection at a scale of 1:200,000/1:400,000
(the parallelograms of the grid are square kilometres).

Fig. 3 Athens, Mt Pentelicon and the *lithagogia*.
Bimetric projection at 1:50,000/1:100,000.

In **Pl. 1** Athens, the historical, financial and political centre of the Athenian state, is shown unwalled, because in the second decade of the fifth century its boundaries undoubtedly extended a considerable distance beyond its earlier, somewhat conjectural, limits, and the walls of the Classical period had not yet been built. The city plan was irregular because it had grown up progressively over many centuries, in accordance with the complex laws that govern every organic development. The city, consisting of the Acropolis (originally the *Polis*) and the *Asty* (town), spread over an area of ~1.6 square kilometres. Its compass is known to us chiefly from the line of the *Themistoclean Wall* (479 BC), shown in Fig. 6 by a heavy dotted line. The distance from the *Kerameikos* (on the left, but hidden behind the hill of *Munichia*) to the 4th c. *Stadium* (at *Ardettos*) is not more than two kilometres and thus the full width of the ancient city fits exactly into Pl. 1 (and Fig. 1). As Fig. 6 shows, the greater part of the city lay to the north and west of the Acropolis, but this is not very apparent in Pl. 1 because it is hidden by the hills of the Acropolis, *Areopagus*, *Mouseion* and *Nymphs*. The part that is most conspicuous in Pl. 1 was built on the ridges and slopes of the hills visible from the sea. In the middle, one right behind the other, rise the hills of the *Mouseion*, *Acropolis* and *Lykabettos*. To the left of the huge scaffolding for the first marble Parthenon on the Acropolis the poros temple of *Athena Polias* still holds a commanding position. To the right, just behind the low but extensive rocky hill of *Sikelia* can be seen the great unfinished temple of Olympian Zeus. At the right-hand side part of the hill of *Ardettos* is also visible. A line of thicker greenery running down to the left of Ardettos, which disappears behind *Sikelia* and reappears in the centre of the landscape and continues to the left, indicates the course of the *Ilissos* river.

The quarries that supplied the marble for the ancient monuments were chiefly situated on the south slopes of Mt Pentelicon, along a ridge running SW-NE that starts almost from the base of the central mountain mass and meets the crest line on the SE side of the main peak. The regular, almost straight formation of this ridge, as of the other geophysical formations on the mountain, are largely the result of the combination of an internal and an external factor: the geological composition and its structure and the form and age of the erosion.

The rock of the ridge presents folds, whose axes are roughly parallel to the ridge itself. Because of the formation of these folds the two finest veins of marble, which also happen to be the finest on the whole mountain, appear roughly on the line of the ridge as almost vertical veins alternating with other layers of a different composition. The visible manifestation of this formation in the natural landscape of Pentelicon can no longer be seen due to the prominent presence of the quarries, but it is a familiar phenomenon in similar geological contexts where the landscape is well preserved. It is therefore very probable that 25 centuries ago the surface outcroppings of the underlying geological formation were visible along the ridge as parallel bands of different earth texture, colour and vegetation growth. In particular the two veins of fine marble must have been evident. The alternating veins, containing rich layers of argillaceous schist, supported a greater growth of vegetation and retention of plant cover. A differential development of vegetation, whether of shrubs or trees, is usually more apparent from a distance. In a clear atmosphere and in the right light the fine marble-bearing veins along the ridge on Mt Pentelicon would have been visible to an expert eye from Athens itself (see Pl. 1).

The final geomorphological shape of the ridge was itself certainly the result of the differential erosion of the mountainside. The perpetual violent action of water has scoured on both sides of the ridge the two gullies that form its natural boundaries. The two gullies are roughly parallel and like the ridge run from high up on the mountain down to where they terminate and converge at an altitude of ~450 m. Their common continuation, a central torrent with a deep bed, augmented by the confluence of numerous other Pentelicon torrents, traverses the eastern part of the plain for a distance of ten kilometres (now interrupted by the horizontal cut of Attiki Odos) as far as Halandri; there it turns westward and continues for another ten kilometres to Sepolia, where it joins the Kephissos as a main tributary.

The shape of the marble-bearing ridge and subsequently the ten first kilometres of the course of the large torrent were the chief geomorphological factors in antiquity that led to the first systematic construction of the road for the *lithagogia*, whose ultimate descendant is the modern Pentelis Avenue. The ridge has an average slope of ~30° between the altitudes of 500 and 800 m, ~18° between 800 and 900 and ~33° between 900 and 1020 m. Its total length is some two kilometres, its width, defined by the two gullies, ~350±50 m and its elevation ~90 m, measured as the difference in altitude between points on the crest of the ridge and corresponding points in the bottom of the deepest gully, namely the one to the south. This elevation is more or less the same over the length of the ridge, because the two gullies are parallel to each other and their downward inclination automatically determines the slope of the ridge itself. A thin vein of argillaceous schist forms, or formed (before the recent changes in the area) the crest of the ridge. On either side of it lie the veins of fine marble, the narrower one on the left and the wider one on the right (Fig. 13). The longitudinal direction of the geological structure of the two veins, which was very important for quarrying, exactly coincides with the direction of the ridge itself, and consequently the quarrying advanced in a linear fashion along the ridge on either side of its crest (Fig. 20). The largest quarries, at an altitude of 700 to 900 m, acquired great importance, one indication of which was the establishment of the characteristic cult of the Nymphs, and undoubtedly of Pan as well. The statue of Athena mentioned by Pausanias (I, 32, 1-2) probably stood near the top of the mountain.

Unhappily modern quarrying began right at the site of the ancient quarries and proceeded to excavate almost the entire length of the ridge, virtually destroying it. All that we have left are the positions of the ancient quarries marked on maps by early scholars. Various remnants of the ancient quarries can still be discerned inside the modern ones.

However, distinguishing the ancient from the modern quarries is not always so easy. As a rule the ancient surface cuttings in the rock show evidence of the characteristic picking by heavy or medium heavy implements, the marks of which form regular grooves running in parallel or alternating directions. Unfinished sculptures left in the quarries or along the *slipway* are further proof of the antiquity of these quarries. The most famous is the one known as the *Spelia Quarry*. The lower end of the steep, still surviving slipway for the loaded sledges (Pl. 13, figs. 1-4 and 20-21) was at an altitude of ~490 m. Its length as far as the *Spelia Quarry*, at an altitude of ~700 m, was ~800 m, and it was cut in almost a straight line with a more or less constant gradient of ~25 ±1% in the upper part and ~30% in the lower. Some parts of it have been completely, and others partially, destroyed by modern quarrying activities (for the original form of this ancient slipway see the Explanation of Pl. 13 and pp. 100-103).

Along the way, before and after the *Spelia Quarry* and between the altitudes of 500 and 920 m, for a distance of ~1700 m from its lower end, there were many other quarries, of which only slight remains have survived. The road would have been stone paved, probably as far as the farthest quarries of the continuous upper series. The road continued to the summit (1108 m), ~3 km distant from the 470 m point. At a horizontal distance of ~400 m from the summit towards the SE (on the left looking from Athens) at an altitude of ~1020 m is the highest of the ancient quarries on Pentelicon, removed from the rest (and now much altered by recent quarrying)[1].

1. The closest to the crest on the map of Kaupert; See J. Wiseman, An Unfinished Colossus on Mt. Pendeli, *AJA* 72,1968, 75-76. R. Carpenter, The Unfinished Colossus on Mt. Pendeli, *AJA* 72,1968, 279-280.

The stone transport road, the *lithagogia*, started at the bottom end of the *slipway* (490), followed the right bank of the *Halandri stream* for a distance of some four kilometres and then the left bank for another four kilometres; afterwards it ran close to the course of *Kephisias* st. (now Vas. Sophias Avenue), with a part of which it coincided, and via the present-day *National Garden* and the south slope of the Acropolis it terminated just beyond the *Sanctuary of the Nymph*, at an altitude of 96 m, where it crossed another road that ran along the west side of the *Herodeion* to the Acropolis. The road distance from the lower end of the slipway to the crossroads west of the *Sanctuary of the Nymph* was 14.4 km, in other words only 100 m further than the horizontal straight line distance between the two points. This was due to the constancy of the NE-SW direction of the road, which was itself the result of the similar orientation of the principal geophysical features which determined the cutting of the road, such as the stream bed and the central range of hills of the Athenian plain.

The *lithagogia* road was downhill for nearly its whole length. For the first 2000 m (from the point where the waggons were loaded) the average gradient was fairly steep, ~6.6%, and over the next 2000 m, ~4.5%. After that, for 5000 m, as far as the southernmost torrent bed of the stream (Fig. 3, 175), the average gradient was only ~1.6%. From there, for 2000 m, until the line of the Ilissos watershed (Fig. 3, 181) the road went slightly uphill, ~+0.5%, after which it went downhill again for ~5000 m as far as east of the *Sanctuary of Dionysus*, which was its lowest point, ~78 m, with an average gradient of -1.8%, but with pronounced variations of ~± 1%. The rest of the way was uphill. For 300 m, as far as the *Sanctuary of Dionysus*, the gradient was ~+0.5%, and then ~+2.5% for another 200 m to the *Sanctuary of the Nymph*. From there on the much steeper gradients combined with the narrow city confines made it impossible to continue hauling the loaded waggons with draught animals alone. From the *Sanctuary of the Nymph* to the line of the west slope, a distance of only 150 m, the gradient was ~+13%! The remaining section of the road up to the Propylaea, in the form a huge inclined plane, had an average gradient of ~+28%!! and the last part, from the Propylaea to the east side of the Parthenon (altitude ~155 m), a distance of ~+150 m, with an average gradient of +11.5% was also very difficult.

For the precise course of the *pentelethen lithagogia* there is no particular evidence, ancient or modern, nor are there any other contemporary archaeological studies. Only a few decades ago, and more so in the last century, the terrain would have been largely free for surveys and particular archaeological investigations, which unfortunately were never carried out.

Today, after the vast uncontrolled, unplanned building operations that have covered and defaced the Attic plain, historical and topographical investigations are very difficult. Nevertheless, even under these unfavourable conditions, it has still been possible to carry out some research into the historical topography of the Attic plain by making appropriate and systematic use of all the available evidence.

A careful comparison of recent street plans (Fig. 6) with older topographical maps, prior to the great building boom in Athens (Fig. 4), shows that the original narrow country roads which traversed the uninhabited areas between small villages like *Halandri*, *Koukouvaounes* (modern *Metamorphosi*) or *Arakli* (modern *Irakleio*) did not as a rule go out of existence as a result of the new overgrown shape of the densely populated city, but continued to exist incorporated or transformed in various ways in the indescribable, irregular, but not entirely fortuitous town plan. The same thing may also be said of some very ancient geophysical features of the landscape, including the beds or even only the courses of the different seasonal torrents that once freely traversed the terrain, including very small ones. On the other hand the buildings of earlier and even relatively recent times have nearly all disappeared, and with them all their evidence, with one sole exception: the churches.

Although these have undergone transformations, often drastic and deplorable, they have remained generally immovable. On the site of the large church of *Hagia Paraskevi* on *Mesogeion* Ave., as in numerous similar cases, there was originally a much older, humbler church; and a hundred years before the community of *Hagios Silas* came into existence at *Nea Penteli*, the little church of that name was already there. There are of course instances of very old roads that went out of use and disappeared, of torrents that were filled in and made into roads and building plots, of little old churches that instead of being preserved or replaced by modern ones were simply pulled down and forgotten, and of modern churches being built where there was no old religious or other sort of building.

Ancient Greek roads were as a rule very simply built. They did not have solid stone paving or foundations like the Roman ones. They had only a light road surface made of levelled and compacted earth, sometimes reinforced with layers of pebbles or stone debris. Such roads are easily destroyed by the weather, if they are not kept up, and soon become merged again into the terrain. Nevertheless, due to certain natural causes, even these lightly built roads have not entirely merged into the rest of the terrain, and they can be recognized at points where chance or excavation has revealed them, even if no roadside buildings, gutters or other diagnostic features have survived, but it needs careful attention and some experience to identify them. Sometimes, where the surface of a road is on rock or softrock, parallel ruts are preserved, left by the passage of waggon wheels. Sometimes there is archaeological evidence, usually consisting of indirect, but nonetheless sure, indications of ancient roadways in the form of ancient aqueducts, grave monuments and commonly old churches. The evidence we have indicates that it was always found easier to dig ditches in the ground or tunnels for aqueducts along existing roads rather than across a series of private properties. Graves, especially those with funerary monuments, were almost exclusively built beside roads, especially main roads. In searching for the traces or even for

Fig. 4 From Athens to Pentelicon a century ago. Section of sheets VI, V and XII of J. A. Kaupert’s maps of Attica (1881, scale 1:25,000). Scale 1:30,000.
Fig. 5 From Athens to Pentelicon, longitudinal section showing points of historical interest and archaeological topography. Scale 1:30,000.
Fig. 6 From Athens to Pentelicon, 1992, historical map showing features of historical and archaaeological topography. Scale 1:30,000.

whole sections of a road, certain functional or geophysical criteria prove very useful, like the shortness of the road connections between two places, natural fords, the easiest spots for bridging torrents, the route offering the fewest or smallest natural obstacles, and so on. For all these reasons, in addition to other, chiefly practical and historical ones, the courses of the older roads have remained almost unchanged until today. A good example is the Penteles road, which always followed a route that ran partly along the north side and partly along the south side of the *Halandri stream* (Figs. 4, 6). The course of this road has undergone only minor local changes, mainly connected with various works of improvement. Until about 1840, from Halandri onwards, the road ran along the north side of the stream. The existence of two ancient aqueducts on the same side makes it very probable that the road was also there in ancient times. One of these aqueducts, on the surface and cut into the ground, ran along the present *Kyprion Agoniston* st. At the imaginary intersection of this road with today's *Mesogeion* Ave. in Marousi, and roughly opposite the modern *Schole Douka*, there was also a large Tumulus which was still in existence at the beginning of this century. About 6.3 km from Halandri, somewhere in the present small street of *Ippokratous* in Nea Penteli, the road forked. The south branch crossed over a small bridge to the south bank of the stream and led to the monastery Moni Pentelis, and more generally to the location of the ancient village of *Pentele*. The north branch, which coincided with the modern streets of *Sokratous*, *Aristophanous* and *Perikleous* in Nea Penteli, went directly to the quarries, which began to be operated again at the end of the 1830s due to the demand for marble created by the Athenian neoclassical buildings. In 1841-42, with money provided by Sophie de Marbois, Duchesse de Plaisance[2], and to the design of A. Georgantas[3], a fine five-span bridge (Fig. 7) was built over the stream at a distance of some four kilometres from Halandri and three from Penteli on the modern Doukissis Plakentias st. in Melissia (Fig. 6). This bridge served to shorten the road, by shifting a section of it, four kilometres long, to the south side of the stream, the main objective being to expedite the transport of marble to Athens, primarily for the construction of the Ilissia Megaron, today the *Byzantine Museum*. In any event it is very probable that this new route is the same as an ancient one whose purpose must also have been to facilitate the stone transport. And it is therefore also probable that the modern five-span bridge stands on the site of an ancient one, no traces of which have survived or at least can be recognized. The greater part of the road we have described still exists. It coincides with the modern streets (from east to west) of *Aristeidou*, *Hagias Marinas*, *Palaion Latomeion*, *Doukissis Plakentias* and *Keas* in Melissia, the street Troias in Vrilissia, as far as the intersection with Menelaou st. and Pentelis Ave. from the present Halandri Municipal Sports Centre to Halandri. The section of the avenue above the Sports Centre as far as the first fork to Nea Penteli is more recent and was built to shorten the route to the Moni and Palaia Penteli. It is worth remarking here that from the quarries to Halandri the road was continuously downhill and therefore very advantageous for hauling heavily laden waggons. Only the earlier route across the stream, exactly north of Halandri, had in succession a downhill and an uphill section. But as we have seen, this obstacle was avoided by moving a four kilometre section of the road across to the south side of the stream. However, the continuation of the road on to Athens after Halandri was slightly uphill for 1.5 km, as it still is today. The map by the engineer A. Sommer shows that even 150 years ago, when Halandri was a very small village with only a few houses, the road joining it to Athens followed its present course for the most part: Vasileos Konstantinou Ave., Ethnikis Antistaseos st. and Kifisias Ave., the only difference being that at Hagia Varvara the road did not have its present bend towards Kifisias Ave., but followed the line of Mistral st. and joined Kifisias some three hundred metres further south at the crossing with Al. Papanastasiou st., at an altitude of ~180 m. The lowest point on the route, ~170 m, was one and a half kilometres before this, at the junction of the streets *Ethnikis Antistaseos* and *Kodrou*, which follows the line of the filled-in stream on the NW side of *Hymettus* and *Argonauton* st., beneath which the so-called *Hadrian's Aqueduct* ran at a depth of ~20 m.[4] At this point the road forked, acquiring a southern branch that led with only a slight southerly detour to *Mesogeion* Ave. Beneath this branch, which coincided with the present *Apostolopoulou* and *25th Martiou* st., ran the tunnel for Hadrian's Aqueduct. One other road connected Halandri with Athens, via the Mesogeia road. It coincided with the present *S. Venizelou* st. and must have arrived at *Mesogeion* Ave., following a route almost parallel to the modern streets of *Naupliou* in Halandri and *Bouboulinas* in Neo Psychiko. Along this route, about half a kilometre south of the centre of Halandri, is the Panhagia Marmariotissa[5] a very important Roman funerary monument, whose lower surviving part has been transformed into a church. Both the existence of the tomb and its survival in the form of a church are strong indications of the antiquity of the road. This road had certain advantages over *Kephisias* st., not only for the *lithagogia* but for all transport generally. The only uphill stretch along it was shorter than the similar one on the road to *Kephisias* st. It started at an altitude of 175 m, some three hundred metres south of the church of Panhagia Marmariotissa, at the intersection of the road with one of the torrents in the natural depression of Halandri (today filled in, beneath *Sarantaporou* st.), and after some nine hundred metres reached its maximum altitude of ~183 m. The route via *Mesogeion* Ave. was nowhere as steep as *Kephisias* st. in the region of

2. Δ. Κάμπουρογλου, Ἡ Δούκισσα τῆς Πλακεντίας, Athens 1923 in *Μελέται καί Ἔρευναι*, Ἑστία, 1927, vol. 1.

3. Δ. Καμπούρογλου, op. cit., 289-290, for A. Georgantas see I. Τραυλός, A. Κόκκου, Ἑρμούπολη, Athens 1980, 68, 70, 81, 93,124-125

4. E Ziller, Untersuchungen über die Wasserleitungen Athens, *AM* 2,1877, 120-122, pl.6, 8.

5. H. Möbius, Attische Architekturstudien, *AM* 52, 1927, 189-196, fig. 4, 8-14.

Ampelokepoi, where in the space of only 500 m the difference in altitude exceeded 20 m, as it is today. Hauling waggons over this stretch to Pentelicon must have been very hard work, while conducting them towards Athens would have called for good brakes. At all events it is reasonable to suppose that both roads would have been in use, especially while the Parthenon was being built. Due to the large number of waggons travelling back and forth between Athens and Pentelicon some traffic problems must have been inevitable, particularly whenever two waggons met and had to pass each other without causing chaos among the two teams drawing them, since each team would have numbered dozens of animals. In such cases the width of the road must have been considerably greater than the mere sum of the widths of the two waggons. There would have been less of a problem if both roads were used, and perhaps they adopted a one-way system in every place where this was feasible. These places have already been mentioned: one from Ampelokepoi to Halandri (Mesogeion Ave. – Kifisias Ave.) and the other from Halandri to the five-span bridge (roads on both sides of the stream).

That the junction of the *Mesogeion* Ave. and *Kephisias* Ave. was at the same spot a hundred and fifty years ago as it is today can plainly be seen on Aldenhoven's map (1837), and it must always have been there, as the geophysical data indicate. However, although the precise course of the road from this point to the town cannot be identified today with any certainty, even at the beginning of the last century, when *Syntagma* Square was just an empty open space, two hundred metres beyond the last houses, the road from the Mesogeia coincided exactly with the present *Vas. Sophias* Ave. as far as *Regilles* st. From there on it followed *Mourouzi* st., crossing the *National Garden* below the modern *Boule* (the Parliament), and ended at the *Mesogeitike Porta* (Gate) of the town at the beginning of *Amalias* Ave. Very probably in antiquity the road followed roughly the same route, with the exception of the last part, which was somewhat displaced in the 18th century due to the peculiar position of the *Mesogeitike Porta*. During the Middle Byzantine period a southerly branch of this road arrived at the *Kastro tes Athenas*, as the Acropolis was called at that time, via *Kydathenaion* st. and its continuation, *Thespidos* st., which ended at the east gate of the *Rizokastro*, which was the circuit wall at the beginning of the 13th c. At any rate, the ancient continuation of *Mesogeion* Ave. to the Acropolis took an even more southerly route at a lower altitude. Indications of the line of this road are given by the so-called *Aqueduct of Peisistratus*, parts of which have been uncovered at different times in the *National Garden*, in *Lysikratous* Square, in the *Sanctuary of Dionysus*, south of the *Herodeion* and on the north side of the *Hill of the Nymphs*. An even more southerly branch of the ancient road came to the *Olympieion*. This is the route that must have been taken by the bulkiest blocks of Pentelic marble for the later construction of the huge temple in the 2nd c. BC under Antiochus V and in the 2nd c. AD under Hadrian.

In the Hellenistic, and even more so in the Roman period, a large part of the production of the Pentelicon quarries, chiefly sarcophagi and secondarily statues and architectural elements, was exported, and consequently there must have been some extension of the road to Piraeus.

The final point in these comments concerns toponyms, and first of all the ancient names of *Pentelicon* and *Pentele*: the older of the two is *Pentele*. This was the name of a settlement on the site of the present Moni Pentelis. The original name of the mountain was *Brelissos*. The names of *pentelethen lithagogia* in the Acropolis inscriptions and *Pentelicon* derived from the name of the settlement.

A more recent name, *Oros ton Amomon* was due to the growth of asceticism in the Middle Ages. The older name *Pentele* was never forgotten, but it sometimes became corrupted in later times to *Mentele*, the consequence of which was the use of the name *Mone Menteles*. Simultaneously with the name Penteles, a variation of the name as the epithet of the monastery is *Mone Pentele* instead of *Mone Penteles* (commonly used by German authors; today Moni Pentelis). The area of the ancient quarries, at an altitude of ~800 m, is sometimes referred to as *Aspra Marmara* (White Marbles). There are many more occasional toponyms, invented by the casual workers in the different quarries. Rather older are the toponyms Bathyrema and *Soulenari* (west of Spilia). The name *Spelia* or *Spilia tis Pentelis* is the oldest and surest of the more recent toponyms. The popular *Spilia tou Daveli* has no basis. Often, especially in scholarly studies, the name *Spelaion ton Amomon* is used.

- A. Ἀραβαντινός et al, *Γενική ρυθμιστική μελέτη ἀναπτύξεως Πεντέλης*, Athens 1975.
- A. Γαλανόπουλος, Ἐξορυκτικές δραστηριότητες στην Ἀττική, κατάλογος έκθέσεως "*Ἀττικό Τοπίο καί Περιβάλλον*", ΥΠΠΟ, Athens 1989, 284-287.
- J. Camp, *Watersystems of Ancient Athens*, Univ. of Michigan 1976.
- E. Curtius – J. A. Kaupert, *Karten von Attika*, Berlin 1881-1900, 4, 5, 12.
- O. Fountoulaki, *Stamatios Kleanthes*, Athens 1979.
- W. Judeich, *Topographie von Athen*, München 1931.
- G. Koch – H. Sichtermann, *Römische Sarkophage*, München 1982.
- A. Κορδέλλας, *Αἱ Ἀθῆναι εξεταζόμενοι ὑπό ὑδραυλικήν ἔποψιν*, Athens 1887.
- R. Lepsius, *Griechische Marmorstudien*, Berlin 1890, 11-23; *Geologie von Attika*, Berlin 1893, 55-60,151-153.
- A. Milchhöfer, *Erläutender Text zu den Karten von Attika*, Heft III-VI (Berlin 1889), 32-35.
- K. Μπίρης, *Γιά τή σύγχρονη Ἀθήνα*, I, 1956, 39-41 (Τά λατομεῖα καί οἱ λόφοι τῶν Ἀθηνών); *Αἱ Ἀθῆναι*, Athens 1966; *Αἱ τοπωνυμίαι τῆς πόλεως καί τῶν περιχώρων τῶν Ἀθηνών*, Athens 1971.
- J. Travlos, *Bildlexikon zur Topographie des antiken Athen*, Tübingen 1971; *Bildlexikon zur Topographie des antiken Attika*, Tübingen 1988.
- J.B.Ward-Perkins (Collected Papers of), *Marble in Antiquity*, H. Dodge and B. Ward-Perkins, eds., British School at Rome, London (1992) passim and fig. 59.
- R.A. Wycherley, Pentelethen, *ABSA* 68,1973, 349-353.
- E. Ziller, Untersuchungen über die antiken Wasserleitungen Athens, *AM* 2,1877,107-131.

Fig. 7 Five-span marble bridge on the ancient quarry road. Condition in 1992. Plan and east view (1:120).

The bridge is about 4 km from Halandri and 3 km from Pentelicon on the modern *Doukissis Plakentias* st. in Melissia. It was built in 1841-42 at the expense of Sophie de Marbois, Duchesse de Plaisance to the plans of the architect-engineer Alexandros Georgantas. It was intended for the transport of marble to Athens, primarily for the Ilissia Megaron, today the *Byzantine Museum*. The bridge had a length of 40 m, an effective width of 3.50 m and an overall height of 10 m. A study of the different measurements of the bridge makes it possible to arrive at certain conclusions about the principles behind the calculations used in its construction: the arches all have a radius exactly equal to 3.00 m and an angular measurement of 120° instead of the more usual 180°. Thanks to the quality of the materials and its structure, the bridge is in an excellent state of preservation. Nevertheless, one part of the bridge appears to be of a poor construction not in keeping with the rest. The parapets are very low and built of obviously second-class materials. This was not due to carelessness in the choice of the material at the time it was built, however. It is solely due to the robbing of the very part of the structure that in bridges of this kind was intended to present the most finished appearance, in other words the marble capping of the parapet characteristic of such bridges. When Kambouroglou gave a rather summary description of the bridge in 1923, the marble capping stones, the *kraspeda* (kerbstones) as he called them, had already been removed. An aesthetically interesting feature of the bridge is the deliberate changes in the styles of construction apparent in the different zones from the lower to the upper parts. The lower, wide parts of the piers are built of rough stones. The rest, up to the beginning of the arches, is of more carefully and decoratively fashioned rubble masonry. The arches themselves and the corresponding parts of the piers exhibit a much more carefully dressed appearance, and the surviving parts of the parapet are almost the same. Evidently the missing capping stones must have been the most perfectly cut.

This solidly built structure dating to the very beginnings of the modern Greek state is not yet threatened by old age. The only threat to it is from the aesthetic destruction of its original environment, from its proximity to the products of an unfortunate architectural development, and from the accumulation of garbage along the banks of the stream and other evil tokens of our era.

Casual visitors of today overlook the monument; they are usually riding in some vehicle and do not realize its original beauty. In other circumstances, however, they would undoubtedly have formed a different impression, like that of Kambouroglou:

“And the encounter is truly a delightful one, among woodlands in their natural state, with a naive and simple, but ever poetic bridge. What astonishes one, however, is this majestic, age-old, many-arched bridge, that was destined for the transport of marble from the mountain quarry to Athens.”

– Δ. Καμπούρογλου, *Μελέται καί έρευναι*, vol. 1, Athens 1927, 289-290.

Explanation of Plates 2-5.

Obtaining large building blocks is only easy if they happen to have already become separated from the parent rock by existing natural joints. If this is not the case, they must be detached from the rock mass with the aid of cutting and splitting tools. More specifically, it is only possible, or at least practicable, to split a rock with wedges along the strata or perceivable cleavage planes if the rock is free all round. If it is not, then the task is much harder, because it is first necessary to cut around the perimeter of the stone to a depth corresponding to the height or thickness of the desired block. If the rock is marble the most usual method is to cut narrow grooves, if the depth does not exceed 50-60 cm, or by cutting a wide trench if the depth has to be greater. The ancient Greeks only resorted to this laborious method of cutting around a marble block by grooving or more rarely channelling it if it was absolutely indispensable, or if, that is, the rock was continuous and unfissured over an area much greater than that of the desired block. Since it was easier to obtain a block when it happened to be bounded by accidental natural fissures or by regularly repeated natural joints in the rock, ancient quarrymen, like modern ones, tried to exploit as far as possible the possibilities afforded by these natural discontinuities in order to save themselves all or some of the labour of freeing each block all round; they therefore organized the quarrying to follow as far as possible the pre-existing natural joints. Thus every quarry acquired a particular irregular shape as a consequence of the special geometry of the strata and the natural fragmentation of the rock. The part of an ancient quarry shown in Pls. 2 and 12 is irregular for the same reasons. Its multiple surfaces are of three distinct types: the dark-coloured surfaces of the natural fissures and joints ("master joints" in the language of English quarrymen), usually yellowish-red due to the argillaceous and stalactitic material, surfaces with parallel rows of marks left by a heavy cutting tool (the *tykos*, Pl. 7) and the white surfaces of the fresh breaks or splits. Around the edge of the splits are preserved parts of the sockets cut for the wedges in previous stages of the quarrying. This is also the origin of the dressing with a punch along approximately the median line of the upper surface of the stone for the capital. This continuous line is the remnant of the groove cut in a previous operation to free the front part of an overlying mass. The back part of the same mass was removed immediately afterwards with the help of wedges, the positions of which are apparent from the remains of their sockets along the same line.

On the left (Pls. 2, 4) rectangular slabs are being detached by exploiting the natural fissures and cutting a few grooves. On the right (Pls. 2, 12) there are only steep rocky surfaces with temporary tracks for hauling the marble blocks out of the quarry.

The shape of the quarry in our illustrations was in a state of constant change and growth, as would have been the case in every quarry, so that Pls. 2 and 12 only depict transitory phases in the quarry Λ1.

– M. Korres, The Geological factor in Ancient Greek Architecture, *The Engineering Geology of Ancient Works, Monuments and Historical Sites* (P. G. Marinos and G. C. Koukis, eds.), Rotterdam 1988, 1779-1793.

Explanation of Plates 6-7.

(see Figs. 8, 9)

The marble of the Parthenon and of Pentelicon generally, like many other places, exhibits a grading of its mechanical properties in different directions, according to the *length* (***1***) (longitudinal axis of the fabric), *width* (***2***), and *thickness* (***3***) of its crystalline structure (see Fig. 8). The length offers the greatest tensile-bending strength, and the thickness, the least. The conceptual surfaces ***III***, which are defined by the directions ***1***, ***2***, are the softest and a fairly smooth cleavage is possible along them. This cleavage occurs more easily in direction ***1*** and less easily in direction ***2***. The conceptual surfaces ***I***, which are defined by the directions ***2*** and ***3*** are the hardest and at the same time those along which a smooth cleavage is not possible. Lastly, the conceptual surfaces ***II***, defined by the directions ***1*** and ***3***, are harder then those of ***III*** and softer than those of ***I***. Cleavage along surfaces ***II*** are more difficult and less perfect than those along surfaces ***III***.

In virtually all the quarries on the south side of Pentelicon the *length* of the rock is orientated from SW to NE, with an inclination of 10°-30°, and the rock is interrupted transversally by natural vertical tectonic joints, the distances between which range from 1 to 8 m. The two other directions of the geological structure (***2*** and ***3***) exhibit variations of inclination due to the folding of the rock (see Fig. 13).

In accordance with the above, the marble slab depicted in the illustrations, from which the large Doric capital would have been made, is bounded by two natural joints and the *length* of the rock runs from the bottom left to the top right, approximately at right angles to the joints. The trimming of the superfluous rock from the upper part along the *length* and *width* is done only with wedges, while removing the superfluous rock on the left side, which is perpendicular to the *length*, is effected, after deep channels and numerous wedge slots have first been cut to make the splitting run as near to the desired plane as possible. The detachment of the front part in such a way that it is perpendicular to the *width* of the rock, is moderately difficult, and for this reason can be effected over a larger area than that of the small piece, using shallower grooves and wedge slots (Pls. 7, 8). These factors also apply to the further cutting up of the top slab (Pl. 7).

The difference in hardness and cleavage according to the different directions or dimensions of a piece of marble may be compared to the differences in the hardness and cleavage of a piece of wood according to whether the grain is parallel or perpendicular. The structural causes of the differences may be dissimilar: the process of crystallisation in one case, and the process of organic growth in the other, but such differences do not prevent the artisans working in stone and wood from approaching the problems of breaking and splitting in a similar way. These differences in the case of wood or schist can be easily grasped by an ordinary person, even if he is not familiar with wood or stone working. On the other hand, the differences generally intrinsic to a body of white, veinless marble are not readily apparent to the eye. The ways of distinguishing them are one of the secrets of the skilled stone-mason's craft.

The traditional terminology of the marble-cutters when referring to the faces of a marble slab is worth noting:

- *face* equals surface ***III***
- *head* equals surface ***I***
- *mourelo* equals surface ***II***

The two first terms are also used by Greek woodworkers for the corresponding surfaces of a piece of wood[1]. The third term also comes from woodworking: the Venetian morèlo is the thickness lengthwise of a wooden board[2].

1. Z. Τζάρτζανος, *Περί τῶν λαϊκῶν τεχνικῶν ὅρων τῆς οἰκοδομικῆς, μετά λεξικοῦ αὐτῶν,* Athens 1961, 117, 152, 193.

2. G. Caniato (ed.), *Arte degli squerarioli,* Venezia 1985, 202.

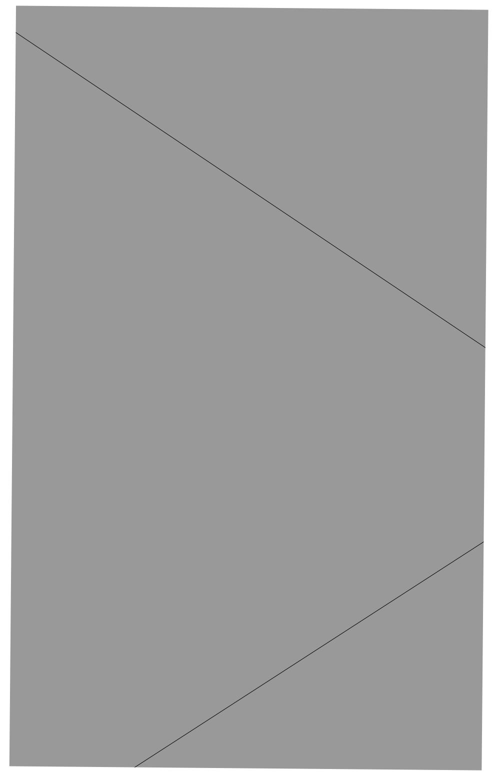


Fig. 8 Crystaline stucture (fabric) and stone-cutting.
A Cutting obliquely to the axes of the fabric
B Cutting parallel to the axes of the fabric

1	*length* of the fabric (greatest tensile strength) direction of driving wedges >	***I***	head of the rock hard face
2	*width* of the fabric (moderate tensile strength) direction of lateral driving of wedges >	***II***	cheek of the rock moderately hard face
3	*thickness* of the fabric (little tensile strength) direction of hewing < quarrying grooves	***III***	face of the rock or plane of cleavage soft face

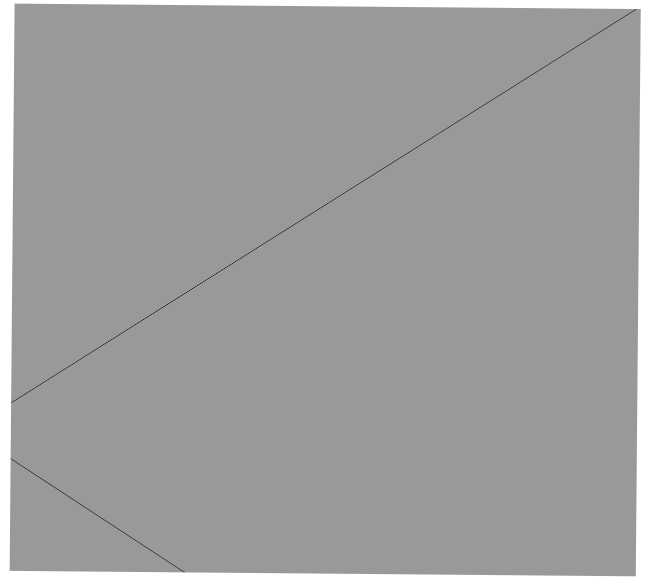


Fig. 9 Fabric and stone-cutting.

The determination of the quarrying grooves followed rules for the most efficient exploitation of the different mechanical properties of the *length*, *width* and *thickness* of the geological structure. The grooves were *perpendicular* to the *face* of the fabric and generally not deeper than ~ 60 cm, so that they could be cut from the outside and would therefore be much narrower and more economical than the common quarrying trenches. It was therefore advantageous for even very large buildings to be constructed of stones that, where possible, would not be thicker than 60 cm (this was the main reason why the architraves of the Parthenon had a *thickness* of three blocks 60cm thick instead of two 90cm thick). The other dimensions followed the length and thickness of the geological grain, so that every stone conformed to the requirements of its static function in the building and the stone-cutting requirements of dressing it in the different stages. Architraves and beams had to be parallel to the length of the fabric, while the different sculptured decorations were more easily carved on the softer sides (e.g. *faces*) of the fabric. It was better if the harder sides (e.g. *heads*) ended at the joints, primarily the side ones, for maximum economy in the labour of hewing.

Explanation of Plate 8.

The first step in giving the block a regular geometrical shape was to create a *plane of reference*. This was laid out by chiselling guide lines around the perimeter. These were levelled up by making successive corrections until two long straight rods, placed on two opposite sides of the slab, were exactly aligned with each other; the rods were of wood in the first stages of the work, and of iron or stone in the later ones. The slab intended for the capital is seen here at the stage in which the edges are being prepared; the remaining, larger part of the surface is left unworked or only roughly dressed. This is a common feature of most of the unfinished marble members. This is the stage when the lifting bosses or "ears" begin to appear; these were parts of the original stone mass that were deliberately left as projections, useful both as indicators of the thickness of the marble that had been removed in the course of the dressing, and as bosses for gripping or supporting the stone while it was being moved, turned over or lifted.

In the foreground of the illustration two stout wooden beams and a small pile of stone debris are visible; these will be used for turning the block over in order to dress the underside.

Explanation of Plate 9.

Turning the marble blocks over in the quarry was always a difficult operation in the days before industrial lifting machinery came into use. Sometimes, however, the underside, although having a natural clastic fracture surface, turned out to be moderately even, and it was therefore not entirely necessary to dress it at the quarry. In this case they preferred to transport the stone together with its relatively slight surplus thickness on the underside rather than confront the difficulties of inverting it. One such instance was the huge half-worked cylindrical marble block (see Fig. 17) whose fragments still lie on the right of the slipway at a distance of ~250 m from the *Spelia Quarry*. Such stones only needed to be turned over one time before being finally dressed and set in place. Depending on the evenness or otherwise of the lower separation or cleavage surface of the rock, the blocks for a building needed to be turned over at least once in the course of dressing and setting them in place, and very often twice. The result was that the relative positions occupied by some of them, particularly the many blocks in a wall, when a building was constructed often corresponded to those they had occupied for millions of years in the rock matrix from which they were taken.

Explanation of Plate 10.

(see Fig. 10)

Some of the most important tools used for working marble had evolved from similar tools used for poros stone or even wood, while others were clearly intended especially for marble. They can be divided into quarrying, stone-cutting and carving tools. The main quarrying and stone-cutting tools were for *hewing*. They are generally classified into *direct percussion* and *indirect percussion* tools. The direct percussion tools, most important of which were the *tykoi* (*sokoi*, *pikounia*), the surfacers and various adzes, were more effective but also more tiring to use. The *indirect percussion* tools, such as punches, chisels, *xoides* and others, were struck with different sized hammers, hence their impact was lighter and more accurately directed.

Today marble working by artisans is largely carried out with indirect percussion tools, while in ancient times large surfaces were mainly dressed with direct percussion implements, and the indirect percussion ones were only used where it was absolutely necessary, along the edges of the blocks or more generally the borders of the different surfaces, where the blows needed to be lighter and more accurately aimed. At all events, the ancient tools were from a metallurgical and functional point of view much superior to the modern ones and much more varied in size. Generally they were harder and also less fragile than the modern ones and thus sharper; as a consequence they were lighter, faster in operation and were capable of delivering more blows per minute.

The unsurpassed quality of the ancient stone-working tools was principally due to their equally unsurpassed metallurgical quality. Unfortunately, apart from the names of some of them, a few simplified representations of them and some very corroded remnants, nothing of the tools themselves has survived. However, the marble products created with them will remain as an eternal, incontestable testimony to the worth of these tools.

There is a generally prevailing opinion that the shapes of the ancient tools were rather similar to the modern ones (cf. Fig. 10), but the existing evidence indicates that many of them were, at least in size, if not always in shape, unique types bearing no similarity to those of any other period, including our own.

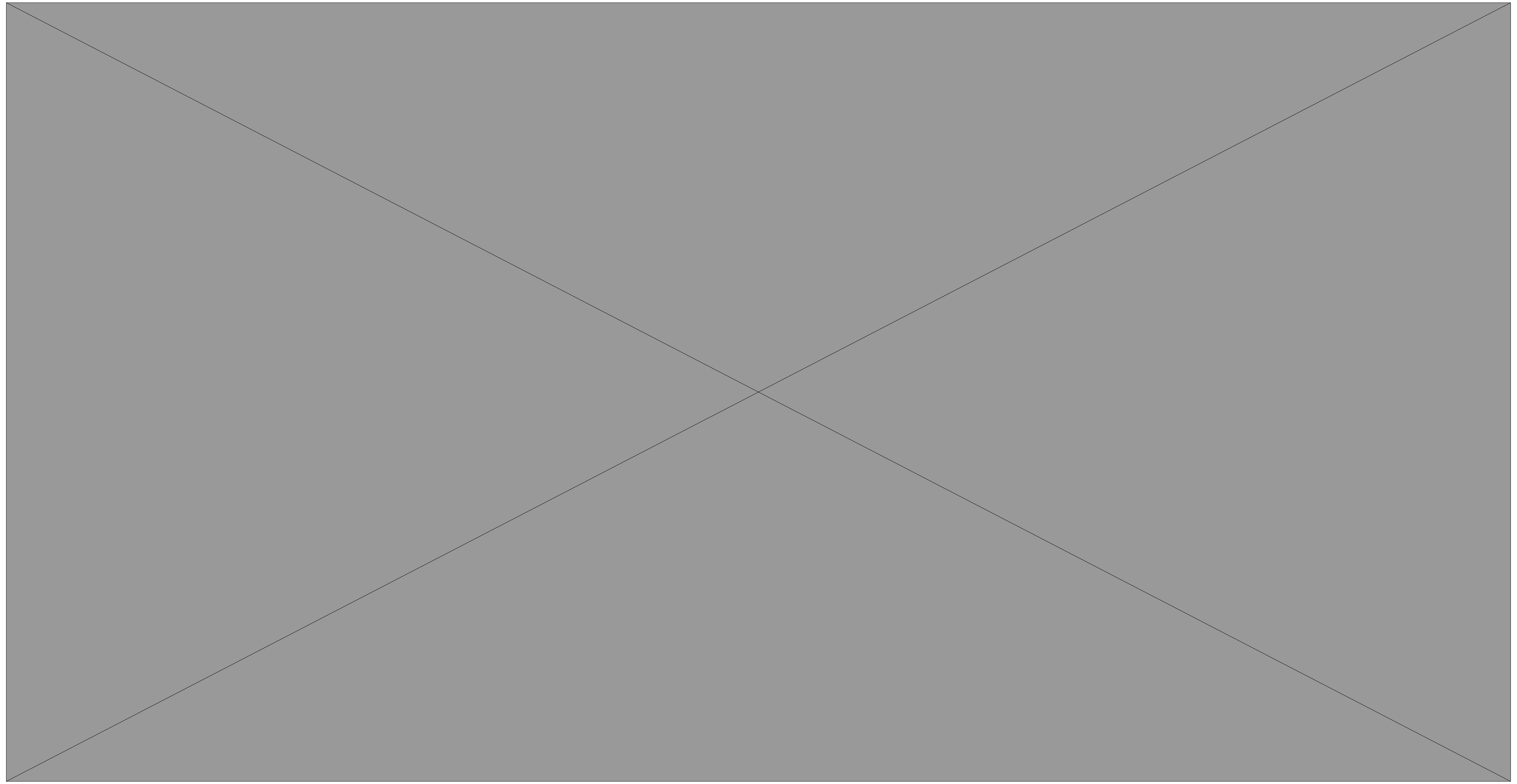


Fig. 10 The principal ancient and modern tools for quarrying and cutting marble (excluding those for sculpture). Scale 1:10.

1 *tykos*, **2** large pick-hammer, **3** small pick-hammer, **4** spalling-hammer, **5-6** probable shapes of ancient extra small pick-hammers for light, decorative surface dressing, **7-9** iron crowbars, **10-11** iron try squares, **12** rule, **13** measure, **14** large *bareia* (sledge hammer), **15** straight pein hammer, **16** mason's hammer, **17** dub hammer, **18** hammer for marble working, **19** small hammer for marble working, **20** pitcher, **21-22** points, **23-25** waster and toothed chisels, **26-28** boaster and flat chisels, **29-30** flat-toothed chisels, **31** long chisel for holes, **32-33** iron wedges (*plugs and feathers*), **34-36** sharp-toothed surfacers, 35 and 36 also existed in a flat-toothed form, and also as mason's axes (not toothed, *skeparna*) by analogy with the chisels 26-30, **37-38** compasses, **39** plumb-level, **40** line and red paint (ruddle) for marking, **41** iron crab-hooks, **42-43** various wooden rollers, **44** iron roller, **45-46** small bronze rollers.

Explanation of Plate 12.

The *Spelia Quarry* (=Λ1: see Figs. 11-17, 20, 21, 23-25, 38, 39).

Plate 12 is a reconstruction of a general view of the most important of the ancient quarries (Λ1: see Figs. 1-6 and 11-22). This quarry, known as *Spelia Quarry*, is the best example of massive deep quarrying. It is at an altitude of ~700 m above sea level and 1800 m in a straight line (almost 3 km on foot) from the square of modern Palaia Penteli (altitude ~460 m) in a NNE direction (~20°).

As it appears today (Figs. 11-15) there is no ascent from the interior of the quarry to the entrance, but from various surface signs and indications it seems that the earliest bottom surface was 10-20 m below the present surface, so that in many places the quarry bottom must have been at a lower altitude than the entrance. The marble in that early stage would have been hauled up to the level of the entrance by powerful windlasses. The plan of the quarry would also have been different. Originally it took the form of deep parallel trenches. The present shape (Figs. 11-16) will have been the result of subsequent rock quarrying between the trenches, the predatory quarrying of rock from the walls of the most northerly trench and the filling up of the deepest parts of all the trenches and of the cave itself with stones and debris. Fortunately a large part of the original shape of the quarry has been preserved beneath the huge accumulations of stone and debris. Nowadays the only visible working surfaces are those outside the cave on the left (Figs. 23-24). These surfaces, ~35 m high, are merely a part of what once was the north side of quarry Λ1. Before the quarry was opened up the cave would have been inaccessible from the surface. The central chamber, ~100 m in length, was originally much deeper. At the bottom of a natural chasm, starting from the lowest part of the large central chamber, there is a small passage hewn in the rock with flat vertical walls and a narrow roof, which leads to a small, natural, circular cistern-chamber of an underground spring (Fig. 15). It is very probable that this place, apart from its practical use, also had a cultic function. Its shape and the cutting of the passage suggest that it is Classical in date. Unfortunately, due to the vandalistic operations carried out on a large scale in the years 1977-83, various subterranean parts of it were damaged or rendered inaccessible, at least for the present.

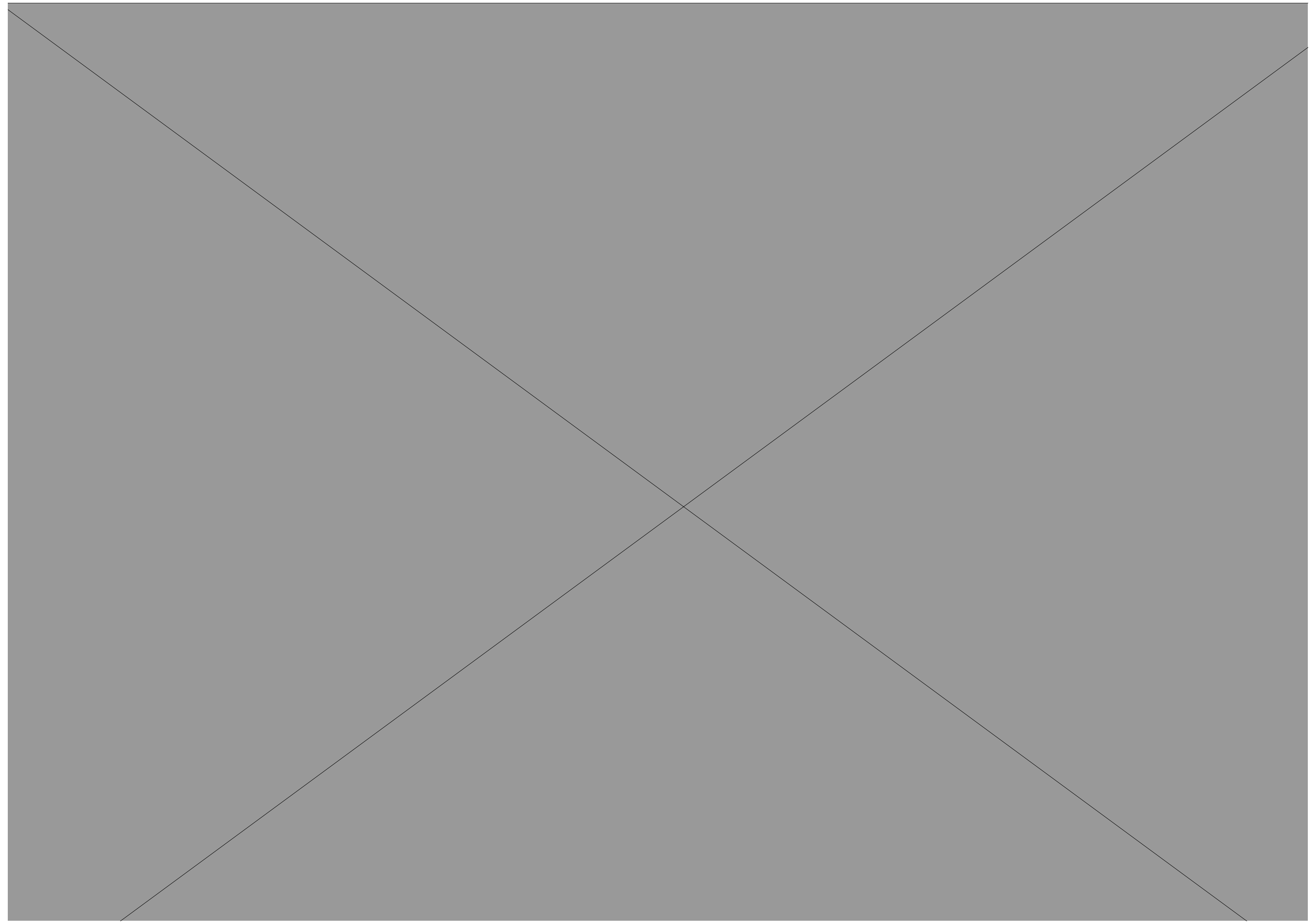


Fig. 11 The *Spelia Quarry* (Λ1) and the large trench-shaped quarry Λ2. The situation until 1976. Scale 1:1000.

The realization that the material in the bottom of the *Spelia Quarry* consists of ancient, regularly formed layers of debris twenty or more metres deep, automatically entailed the necessity of reconstructing the phases of the quarrying and exploitation of both this and the other nearby quarries. A comparison of the stratigraphies that it is possible to observe at different points in the *Spelia* and other quarries (see Figs. 22-25), shows that the quarrying operations proceeded in successive sections from the lower to the higher parts of the slope. The debris produced in one section was dumped into the empty space left in the previous section, and so on. Within the layers of debris inside the cave were found unfinished architectural and sculptural pieces from many different periods (Fig. 17), including the statue of a seated goddess, fragments of a large Laconian tile and unfinished covering tiles, fragments of a Roman sarcophagus, a small altar with mouldings on three sides, and other objects.

From the different finds and a comparative stratigraphical study of the quarries it appears that the *Spelia Quarry*, as the oldest of them, was the source of marble for the Parthenon and other Classical buildings in Athens. It continued to operate on a declining scale for some centuries until it finally ceased.

The sequel to the quarry's history is witnessed by the Christian monuments in it: the little 11th c. churches standing at the entrance to the cave (Fig. 39), the 6th c. reliefs on the rock in the little church of Hagios Spyridon, the remains of a third church in the SE corner of the quarry (Fig. 12, no. 6), various hermitages, three water cisterns, and other features. The actual cave was also an ideal place of refuge. A stout wall, the south end of which still survives, occupied the whole width of the cave mouth. Its appearance (Fig. 14, no. 33) is known from 18th and 19th c. drawings (Fig. 39).

Until the end of the 16th c. the *Spelia Quarry* with its small churches, hermitages and other features, was a place where asceticism flourished. When Moni Pentelis was built in 1578 by Timotheos, the Metropolitan of Euripos, the ascetics in the cave and others from different places on Pentelicon moved to the monastery and abandoned their retreats. The hermitages at the quarry were also abandoned at this time, although not entirely. They were often used as refuges during pirate and other incursions, as well as in times of plague.

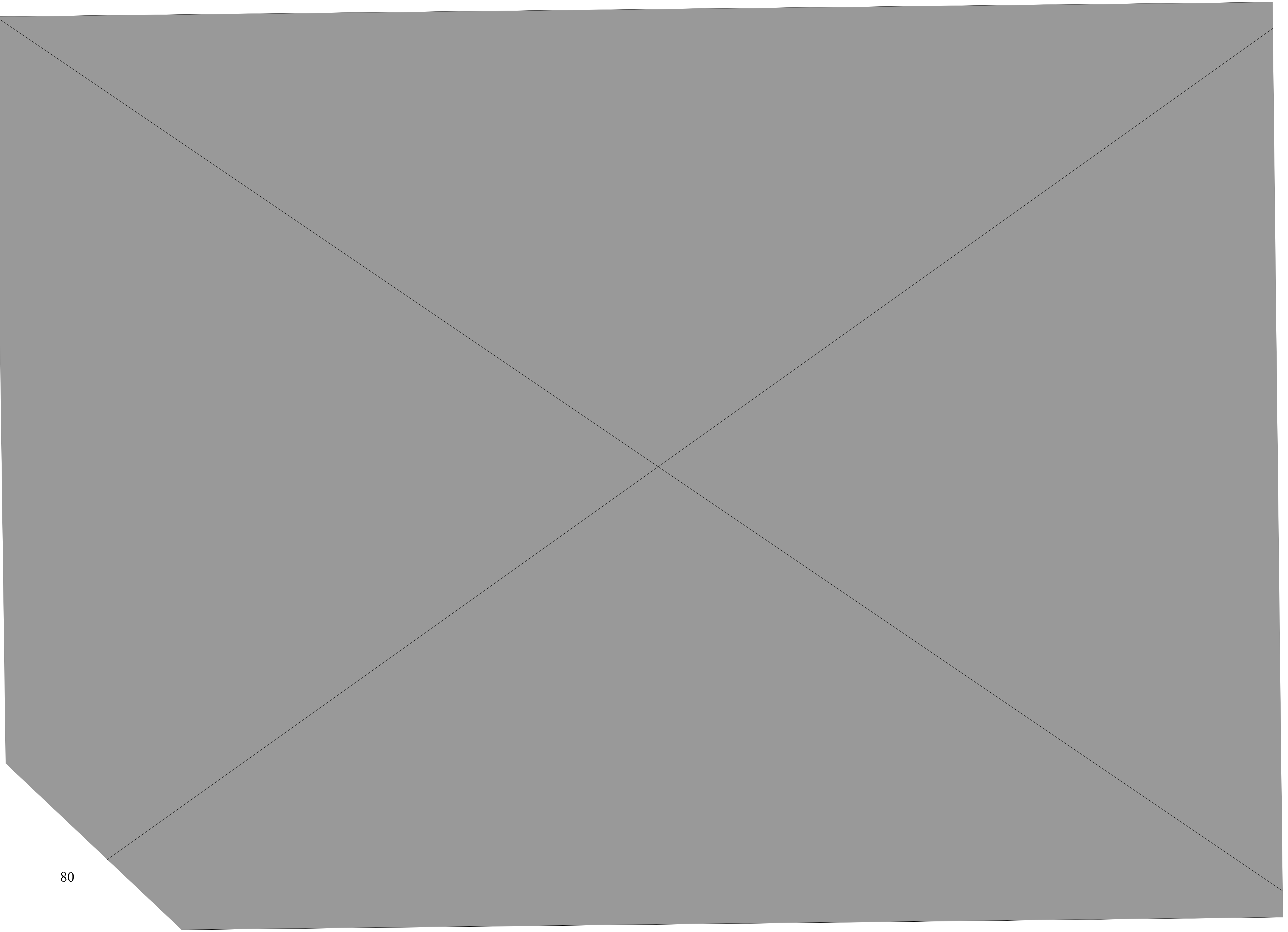
From the mid -17th c. onwards it was one of the places much visited by antiquarian travellers. This is known not only through their travel journals, but from the many names carved on the rock walls of the churches.

In the spring of 1836, by royal decree, quarrying began again in the *Spelia Quarry* for marble for the palace. The tools and materials were kept in a small building (Fig. 38) with a porch facing south, the ruins of which can still be seen (Figs. 12, no. 17). The quarrying there stopped, fortunately, before serious harm was done to the central quarry, but unhappily operations continued intensively in the other ancient quarries north of quarry Λ2.

The fascination exercised by the place on the early travellers grew in the years that followed. Its natural and historical attractions made it one of the most popular excursion places for older Athenians up until the 1960s. Among the countless known and unknown visitors, D. Kambouroglou was one of the regular ones. The name Spelia tou Davele, by which the place has become known to modern generations, is a recent, rather arbitrary fiction.

The magnificent surroundings of the Spelia Quarry were violated once again between 1976 and 1988 when excavating and blasting were carried out for military works, which in the end were cancelled. This caused the foundations to collapse and produced cracks in the walls of the little church of Hagios Nikolaos, and its frescoes had to be removed from the walls and taken to the Byzantine Museum.

– F. Aldenhoven, *Itineraire descriptif de l'Attique et du Peloponnèse*, Athènes 1841, 46-47.
– R. Chandler, *Travels in Greece*, Oxford 1776, 170.
– E. Dodwell, *A classical and topographical Tour through Greece during the Years 1801, 1805 and 1806*, Vol. I, London 1819, 499.
– Ἐβλια Τσελεμπή, *Τά Ἀττικά τοῦ Ἐβλιᾶ Τσελεμπῆ* (Κ. Μπίρης, ed.), Athens 1959, 59; *Ταξίδι στην Ἑλλάδα* (Ν. Χειλαδάκης, ed.), Athens 1991, 189-190.
– L.S. Fauvel: Vue des Carrières du Pentelique à 3/4 d'heure NE du monastère, water colour 1781. Bibl. Nat. Paris, C.48095. I am indebted to Prof. L. Beschi for this information.
– Haller v. Hallerstein 1817, in H-G. Bankel (ed.), *Haller von Hallerstein in Griechenland*, Berlin 1986, 108-109 (The first measured topographical plan of the area and particularly of the large quarry, the slipway and the smaller quarries).
– B. Καλλιπολίχης, ΑΔ 19, 1964, Β΄ 72.
– Δ.Γ. Καμπούρογλου, *Ὁ Ἀναδρομάρης τῆς Ἀττικῆς*, Athens 1920, 55-56.
– Γ.Γ. Λαδᾶς, Ἡ σπηλιά τῆς Πεντέλης, Συλλέκτης Α', 1950, 137-168, cf. *Συλλέκτης* Β΄ 1957, 1-19.
– Ludwig Lange, *Steinbruch zu Pentele*, June 1836 (Two water colours in Graphishe Sammlung, München Inv. Nr. 35763 & 35764).
– R. Lepsius, *Griechische Marmorstudien*, Berlin 1890, 11-23; *Geologie von Attika*, Berlin 1893, 55-60, 151-153.
– A. Milchhöfer, *Erläutender Text zu den Karten von Attika*, Heft III-VI (Berlin 1889), 32-35.
– Μ. Μαγνήσαλη, Θ. Μπιλῆς, *Μελέτη ἀποκαταστάσεως τῶν ἀρχαίων λατομείων...*, National Tehnical University of Athens 1991.
– Ντ. Μουρίκη, *Δελτίον τῆς Χριστιανικῆς Ἀρχαιολογικῆς Ἑταιρείας* 1, 1974, 79-119.
– A. Ὀρλάνδος, *Ὑλικά καί τρόποι δομῆς τῶν ἀρχαίων Ἑλλήνων*, vol. 2, 80-81, 90-91, pls. 31-33.
– A. Ὀρλάνδος, *Εὑρετήριον τῶν Μεσαιωνικῶν Μνημείων τῆς Ἑλλάδος* Γ', 1933, 196-197.
– S. Pomardi, *Viaggio nella Grecia* II, Roma 1819, 66-67.
– Prokesch von Osten, *Denkwürdigkeiten und Erinnerungen an den Orient*, vol. 2, Stuttgart 1836, 424-429.
– L. Ross, Das Pentelikon bei Athen und seine Marmorbrüche, L. Schorn's *Kunstblatt* 18, Tübingen 1837, 5-6, 10-11, 16.
– J. Spon, *Voyage d'Italie, de Dalmatie, de Grece et du Levant*, II, Lyon 1678, 124.
– O.M. v. Stackelberg, Latomies du Pentelique (lithograph, 1810), *Vues pittoresques et topographiques de la Grèce*, Paris 1829-38.
– Γ. Σωτηρίου, Ἡ σπηλιά τῆς Πεντέλης, *Ἡμερολόγιον τῆς Μεγάλης Ἑλλάδος*, 1927, 45-59.
– J. Travlos, *Bildlexikon zur Topographie des antiken Attika*, Tübingen 1988, 329-334.
– D. Vanhove et al.. *Marmer in Hellas*, Brussel 1988, Katalogue, fig. 8 (quarry Λ2), fig. 10 (quarry Al, drawing by Stackelberg), fig. 11 (quarry Al, drawing by Dodwell).
– J. M. Wickens, *The Archaeology and History of Cave Use in Attika*, Indiana Univ., Univ. Microfilms, Ann Arbor, MI 1986, 194-202.



Note. The orientation of the *Spelia Quarry* and the other quarries is approximately diagonal to the principal north-south axis. The high quarried wall forms the NW side and the entrance is on the SW side, and so on. But to make it easier for the reader to follow, we have labelled the directions N instead of NW, E instead of SE, etc. The decision to use the convention E rather than N to represent the NE compass direction was not purely arbitrary. The true orientation is not completely diagonal. The NW side is pointed slightly more towards the north (~40°) than the west, and the other sides correspondingly. Apart from this, however, the arbitrary compass direction chosen gives the front of the little churches, which actually face SW, a westerly rather than a southerly orientation, thus conforming to the general rule for other churches.

Fig. 12 The *Spelia Quarry* (Λ1) and the large trench-like quarry (Λ2).
Plan. Scale 1:800.

1 Stone paved *slipway* for the marble.
2, 2 Visible parts of the SE end of the quarry: surfaces showing the parallel horizontal grooves made by the ancient *tykos* (pointed hammer). The points 2, 2 show the position of the entrance to the *Spelia Quarry* at the period of its greatest expansion.
3 Visible part of the west side of the quarry: ancient surface of the rock cutting along a natural joint. Some sections of this surface can be recognized on adjacent detached masses of rock.
4 Scree of ancient deposits of debris and stones.
4' The NW mound of deposits in the quarry.
The stratigraphy of the mound, visible in the modern surfaces of the cutting (55), consists of very regular layers of fine debris alternating with layers of stones and layers of a mixture of debris with an even finer earthy material. The successive strata terminate against the north rock-cut surface of the quarry and slope downwards to the S. All the strata underlie the oldest ruins (15-18) of the upper parts of the quarry walls, which thus proves that the mound of debris and pile of stones are ancient. Its greatest thickness at position 11 in 1982 was almost 20 m. Therefore at position 4' the thickness of the accumulation of debris and stones must be considerably greater than 25 m.
5 Point where an older bend in the paved road to the N is visible.
6 Ruin of an old building. It is identified as the little church marked on the Hallerstein map (1817) in about the same spot.
7 Ruin of an old building with traces of a tetrastyle porch on the west side. The age of this structure is indicated by L. Lange's watercolour (Fig. 38), which also establishes its identity. The building was new at that time (1836), plastered, with a wooden door and tile roof. It evidently served as a headquarters or toolshed.
8 The SW mound of debris inside the quarry.
The stratigraphy of the mound is visible from the south in the scarp of the later quarry.
8' Ramp of the latest prolongation upwards of the *slipway*. On the west side of the ramp was an old stone retaining wall.
9 Traces of a paved, somewhat older, continuation of the *slipway* onwards to the cave.
10 The latest form of the upward continuation of the *slipway*.
11 Recess in the north wall of the quarry. The lower part of it was uncovered by chance down to a depth of ~20 m in the course of the destructive government operations (1976-1983), which were fortunately discontinued after action by the competent state authorities. The north side of the recess has a negative deviation from the vertical of ~30% and is worked in the ancient manner (parallel grooves, etc.) for the whole of its height. The east side coincides with a natural clastic rock surface.
12 Parts of the crumbling rock mass in situ between quarries Λ1 and Λ2.
13 Recess in the south wall of quarry Λ2.
14 Ancient chiselling and regular wedge sockets in the south wall of the recess.
15-26 The fallen parts of the crumbling rock mass between quarries Λ1 and Λ2. Pieces 15-23 had fallen long before the 19th century, and pieces 24-26 fell after the robbing of buttress 27. Piece 26 broke away and was shifted after 1940.
27 Position of a rock mass which, along with others, was intentionally left unquarried because it was considered necessary to act as a buttress for the overhanging north wall of the quarry (cf. Fig. 13). This buttress can be seen in the drawings by Fauvel and Stackelberg.
28 Recess in the north wall where there had once been a small structure, probably a hermitage. Earlier visitors, notably Prokesch von Osten, commented on it (see Appendix 1) and it appears in the drawings of Fauvel and Stackelberg.
29 Modern buttress of reinforced concrete, part of the cancelled government project (1976-1983).
30-33 The intact part of the rock mass between quarries Λ1 and Λ2. Its upper surface preserves the height and slope of the original natural surface. The south face forms part of the north wall of the quarry Λ1, has an overhang and is worked in the ancient manner. The height of point 32 above the present surface of the quarry is ~40 m. The whole of the face is white marble, but at a slight depth the white marble gives way to a rock mass with vertical schistose, chloride and other strata, which also contains amounts of marble, but small and fissured. The collapsed part of the rock mass (12-26) has the same composition. The sloping north side of the rock mass, which forms the south wall of the large trench-like quarry (Λ2), is also marble, but only to a slight depth below the surface. Based on what has been said, it is clear that the rock mass between quarries Λ1 and Λ2 owes its preservation to the fact that the rock was unusable, chiefly because of its geological composition (cf. Fig. 13). The marked overhang of the north wall of the *Spelia Quarry* is the result of taking away the material up to the face of the boundary between the marble and the schistous

rock, which has an outward inclination from the vertical. For the same reason, the other side, which forms the south wall of quarry Λ2, slopes in the opposite direction. Similarly, and for the same reasons, the north wall of Λ2 also has or had an overhang, just like the north wall of the *Spelia Quarry*. The static stability of the southward overhanging walls was assured by the "buttresses" (cf. Fig. 13); these, unfortunately, standing almost totally free on all sides, fell victims to later predatory exploitation.
34 Horizontal section of the wall on a level with today's surface.
35 The north wall of the quarry directly above the entrance to the cave.
36 The east termination of the quarrying at different heights above the cave mouth.
37-38 The east wall. It is irregular in shape and contains only a very few worked surfaces because on the east, as on the west, the natural joints in the rock were used as the natural boundaries of the successive steps in the enlargement of the quarry.
39 The visible part of the south side, mostly destroyed by operations in the years 1977-1983.
40 Projection of the outline of the cave.
41-44 Sections of the north wall of the trench-like quarry (Λ2), worked in the ancient manner (parallel grooves, etc.). The recess at 43 corresponds, as for its level and place to the recess at 13 on the south side of the same quarry.
45 The south side of Λ2 consisting chiefly of sloping cuttings and separation surfaces of regular slabs of marble. The greater part of it is ancient and unfortunately, due to its orientation, eroded by lichens, which have given it a characteristic grey hue.

Recent predatory quarrying has occurred only in certain places, where apparently the ancient quarrymen had left some sections untouched because the rock presented more densely spaced natural joints and cracks.
46-47 Part of the bottom as it was until 1987. At point 46, the upper part of a rock-cut wall worked in the ancient manner.
48 Limits of the stone pile in the eastern part, showing the visible stratigraphic division between the ancient (below) and modern (above) deposits, of a thickness of ~4 m.
49 Stone base for a machine, probably a windlass, from the first period of predatory reworking of the quarry (~1850-1900).
50 Modern stone filling.
51 Extensive modern predatory quarrying from the upper part of the ancient walls. The lower is hidden deeper below the surface of the modern and ancient stone piles and stone fill.
52 Recent rock-blasting (1977-1983).
53 Recent access road (1977-1983 works).
54 Recently infilled part (1987-1989 works). It was filled in with a heap of stones of maximum height 20 m and a volume of ~15,000 cubic metres.
55 Recently excavated and shifted part of the ancient heap of stone (1987-1989 operations).

Fig. 13 The relation of the shape of the quarry to the geological structure. Axonometric reconstruction of the *Spelia Quarry* and the large trench-like quarry (before the collapse, demolition and predatory quarrying of their walls).

The shapes of these quarries were the result of the almost total removal of the best marble (M), between and outside of two parallel bands of commercially useless material (Z). The continuation of the rock along the *length* of its geological fabric (that is, the *veins*) is interrupted by parallel natural joints (P), whose distances apart governed the greatest length of the blocks that could be quarried.

It is interesting and no coincidence that the expansion of quarries Λ1 and Λ2 was towards the part where the joints were fewer. The termination of the quarry at the east end, where the cave appears, was due less to the presence of the cave than to the sudden greater frequency of the natural joints at this point, with which in fact the existence of the cave itself is directly connected. The same phenomenon can be seen in the other quarries (Fig. 20).

A study of the varying distances between the natural rock joints suggests that the blocks were for the most part cut in batches according to their size from the parts of the quarry where the distances between the natural joints equaled the lengths required for the blocks, thus economizing on both labour and marble. In this context it may be noted that the design of an ancient temple assisted greatly in taking full advantage of the varying sizes of the natural divisions of the rock in a quarry. From the huge blocks for the Parthenon architraves and lintels to the marble roof tiles, many sizes of blocks were needed: square ones with 2 m sides and a thickness of ~0.95 m for column drums, oblong blocks 2.10 x 1.40 m and 0.60 m thick for the *crepidoma* and 2.5 x 1.20 m and 0.60 m thick for *orthostatai* or architrave blocks, square ones with sides of 1.30 m and oblong ones 1.30 x 0.60 m and 0.60 m thick for the walls, as well as many others, larger and smaller, for other parts of the building.

The blocks for the Parthenon lintels must have been cut at point 1, where the largest space between the joints occurred (~8 m), the architrave blocks at the nearby points 2 and 3, and so on. A careful examination of the walls on the north side suggests that before they were damaged in recent years, they were everywhere ~40-50 m high (together with the parts beneath the fill) and had a very pronounced southward overhang. To prevent the overhanging parts from collapsing, sections of the marble (A) were left unquarried to act as buttresses. In the creation of these buttresses they generally preferred the same sections of rock that, left unexcavated in the lower parts, had served as partitions to contain the debris (see Figs. 22-24).

In choosing the sections to serve as partitions and buttresses, static, functional and commercial criteria all apparently contributed. Usually they selected places where the rock, because of its composition or the frequency of joints, was less useful. In this way the existence of the buttresses and partition walls also avoided useless rockbreaking labour. It is also reasonable to suppose that some of the buttresses may have served as boundaries for the administrative division of the quarry.

The system of partition walls and buttresses is still plainly visible in quarries Λ7 and Λ10, as it was in ancient times in the *Spelia Quarry*. From the drawings by Fauvel and Stackelberg it appears that the buttress A3 (no. 27 in Fig. 12) survived into the last century (this also made climbing up to the nearby hermitage easier). Traces of the buttresses can still be recognized in other places, for instance the lower part of buttress A2 beneath the fallen masses nos. 19 and 20 in Fig. 12. Larger sections of buttresses must still be preserved in the earth fill (the level of which as it was at the beginning of the last century is shown in the drawing by a dotted line).

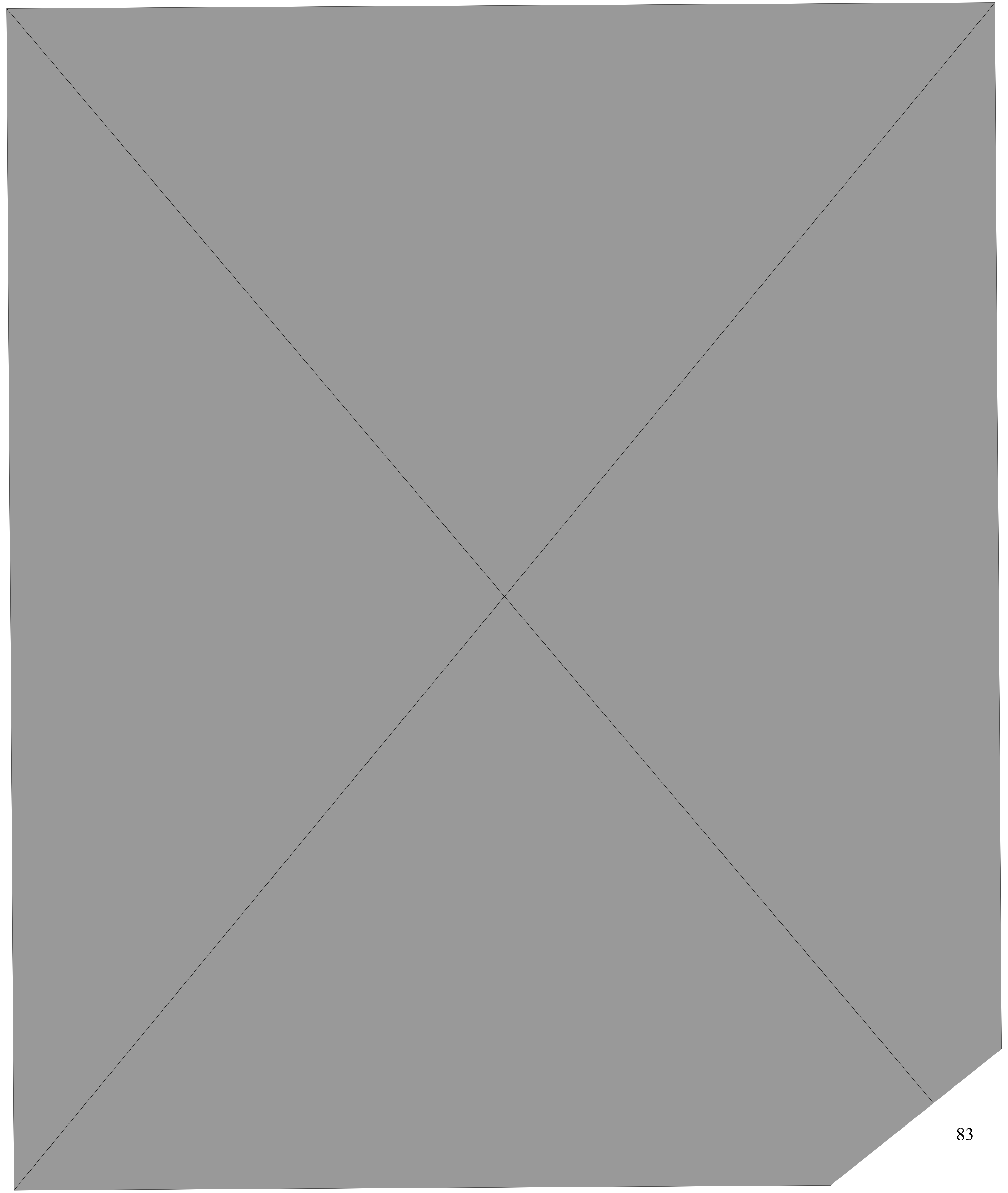
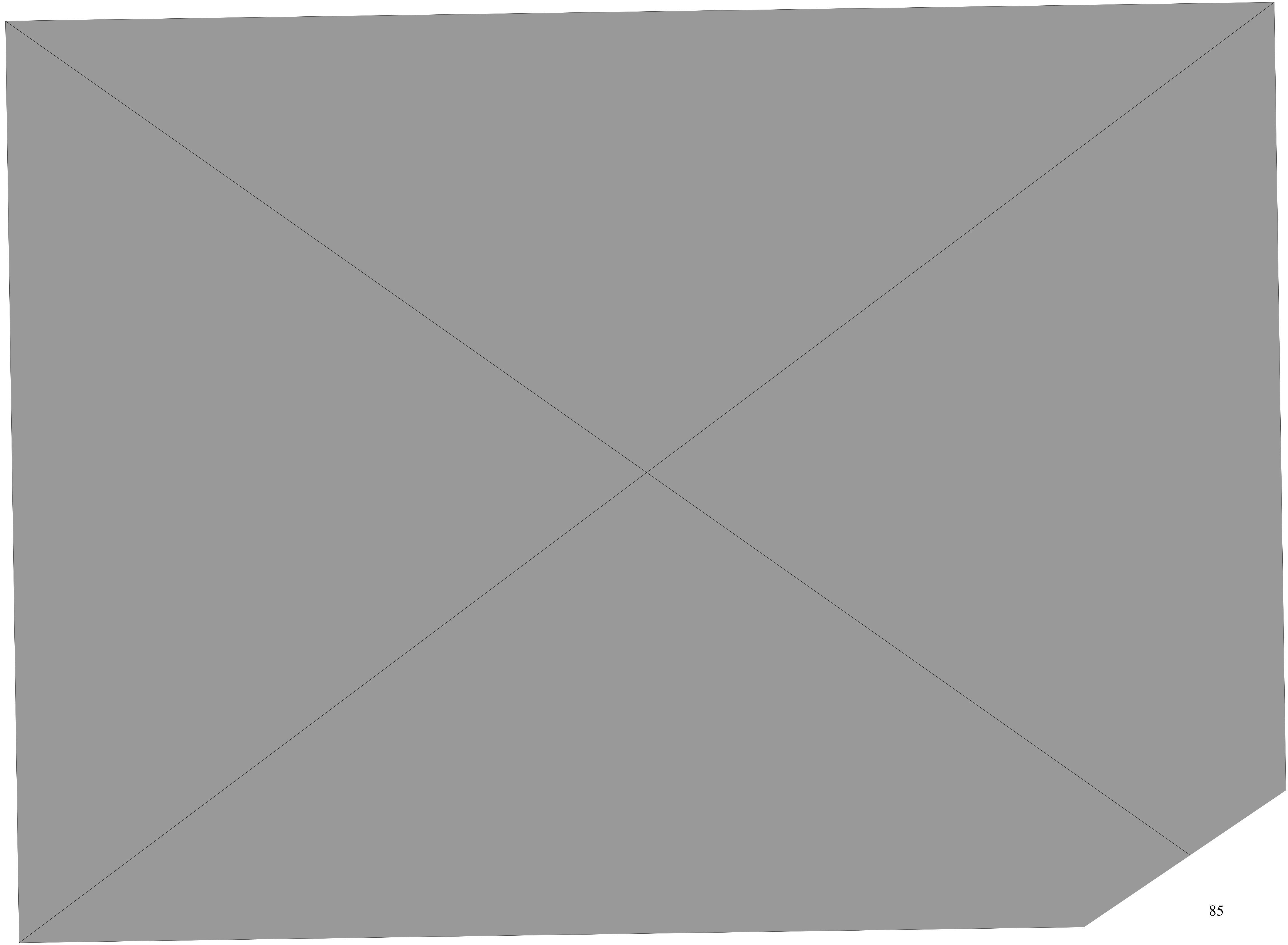


Fig. 14 The *Spelia Quarry* (Λ1) and the large trench-like quarry (Α2).
Horizontal section. Scale 1:800.

1-7 As in Fig. 12.
8 Recess in the south wall of quarry Λ2.
9 Ancient cuttings and wedge sockets on the north side of the recess.
10-11 Recesses in the north wall of quarry Λ1.
Recess 11, after the fall of the overlying rock, assumed a cave-like form and at some time was converted into a sort of cave refuge by building small walls. In the roof of this chamber, once part of the north wall, are a series of ancient beam sockets similar to those at various other points on the north wall and to those sketched by Fauvel in the most westerly part of the wall, of which a longer section still (1782) survived in his day.

In the west side there are also beam sockets, but smaller, and a specially shaped cutting for attaching a rope.
12 Dividing wall between recesses 8 and 11, also useful as a buttress for the overhanging north wall of quarry Λ1. It may be noted that the two recesses, although belonging to opposite sides of the rock mass, penetrate so deeply into its thickness that the south side of 8 is further south than the north side of 11. This, it is true, would not have created a serious static weakness in the rock mass, since only the bottom of recess 11 was very deep, and underneath recess 8, at a higher level, the rock mass separating the two quarries was solid over its whole thickness.
13-14 Recesses and projections on the north wall. A row of wedge sockets at point 14.
15 West wall of the quarry.
16 Visible part of the south wall of the quarry.
17 Projection of the overhanging part of the north wall.
18 Projection of the upper part of the mouth of the cave.
19 Large stalactitic mass.
20 Recesses and small side passages.
21 Place where pieces of an unfinished marble sarcophagus were found (see Fig. 17).
22-22 Surfaces with many old and some modern cuttings.
23 "Attic" behind stalactites. Destroyed during recent operations (1976-1983).
24 Well-like natural chasm. The upper part destroyed and the rest filled during recent operations (1976-1983).
25 Natural passage with stalactites. Closed off by the recent filling in of the entrance (see 24).
26 Hewn rectangular passage with roof-like ceiling.
27 Circular chamber—natural water cistern.
28 Chasm narrowing downwards.
29 Side chamber inside the cave with traces of ancient quarrying.
30 Hagios Spyridon.
31 Hagios Nikolaos.
32 Cruciform chamber with a hemispherical dome. A grave at the north side and another under the floor.
33 Remains of a sturdy medieval rampart in the cave. It occupied the whole width of the cave mouth. At point 33´ there was a large blind arch on its inner side.
34 Remains of a water cistern outside the rampart.
35 Cisterns with barrel-vaulted roofs.
36 Remains of auxiliary buildings. Hermitages or lodgings.
37 Site of a cave-like hermitage. On the north wall is carved: *Ιοάνης, Ιουνίου 14, 1836* below a neatly proportioned incised cross.
38 Cave-like building beneath a fallen rock.
39 Wide, but low, cave-like refuge beneath the fallen rock.
40 Position of an ancient "buttress" for the quarry wall, now destroyed, by which it was possible to reach the rock hermitage.
41 Probable position of the filled-in part of the north wall of the quarry.
42 Probable position of the filled in part of the west wall.
43 Probable position of the filled in part of the south wall.



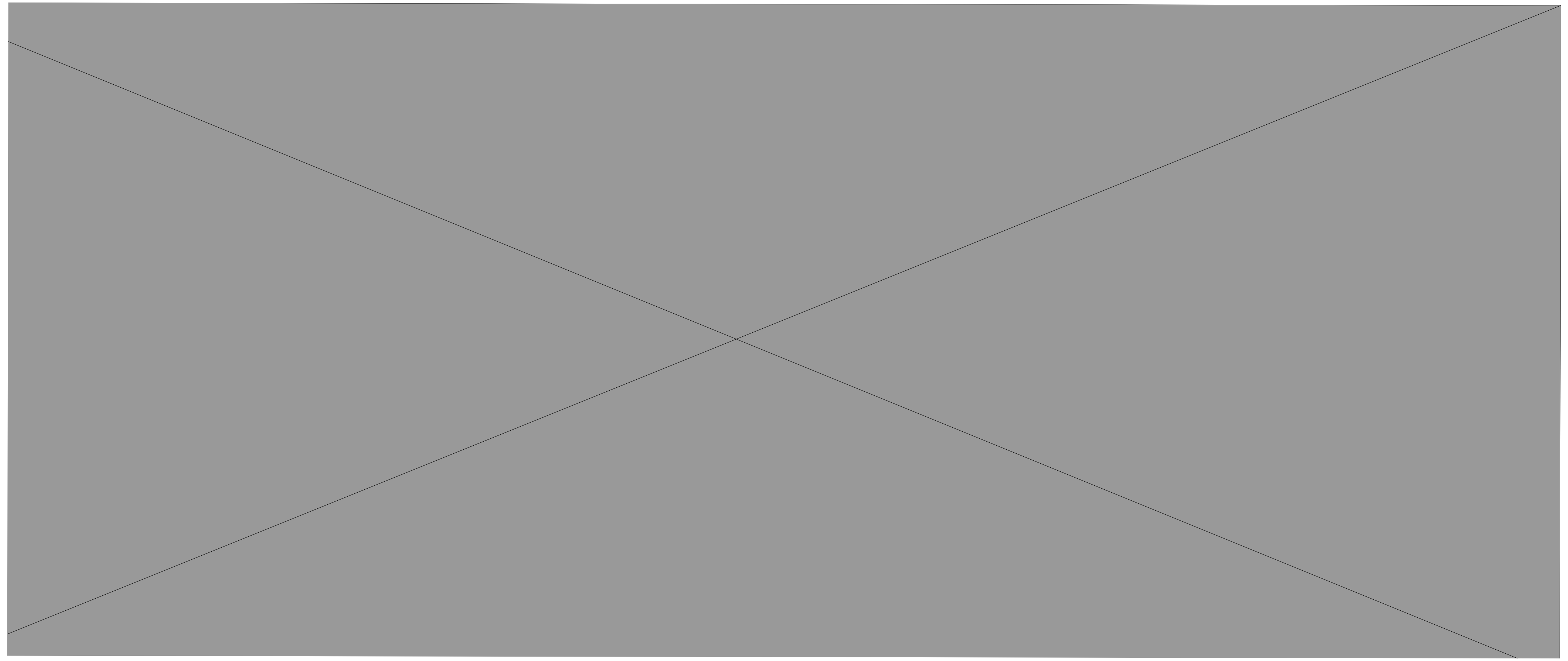


Fig. 15 The *Spelia Quarry* (Λ1) and the large trench-like quarry (Λ2). Cross section. Scale 1:800.

1 Modern quarry to the north.
2 Rock mass north of quarry Λ2.
3 Ancient north wall of quarry Λ2.
4 Original (natural) surface on the north side of Λ2.
5 Upper part of the north side of Λ2, destroyed by predatory quarrying with explosives.
6 Surface worked in the ancient manner.
7 Ancient debris and stone pile.
8 Probable level of the bottom of Λ2.
9 As Fig. 12, 45.
10-12 The north, upper and south sides of the fallen rock mass. The lengths and inclinations of the surfaces were calculated from measurements of the dimensions of the fallen pieces and the identification of their original positions.
13 North wall of Λ1.
14 Layering of the ancient debris and stone strata on the north side of Λ1.
15 Probable level of the bottom of Λ1.
16 Probable unexcavated bedrock between Λ1 and Λ2.
17 Probable level of the bottom of Λ3.
18 Probable form of the south wall.
19 Original (natural) surface on the south side of Λ1.
20 Slide of the ancient stone pile.
21 Modern quarry to the north.
22 The stone-paved *slipway* for the marble. The section of the road within the quarry runs into stone piles that are even older than the road!
23 Fallen pieces of the rock mass between Λ1 and Λ2. Some of them weigh hundreds of tonnes.
24-28 New approach road (1987-9 works).
25-26 Rock clearance north of Λ1 (1987-9).
26-27 Partial infilling of Λ2 with new stone fill with a total volume of ~15,000 cubic metres (1987-9).
28 Excavation and removal of the ancient debris (1987-9).
29 Trench-like transverse cutting.
30 Intact part of the rock mass between Λ1 and Λ2.
31 North, worked, wall of Λ1.
32 The east termination of the quarrying at different heights above the mouth of the cave.
33 The east wall (see Fig. 12, 37-38).
34 The visible part of the south side, for the most part destroyed.
35 Modern stone fill.
36 As no. 5.
37 Recently blasted part of the south side of Λ2 (1976-1983 works).
38 Older continuation of the *slipway* higher up.
39 Mouth of the cave.
40 Hagios Spyridon and Hagios Nikolaos.

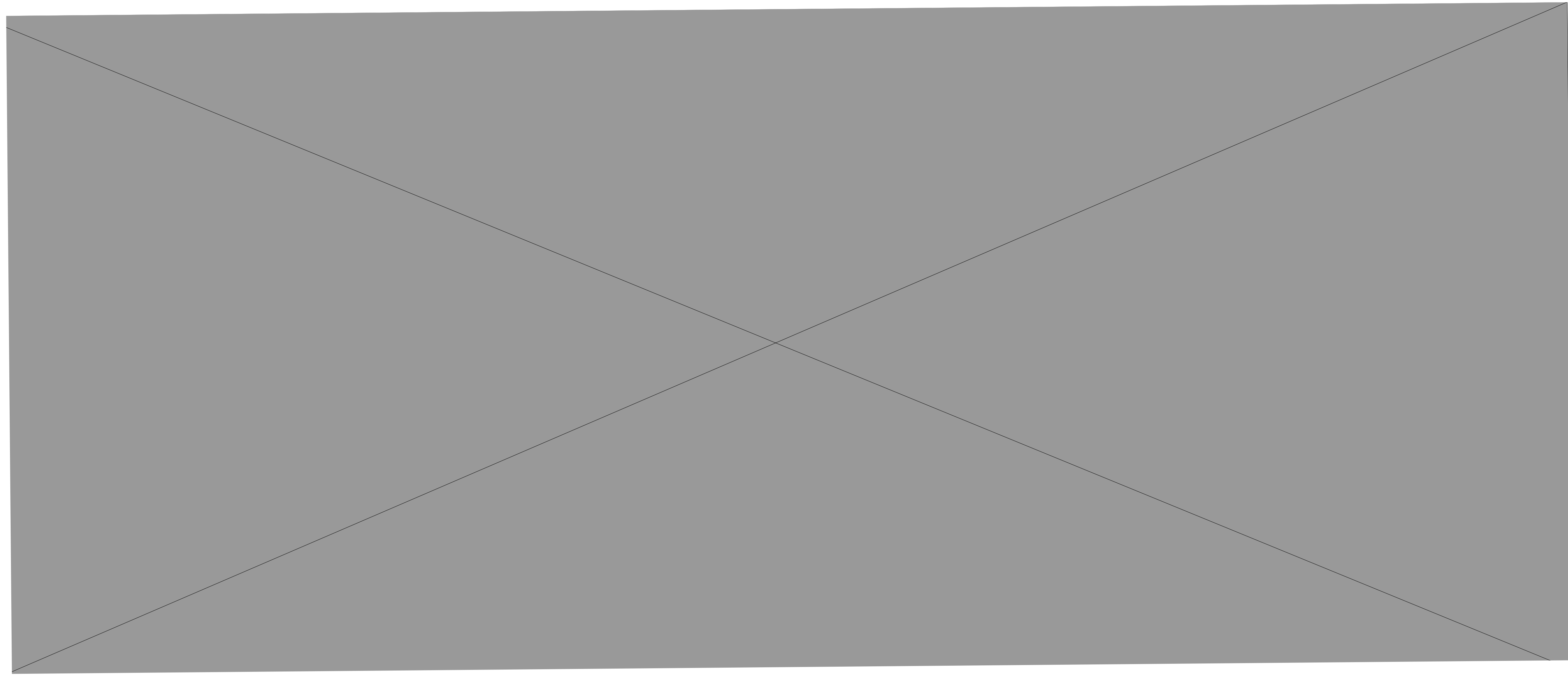


Fig. 16 The *Spelia Quarry* (Λ1)
Longitudinal section. Scale 1:800.

1 Modern quarry to the west.
2-4, 4' as in Fig. 12.
5 Slide of the ancient debris scree due to undercutting by the modern quarry. The layering is visible.
6 Stone and debris strata beneath the *slipway*.
7 As in Fig. 12 (restoration on paper of the 1836 building).
8 The crest of the slope before the start of the ancient quarrying.
9 Probable level of the ancient quarry bottom.
10 Ancient stone layers beneath litle church Hagios Nikolaos.
11-27 As in Fig. 12.
28-33 As in Fig. 12.
34 Recess in the wall at the height of the present-day ground level.
35-36 As in Fig. 12.
37 Position where the longest marble blocks were cut.
38 The rampart in front of the cave as it was until the beginning of the 19th c. Its great thickness makes it probable that the upper part of the wall was a walkway with a crenellated parapet, or that it was intended to build it in this form.
39 Hagios Nikolaos.
40 The cave.
41 The form of the bottom before 1977. This form, a sloping, slightly conical surface, was simply due to piling up the debris and stones from the quarry during the last stage of its operation (~2nd c.).
42 Successive ancient layers of debris.
43 The bottom after the 1981 digging operation.
44 Extension of the waggon road inside the cave to serve the excavation works of 1981.
45-46 Slide of loose rock into the interior of the cave after the excavation of its bottom, resulting in the creation of an extensive gap (46) between the marble and the schist and posing a severe threat to the stability of the cave roof.
47 Probable original surface of the cave bottom.
48 Probable original lateral surface before the accumulation of the debris inside the cave.

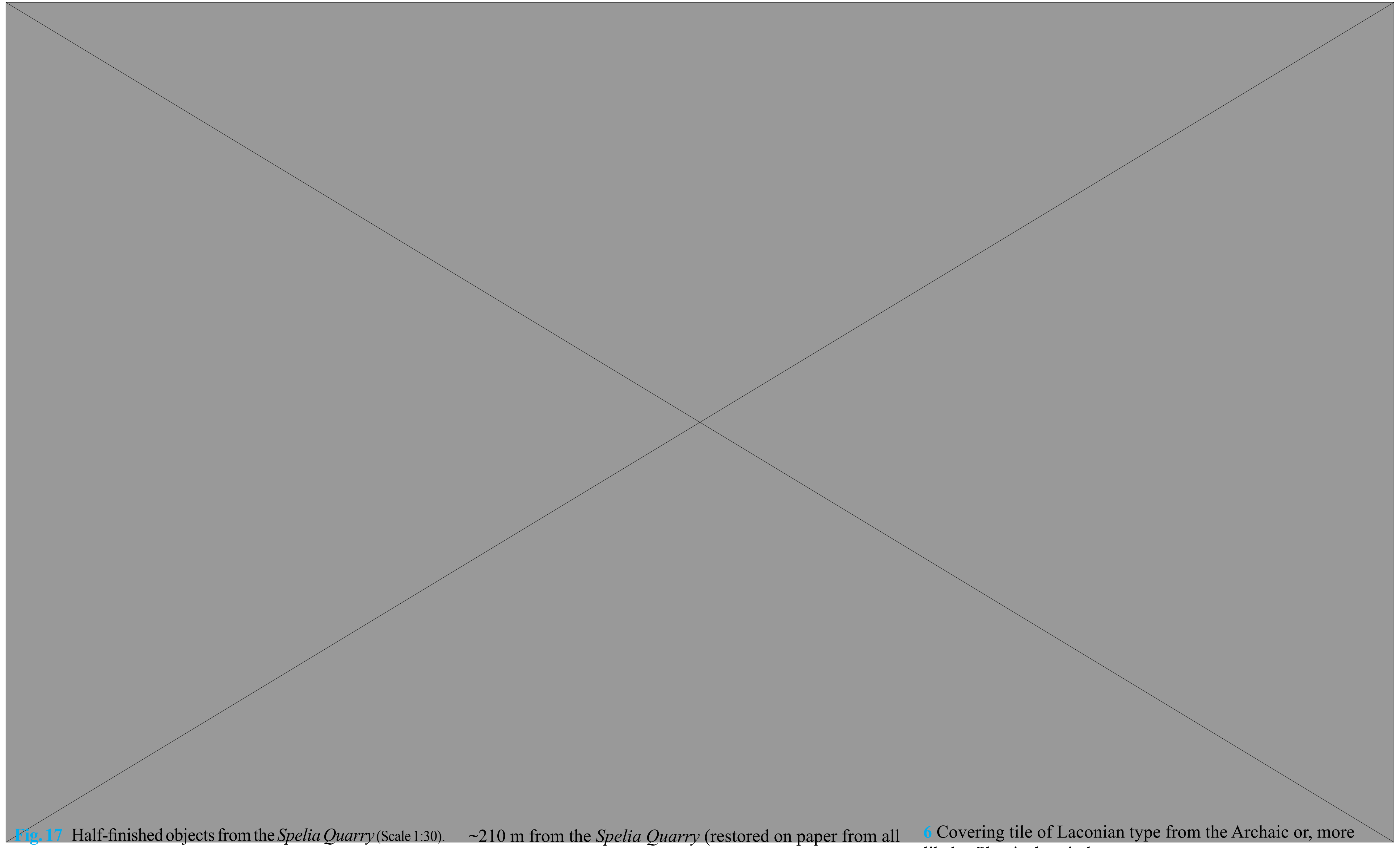


Fig. 17 Half-finished objects from the *Spelia Quarry* (Scale 1:30).
1 Column drum for the Olympieion, weighing 10 tonnes, found beside the slipway ~250 m from the *Spelia Quarry*. It belongs to the Roman period of operations, during which the drums were hoisted with iron lewises. In earlier stages of the work they were raised by the lifting bosses.
2 Cylindrical stone with greatest diameter ~2.50 m, height ~1.90 m and weighing ~23 tonnes, found beside the *slipway* ~210 m from the *Spelia Quarry* (restored on paper from all the fragments). It had been broken up with wedges. Heat damage indicates an earlier forest fire.
3 Seated figure of Archaic type (probably a goddess) in natural size.
4 Sarcophagus, inside the cave (restored on paper from fragments).
5 Covering tiles of Corinthian type.
6 Covering tile of Laconian type from the Archaic or, more likely, Classical period.
7 Pan-tile of Corinthian type
8 Base or small altar of the Hellenistic period. The mouldings and bottom surface completely finished. The fourth side has no moulding.

The objects nos. 3, 4, 6 and 7 came from the recent excavation (1977) and removal of the remains of the ancient quarrying inside the cave.

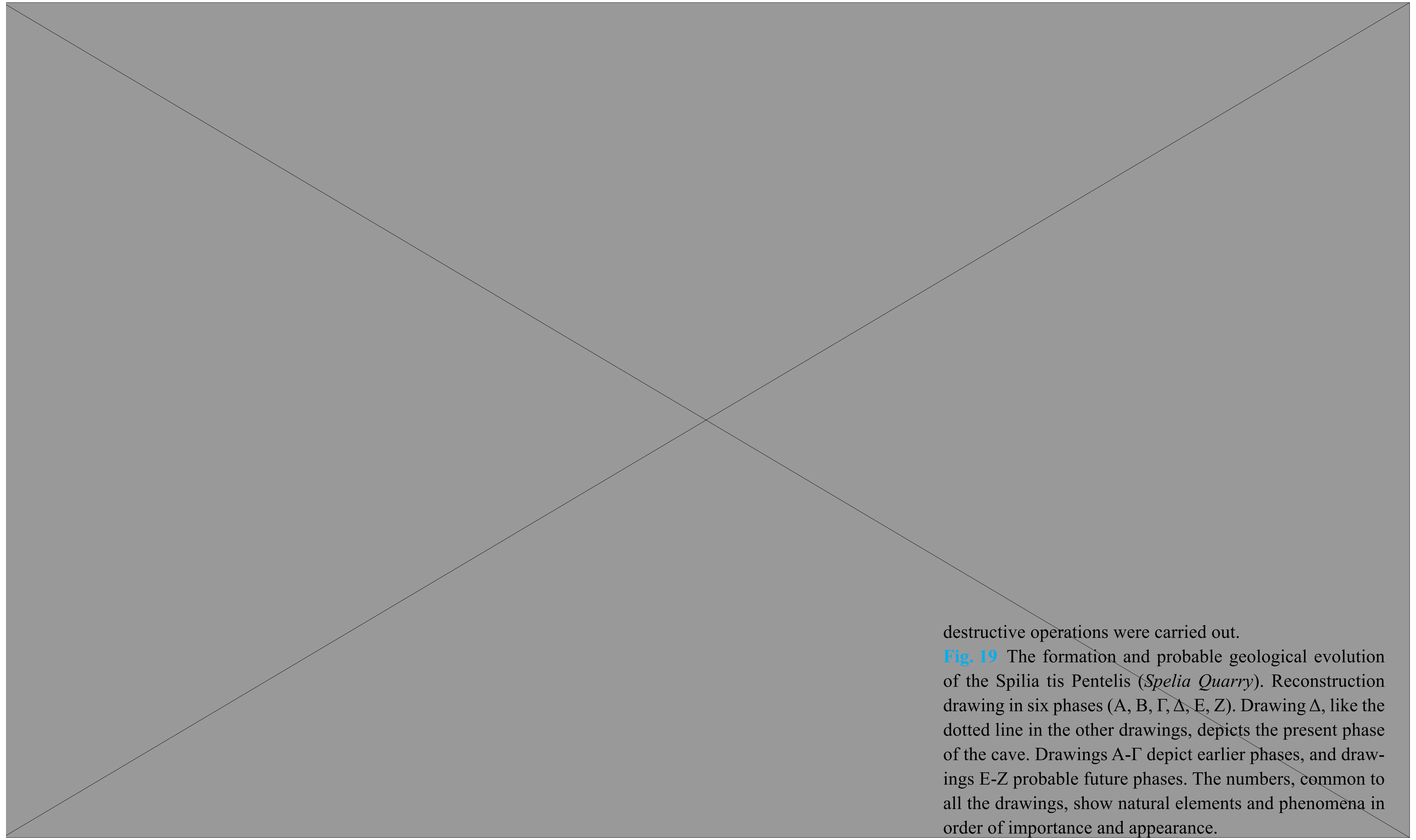
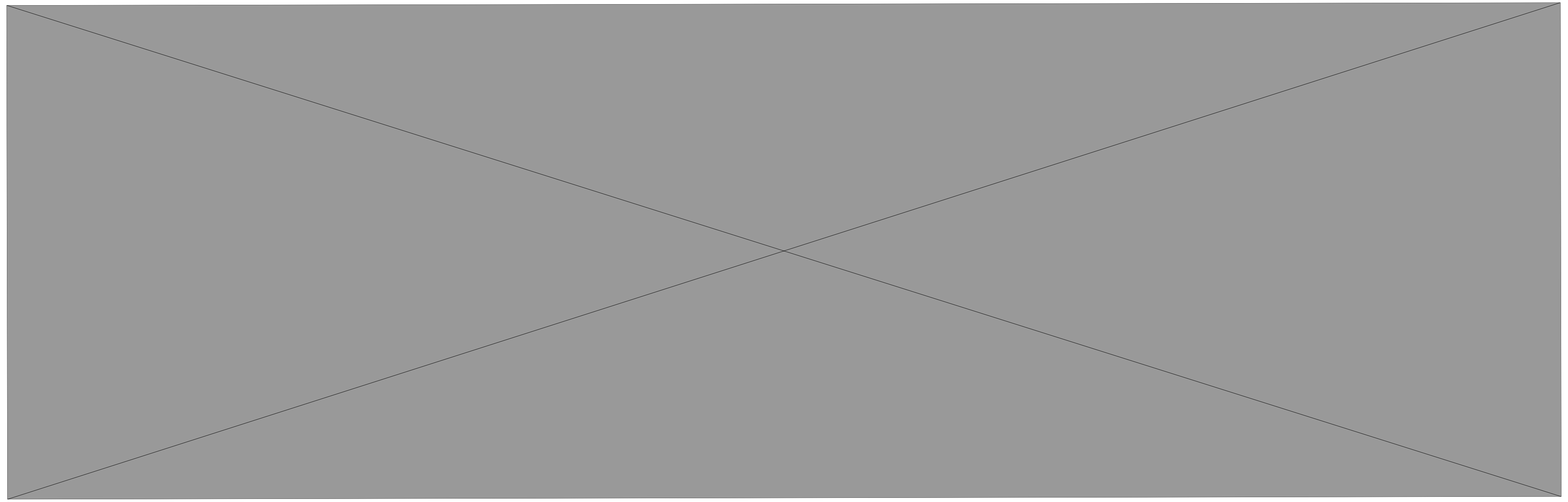


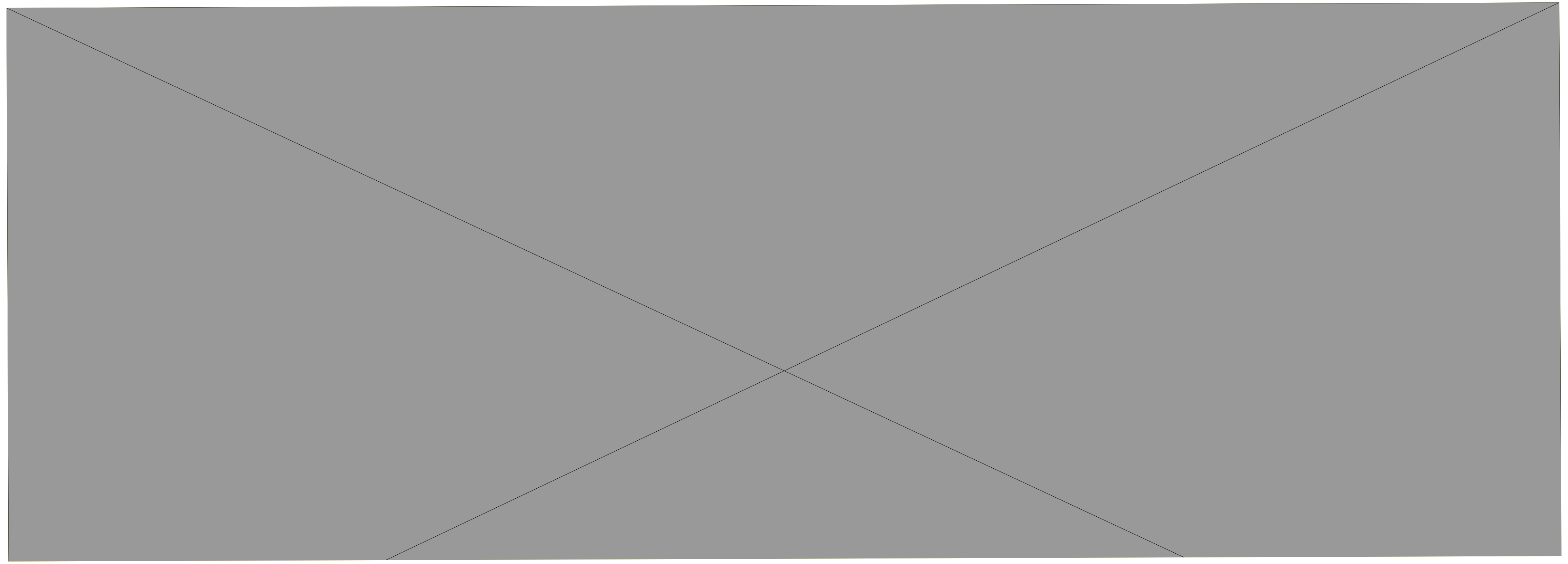
Fig. 18 Rest of the half-worked marble objects. Scale 1:3.
1 The unfinished colossus of Mt Pentelicon. In the highest up of the ancient quarries (~1020 m); it survived until at least 1968 (J. Wiseman, *AJA* 72, 1968, 75-76; R. Carpenter, ibid, 279-280).
2 Lion waiting to pounce, of Archaic type, from the marble quarry at *Dionysos* in Attica (length ~1.20 m). Since 1987 in the Piraeus Museum (Inv. no. 5760).
3 Architectural member of unknown purpose. It was confiscated by the police in 1992 at a marble factory in Vrilissia, where the lefthand side had already been sawn off. It came from the clandestine operation of an ancient quarry, which from various technical indications seems to have been the quarry Λ7, Classical in period, and one of the many ancient quarries where, unfortunately, illicit quarrying and other destructive operations were carried out.

Fig. 19 The formation and probable geological evolution of the Spilia tis Pentelis (*Spelia Quarry*). Reconstruction drawing in six phases (A, B, Γ, Δ, E, Z). Drawing Δ, like the dotted line in the other drawings, depicts the present phase of the cave. Drawings A-Γ depict earlier phases, and drawings E-Z probable future phases. The numbers, common to all the drawings, show natural elements and phenomena in order of importance and appearance.
1 Underlying impermeable stratum.
2 Clastic surfaces, for the most part of tectonic origin. These surfaces allow the percolation of rainwater.
3 Chemical dissolution of the lower part of the calcareous rock, more pronounced at the clastic surfaces and more soluble intercalations.
4 Chemical dissolution along the clastic surfaces and easily soluble intercalations, at different depths from the external



surface, and continuous formation of stalactites.
5 Formation of large cavities by the progressive amalgamation up of other smaller ones.
6 Detachment and collapse of pieces from the walls and roofs of the cavities. Displacement upwards of the large hollow comprising the cavities, due to the continuous fall and accumulation of pieces in the lower part of the cavity. The continually changing roof tends each time to assume a dome-like shape, as close as possible to the line of equilibrium of the mechanical stresses. The different departures of this shape from the ideal geometrical dome form depend on the irregularities of the other factors.
7 Formation, in the manner described above, of spacious chambers. Unbroken development of the phenomena 2-6 on the roofs and sides of the chambers, and of the phenomena 2-5 in the earlier fallen masses under the floors and in the labyrinthine cavities (chemical dissolution, transportation, recrystallization, etc.).
8 Tensile opening of the joints along the clastic surfaces.
9 Tensile genesis of new multiple clastic surfaces, parallel to the roof and walls of a large chamber, which promote a continually accelerating fall of fragments, a commensurate increase in the size of the hollow space and a corresponding increase of the stressed condition of the walls and roof. The continuous reduction of the overlying mass reduces the load on the roof, but also reduces its resistance even more.
10 Final exhaustion of every limit of resistance and all equilibrium. A mass collapse of the overlying fragments ensues and a large open-air sinkhole (*karstic doline*) results. Its depth is generally less than the height of the chamber before the collapse, because the chaotic fallen and piled up fragments leave large cavities between them and therefore occupy a larger space than the original mass before its collapse.
11 Progressive filling up of the bottom of the depression and the growth of vegetation. Unbroken continuity of the phenomena 2-5 on the walls and beneath the bottom.
12 Progressive collapse of fragments of the walls of the *doline*, formation of smoother scarps, fresh infilling, and so on.

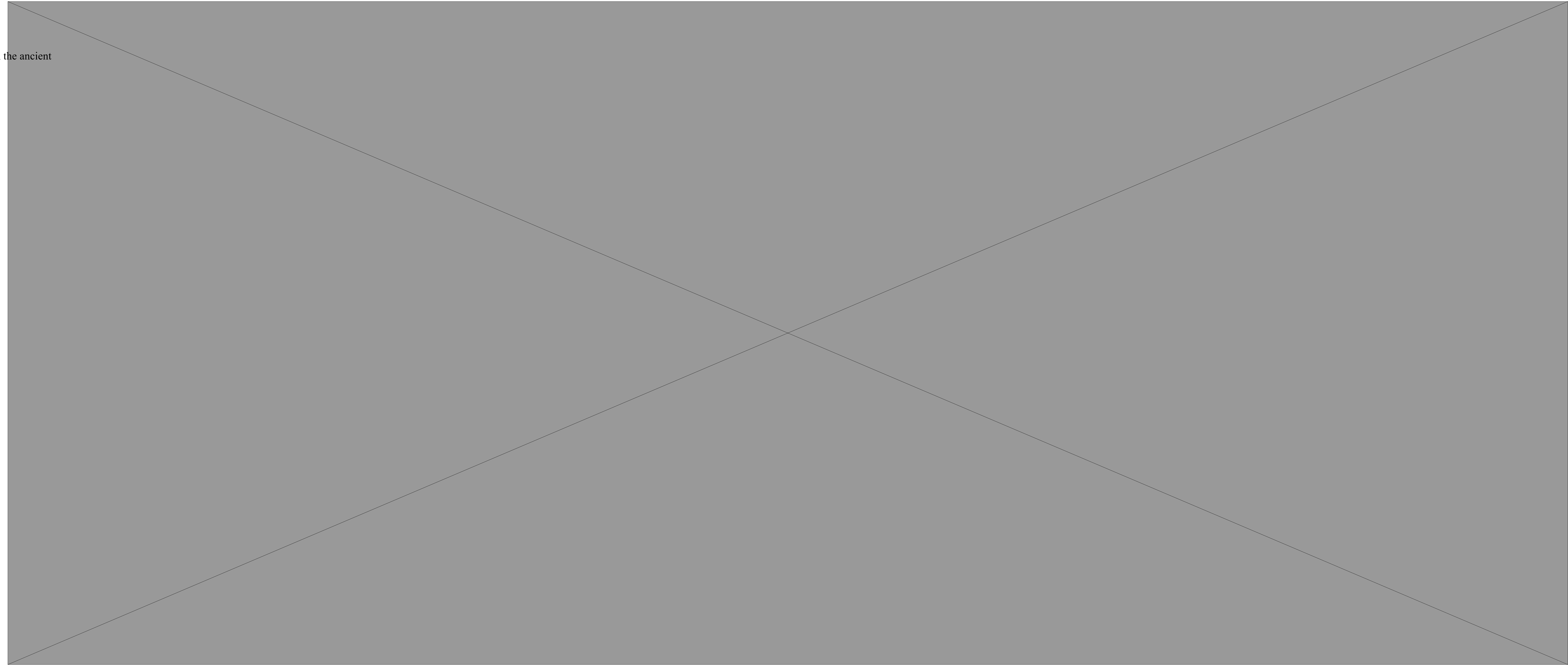
In analysing the evolutionary development of the large chamber, it is useful to bear in mind the almost total absence of stalactites in the interior (they are chiefly on the right side), in spite of the dense manifestation of clastic surfaces all over the roof and the continual water dripping through them. The roof surfaces are almost everywhere relatively fresh, and only in certain places is this due to ancient quarrying, indicated by a few traces of chiselling. Before the digging operations inside the large chamber (1977), the floor, although it consisted of accumulated ancient debris, had a continuous stony surface built up over the last 18 or 17 centuries from layers of stalactitic material that had combined with the upper layer of debris to form a kind of natural concrete.



On this surface there were also some broad, flat fragments that had evidently fallen from the roof after the debris had been deposited, most of them from the most distant part of the chamber, in the place where in recent times (mainly because of the disturbance by digging operations in 1976, etc.), a fall of very large masses (over 100 tonnes) was observed.

Also of particular interest is the shape of the narrow cleft that descends at the north side of the large chamber in the cave (Fig. 12, 20), which unfortunately can no longer be seen or visited. The material that was shifted during the digging operations (1976, etc.) must have closed off at least its upper part. Before 1976 the cleft was visible as a horizontal fissure at the point where the north wall met the sloping stalactitic floor, which continued on at a steeper inclination into the cleft, forming its lower side. The cleft could only be entered by wriggling, and anyone exploring it had to decide before entering whether to lie on his back or his front, because the roof, which was parallel to the floor of the cleft, was so low that it was impossible to turn over once he was inside. He also had to consider his reserves of strength, bearing in mind that to return he had to work his way back from the depths of the cleft up a very steep incline and with very little room to move his limbs. For this reason exploration of the cleft was somewhat limited, chiefly because the distance between the two sides diminished progressively as it descended. At a depth of 20 m they were so close in places that even breathing became difficult, and there was also the added psychological stress caused by the hundreds of thousands of tonnes of overlying rock. On the other hand the length of the cleft, together with its curvature and the winding irregularities of the sides, made it impossible to see its actual end. At most, even by directing the beam of his torch at different angles and from different positions, the explorer realised that at any distance over ten metres the curvature of the cleft made it impossible to see how it continued. It is evident from this description of the cleft that it is a gap formed by the separation of a lower from an upper mass. At present it is not possible to examine whether the lower mass is also formed of rock or of naturally cemented debris, like the rest of the floor of the large chamber, or of both. In any event, whatever the nature of the material of the floor of the cleft, it is probable that its separation and progressive movement away from the solid upper side started after the last dumping of debris towards the end of the Roman period. Assuming that the downward and southward movement of the lower side of the fissure has been constant, then its average rate would have been ~2 cm per century. The causes of this phenomenon must be looked for chiefly in the local deformations caused by the uneven settling of the fallen slabs on the underlying aquiferous strata and the continual loss of the material of the rock mass in the form of solutions.

Recently, intrepid nature lovers discovered a new way into the cleft, which enabled them to reach the ancient well.



QUARRIES

The marble quarries for the ancient monuments were mainly on the southwest side of Pentelicon, along a ridge running SW-NE, which started almost at the base of the central mountain mass and met the line of the summit on the SE side of the summit. On the crest of this ridge, running nearly its whole length as far as the col at the top, the two parallel veins of the fine marble were always visible (see p. 66 and Fig. 13). These veins, "central veins", have a width of approx. 10-25 m, the northern one, and approx. 60-75 m the southern one, and they are separated by a vein of useless rock, 5-10 m thick, containing a large amount of crystalloschistose intercalations. Other crystalloschistose veins, but much thinner, separate the two central veins from other veins of good and abundant, but not best quality, marble on either side. The ancient quarries for the most part developed along the two central veins and became famous for the quality and quantity of the marble they yielded. The zone of ancient quarries also possessed the necessary cult places for the quarrymen, usually dedicated to the Nymphs and, without doubt, Pan. Earlier scholars presumed that the statue of Athena mentioned by Pausanias (1, 32, 1-2) stood on a small platform near the summit. Unfortunately recent quarrying operations began right at the ancient quarries and have subsequently continued along virtually the whole length of the ridge, resulting in extensive destruction. Nevertheless, the ancient quarries were so large and deep that even today, when the greater part of them has been destroyed by modern vandalistic quarrying, what has remained, chiefly tool-worked surfaces on some of the walls of the new quarries, is immensely impressive and grand. Thanks to the ancient surviving surfaces that are still visible, it is possible to discover something about the original shape of most of them, and their general layout. These discoveries make it clear that the ancient Pentelic quarries, which continued in use for centuries, were developed and exploited in accordance with a very well-considered plan.

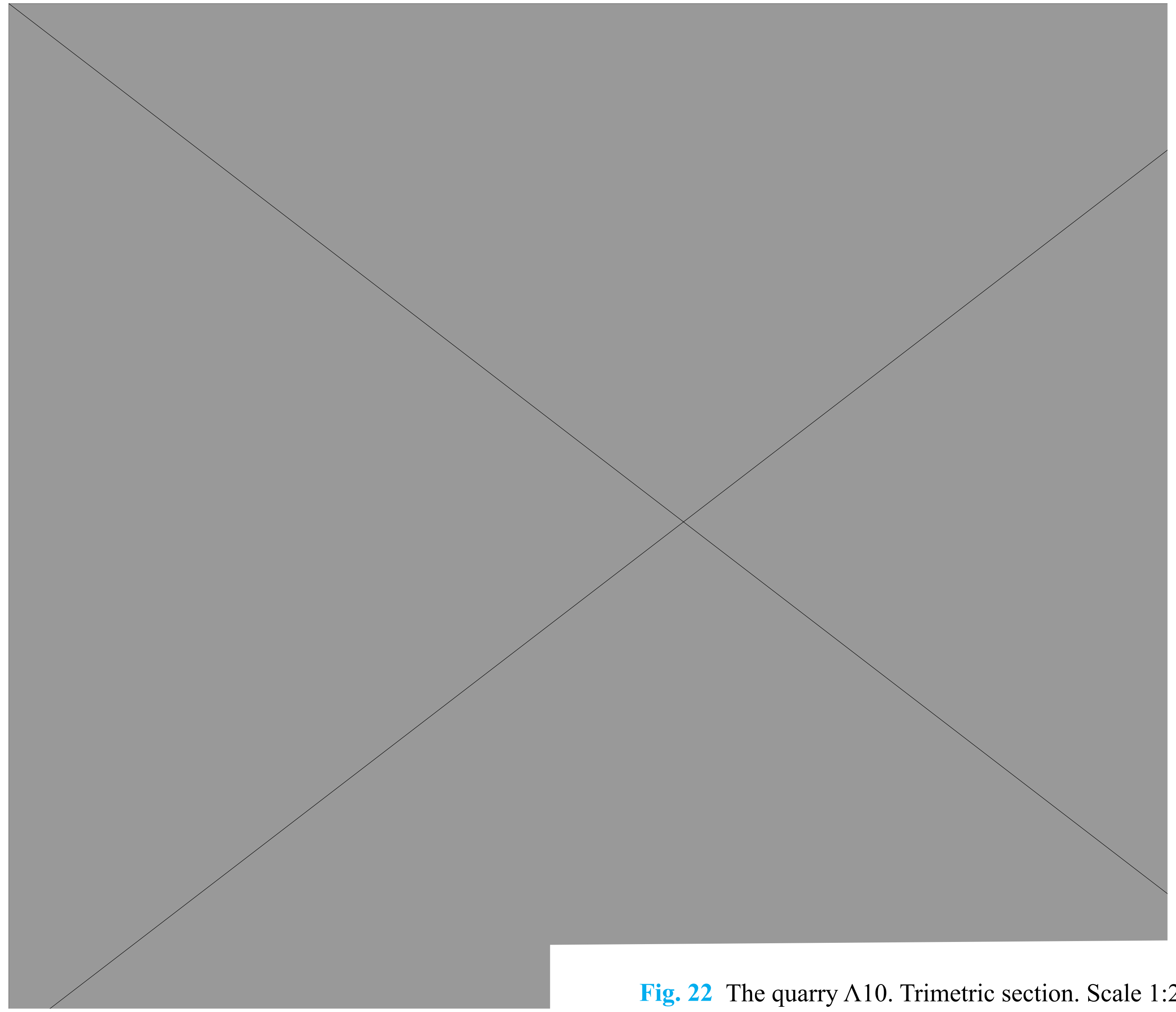


Fig. 22 The quarry Λ10. Trimetric section. Scale 1:2000.

The quarries that are still visible along the line of the ridge, from *Spelia Quarry* (Λ1) upwards, are eleven in number: four along the north vein (Λ2, Λ5, Λ8, Λ9) and seven along the south one (Λ1, Λ3, Λ4, Λ6, Λ7, Λ10, Λ12). Before the *Spelia Quarry* there were various other, relatively smaller quarries, of which only one can be recognized (Λ14), and another six (Λ15, Λ20) are shown on the Hallerstein map (1817).

Further away from the line of the ridge there were also other, smaller quarries, of which at least two can still be recognized (Λ11, Λ13). And some eight or nine more ancient quarries are marked by Kaupert in the area of the modern ones λ24-λ44.

The quarries on the south vein all had their entrance in the SW corner, where the outside ground level was lowest and gave the most direct access to the *slipway*.

The *slipway* was parallel to the line of quarries and ran along their south sides, directly on top of the crystalloschistose vein, which formed their natural boundary.

The largest quarry (Λ10) was opened in the south vein for a length of ~200 m, between the altitudes of 880 and 930 m.

Its average width was ~70 m. The worked north side is visible for 155 m and the south for ~60 m. In the eastern part some sections of the original bottom have survived and are visible. Its greatest visible depth, in the NE corner, exceeds 30 m. The western half of the quarry is filled up with a very thick, well-strewn accumulation of debris, so that its real depth is uncertain, as also is its western termination (Fig. 22).

The *Spelia Quarry* (Λ1) is second in extent. It is ~140 m long with an average width of ~80 m, but is deeper and can perhaps therefore claim first place in overall size. Its visible depth in the NE corner is ~37 m, but the real one, including the thickness of the fill, is much greater. The real depth, at the middle of the north side is reckoned to exceed ~40 m. The greater part of the west side is buried under a large mound of ancient debris (Figs. 11-16).

The third quarry in size lies between the altitudes of 805 and 850 m. It was ~120 m long with a greatest width of ~70 m and greatest depth of ~30 m. It must also be regarded as an important quarry for another reason: in the right-hand side of the now destroyed entrance passage is the *Cave of the Nymphs*[1], a cult place famous for the two votive reliefs (Nat. Mus. nos. 4465 and 4466) that were found inside it when it became accessible in 1952 in the course of quarrying operations. The cave must have first become accessible during the operation of the quarry Λ7, when the entrance passage was deepened, thus creating a side entrance into the cave. The archaeological finds date the use of the cave to between the 4th c. BC and 2nd c. AD.

A similar instance is the large cave that became accessible during the course of quarrying in Λ1. The belief that it was a cult[2] cave is plausible, although it is not generally accepted because of the lack[3] of relevant material evidence.

Quarries Λ4 and All are also large and imposing. They might indeed have claimed a first place had they not been in the vicinity of the huge Λ1, Λ7 and Λ10. Of the quarries exploiting the north vein significant traces have survived of only one, Λ2, which we have called the large trench-shaped quarry. These traces extend over a length of ~140 m, and before the recent infilling of the lower part it was visible to a depth of 40 m. Its original length may have been 200 m, and the average width was over 20 m.

Only a few traces have survived of the other trench-like quarries along the north vein, Λ3, Λ8 and Λ9, and they are not sufficient to estimate the original lengths and depths. Recent quarrying operations have used up all the geological width possible and attained an average depth of ~40 m. The rest of the quarries were either much smaller, perhaps because of their smaller geological potential, but also perhaps because they were only used for certain building projects, and when these were completed the quarries ceased to be used.

A common feature of the large quarries in the south vein is that from the north walls, which are the highest, unexcavated sections of less useful rock project at intervals of 10-20 m, and these served as buttresses to shore the very high and usually overhanging walls (see Fig. 13). Another common feature of these quarries is the presence of ancient accumulated layers of debris, which fill nearly the whole area and are thickest on the west side, where in the form of mounds they protrude many tens of metres outside the quarry and rise some five to ten metres above the original ground level.

In Λ1 the thickness of the ancient fill is estimated to be over 20 m. The debris from the huge Λ10 forms a pile that starts from about the middle of this quarry and blankets everything as far as Λ7, over a distance of ~200-250 m. The greatest thickness of the accumulation must have been at least 30 m, in view of the fact that its summit, too, is some ~15 m higher than the original natural ground level. Consequently not only is the position of the western end of Λ10 undiscoverable, but so is the probable existence of another, conjectural, quarry (Λ10') between it and Λ7. In the latter case, a part, the lower and more westerly one, of the huge piles of debris must have come from the conjectural Λ10΄.

Equally Λ7, before the unholy resumption of quarrying, which unhappily is still continuing today, quite illegally, used to be filled with ancient debris over its entire extent and to a considerable height. The thickness of this filling was more than 10 m even in the eastern part. Obviously much of the debris filling, the upper part, could not, because of its position, have come from the same quarry. It could well have come from Λ10 or the conjectural Λ10΄, in which case Λ10, situated higher up, would have been later than the lower Λ7. For similar reasons Α3 and Λ4 must have been earlier than the quarries lying directly above them. They too contain debris, of which at least a part, the upper, can only have come from quarries higher up.

Similar comments apply to the *Spelia Quarry*. The lower strata of debris must have come from the quarry itself, while the upper ones, covering its whole extent and part of the cave, probably came from other quarries higher up. If the whole of the debris from this quarry had to be thrown out, somewhere lower down, then heaps of debris and stones would have formed outside the quarry much larger than the existing ones and much more extensive, due to the steepness of the terrain. And, as has been said, there is no large quarry lower down than the *Spelia Quarry* where it would have been possible to dump the debris.

These conclusions concerning the source of the accumulations of debris inside and outside the quarries are also revealing about the way in which the quarrying advanced. They may be summarized as follows (Figs. 23, 1 and 23, 2; and see p. 83, Figs. 13-16 and 22):

1. In every quarry the quarrying progressed by sections or compartments, which were separated by unquarried walls of unusable marble.

1 Π. Ζορίδης, Ἡ Σπηλιά τῶν Νυμφῶν τῆς Πεντέλης, *AE* 1977, Χρον., 4-11. J. M. Wickens, *The Archaeology and History of Cave Use in Attika,* Indiana Univ., Univ. Microfilms, Ann Arbor, MI 1986, 194-202.

2 Α. Ὀρλάνδος, *Εὑρετήριον τῶν Μεσαιωνικῶν Μνημείων τῆς Ἑλλάδος* Γ΄, 1933, 196. Κ. Μ. Γιαννουλίδου, Ἱστορικά σπήλαια τῆς Ἀρχαιότητος, *Πλάτων* 1970, 195.

3 Wickens, op. cit., 197.

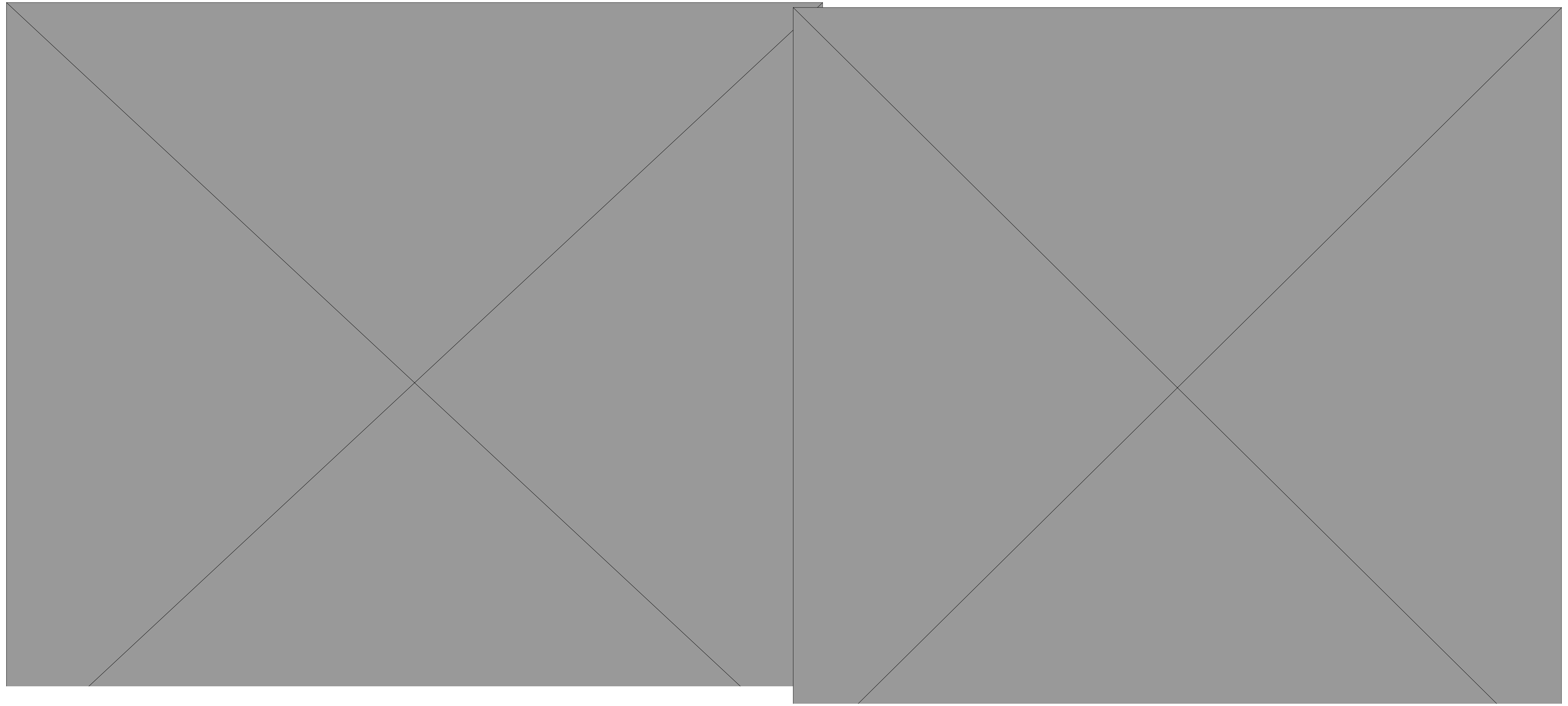


Fig. 23,1 First phases in the development of quarry Λl.

2. The quarrying advanced more along the north side and in the area of the entrance. The discovery of the different rock types indicated which zones were to remain as unexcavated transverse dividing walls.
3. The quarrying advanced more deeply in the compartments nearest to the entrance. The debris produced by the quarrying and extraction was piled up outside the entrance to the quarry or inside a nearby quarry lower down, if there was one and it was available.
4. When the quarrying in the compartments nearest to the entrance reached the greatest desired depth, they were filled up with the debris produced by the work proceeding in the neighbouring compartments. The transverse dividing walls allowed the debris to be piled up to a considerable height, while on their free sides the excavation continued at levels much lower than those of the piled up debris. At the beginning the piling up of the lowest strata of debris proceeded easily, since it was dumped from the higher level of the half-excavated compartments into the deeper fully excavated ones. As the work advanced, however, the level in the compartments being excavated became steadily lower and that of the accumulating debris continually higher, so that it became necessary to haul the debris up in baskets with pulleys and other mechanical means or carry it up on pack animals, using temporary ramps built from the fill itself.
5. The successive stages of laying out, quarrying and subsequent filling in of the different compartments had to proceed from the entrance towards the further end. The debris from the last compartments did not necessarily have

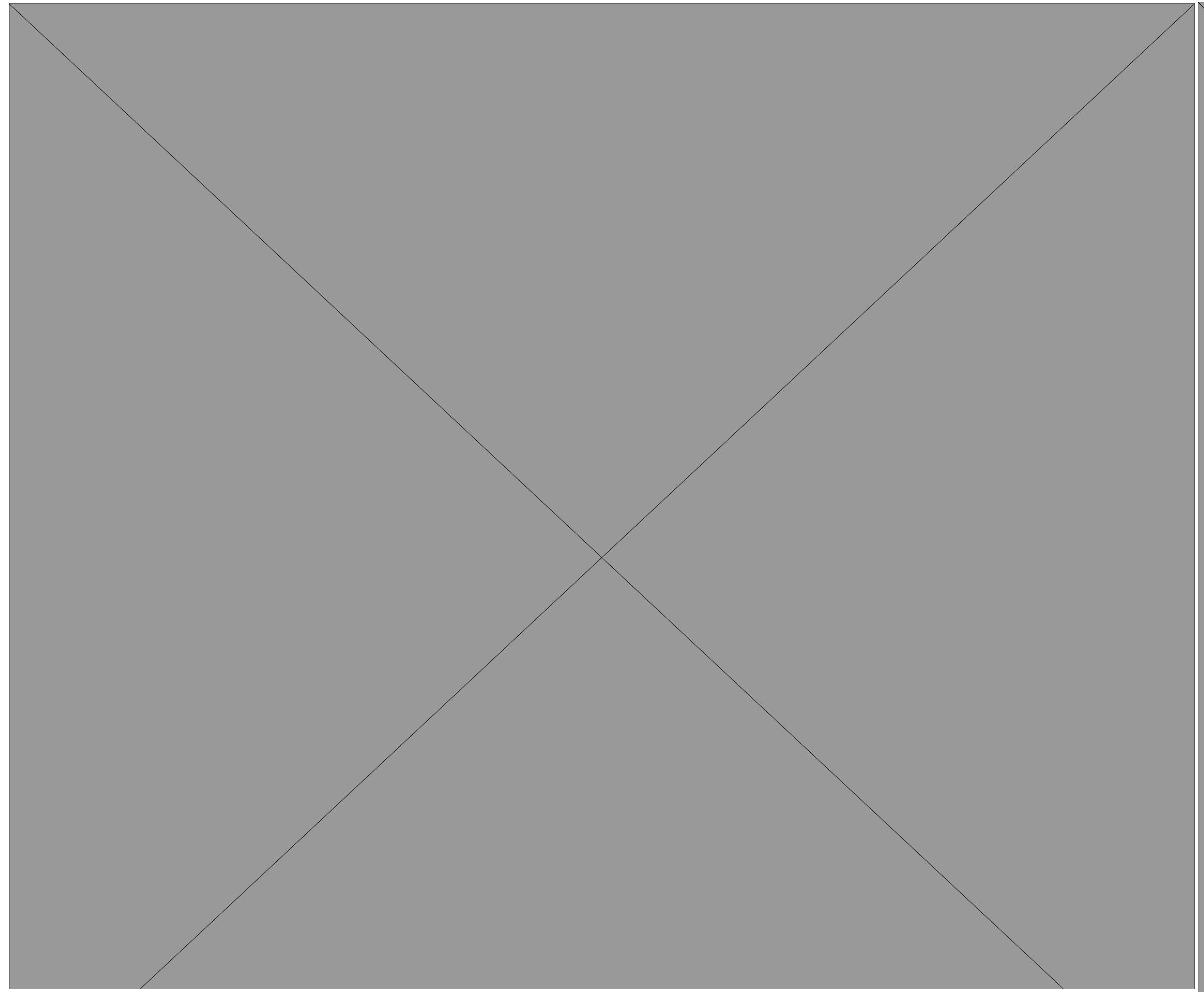


Fig. 23,2 Final phases in the development of quarry Λl.

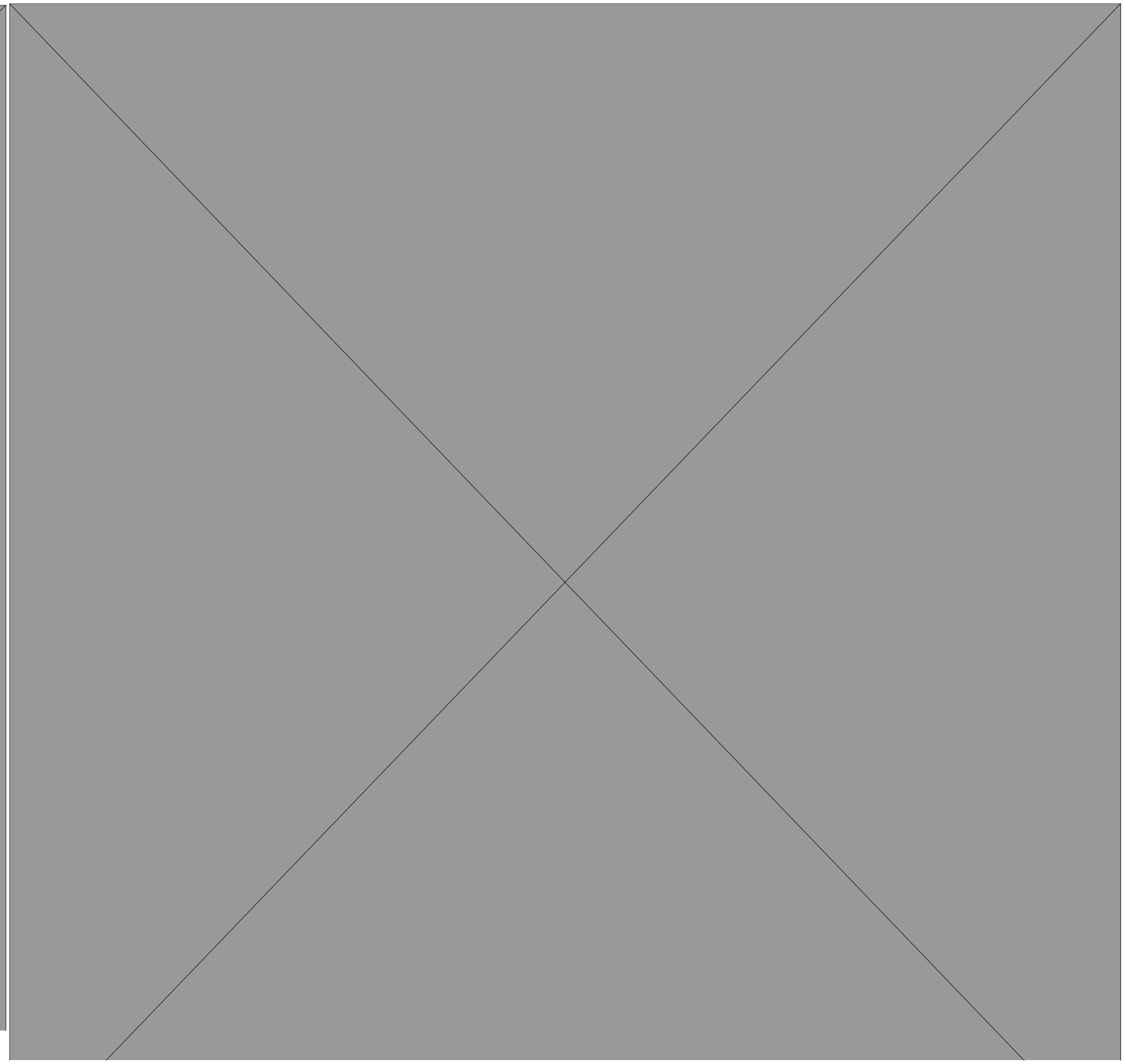


Fig. 24 Original and final form of quarry Λl.

to be heaped up to a particular height in the preceding compartments, as in the beginning. It was easier to level it over a larger area, and spread it less thickly over all the compartments in the lower southwestern area, which had already been filled up to the tops of their walls.
6. The progressive advance of the quarry necessitated the continual extension of the road inside it. As the length of the quarry steadily increased and the main face became higher, the debris produced was much greater than at first. Disposing of it caused a general rise in the level of the quarry floor and the road inside the quarry had to be repeatedly rebuilt at a higher level.
7. When it was no longer possible to raise the road any further the waste was dumped at the sides in order to keep the road free. The result of this continual dumping was the formation of two elongated mounds of debris on either side of the road extending outside the cave, as in the case of the *Spelia Quarry*, for example, and outside the huge quarry Λ10 (see Figs. 22, 24, 25).

The continuous build-up of piles of debris from Λ10 (or the conjectural Λ10´) in and around Λ7 put an end to the use of the *Cave of the Nymphs* in the 2nd c. AD. From this it is clear that Λ7 had already ceased to operate when Λ10 attained its maximum size. The greatest expansion of Λ10 must have occurred during the 2nd century AD and not before, for the reason that Λ10 was the last and highest up in the row of large quarries and therefore the only one that could have supplied the marble for the great building programmes at Athens, including the completion of the

Olympieion and the reconstruction of the Stadium, during the sixth decade of the 2nd c. (Fig. 25, nos. 5, 7).

It is probable that Λ7 began to operate in the 5th c. BC, but it must first have been exploited in a big way in the 4th c. *The Cave of the Nymphs*, which became accessible through the entrance to quarry Λ7, was first used in the 4th c.

From all this it is fairly certain that quarrying activities along the central veins must have started on the lower part of the slope and proceeded upwards. This system made it possible to continuously follow and fully exploit the desired rock, and at the same time to organize the removal of the debris in the most efficient way and with the maximum economy of labour. The unique advantages of this system were happily compounded with ecological, aesthetic and important geological benefits; any other arrangement of the excavated divisions would have caused greater static weakening of the sloping terrain and an acceleration of the solvent action of the surface and subterranean water.

If we make the reasonable assumption that quarrying operations advanced progressively in an upward direction, then the *Spelia Quarry*, with its entrance at an altitude of ~680 m, would have been the chief supplier of marble for the Parthenon and other 5th c. structures. The quarries immediately higher up (Λ3, Λ4, Λ7), with entrances at 740 m, 760 m and 800 m respectively, must have been the marble sources for the buildings of the next two centuries, including the large two-storeyed stoas and the oldest parts of the Olympieion. Lastly, the next quarries higher up, particularly the huge Λ10, with its entrance at ~870 m, should be associated with the Hadrianic parts of the Olympieion, the Stadium, the Odeion of Herodes Atticus, etc. The other much smaller quarries lying at different altitudes below and above the *Spelia Quarry*, some of them at a distance from the line of the ridge, must have been the sources for other smaller buildings and/or parts of the large ones mentioned above (the chronological order in which the smaller quarries were worked is not clear).

It should be said here that the chronological order suggested for the large quarries refers to the principal phases of their operations and not necessarily their beginning or end. It is evident that even after the accumulation of debris 20 m deep, they could have still continued to quarry any parts of the walls that remained exposed, like the east and south sides of the *Spelia Quarry*.

An important aspect of the study of ancient quarries concerns the different fills of earth and stones, and particularly their composition, form and quantity. The question is by its nature a difficult one. It is obvious that the better preserved a pile of debris is, the more difficult it is to study. However, due to modern quarrying the ancient accumulations of rejected material have been cut into in many places, revealing their internal structure. The largest sections have been cut into the agglomeration that only a few decades ago almost completely filled quarry Λ7. In one place it has been exposed to a depth of nearly 20 m without the bottom of the quarry appearing. The material comprise a lower part with a maximum visible height of 14 m, and an upper one. The lower part came directly from the quarrying of Λ7 itself and consists of regular successive strata of gravel, with an average size of 3-5 cm. Nevertheless the strata do not all have exactly the same composition; some also contain a quantity of large fragments, and certain sections of ancient accumulations in quarries Λ1 and Λ10 and a pile south of Λ7 (Fig. 25) are particularly revealing.

At this last place the pile was found to consist of successive bands of strata corresponding to repeated raising of the surface, which is smooth and horizontal. At one point a large half-worked stone projects, incorporated in one of the strata in the pile, where it was abandoned because of an internal flaw. It is parallelepipedal with a thickness of ~80 cm. Its other dimensions have not been measured. The block had not been deposited there by chance: it lies in a horizontal position and its lower side rests on one of the many consecutive surface levels of the pile. It seems, then, that this surface, like many other similar ones, served as a kind of work site where preliminary preparation of the stones was carried out before hauling them out of the quarry.

The observation that the quantity of small pieces was much greater than that of the larger fragments suggests that the utilization of the stones in the quarry was virtually total. From the large, naturally formed slab of marble they had to produce not only the particular shape for which it had been primarily chosen, but also as many other usable objects from the leftover fragments as possible, such as marble tiles, etc. This resulted in a big reduction in the quantity of large fragments and a considerable increase in the quantity of debris chips. An important factor in the quantity of debris produced was the way the size and shape of the stone products of a quarry were matched with the kind and spacing of the natural jointing of the rock. Generally the preparation of smaller stone shapes produced much larger quantities of debris compared with that of massive shapes. This was also true of slab-like shapes, such as tiles, etc., if the rock did not split naturally into slabs. Pentelic marble is not schistose, but it was nevertheless used for making the tiles for most of the religious buildings. The tiles of the Parthenon, some ~9000 pieces, had a total surface area of ~8000 sq. m. For all the stages in the manual production of a simple tile by a good mason at least five days of intensive work were needed, in the

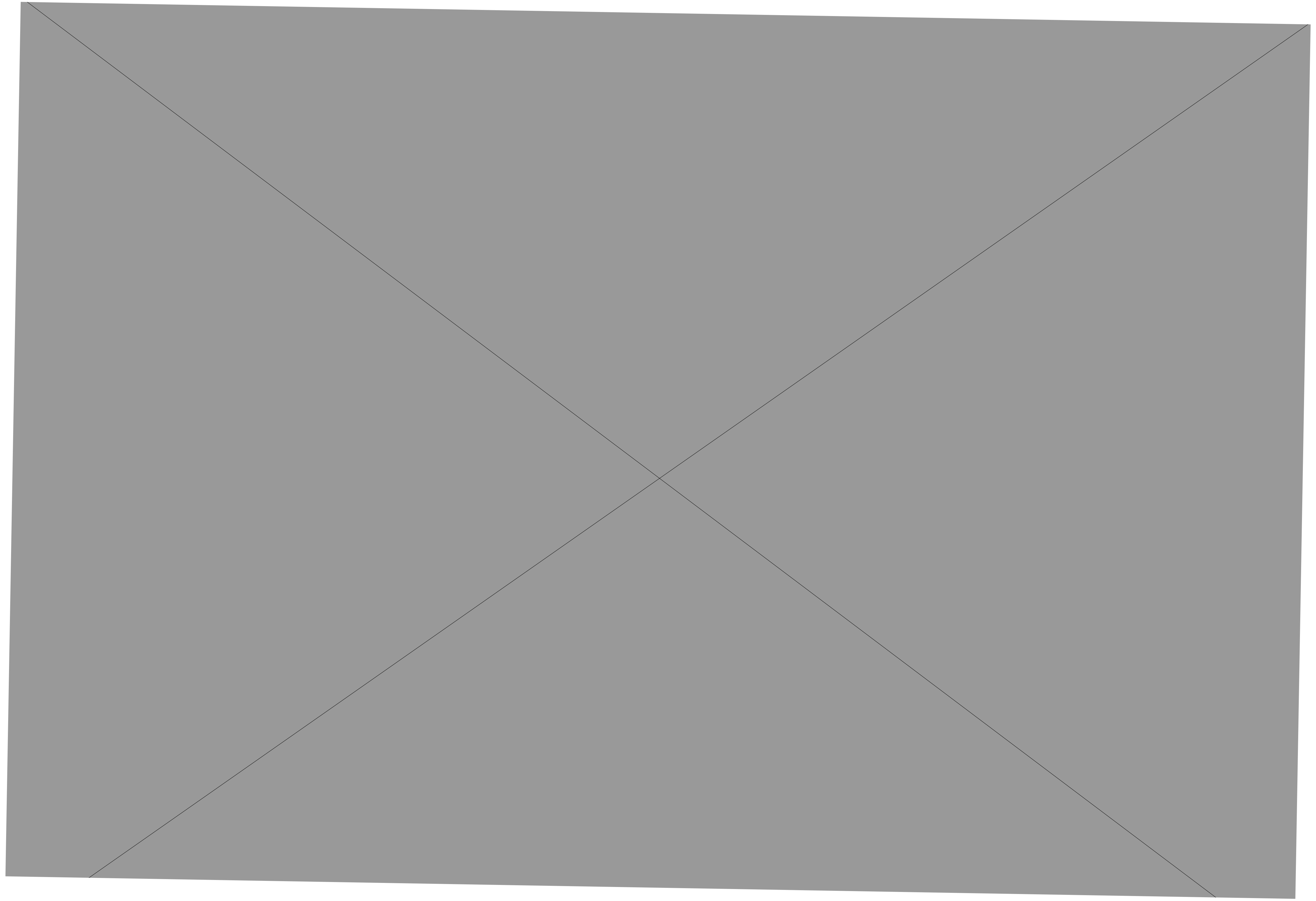


Fig. 25 Pentelicon - Athens - Eleusis. Scale 1:4000.

The quarries Λ1-Λ10 in the central zone and their connection with the major building programmes.

- 5th c. BC: 1 Parthenon, 2 Propylaia, 3 Temple of Hephaestus.
- 4th c. BC: 4 Telesterion of Eleusis.
- 2nd c. BC: 5 Olympieion, 6 Stoa of Attalus.
- 2nd c. AD: 5 Olympieion, 7 Stadium.

NY *Cave of the Nymphs* (4th c. BC - 2nd c. AD).

course of which thousands of small chips of debris were produced and some kilograms of marble dust. The ratio of the volume of debris to the usable product for a handmade Pentelic tile was on average about 5:1. The ratio was also very high in the case of marble intended for sculpture in the round. For large blocks of regular shape the ratio was more economical. If it was necessary to cut grooves all round in order to free a stone from the parent rock, the quantity of debris produced was not much less than the volume of the stone itself. A large amount of debris was also produced during the dressing of the surfaces after the block was separated from the rock. As the stages in dressing the surface progressed the size of the chips became smaller. The size of the debris chips is a sure criterion that makes it possible to correlate the strata and levelling of the debris with the different tasks carried out in the quarry.

A precise calculation of the quantity of debris produced for every shape of stone object would require very specialized information, but careful observation of the quarries themselves and the accumulations of ancient debris suggests that the ratio of the volume of debris to that of the excavated part of the quarry varies between 3:4 and 1:1. The smallest, or most economical, figure is estimated for the *Spelia Quarry*, and the largest in the area of Λ7-Λ10. From these observations it emerges that the proportion of the usable product to the volume of the excavated part was ~1/4-1/3. For the sake of comparison it may be said that from the quarries Λ1, Λ7 and Λ10 ~400000, 250000 and 400000 tonnes of marble respectively have been extracted, of which only 1/4 was useful. It may also be said that the marble part of the Parthenon in its finished state was about 20000 tonnes (with the same again for the poros foundations), of the facade of the *Telesterion* of Eleusis ~4000 tonnes, of the Olympieion ~50000 tonnes, of the facade of the Stoa of Attalus and its internal columns ~1200 tonnes (there were two other similar stoas in Athens except for that of Eumenes), and of the Stadium ~17000 tonnes, etc. (see Fig. 25 nos. 1-7).

ROADS

The lower terminus of the steep *slipway* for the loaded sledges, which still survives (PL 13, Figs. 1-4 and 20, 21 and 25) was at an altitude of ~490 m. The section as far as the *Spelia Quarry*, at ~700 m, was ~800 m long and almost in a straight line, with a constant gradient of ~25%±1% in the upper part and ~30% in the lower. It continued on to the top (1108 m), which was ~3 km by road from the loading point for the waggons having only one bend near the crest line at a point ~400 m horizontally SE from the summit (to the left of the summit looking from Athens). The surviving section of it (Figs. 20, 21, 25, KA1) runs between the altitudes of 500 and 700 m for a distance of ~850 m, but within this stretch there are clear signs of recent destruction in different places caused by the illicit exploitation of the large quarries to the north of it. In other places the surviving section has suffered serious damage from road construction, chiefly during the 19th c., but also before the Last War, in order to connect it with new roads to the modern road system of the quarries. Three such modern linking roads interrupt the continuity of the surviving part of the ancient road. The condition of the road during the last century is documented by H. von Hallerstein's map (September 1817, scale 1:2400) and sheet 12 of Kaupert's Map of Attica, 1882, 1:25000). The line of the road to the saddle and peak was originally nearly straight and ran parallel to the south side of the *Spelia Quarry* (Λ1), which it skirted closely. At an altitude of some 680 m another road, also paved, branched off to the north, which served the *Spelia Quarry*. This branch still survives in good condition, except for the main line south of the quarry, which led to the summit. This has been destroyed by a very large modern quarry λ12 and various other operations, including those carried out by the state (1977-1988, with interruptions). The western part of the road still survives for a length of 750 m (Fig. 26), but this too is damaged in many places. Its north side, between the altitudes of ~540 and ~555 m and for a distance of almost 50 m, has been undercut by a deep modern quarry (λ3) and is in danger of collapsing.

The *slipway* is for the most part laid directly on the natural ground surface, after levelling the bumps and filling in the depressions with stones. The section of it entering the large quarry (Figs. 14, 15 and 23) runs over a great thickness of older accumulations of debris. This part is also evidently ancient, not only because it was already there in 1817 (Hallerstein), but because it is associated with the mound of ancient debris on the west (see Figs. 23 and 24). Hallerstein's map also shows something more important: south of the road and parallel with it, at a distance of ~40 m, the remains of another ancient road are marked. This road, remnants of which still survive and have been identified thanks to Hallerstein, we shall call *slipway* 2 (Fig. 20, KA2), to distinguish it from the main *slipway* 1. According to Hallerstein's map, *road* 2 does not appear to have been an independent road, but more probably a branch of *road* 1, starting at an altitude of 610 m and leading, like *road* 1, directly to the bottom of the slope. Hallerstein clearly drew the already destroyed upper part of *road* 2, which he joined up obliquely with *road* 1. The lower part, which must have ended in a loading point for the waggons, was not drawn by Hallerstein, nor was that of *road* 1. Most probably the lower sections of both roads had already disappeared as the result of erosion or alluvial fill at the bottom of the slope, which extended upwards to an altitude of 500 m. Today still more of the lower sections of the two roads has vanished. The better preserved *road* 1 (KA1) is abruptly cut at ~516 m by a modern road crossing it obliquely (Figs. 20 and 26, no. 7). The level of this modern road, which with various changes has existed since the last century (it is marked on the 1882 map) is ~1 m lower than that of the ancient one. The difference of levels apparently aided in the unloading of the sledges onto the carts.

With the appearance of the first motor trucks this ancient system of loading was abandoned, as was the use of the

ancient slipway. The modern road that cut it, however, remained in use as a link road for the modern haulageways to the north and south, which run nearly parallel to the ancient ones and connect virtually all the quarries on the slope.

Of the modern roads, the one running ~40 m south of the ancient *road* 2, with a total length of ~300 m, is remarkable; it starts from the modern road at ~516 m and meets the ancient *road* 2 at an altitude of ~565 m after making a very sharp bend at ~560 m (no. 8 in Figs. 20 and 21). This is one of the oldest roads and is connected with the first reuse of the ancient *road* 2, of its upper part in fact, which with a gradient of ~15% is the most level. The lower part, with a gradient of nearly ~40%, could not be brought back into use. The cutting of this road into the softrock is very similar to that of the ancient *road* 2. The first reuse of *road* 2 is also connected with its continuation beyond the altitude of 590 m up to the average altitude zone of the quarry region south of the *Spelia Quarry*. The steady improvement in motor transport is also associated with the incorporation of the section of *road* 2 between 570-600 m into the modern one, which climbs up with two bends from the south and meets the main ancient *road* (*road* 1) at a height of ~610 m and a distance of ~350 m from *Spelia Quarry* (Fig. 20, no. 9). Fortunately this heavy reuse was not sufficient to obliterate the traces of the ancient use of the road, which can be easily distinguished in many places. Parallel ruts cut by the continuous passage of sledges or braking carts (to brake them they chained the wheels, often protecting them with special iron runners). Traces of the older use of *road 2* are also preserved before and after the section of it incorporated into the new road. In connection with the new road, it should be mentioned that it does not simply end at *road* 1, but continues along it for ~160 m to an altitude of 640 m, where it bends slightly southwards and continues for another 100 m to a point where it ends abruptly and dangerously at the edge of the modern quarry λ12, south of the *Spelia Quarry*. Originally, before it was cut by the continual enlargement of quarry Δ12, this modern road went on further (~200 m) and served other smaller quarries lined up in the upper zone of the quarry area south of *Spelia Quarry*. These quarries, one of which at least was ancient, now constitute only a part and an initial phase of the large quarry south of *Spelia Quarry*. The few surviving sections of their surfaces, continuing onto other modern quarry surfaces, are difficult to make out.

Some metres before the entrance to the *Spelia Quarry* the ancient road (*road* 1) is again cut by another modern road, which up till a few years ago still served the modern quarries on the west and east of *Spelia Quarry* (Fig. 20, no. 10). This road, for a length of ~100 m, is identical with the section of the ancient road within the ancient quarry and has not caused any visible alterations (except for the breaks at the beginning and end); among other things the ancient stone paving is well preserved, intensely white in colour due to constant use up until the first post-war decades, with the daily passage of numerous heavily loaded trucks.

The reuse of the ancient central *lithagogia* road and the ancient road 2 in modern times can be summarized as follows:

- From 1836, the year when the ancient quarries started to operate again, until the beginning of this century, almost general use of the two roads.
- From the appearance of the first motor trucks until the 1960s, use of sections of both roads, 150, 100, 150 and 100 m in length (the two last overlap for 80 m), incorporated in the modern, very complex, dense and continually changing road system of the modern quarries, resulting in the widening of the first section, the extensive destruction of the stone paving of the second and the break in the continuity of *road* 1 at four intermediary points, and of *road* 2 at two points. As a result of these disastrous alterations it is very difficult for the modern visitor, even the specialist, to recognize the original morphology.

The modern roads of the central and largest quarry zone on Pentelicon, where the large quarries are, constitute a real labyrinth ~2 sq. km in area. Most of them, small and with no exit at the top, end up in different quarries, while others end on the crests of huge mounds of useless debris from the quarries. Some roads are completely isolated from the general network and rendered useless by more recent digging and other operations. Most of them, however, converge further down and terminate progressively in only two central branches (Fig. 20, nos. 5 and 6), which from a topographical, operational and historical point of view are the distant respective offshoots of the two ancient roads. These two branches converge on a central road (Fig. 20, no. 1) at an altitude of ~455 m, which was the ancient *lithagogia way*. Its modern history began in 1836 with the search for the ancient road by the first civil engineers of the newly formed Greek state, and their discovery, confirmed by L. Ross, that the ancient road still survived at many points, well-preserved in some places and with only traces in others. This discovery made it possible to reconstruct the road on its ancient course, and so right up until today the oldest and the newest roads for transporting the marble down all converge on a single marble route, which follows the ancient way along the modern *Perikleous* st. in *Nea Pentele*. Heavy use of the road ceased in 1977 after quarrying was banned on the side of the mountain visible from Athens.

The roads to the quarries constructed or reconstructed after the Last War, intended for heavy motor trucks, are entirely different from both the ancient road and those of the last century, which were used by waggons drawn by large teams of draught animals.

Numbers of these waggon roads have survived over distances of many kilometres in different places. Some, indeed, which are marked on the oldest maps, belong in the sphere of industrial archaeology and deserve state protection and maintenance, for they are not only documents of the history of Mt Pentelicon, but afford splendid routes for walking and hiking as well.

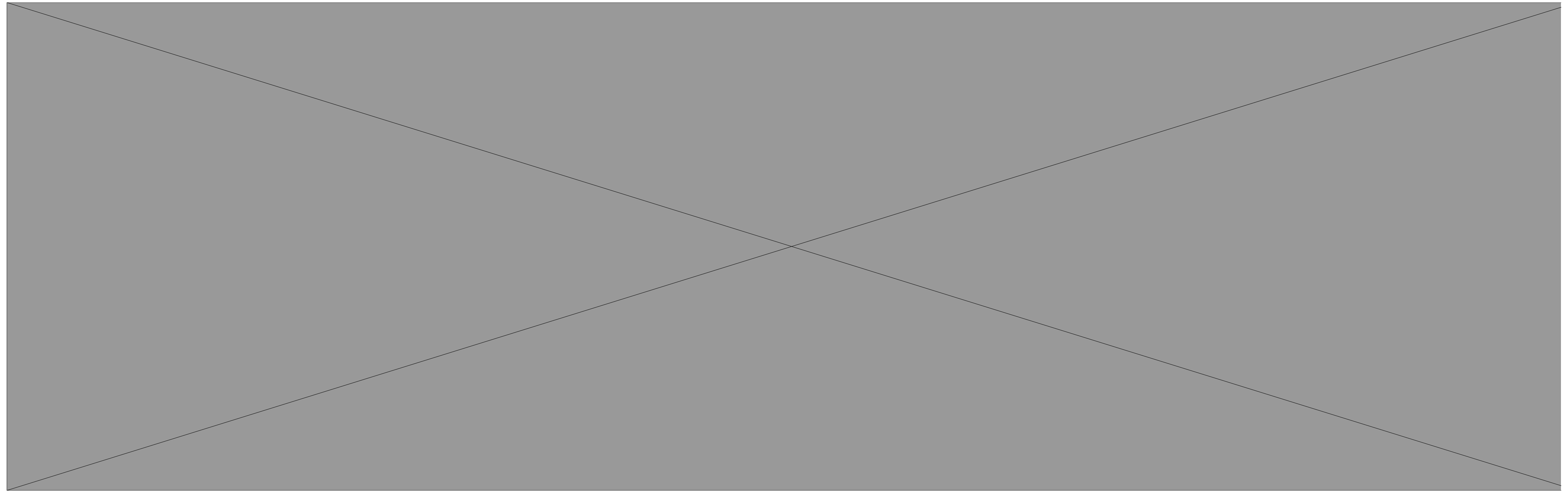
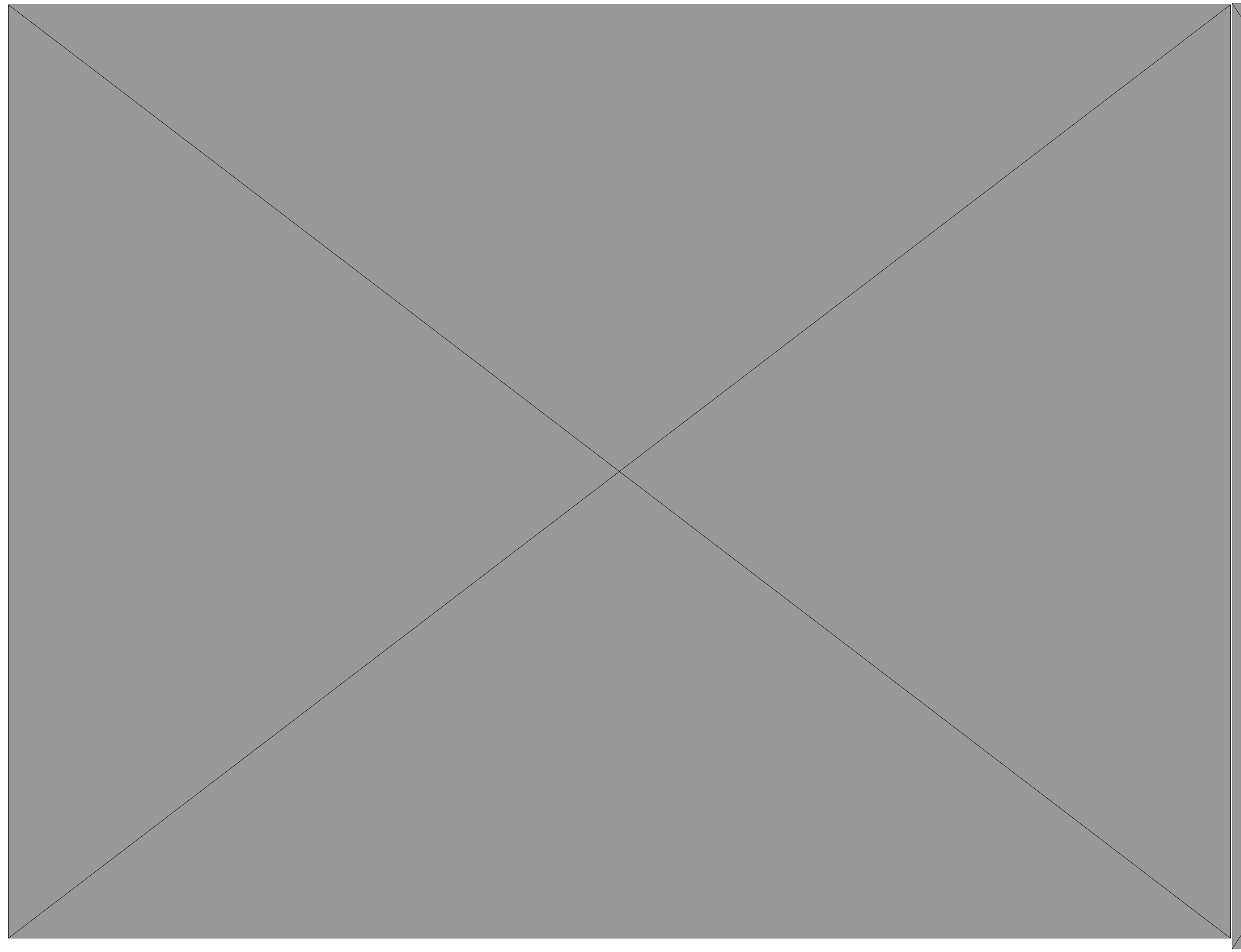


Fig. 26 The best preserved sections of the *slipway*. Scale 1:2000.

KA, **5**, **7**, **8**, **9** as in Fig. 20.
Π Postholes (based on Hallerstein's map).
TP Tracks worn in the rock by iron sledge or waggon runners.



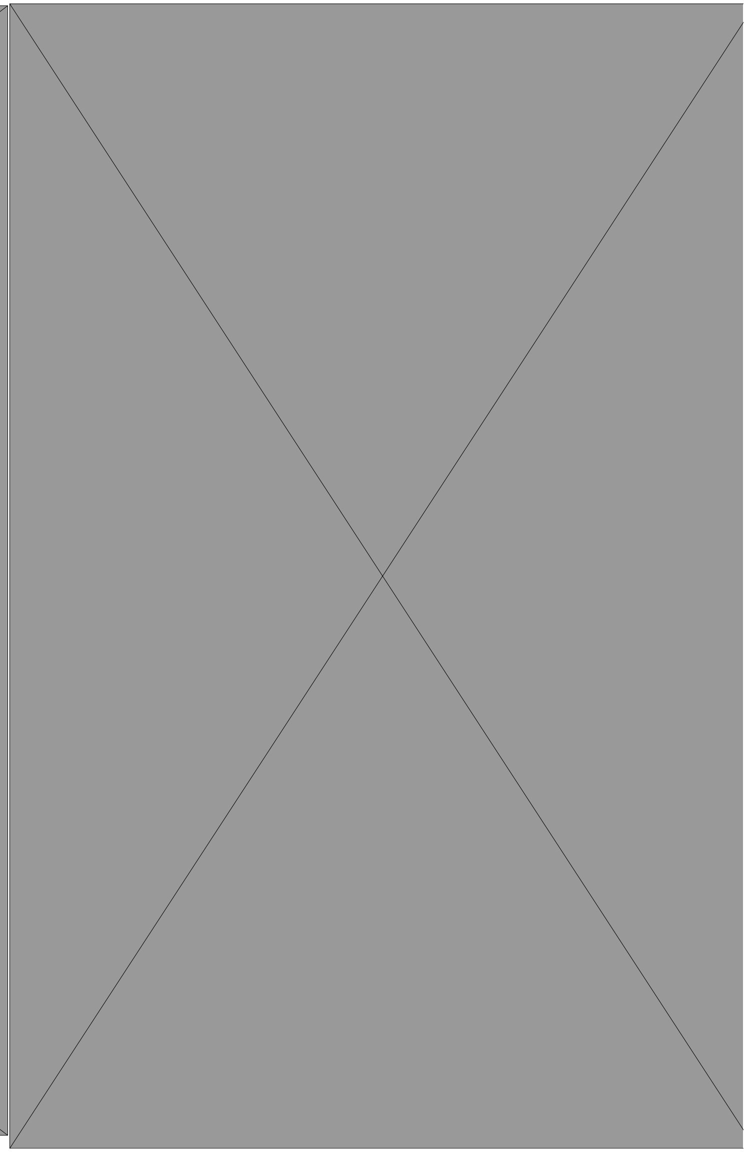


Fig. 27 The construction of the *slipway*.

1 General excavation of the softrock.
2 Cutting for the paved roadbed.
3 Road paving of marble stones.

Fig. 28 Special method of braking the sledge by taking simple turns of the rope around four successive posts driven into the south side of the road ~400 m from the *Spelia Quarry* (Fig. 26, point Π1). Holes 1-3 have survived and part of 4. They have a maximum depth of ~0.40 m and take square posts ~0.33x0.33 m. The system resembles a much older one used in Egypt for lowering sarcophagi down the steep passages of the burial monuments.

Fig. 29 Special method of braking the sledge by taking turns of the rope around a post driven horizontally into the south wall of the cutting in the rock made for the road, ~500 m from the *Spelia Quarry* (at point Π2 in Fig. 26). The hole is at a height of ~1.50 m. It has a greatest depth of ~0.40 m and originally held a square post ~0.33x0.33 m. There is another horizontal hole on the same side of the road some metres further down.

Explanation of Plate 13.

(see Figs. 20, 21, 26-29).

The postholes are square with sides of ca. 30-33 cm, and ~35-40 cm deep.

The ropes are only used to control the sliding of the sledge, in order to maintain a more or less constant speed. The force of resistance was provided simply by the friction between the rope turns and the wooden post. Two or three turns of the rope were enough and the artisans did not need to exert themselves particularly. They merely paid out the rope a little at a time to increase or reduce the frictional force. The posts might be driven into both sides of the road or only one.

Based on the number of marble blocks and the time it took to build the Older Parthenon and the Parthenon, it is estimated that five to fifteen heavily loaded sledges must have traversed the lower stretch of the *slipway* each day, at a speed of ~500-1000 m per hour. It is further reckoned that at each of the quarries there must have been two knockdown sledges and several mules to carry back the dismantled sledges and ropes after each trip down.

Explanation of Plate 14.

The very laborious task of reloading the marble from the sledges onto the waggons must have been effected, as in modern times, by building a raised ramp of stones at the terminus of the *slipway* and using suitable heavy beams to anchor the waggon and connect it to the stone paved surface of the *slipway*. Specialized artisans, fully employed, and four or five mules would have been needed to manoeuvre each sledge down, unload the marble onto the waggon and carry the sledge up again (cf. *Il Maimo, ieri e oggi*, Società Editrice Apuana, 1978, fig. 89, unloading from a sledge onto a cart).

Explanation of Plate 15.

(see Figs. 3-6).

The landscape from left to right: hill of the Stadium, *Ardettos*, *Aegina*, *Hill of the Muses* (otherwise *Hill of Philopappos*), *Acropolis*, *Lykabettos*. On the Acropolis, the poros Archaic Temple of Athena and the first marble Parthenon under construction. The position of the viewer corresponds to the corner of the modern roads of *Vas. Sophias* and *Lykaonias* (*Hippokrateion* Hospital). The fourth field to the right roughly corresponds to the site of the American Embassy (1957-61), and the next one to the *Megaron of the Friends of Music* (1980-1990).

The northern rocky peak of Lykabettos was originally larger and somewhat higher (~278 m) than the one that stands alone today (~277) at the southern end of the hill. The greater part of it was quarried away towards the end of the 19th and in the early 20th c.! Except for part of the lower northern end of the ridge, which still survives to the north of the outdoor metal theatre (1964-1970), all the rest has been destroyed to a depth ~40 m below the ancient summit line. After being filled in (~1970), the level of this part is today some 35 metres below the original summit.

It is known from literary and epigraphical evidence that mules were used to pull the four-wheel waggons to transport the marble to the Acropolis. The unfinished column drums for the Parthenon and the architrave blocks weighed up to ten tonnes, and the eight lintel blocks which were up to 8 m long, weighed up to 13.5 tonnes. The weight of the largest waggons themselves must have been ~3 tonnes. Marble column drums with a maximum weight of 9 tonnes were transported from Pentelicon to Eleusis (~40 km) on waggons drawn by teams of oxen (inscription IG II2, 1673) at an average speed of ~2.5 km per hour. Unfortunately the surviving information is not enough to make a precise reconstruction of the waggons nor is the number of draught oxen or mules known. Opinions differ about the efficiency of draught animals in antiquity, but it is generally agreed that it was less than in modern times. Based on various estimates and calculations it would appear that on a level dirt road the pulling power of a pair of animals was ~1-~ 2.5 tonnes (the earlier view that it was less, around half a ton, was mistaken).

The method of harnessing and yoking the animals was a matter of great importance, because on that more than anything else their weight-pulling capacity and efficiency depended. It has often been maintained, based on the lack of finds and the few preserved representations, that the method of harnessing used for horses and mules in antiquity was the same as that used for oxen and did not employ a hard collar. In our drawing of the harnessed draught animals, however, the technically more correct method has been depicted in preference to one of the others that have been considered more probable, which call for soft collars and traction from the highest point, but which are less efficient for heavy work by horses or mules.

At the part of the route shown in the illustration the downhill gradient is -3% and six pairs of large mules would have been enough to draw the waggon.

It is reasonable to suppose that in the more difficult parts of the route, where the road was slightly uphill, it would have been necessary temporarily to augment the team of each passing waggon with some extra pairs of mules to assist in the pulling. The total time a waggon was in use, including loading, transferring the marble and so on, must have been ten or more hours. The waggons must therefore have returned to the quarries on the day following each marble delivery, and consequently the number of waggons used must have been at least twice the greatest number of daily delivery journeys. A figure of 10-20 waggons, 100-300 mules and 50-150 mule drivers must be considered probable.

Another major enterprise, which would have been completed before the present one, was the transport and hauling up to the Acropolis of ~8000 poros blocks weighing ~2 tonnes from Piraeus (*ΠΑ*) for the solid foundation of the Older Parthenon.

- A. Burford, Heavy Transport in Classical Greece, *The Economic History Review* 13, 1960, 1-18.
- A. Burford, *The Greek Temple Builders at Epidauros*, Liverpool 1969, 184-191.
- K. Clinton, The Inscriptions of Eleusis, *AE* 1971, 81-136.
- M. Κορρές, *Συμβολή στήν οἰκοδομική μελέτη τῶν ἀρχαίων κιόνων*, Athens 1991,103.
- J.G. Landels, *Engineering in the Ancient World*, London 1980, 170-185.
- *Il Marino, ieri e oggi*, Società Editrice Apuana, 1978, fig. on pp. 88-89.
- G. Raepsaet, Transporte de Tambours de Colonnes, *L 'Antiquité Classique* 53, 1984, 101-136.
- G. Raepsaet, Vervoer van Steen in het oude Griekenland, in D.Vanhove et al., *Marmer in Hellas*, Brussels 1988, 34-45.

Explanation of Plate 16.

(see Figs. 3-6).

The landscape, from left to right: "Mets Hill", vegetation along the Ilissos, Aegina, Olympieion, hill of *Sikelia*, Piraeus *Akte*, *Hill of the Muses* (the Philopappos monument was only built 600 years later), Acropolis.

The position of the viewer corresponds to the corner of the modern streets of Herodou Attikou and Mourouzi. The waggon is nearing the site of today's *Presidential Guard* building. The part of the Ilissos illustrated is at the beginning of today's *Vas. Konstantinou* Ave., with the gymnasium of the *Ethnikos* and the south side of the *swimming pool*.

The road to the left leads to the old built-up quarter of the Olympieion. In six years' time, one of the gates of the new *Themistoclean Wall* will be built on this road. Its existence was mainly brought to light by the excavation of the gate in 1958 (J. Travlos, *Pictorial Dictionary of Ancient Athens*, London 1971, 160, 402, Figs. 217, 222). The road to the right leads directly to the Acropolis. No archaeological surface finds are known from this road, but its existence is borne out by the underground course of the so-called *aqueduct of Peisistratos*, because for various technical reasons underground aqueducts followed the course of existing roads (for the aqueduct, E. Ziller, *AM* 2, 1877, 112, Pl. 7). Frequently in drawn reconstructions of the plan of the ancient city roads are marked as continuous curved lines, particularly those going around the Acropolis. This does not accord with the principles of street planning current at the time and is purely a simplification of the drawing board. In actuality these roads were never built with continuous curves. This may have been the case many centuries earlier, but from the Mycenaean, and more systematically from the Archaic period onwards, the roads and the building blocks on either side of them consisted of a succession of rather long straight sections: in other words, they followed a polygonal line. The *horoi*, or marker stones indicating the boundaries of the different properties (buildings, grounds, gardens and so on) stood in the first place at the angles of the straight boundary lines, and additional ones were set up at points where internal dividing lines met the external peripheral line of a property unit (e.g. a building block or a piece of property); lastly, marker stones were also placed at intermediate points along straight boundary lines if these were very long. The boundaries were inscribed only when they delimited an important property; usually they were not. We know from innumerable excavation finds that the construction of the walls followed a very ancient system, which in some regions has lasted until the present day: the lower part was built of fieldstones or half-hewn blocks, and the upper and larger part with mudbricks laid in thin horizontal courses.

In Plates 16 and 17 the drawing of the walls was based on what has already been said about the polygonal course of the roads, the marker stones and the method of construction. The style of the stonework was that used in modest building structures from Archaic times onwards.

The huge Archaic Doric temple of Olympian Zeus, the *Olympieion*, although only half-finished, dominates the centre of the picture. It was *octastyle dipteral* in plan and nearly 110 m long. Some of its columns had already been assembled to a height of eight metres, or about two thirds of their full size. The external columns had a diameter of ~2.474 m, and the internal ones 2.21 m. The capitals must have measured over three metres a side.

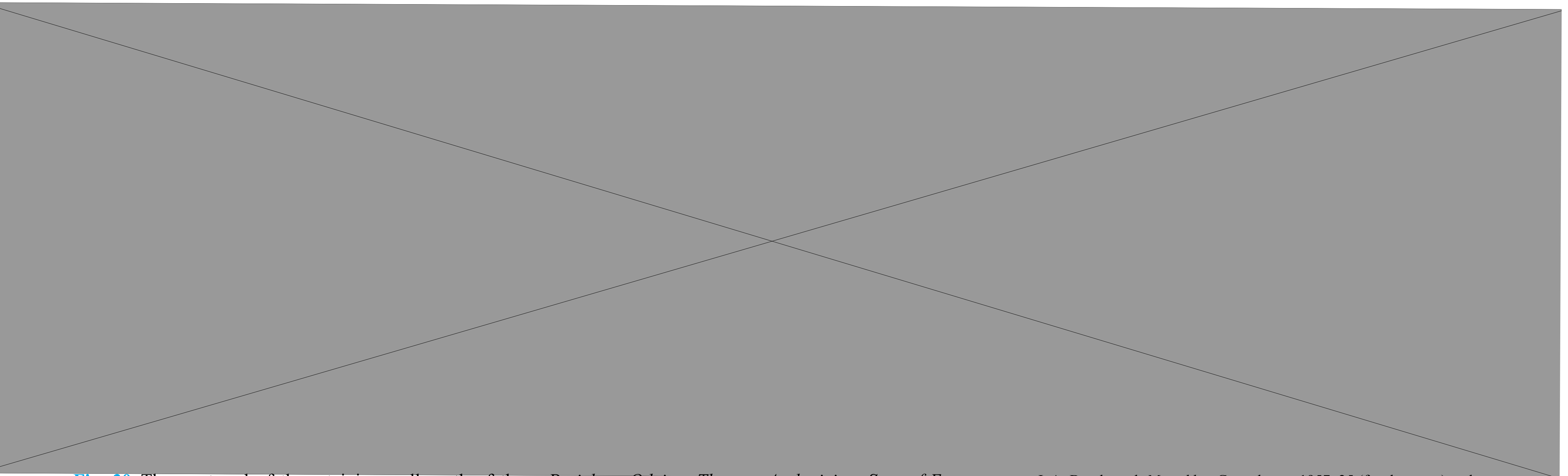


Fig. 30 The west end of the retaining wall north of the Sanctuary of the Nymph. Scale 1:50.

1α, 1β Two pieces of a half-worked marble column drum. Diameter ~1.65 m, height ~0.90 m. The remains of two bosses can be distinguished.

2-11 Original part of the retaining wall.

15-17 Rebuilt part of the retaining wall.

18-20 Later building in the place of the destroyed end of the retaining wall.

AT Smaller transverse walls.

AO, ΦP Ancient drainage work.

PA Projection of the west side of the vaulted Roman cistern.

Explanation of Plate 17.

(see **Fig. 30**)

The way the Acropolis looked before the building of the high Classical walls, with the surviving half-ruined Mycenaean walls. It shows the shape of the rock and hill before the 5th c. fill and the large cuts made in the slope for the *Periclean Odeion*, *Theatre*, *Asclepieion*, *Stoa of Eumenes* and *Odeion of Herodes Atticus*.

Reconstruction based on modern topographical plotting of older level measurements of the original levels of the different excavated parts and geomorphological observations.

At the east end of the Acropolis the sanctuary of *Pandion*, on the left a temple of *Brauronian Artemis*, the existence of which is very probable.

In the space between the original theatre and the rock there used to be houses before the extension of the theatre (~340 BC) was built; the wells and other remains are still preserved in the earth fill of the *cavea* (auditorium). The crooked road south and west of the Sanctuary is much older than all the other works in the illustration, including the Mycenaean walls. It once led to the very ancient spring of *Krene* and from there to the Acropolis, and it generally connected the Acropolis with the hill of the *Olympieion* and the very old settlement there. The ascending road along the east side of the Sanctuary has been confirmed by recent excavations. At the crossing of the two roads was a small *Oikos* (a kind of small temple: Travlos, op. cit., Figs. 202, 678).

– J. A. Bundgaard, *Mnesikles*, Copenhagen 1957, 25 (for the ramp) and fig. 40.
– J. A. Bundgaard, *The Excavation of the Athenian Acropolis*, Copenhagen 1974, figs. 18-20, 36-43, 50-60, 66-74, pls. 114, 122-116, 149-156, 159, 161-163, 165-166, 177, 186, 188 (plans of the excavation of the year 1888 and measurements of the levels of many points on the surface of the rock by G. Kawerau).
– J. A. Bundgaard, *The Parthenon and the Mycenean city on the Heights*, Copenhagen 1976, pls. A, B, K1.
– W. Dörpfeld, E. Reisch, *Das griechische Theater*, Athens 1896, 13-19 (the Archaic temple of Dionysos Eleuthereus), 30, fig. 7. (Water wells and other remains of private houses beneath the artificial earth-work of the auditorium of the Dionysos Theater).
– Σ. Ε. Ἰακωβίδης, *Ἡ μυκηναϊκὴ Ἀκρόπολις τῶν Ἀθηνῶν*, Athens 1962.
– M. Κορρές, *ΑΔ* 35-36, 1980, 12-20 (Sanctuary of Dionysos Eleuthereus).
– G.P. Stevens, *Hesperia* 15, 1946, 3, 12-16, 21-25 (buildings to the east of the Parthenon).
– O. Walter, Die Parthenonfundamente und das Delphische Orakel, *Anzeiger der östeireichischen Akademie der Wissenschaften* 89, 1952, 97-107 (on an earlier destruction of the mycenean Wall of the Acropolis preceding the Persian Wars).

Explanation of Plate 18.

The buildings from left to right: the northwest corner of the Mycenaean wall, the so-called "building B" (2nd half of the 6th c. BC), and lower down the terrace with the small Archaic altar, the older monumental Propylon, the Mycenaean Tower and on top of it the Archaic naiskos of *Athena Nike*. In the foreground the large ramp.

– J. A. Bundgaard, *Mnesikles*, Copenhagen 1957, 25 (for the ramp) and fig. 40; idem, *The Parthenon and the Mycenaean City on the Heights*, Copenhagen 1976, pls. F, G.
– W. B. Dinsmoor, *AJA* 33, 1929, 101-102.
– W. B. Dinsmoor Jr., *The Propylaia to the Athenian Akropolis* I, Princeton N. J. 1980 (with note 10, p. 2 against the placing of "building B" on the site of the *Pinakotheke*).
– G. P. Stevens, *Hesperia* 15, 1946, 73-93.
– J. Travlos, *Pictorial Dictionary of Ancient Athens*, London 1971, figs. 70-71.
– C. H. Weller, *AJA* 8, 1904, 35-70.

From which side were stones lifted up to the Acropolis?

The uncertainty about where on the Acropolis the blocks for the various buildings were hauled up is an old one. L. Ross believed the marble was taken up on waggons on the west side, except for the largest pieces, like the architrave blocks and beams, which he supposed were hoisted up on the south side using strong scaffolding and lifting machinery (L. Schorn's *Kunstblatt* 18, Tübingen 1837, 15). P. Graindor thought the marble was hauled up on the east side (*Revue Archéologique* 19, 1924, 174f.) and G. Beckel, that a special ramp was constructed on each side of the rock for every construction work (Akropolisfragen, *Χαριστήριον εἰς Α.Κ. Ὀρλάνδον*, vol. 3, 362). Stevens considered the Propylaia to be the place where the marble was brought up to the Acropolis (*Hesperia* Suppl. 3, 1940, 13).

That the material was in fact hauled up at the Propylaia is borne out by the geophysical features of the west slope, by the wide artificial inclined plane that had existed in that exact place from the Archaic period, and from one very important piece of material evidence which has hitherto remained unexamined: in the massive retaining wall (I. Μηλιάδης, *Πρακτικά τῆς εν Ἀθήναις Ἀρχαιολογικῆς Ἑταιρείας*, 1955, 50-52; 1956, 262-265), built after the middle of the 5th c. to contain the compact fill of the tiny valley north of the *Sanctuary of the Nymph* and extending up to the subsequent Herodeion, were incorporated, among other blocks, the two parts of a large unfinished drum from the Parthenon or perhaps the Propylaia, which had broken in two because it was defective (Fig. 30, 1β, 1α).

The last stretches of the route were the shortest but also the hardest (an altitude difference of 48 m over a distance of 240 m, and two changes of direction at angles of 90° and 75°: see above). The only convincing method of hauling up so many stones in such a short space of time onto the Acropolis is the system of waggon counterweights described by *Heron of Alexandria* (*Mechanica*, 3.9). Apart from its speed it had one other advantage: it avoided the need to unload and reload the large blocks of marble outside the Acropolis. This had to be done only once, at the entrance to the Propylaia.

The master builders of of the Parthenon at Nashville, Tennessee, expressed the very interesting opinion that the ideal method of erecting the Periclean Parthenon would have been one that avoided the necessity for successive unloading and reloading of the blocks and allowed the waggons to arrive directly at the worksite of the Parthenon, and if possible at the level at which the blocks were to be laid in place (W. F. Creighton, *The Parthenon in Nashville*, 1968, 45).

Explanation of Plate 19.

In the background from left to right: *Katsipodi or the Hill of Daphne* (modern names) and the island of Hydra.

About the form, date and progress of the construction of the Older Parthenon different opinions have been put forward, most of them contradictory, chiefly by earlier scholars but also by some contemporary writers. Of the eight different plans that have been proposed at various times, only one was correct (B. H. Hill, *AJA* 16, 1912). Similarly, only one of the nine different chronologies advanced can be true, and in any case none of the dates proposed after the Persian Wars. An endoscopic examination of the in situ parts of the Older Parthenon incorporated in the interior of the south side of the *crepidoma* of the Classical temple has shown that the earlier *crepidoma* is largely fractured, that the fractures are of a thermal type (like those on the inside of the Classical temple caused by the 3rd c. fire) and that the fractures were caused *before* the old *crepidoma* was encased in the new one. The same findings were established in the case of other marble members of the Older Parthenon that were discovered in 1987, after the temporary removal of many blocks from the north *toichobate* (wall base) of the Classical temple. It is therefore certain that the Older Parthenon was destroyed by fire and consequently was in existence at the time the Persians captured the Acropolis (480 BC). The measurements of its different column drums (Figs. 31-32) have shown that the columns had *entasis*, like those of the Classical temple, but a much more pronounced taper, and therefore that they had been designed to be one drum shorter than those of the latter. Although shorter, these columns would have supported larger capitals than those of the Classical temple. The capital in our story would have been ~20 cm larger than the Classical ones (see notes to Pl. 23).

From the large number of unfinished columns of the 1st, 2nd and 3rd rows preserved on the Acropolis, and from the presence of thermal fractures in all of them and running the whole length of the in situ *crepidoma*, it is concluded that virtually all the parts of the building were constructed at the same time and that the scaffolding had already been erected. In some constructions the scaffolding was put up in stages as the building progressed, for example the *Colosseum* and the large Roman aqueducts and road bridges. In the case of columns, however, even those with many drums, the scaffolding was erected to its full height right at the start, not only in antiquity but in every period generally. The drawing of the windlass installed beneath the central wooden ramp is based on ancient representations (the earliest dates to the 1st c. BC).

The column drums are shown at different stages of finishing (Fig. 32). Only the under side of the drum, however, was finished in the workshop; the top was left in its quarried state until the drum was set in place, and only then would it have been dressed. This method was economical of workspace and nearly doubled the speed of erecting the columns. The *bosses*, diametrically opposed projections on the roughly hewn sides of the drum, were used not only for slinging and hoisting, but also to invert the drums when they were being placed in position.

At the left and right-hand sides of the picture are some large circular slabs fitted with strong wooden handles. These were *surface plates*, weighing 500-600 kg together with the wooden lifting grid; many fragments of them have been found on the Acropolis and are now in the Acropolis Museum. On two of the fragments (MA 3748, 9055) a very thin, bright red coating is preserved (Fig. 31). The function of these plates was to repeatedly check the smoothing of the drum. The artisans laid the *surface plates*, thinly coated with paint, on the joint sides of the drums, or other members, and afterwards used special grindstones to grind down the parts of the surface marked with the red paint from the plate (Fig. 32). Continued repetition of the process produced a perfect fit between a surface and one *surface plate*. Since, however, the *surface plates* themselves may not have been completely flat - a few irregularities in the order of 1/20 -1/30 of a millimetre (!) were inevitable - two different *surface plates*, forming a *pair* (one for each of the sides that were to be in contact), were used to achieve a perfect fit between two drums:

- Firstly, the two *surface plates* complemented each other, since the one had been used to smooth the other. Any positive unevennesses in the surface of the one exactly matched the negative unevennesses of the other, so that when they were correctly aligned they made a perfect contact. A mark on the edge of each plate indicated the correct position of alignment.
- Secondly, during the process of repeatedly checking the smoothing, a certain orientation of the *surface plate*, although chosen at random, had to be kept unchanged over the entire duration of the process. This orientation was fixed in advance by a mark on the side of the drum. At the end of the process the surface of the drum perfectly matched that of the *surface plate*.
- Thirdly, in preparing the two surfaces (a´, b´) that were to be in contact, one of the plates of a pair (a, b) was used for each surface. Since the two plates (a, b) were a perfect fit, the two drum surfaces (a´, b´) would also form a perfect fit:

If a matches b,
a´ matches a,
b´ matches b,
then a´ matches b´.

- Fourthly, when positioning one drum on top of the other, it was only necessary to align the two marks on their sides made during the process of repeated testing with the two matching *surface plates*.

Surface plates were used in the same way to check the seating surface of rectangular blocks. Fragments of these have also been preserved.

Thus at last the secret has been discovered of the almost incredibly perfect fit of the joints in the Parthenon, which was in the order of one hundredth of a millimetre!

The method of turning one column drum on top of the other (with many supporters: Klenze, Penrose, Choisy, Durm, Korres 1983, and also opponents: Paccard, Bötticher, Michaelis, Dinsmoor, Gruben) has not been demonstrated by any finds so far.

Hauling the marble blocks from the Propylaia to the Parthenon was effected by powerful windlasses. The holes used for mounting these windlasses still survive at different points in the rock.

- G. Beckel, Akropolisfragen, *Χαριστήριον εἰς Α.Κ. Ὀρλάνδον*, vol. 3, 329.
- J. A. Bundgaard, *The Parthenon and the Mycenean city on the Heights*, Copenhagen 1976.
- J. J. Coulton, *Lifting in early Greek Architecture*, *JHS* 94, 1974, 1-19.
- G. Daux, E. Hansen, *Le Trésor de Siphnos*, *Fouilles de Delphes*, II, 4 Paris 1987, fig. 26.
- W. B. Dinsmoor, The Date of the Older Parthenon, *AJA* 38, 1934, 408- 438.
- W. Dörpfeld, *Die Zeit des alteren Parthenon*, *AM* 27, 1902, 379-416.
- H. Drerup, Parthenon und Vorparthenon, zum Stand der Kontroverse, *Antike Kunst* 24, 1981, 21-38.
- B. H. Hill, The Older Parthenon, *AJA* 16, 1912, 556.
- Th. Kalpaxis, *Hemiteles*, Mainz 1986, 88-97.
- M. Κορρές, *Συμβολή στήν οἰκοδομική μελέτη τῶν ἀρχαίων κιόνων*, Athens 1991.

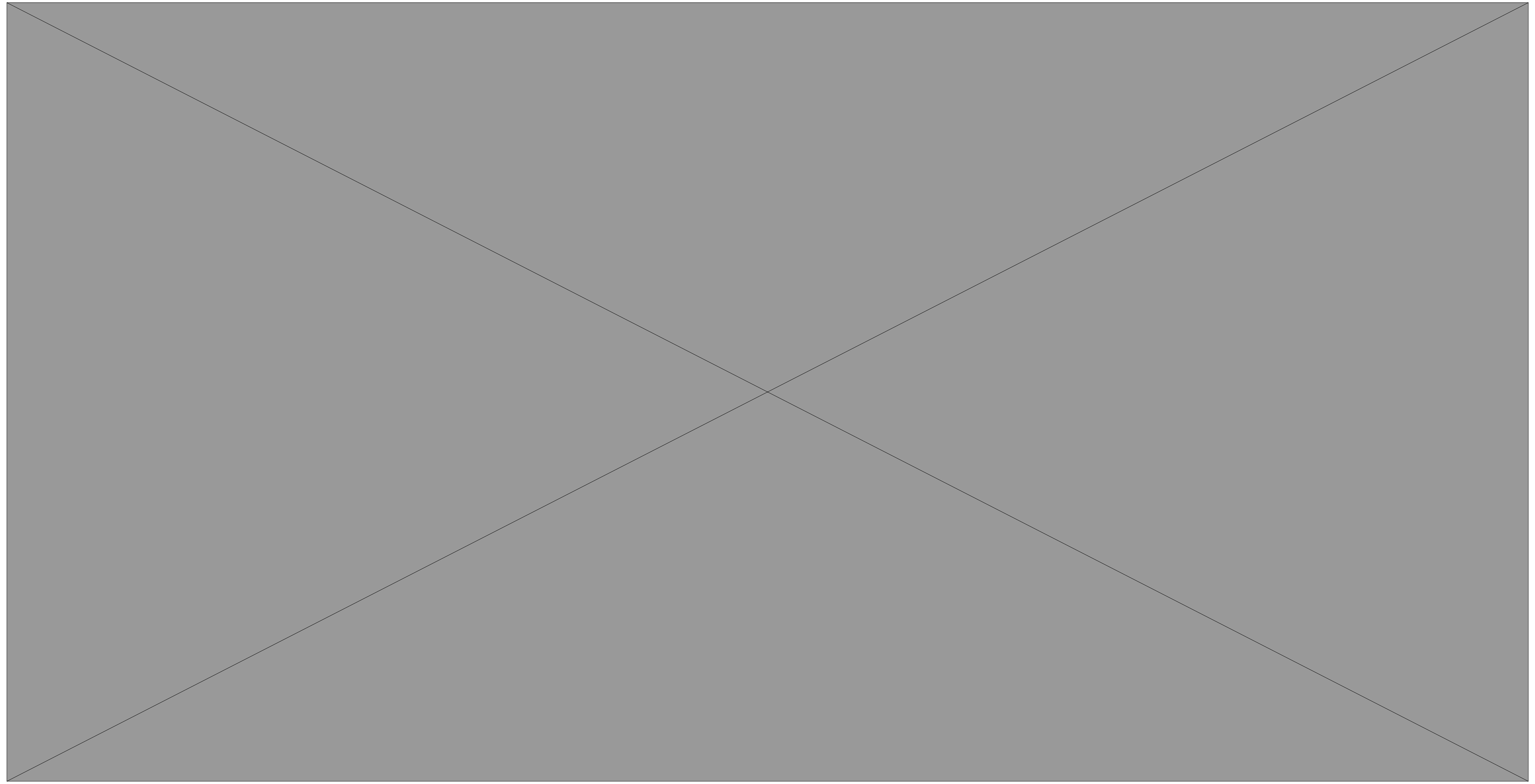


Fig. 31 Fragment of a large circular surface plate (Acropolis Museum 3748).

Fig. 32 Reconstruction of the method of using a surface plate.

Explanation of Plate 20.

(see Fig. 33)

The ruler the Architect is holding is two feet long, subdivided into 8 *palastes* (palms) and 32 *daktyloi* (fingers).

To discover the seriousness of a flaw in the marble the ancient masons usually followed this method: they chipped away small exploratory cuttings in the places where they suspected the existence of a *fissure* in order to test the cohesion of the marble along the length of the fissure. Test cuts of this kind have been detected on the concealed surfaces of some of the entablature blocks at the east end of the Parthenon during the course of restoration work.

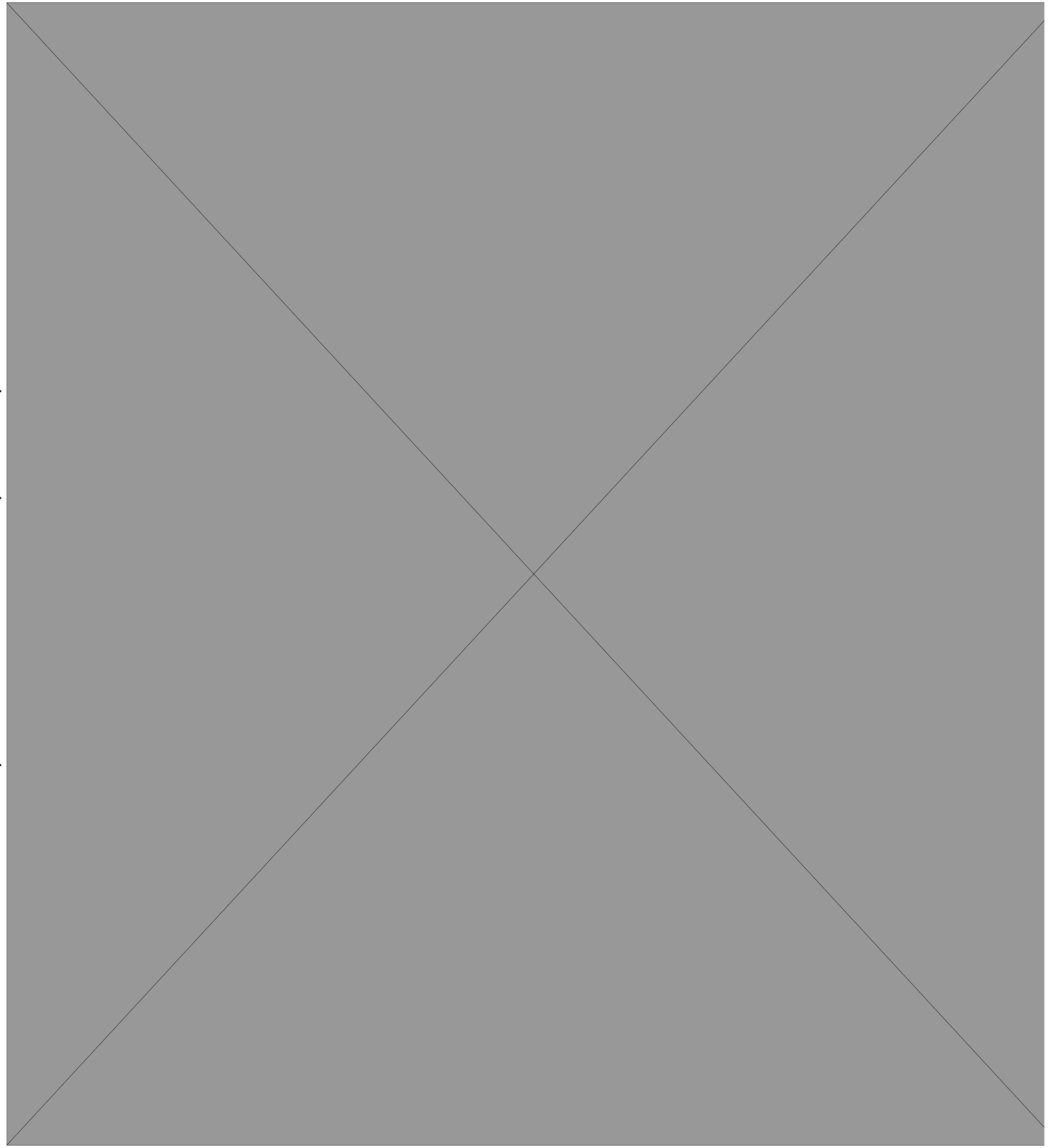
For an ancient mason, discarding an unfinished piece of marble because of a technical or geological flaw would only have been the last resort. First they would have weighed up the possibilities of fixing it or else using part of it for some other purpose. One procedure, akin to cutting a knot out of a piece of wood, was to cut away the flawed areas (fissures, coarse inclusions), if they were not too extensive, and to fill the gap with a perfectly fitting piece of good marble.

Another procedure was to reinforce the marble against cracking by using clamps in the concealed sides of the block. This was only a precautionary measure, not a cure and was used where no sign of any actual break was detected.

Notable anti-cracking reinforcements in the Parthenon are found in the capital of the 7th east column, a cornice block in the west pediment and an unused cornice block of the inner face of the peristyle. They have also been found in the Propylaia in a drum of the 6th west column and in the floor under the bench in the south *pteron*.

Fig. 33 Anti-cracking clamps. Trimetric projection. Scale 1:20.

1 5th drum of the 6th west column of the Propylaia.
2 Capital of the 7th east column of the Parthenon.
3 Unused cornice block of the inner face of the peristyle from the Parthenon.
4 Cornice block in the west pediment of the Parthenon.



Explanation of Plate 21.

(see Fig. 34)

In the background, burning homesteads, and the Persian fleet in Phaleron Bay. The steps of the *crepis* and the columns have already suffered irreparable damage from the conflagration of the large wooden scaffolding poles. The marble has not been calcined, a chemical process that occurs at a temperature of 800°C, but has undergone thermal fracturing or exfoliation, a well-known mechanical phenomenon that occurs at lower temperatures (in a fire, for example). When the surface of large stones is heated suddenly, it expands and flakes off the remaining, colder mass.

– Μ. Κορρές, Χ. Μπούρας, *Μελέτη Ἀποκαταστάσεως τοῦ Παρθενῶνος*, Athens 1983, 288-295, 344-353.

Fig. 34A The form of the thermal fractures in the steps and column drums of the Older Parthenon.

Fig. 34B Different forms of thermal fracture.

Steps of the Older Parthenon *crepidoma* behind those of the Classical temple, in situ but fractured, along the whole length of the south side.
Bimetric projection. Scale 1:20/1:40.

1 Thermal fracture along one edge.
1΄ Fragment from a thermal fracture along one edge.
2 Typical spheroidal form of a thermal fracture.
3 Typical thermal exfoliation.
3΄ Plate-like flakes produced by thermal exfoliation.
4 Typical deepening of the surface of a thermal fracture due to the presence of a plane of discontinuity.
5 Blocks of the new *crepidoma*.
5΄ Surface preparation of the old steps to receive the blocks of the new steps and to enhance the curvature.
6 Impact fracture.
7 Fracture and radial Assuring from the impact of a cannon-ball.
8 Parallel cracks due to the contraction of a vein.
9 Extended hair-line crack due to the temperature variations of the natural environment.

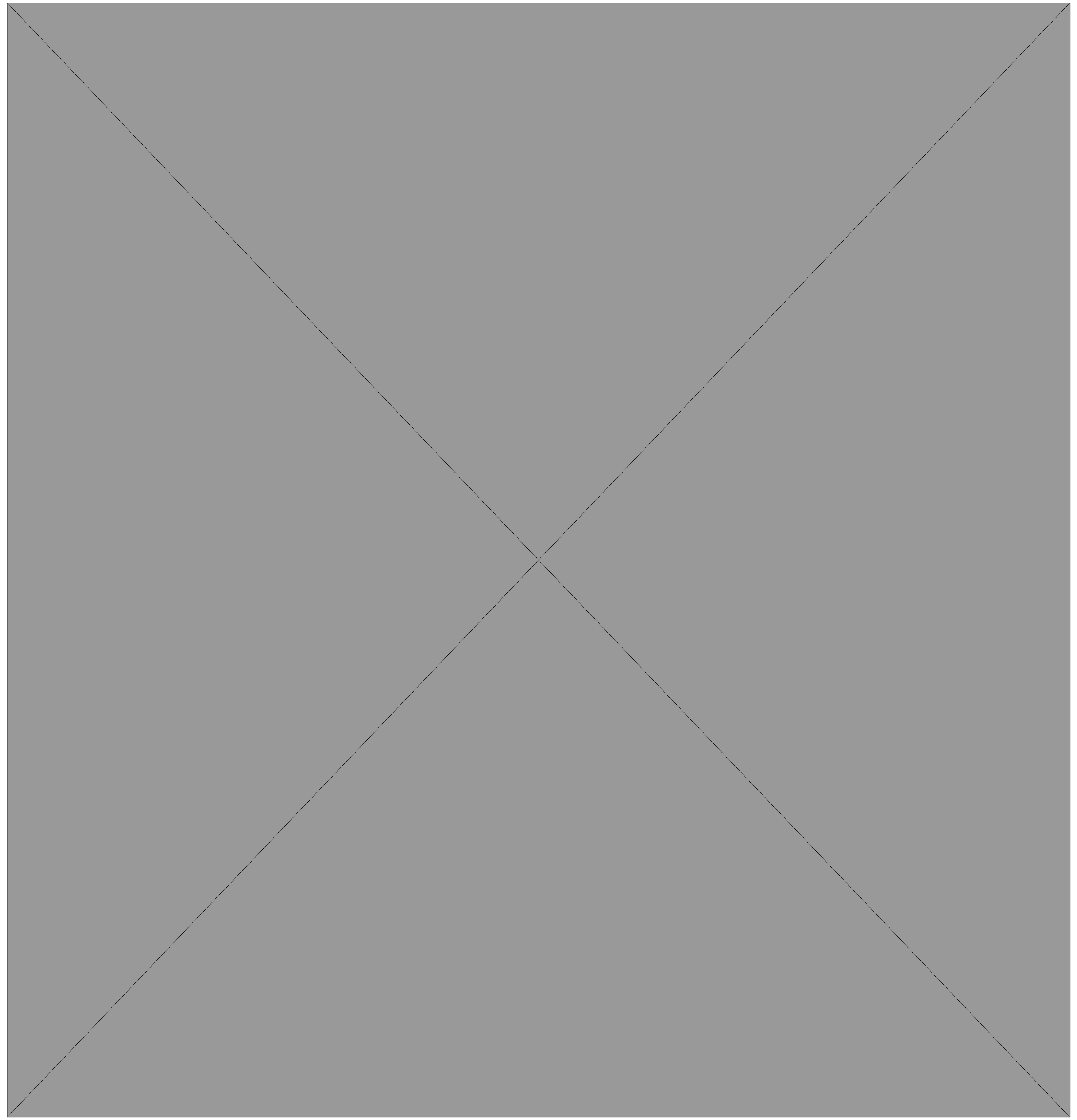


Fig. 35,1 Older Parthenon, reconstruction of the plan and building construction of the walls at the level of the *orthostatai* (wall base). The outline of the later Parthenon is shown with a broken line. Scale 1:400.

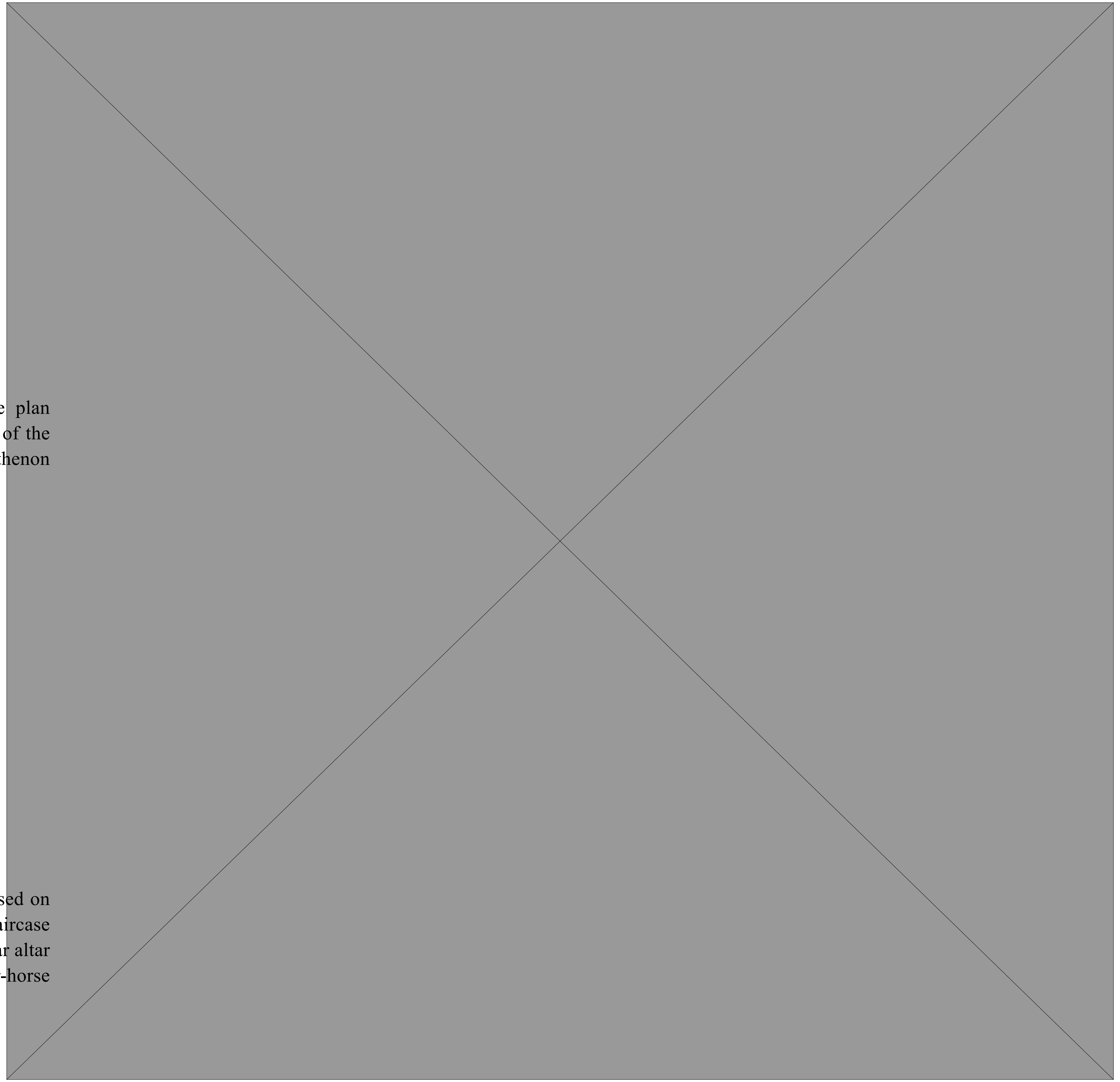


Fig. 35,2 Parthenon, reconstruction of the plan based on modern discoveries: windows in the pronaos and staircase in the thickness of the east wall, *naiskos* and circular altar in the north *pteron*, tower-like pedestal for a four-horse chariot at the NE corner. Scale 1:400

Explanation of Plate 22.

(see Figs. 35, 36)

The plan of the Older Parthenon differs from that of the Parthenon in one important respect: the Older Parthenon was a regular *peripteral Doric*, e.g. *hexastyle* (with 6-columned fronts) temple, whereas the Parthenon has an unusual peculiarity, being *octastyle* (with 8-columned fronts), like most of the large *dipteral* temples (temples with two rows of columns around the outside).

This peculiarity of the Parthenon is mainly due to the intention of creating a large interior room for the more effective display of the chryselephantine statue of Athena. The exceptional width of this interior room led to another peculiarity: a large window on either side of the door. In the illustration the window can be seen to the right of the door.

It took eight or nine years to build the Parthenon (447-438 BC). The largest part of the masonry work undoubtedly went into the carving of the 46 columns of the peripteral colonnade, the 12 of the porches, the 46 of the *naos* proper and the 4 of the west compartment. The second largest part of the work went into the 92 sculptured metopes, and the third into the 212 large, 72 medium and the 160 smaller marble coffered panels of the ceiling of the peripteral colonnade and the porches. Finally, there are the 9000 marble tiles, the walls, the 160 metres in length of the Ionic frieze, the cornice, *crepidoma*, architraves, beams, floors and pediments in order of labor they needed.

The *pedimental* sculptures and *acroteria* (sculptures on the angles and apexes of the pediments) were added some years after the completion of the construction of the building. This is clear not only from the epigraphical sources, which mention the tardy supply of marble, but also from the style of the sculptures and the style of the central acroterion. The task of carving the pedimental sculptures would have been greater than that for the metopes or frieze.

The corner *acroteria*, one of which is shown ready to be positioned in place by the crane, would certainly have been large *Nikes* (*Nike*, the godess of victory), similar to the well-known Nike acroteria on other temples of that period (such as the Athenian temple of Apollo on Delos).

Hoisting the *pedimental* blocks and acroteria into place is the particular theme of Pl. 22.

The *acroterion* of the southeast corner, an over-lifesize marble statue of a winged Nike, has been moved under the crane. It is temporarily propped up by two wooden poles. The base for the *Nike* is in the process of being placed in position with the help of the crane. It is three times as long as the part of it on which the Nike will stand, in order to counterbalance the projecting weight of the statue, which will be fixed to the base by four very strong iron attachments (Fig. 36); one more will be used to fix the base to the pediment.

The base is being hoisted by means of a powerful iron device, a lewis, which has been wedged into a suitably shaped slot over the centre of gravity on the top of the block. (The same method was used to reposition the base on the NE corner, using a modern crane that had much in common with the one used by the ancient workmen and the one illustrated here).

The veteran mason is sitting in front of his latest creation, the base for the *Nike* of the southwest corner, which at this moment is upside-down.

- P. Danner, Die Maße der Akrotere, *Jahreshefte des österreichischen archäologischen Institutes* 58, 41-51.
- A. Delivorrias, in E. Berger (ed.) *Parthenon-Kongress*, *Basel 1982*, Mainz 1984, 289-292.
- J. Durm, *Die Baukunst der Griechen*[3], Leipzig 1910, pl. 68. (The well-known drawing by Durm is apparently based on the similar drawing by Hittorff).
- J.I. Hittorff, L. Zanth, *Architecture antique de la Sicile*[2], Paris 1870. (pl. 89 shows the method presumably applied to build the great temple at Selinunta using cranes, winches etc.)
- M. Κορρές, Χ. Μπούρας, Μελέτη *Ἀποκαταστάσεως τοῦ Παρθενῶνος*, Athens 1983, 41, 103, 463 (*acroteria*); *BCH* 115, 1991, 837, 839.

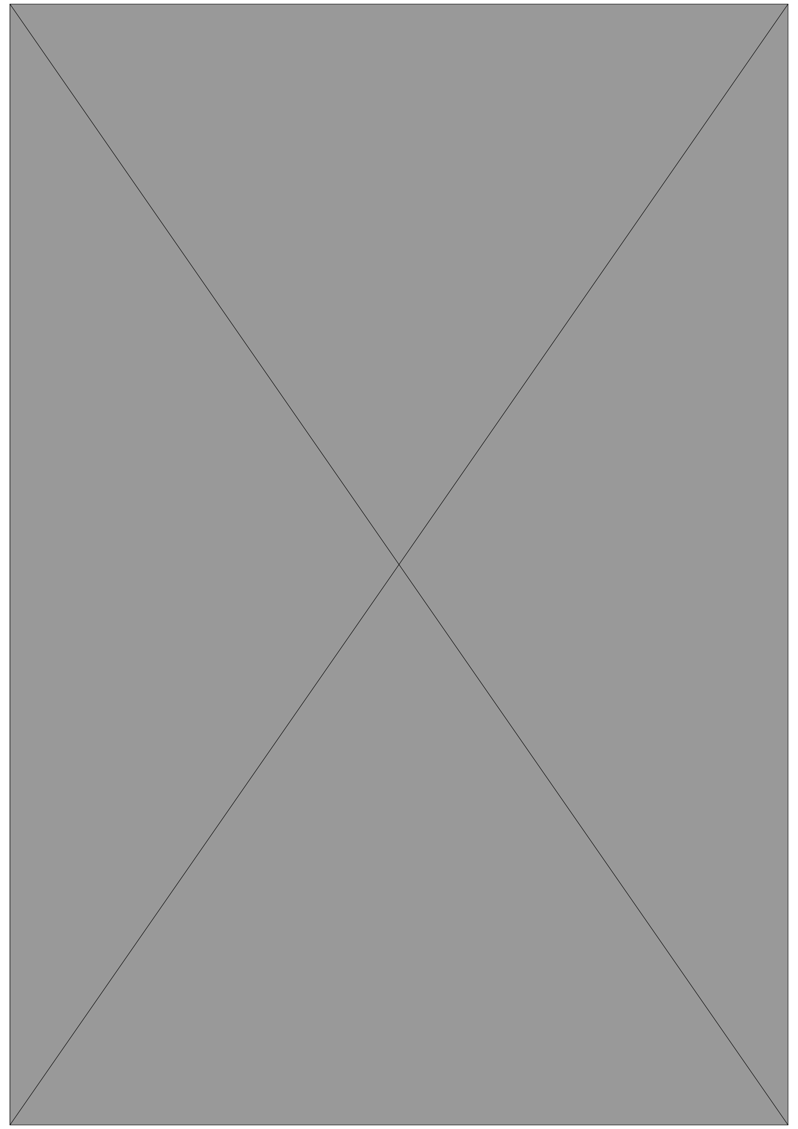


Fig. 36 The sculptures of the northeast corner of the Parthenon and the method of counterbalancing the projecting weight of the Nike with its elongated base, which acts as a counterweight, and the appropriate iron fastenings.

General Explanation of Plates 4-7, 9,11-14.

General comments on the quarrymen:

In Plates 4, 5, 6, 7, 11, 12, 13 and 14 the quarrymen are shown with their legs wrapped in sheepskins and bound moderately tightly with thongs. This would have been very necessary in order to protect them against the sharp chips sent flying by the large and small picks; such measures are still employed today in similar circumstances (J. Ashurst and F. Dimes, *Stone in Building*, London 1977, 29, Fig. 6). In addition they wear protective aprons made of some thick material, and most of them have sun-hats, *petasoi* (floppy brimmed hats) or neckerchiefs on their heads, just like their modern counterparts.

Plates 5, 9, 11 and 12 show tasks being performed that called for larger numbers of workmen than the activities depicted in the other plates. These are obviously large group efforts of short duration, for which other workmen, recognized by their different clothing, would have temporarily left their other jobs to come and help.

Explanation of Plate 23.

(see Fig. 37)

The surviving part of the capital (Pl. 23, Fig. 37) represents about 1/3 of the complete member. The preserved circumference of the *echinus* is an arc of a circle of 165° with a chord of 2.23 m, and consequently its diameter and the side of the *abacus* would have been ~2.25 m. The upper surface is already perfectly flat, dressed with a toothed axe, whereas the rest preserves its preliminary dressing. The excess thickness (*apergon*) ensures the following stages of the dressing and the protection against injuries as well. The upper surface is encircled by a smooth guide cut ~2 cm into the surface of the *apergon* and it therefore measured 2.21 m on each side and was some 21 cm (10%) larger than the regular capitals of the Periclean Parthenon, or some 15 cm larger than the capitals at the east end of the Parthenon. The *apergon*, also, in its final state, is very thin (~2 cm) and geometrically very regular. The remaining thickness of the *abacus* is 41 cm and consequently its ultimate thickness must have been ~39 cm, that is, some ~3.5 cm (~10%) greater than the thickness of the abaci of the Periclean Parthenon. The preserved height is ~89 cm, and clearly, before the upper surface was dressed and the necking-band destroyed, it must have been nearly 110 cm, or 105 after dressing. It was therefore some 20% higher than the capitals of the Classical temples, and the proportions of the echinus would have been closer to those of the capitals of the *Old Temple of Athena* than those of the Periclean one. The weight of the capital at its present stage of preparation would have been about 11,000 kg, and after its final finishing ~10,300 kg. The weight of the capitals at the east end of the Parthenon is about 7,500 kg.

The almost Archaic proportions of the Older Parthenon capital were due to the fact that on the one hand it was at least some 40 years earlier than those of the Classical temple, and on the other that the intercolumniation of the Older Parthenon was somewhat greater than that of the Classical temple.

Half-finished Classical Doric capitals in Athens:

- one in the foundations of the temple of Hephaestus (W. B. Dinsmoor, Observations on the Hephaisteion, *Hesperia* Suppl. 5, 1941; J. J. Coulton, *Greek Architecture at Work*, London 1977, 59, fig. 16).
- some in the Sanctuary of Apollo Delphinios (J. Travlos, *Pictorial Dictionary of Ancient Athens*, London 1971, 83, figs. 111-112).
- one built into the retaining wall on the south side of the *peribolos of the Sanctuary of Dionysus Eleuthereus*.

– J. J. Coulton, The Parthenon and the Periclean Doric, in E. Berger (ed.), *Parthenon-Kongress, Basel 1982*, Mainz 1984, 40-44.

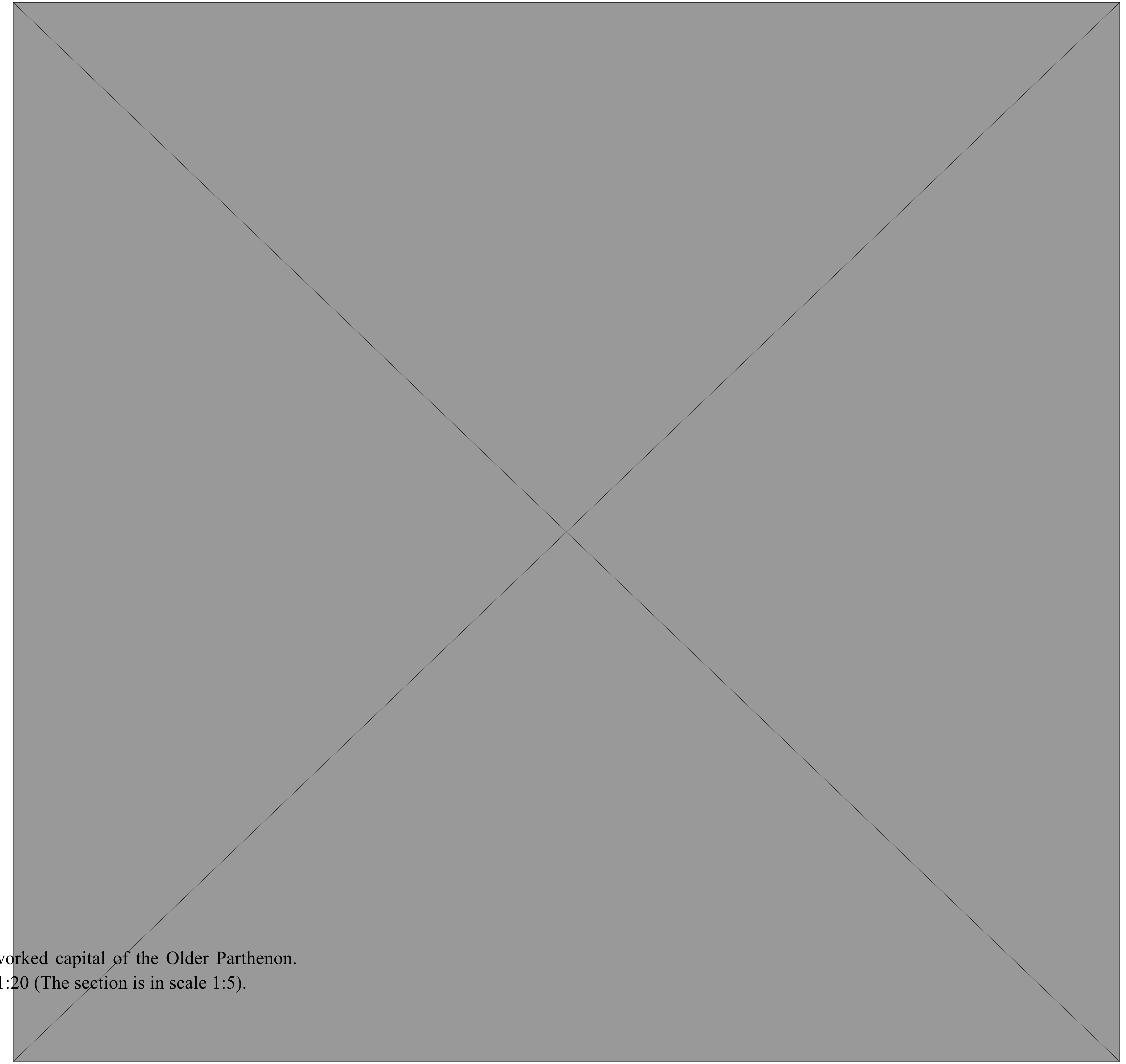


Fig. 37 The half-worked capital of the Older Parthenon. (Acr. 2100). Scale 1:20 (The section is in scale 1:5).

APPENDIX 1

TESTIMONIES

Evlia Çelebi
K. Biris (ed.), *The Attica of Evlia Çelebi* (in Greek), Athens 1959, 59, see also N. Chiladakis (ed.), *Journey to Greece* (in Greek), Athens 1991, 189-190.

... a great mountain all of marble reaching to the third heaven. One can still see the remains of the great palace built thereupon by Solomon for Balkida. All the islands of the White Sea can be seen from the summit. Here still rise the slopes of that large mountain from which all the marble columns and blocks for the buildings of Athens were cut. And how many hundreds of quarries still cut fine marble!

A large, deep cave exists here. The priests lit candles and we all divested ourselves of everything but our underclothes. With one servant, we passed through the narrow corridors between the rocks, descending through one opening and then another till, in about an hour, we found ourselves in the depths of the earth, in the abode of the wise men and ascetics. It is said that all the latter, neglecting their bodily needs in these caves, gained philosophical wisdom with silent, unintelligible words. All these caves are God-made; they are not the work of men. Every now and then, light appears. Every cave and each marble block bears the names of hundreds of wise men, along with all sorts of carvings and symbols such as those that one can see the obelisk in the At Meydani (Hippodrome) in Constantinople. Each of those who entered this cave carved what he saw onto the rock. Further down, towards the nadir, one sees thousands of strange objects and thousands of human bones. We emerged with the guides and the priests three hours later. Afterwards, we enjoyed the vineyards and gardens and flourishing farmsteads, and passed hundreds of thousands of beehives along the ridges.

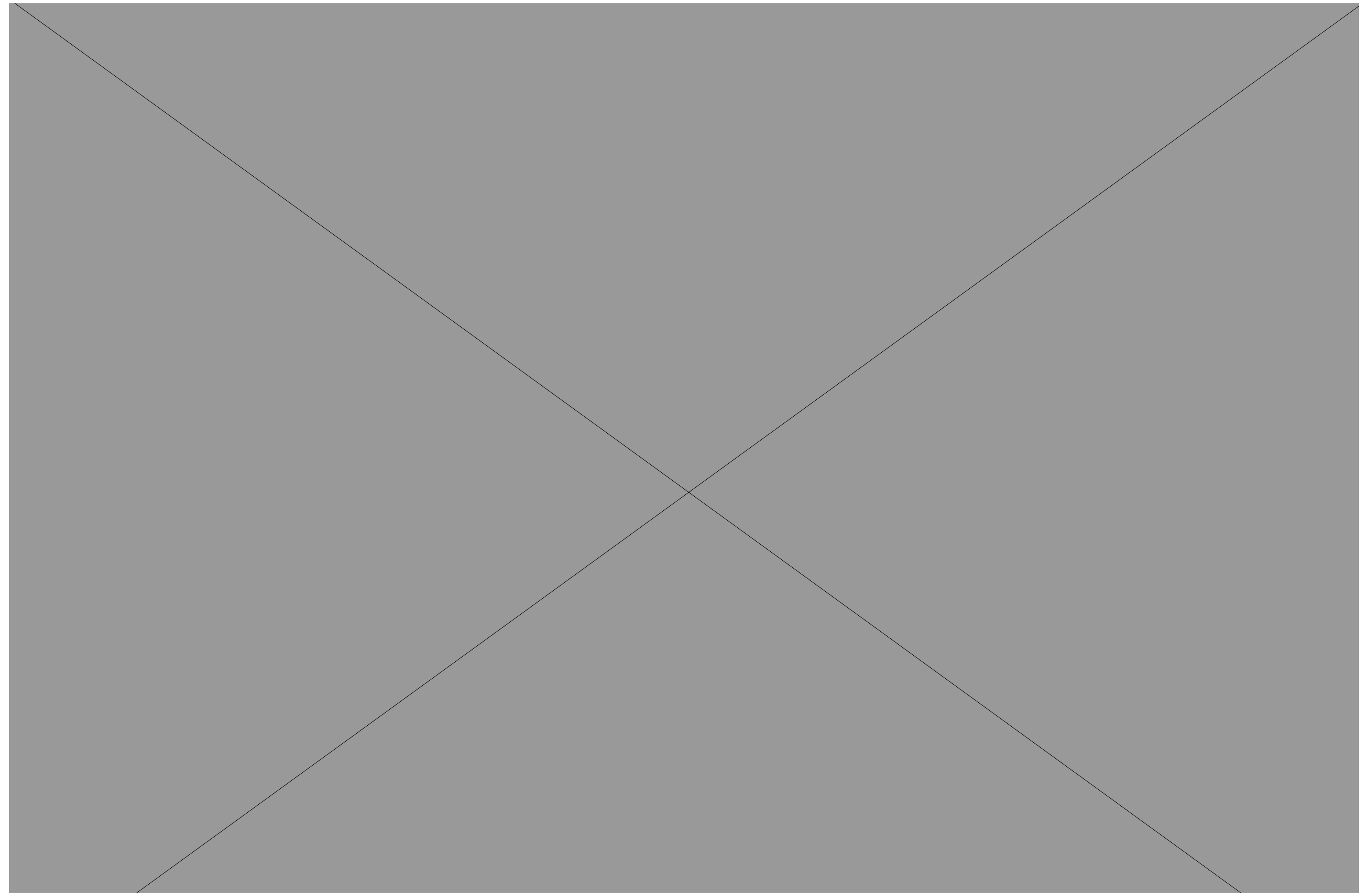


Fig. 38 Ludwig Lange, *Steinbruch zu Pentele*, June 1836 (Staatliche Graphische Sammlung, München Inv. Nr. 35763).

Anton von Prokesch-Osten (1825)
Denkwürdigkeiten und Erinnerungen an den Orient, vol. 2, Stuttgart 1836, 424-429.

After an hour and fifty minutes, I arrived at the abandoned site of Halandri, and thence made my way in an almost easterly direction through the vineyards and meadows till, fifty minutes later, I arrived at the foot of the Pentelicon. ... After an ascent lasting half an hour, one finds oneself before the monastery of Pentele. There, in the shade of tall trees which adorn the courtyard of this extremely picturesque and finely built monastery, I enjoyed a breakfast of honey and milk while the monks prepared themselves to accompany me to the quarries of this famous mountain. The Greek monasteries, if compared to those of the Roman Catholics, have the advantage in that the monks, being less prone to seduction by the Satan of scholastic learning, hold nature much less at a distance, and feed themselves by the produce of their own hands, work which keeps them completely occupied. Thus they radiate

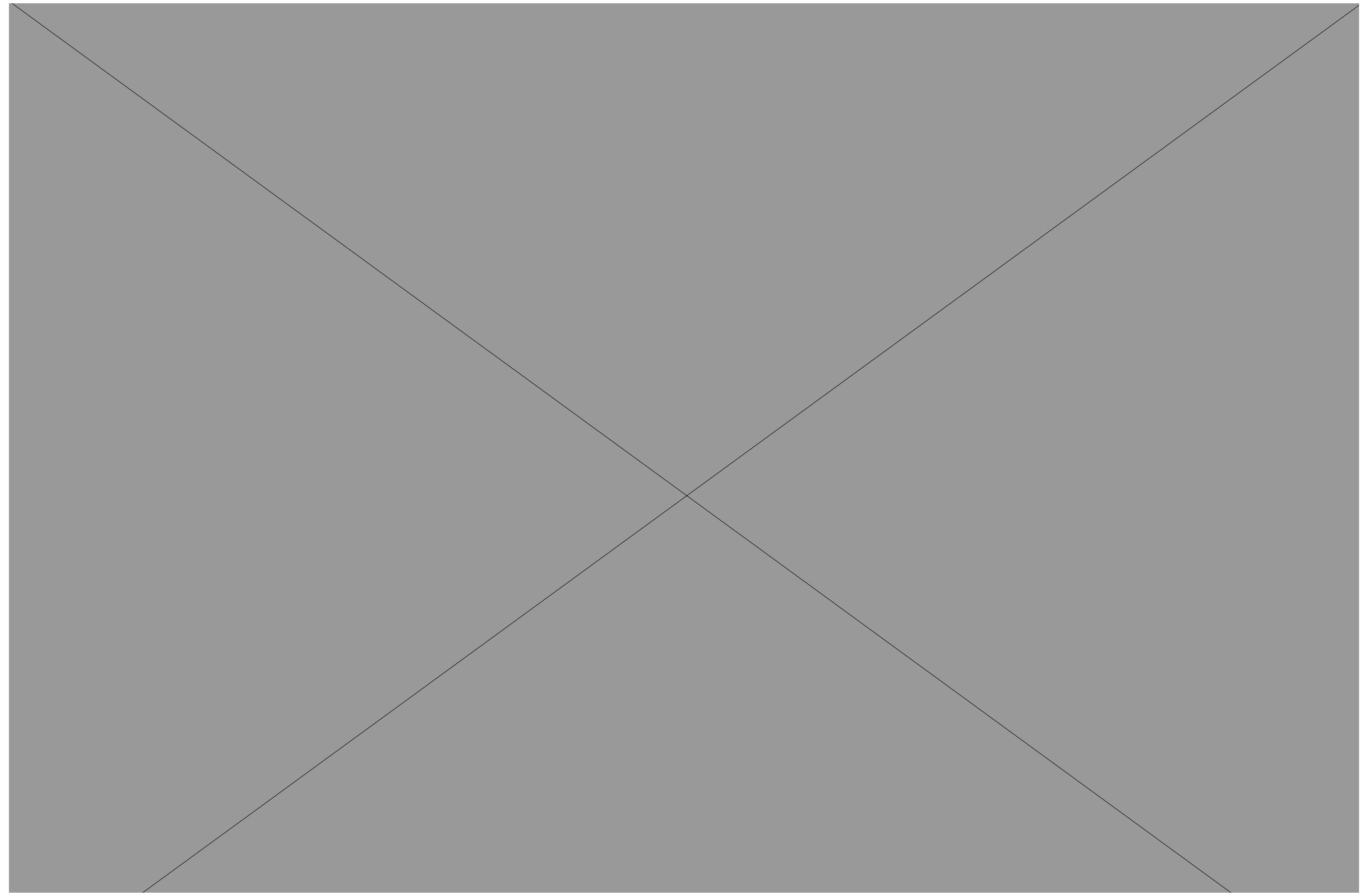


Fig. 39 Ludwig Lange, *Steinbruch zu Pentele*, June 1836 (Staatliche Graphische Sammlung, München Inv. Nr. 35764).

that aspect of peace which can be achieved by being cut off from the rest of the world. Their great lack of education becomes immediately tolerable since one gives importance only to their inner disposition, thus all and more liberating oneself from the bondage imposed by that empty over-estimation of knowledge that all too often limits the traveller's ability to observe the world. It may seem strange, but it made me happy to see the monks taking care of cows, ploughing fields, gathering in the harvest and executing all the chores for both house and stable.

The monastery of Pentele is so esteemed for its honey and olives that of the former alone it must supply the Grand Seignior[1] with 9000 pounds. ...

The monks provided me with an example of their simplicity and lack of education by the way that they praised and described the nearby marble quarries. The wisest amongst them confined himself to the following: "There on the mountainside is a hole, and therein a well. The milords come and creep round there, drink from the spring, carve their name in the rock and then go their way."

The road to the quarries is most exhausting, but well worth the exceptional view of Attica and the Saronic gulf. Only a quarter of an hour from the monastery, where one can see the mountain crest from the low peaks and the interspersed plateaus, the quarry shows itself in the cuttings between huge piles of chippings; these continue upwards, almost to the peak. The road along the quarries' length is ancient, these treasures not having been exploited in modern times. In places one can discern wheel tracks and the ancient flagstones. After reaching a certain height, one is surprised to come across an expanse of rock that has been cut flat in the shape of three-quarters of a circle, and crowned with pines, cypresses, laurels and myrtles. The marble faces tower above, here and there shining white, elsewhere variously coloured due to weathering and the process of time. Lichens cover the intercalations and vines let hang their long branches. Masses of fallen marble lie, as if rent by a tremor from its parent rock... To the left, half way up the low cliff and situated on a projection of rock, is a stone dwelling, inaccessible without a ladder. The monks relate the story behind it: "Three Greek monks, the most handsome in all Attica, facing the wrath of a Pasha, sought refuge in the wilderness and with their own hands built this small hut. They were regarded by the people as saints, and after their death their monument was venerated for a very long period of time." A hermit now lives there, and his church can be seen in the cave's entrance.

Going over piles of stone, marble ruins and worked marble blocks one arrives at the entrance, now closed up by a modern wall. One sees, amongst other things, old column fragments—traces of human handiwork from thousands of years past—in the depths of a broad cave dimly lit by sunlight and colours left by time on the rock face; then there is the chapel with its ambo. About sixty paces on one delves into the depths till reaching a winding corridor which, in places, is so low as to make one crawl with difficulty to fit therein. Then came a sort of chamber and a downward sloping corridor with narrow steps leading to a hollow in the rock that has been cut out and is full of water. A spring gushes forth thence, supplying water to a hollow which continues to run via a conduit of some kind. The coolness of the spring waters is unusual for Greece, and the water itself is much better than that of Peirene at Corinth; indeed, it can only be compared with the Alpine waters of our own fatherland. Carved onto the walls where the corridor

1 He means the Sultan. The honey was for the poorhouse in the Validé mosque.

starts and the steps cease, I encountered the names of many visitors, the most recent being that of Santarosa[2] and Colegno; the former ended his unlucky life even before Navarino. On emerging into the sunlight once more, I investigated the rest of the cave at the quarry entrance where it continues to the southwest for about 100 paces. While at first adorned with stalactites, it terminates in a series of corridors.... Dodwell only visited the cave entrance, not being able to reach the spring without torches.

William Gell
The Itinerary of Greece, containing one hundred routes in Attica, Boeotia, Phocis, Locris and Thessaly, London 1819, 63-64.

Monastery of Pentele or Pentelicus, situated in a well wooded plain, or step of the mountain. A beautifully retired spot, the resort of the rich Athenians during the heats of summer. The church is clean and in good repair, and the monks are hospitable to strangers. Ascending the mountain to the quarries, at 16 minutes is the nearest quarry... The great quarry is 41 minutes distant from the monastery, and affords a most extensive prospect from Cythaeron to Sunium. Here is a cavern in the white marble rock, near 250 feet long, which is well worth visiting. The stalactites are curious. Worth observing is the ancient method of cutting blocks entirely with the chisel; and several inscriptions of different ages cut by the workmen. On the descent lie many unfinished blocks, and several contrivances for slipping down the marbles to the plain below are visible.

L. Ross (1836)
Das Pentelikon bei Athen und seine Marmorbrüche,
L. Schorn's *Künstblatt* 18, Tübigen 1837, 5-6, 10-11,16.

Between Kephisia and the monastery of Pentele, and only quarter of an hour north of the latter, there extends a broad ridge from the foot of mountain going up to and almost reaching the summit. It is this ridge that contains the famous vein of marble. Extending to a height of over three and a half thousand feet, the ridge is full of marble quarries both large and small from which the ancients extracted this most noble of stones for their buildings and sculptures. The first quarries are located at the foot of the mountain, but the stone that has been cut here contains veins of fissured marble, and cutting did not proceed deeply enough to reach the purer level. The largest and most attractive quarry lies almost half way up the ridge. Opening westward to the plain, it is confined on its remaining sides by sheer faces of marble the size of a building which still bear evidence of the care used by the ancients in cleanly extracting the marble, not by splitting it, but by loosening the great blocks section by section with their various quarrying implements. These rock-faces are crowned with pines and wild strawberries, with bushes and climbing plants overhanging from their crests. Against the left face lie the ruins of a hermit's retreat which can be approached only by a dangerous climb or a rope ladder.

The rock face at the back, however, overshadowed by jutting protrusions of rock, opens into a large stalactite cave which human hands must have widened by cutting away sections of stone from the ceiling. On another wall one can see a rough depiction of a temple, carved by a labourer in antiquity, and at many locations on the walls the word ΟΡΟΣ (limit) is visible. The latter is repeatedly encountered in the Hymettus quarries, at times accompanied by some first name or other. Thus it is possible that the quarries classified by Xenophon, amongst others, as sources of public funds were state property. Of the quarries further up, a few are almost as large as the one just described, and perhaps one[3] may be slightly larger but is by no means as pleasant to behold...

That these bulky masses of marble were conveyed by waggons is evident from the tracks carved into the rock surface which can be seen on the mountain at various places near these quarries. From the foot of the Pentelicon, the blocks were taken via a specially built road to the city, remnants of which still indicate its course throughout the plain....

A (new) waggon track has been built up to the foot of the mountain, following almost exactly the same direction as the older, and work has begun in the ancient quarry described.

H. C. Andersen (1841)
Travels in Greece (Greek translation), Estia publ., Athens, 95-96.

...but first we wanted to see the quarries of the Pentelicon. We made our way past bushes and shrubs along our path, where children tended the monastery's sheep and cows. Now and then large tortoises would crawl by us and when I saw one of these writhing upside-down, I undertook to become its saviour.

The road increasingly sloped upward, and walking became difficult. We went on, however, between the rocks, bushes and thorns, but we had to reach the quarries and we had not yet passed the ridge of the Pentelicon.

Up above there stood a shepherd wearing the traditional Greek cap and leaning on his long staff. He was looking down into the grey plain, there where a lonely mound rose in the wilderness. The sea and the mountains of Euboea could be seen on the horizon. A grey-blue column of smoke rose from an almost indistinguishable hut down below. The mound, which amongst the reeds resembled an island, is the most famous in the world. Whose can it be, I wonder? From the name of the plain we can guess. It is the mound of Marathon.

Christiane Lüth (1841)
A Danish lady at the court of king Otto (Greek translation), Athens 1988, 54.

On the third day after Easter we went together with him (H. C. Andersen) on an outing to the Pentelicon. We were two waggons full and two riders. We had planned to climb to the summit since Andersen wished to see the plain of Marathon from that vantage point. But before reaching the ancient quarries, which are so very interesting, he had already become tired, and sat down at the large curious quarry, where he shouted to us, who had gone on ahead and were much higher up—almost at the summit: "If you can see Marathon, I'll come, otherwise I'll stay here!" But nothing was yet visible and out of courtesy for our guest we descended, without in the end seeing what we had hoped to.

N. A. Parmenides (1847)
Visit to Pentele (in Greek), *Nea Pandora* 1956, 180-183.

The ancient quarries can be distinguished from the modern ones since the latter extract the marble using dynamite, rammed deep into the depths of the rock, that destructively splits the marble away in shapeless lumps. But when on beholding the ancient quarries, one ponders with admiration the question of how the quarrymen of antiquity managed to cut the stone away in so regular and skilful a manner. The individual marble masses were separated as monoliths of enormous size and their surfaces were smooth, thus making only a moderate amount of carving necessary afterwards. The regular rock surfaces, almost wall-like, make it apparent that the ancients possessed tools more suitable for cutting away monolithic blocks, while the moderns with their

2 S. Santarosa, an Italian noble, after a lengthly service of outstanding heroic activity, sacrificed his life for Greek independence on the 8th of May 1825 at Sphacteria, aged 38.

3 He surely means the quarry Λ10 (see Figs. 20, 22).

dynamite can only just split shapeless blocks with much destruction, their surfaces unequal and irregular, and their size perhaps never so big as those removed by the ancients.

We reached the Pentelicon cave. In front of the entrance there is a church and small structures evidently used as domiciles for the labourers. On entering this cave, using candles to light our way, we proceeded to a broad chamber-like area which extended far into the depths, although excessive darkness and restricted space did not reveal the point where the cave terminated. This cave, also an ancient quarry, was most attractive with its strange stalactites.

Karl Krumbacher (Nov. 1884)
Griechische Reise, Berlin 1886, 56-57.

That morning, with the gendarme as our guide, we reached the summit before sunrise. Unfortunately, it was covered by cloud which was stirred up into rain by a strong northerly. After having traversed some distance down the slope, we found ourselves underneath the mantle of cloud and were at least able to glean an idea of the exceptional view afforded by the Pentelicon when the sky is completely clear. All of Attica, with Athens and Piraeus, Salamis and Aegina, Parnassos and Kithaeron emerged from the thick morning dew like a new creation. The landmarks further away sadly remained in the mist ... Returning to Kephisia, we passed the new quarries where a gigantic mass of marble had already been cut to size ready to be transported to Athens. They tell me that it will be used for a statue of Gladstone[4] to be executed by the sculptor Vitalis from Syros.[5]

A. N. Vernardakes
On commerce in Greece (in Greek), Athens 1885, 59-61.

The quarrying of the marble takes place in such a senseless and careless manner, that not only does the local price become unnecessarily high thanks to all the waste, but the natural resource itself is being destroyed.

...the quarries belong to the monastery of Pentele, which rents them for an annual rent for each quarryman with one worker of 25 drachmae. There are eleven quarries rented, of which 8 produce white and three dark marble.

D. G. Kambouroglou
The path to the cave (in Greek), *Nea Estia* B΄ 1927, 777.

Now, o reader, become a torch-bearer. Go forward into the mystery of chaos, there will you find the marble staircase that leads to the mystical well of the depths.

K. Biris (1949)
Newspaper Kathemerine, 18 September 1949.
On modem Athens (in Greek), I, 1956, 39-41
(The quarries and hills of Athens).

On the question of the capital's quarries, it is hypocrisy indeed for us to speak of culture in this land. To speak of tourism, when the tourist ... is able to see how those rocks no longer exist and how the hills have been eaten up as if by a mythological beast. When, reaching Athens with a cherished dream of visiting the cradle of civilisation, the tourist peers from his window on the aeroplane to see all those hills peppered with thousands of pits appearing like huge wounds—and Mt Pentelicon everywhere scarred by criminal surface quarrying undertaken over the last few years. He can only form an opinion that this city is today inhabited or administered by barbarians and insensitive agents of destruction.

It is high time that this orgy of destruction should stop.

K. Biris
Athens from the 19th to the 20th century (in Greek),
Athens 1966, 379.

Up till the first three decades of our century, the only marble quarries on the south slope of mount Pentelicon were Vathy Rema, Soulenari and, just beside it, the ancient quarry known as Spelia, the quarry of the Cave ... None of these could be seen from the Attica basin. In subsequent years, other quarries were opened up to the west in locations which were fully visible. For the first time the hitherto pristine aspect of the mountain was disfigured. Land for these quarries had been leased out by the monastery to various concerns. At the same time, beginning from the years just before the war, the abbot's council began to issue plots of monastery land to its south and west to developers and co-operatives.

These installations, along with the quarries and the settlements, represent nothing less than the sentencing of the Pentelicon landscape to oblivion. None of these things occurred without the knowledge of the public authorities responsible for the protection of the area. The quarries were established by permission of the Directorate of Metals of the Ministry of Industry, while the building development was undertaken with screaming advertisements in the newspapers, and based on privately developed plans in a manner expressly forbidden by the relevant legislation.

G. Gruben (1990)
From an unpublished report on the ongoing damages in the ancient quarries (transl. by M. Korres).

These quarries, from the 5th century BC, provided the material for all the important buildings in Attica. They were in operation throughout the duration of antiquity. The three quarries, the largest measuring 200 m long, along with the chamber in the cave, some 100x60 m and also used as a quarry, constitute a unique phenomenon world-wide. This monumental group of remains even includes the ancient flagstone road and underground spring, no doubt a nymphaion, the Byzantine chapel and the remains of hermits' cells.

Here we have a majestic testament to ancient technology, to the history of Greece and to its natural beauty, and in no circumstances should this legacy be sacrificed for short-sighted gains... These venerable quarries, some 2,500 years old, belong to all mankind for the centuries to come.

4 Until 1992 this statue (1883-86) stood on the south side of the University garden. It was moved temporarily because of the Metro works, see Σ. Λυδάκης, *Οἱ Ἕλληνες Γλύπτες*, Athens 1981, 55, 63, 289-290.

5 G. Vitalis (1838-1901) was from Tenos.

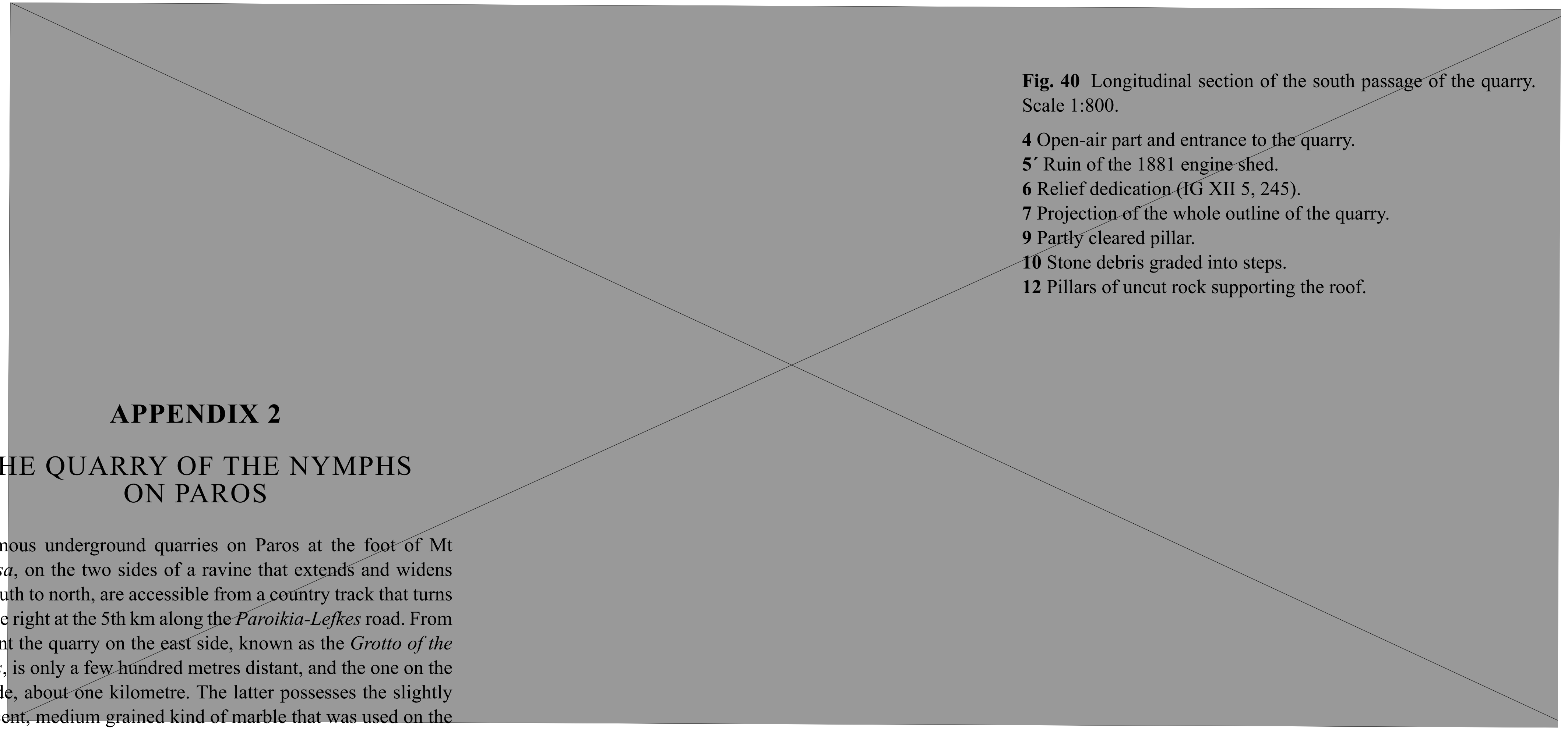


Fig. 40 Longitudinal section of the south passage of the quarry. Scale 1:800.

4 Open-air part and entrance to the quarry.
5´ Ruin of the 1881 engine shed.
6 Relief dedication (IG XII 5, 245).
7 Projection of the whole outline of the quarry.
9 Partly cleared pillar.
10 Stone debris graded into steps.
12 Pillars of uncut rock supporting the roof.

APPENDIX 2

THE QUARRY OF THE NYMPHS ON PAROS

The famous underground quarries on Paros at the foot of Mt *Marpissa*, on the two sides of a ravine that extends and widens from south to north, are accessible from a country track that turns off to the right at the 5th km along the *Paroikia-Lefkes* road. From this point the quarry on the east side, known as the *Grotto of the Nymphs*, is only a few hundred metres distant, and the one on the west side, about one kilometre. The latter possesses the slightly translucent, medium grained kind of marble that was used on the Acropolis for the sculptures on the *Old Temple of Athena* (the latest of the poros temples of Athena). The quarry of the *Nymphs* follows a thin but very fine quality stratum of fine grained translucent marble. This is sandwiched between a stratum of bluish and a stratum of white but not very fine marble. These strata have a downward inclination of 80-85% towards the east.

The underground part of the mine has a length of 190 m in a north-south direction and a width of 50-120 m increasing from south to north. The distance from floor to roof is for the most part three m. The thickness of the overlying rock to the surface of the slope increases from SW to NE from 20 to ~120 m. To prevent the roof caving in pillars of uncut rock were left at intervals. In the southern part, which is the oldest, the intervals between the pillars are 6-10 m and their thickness increases according to the overlying mass. The pressure on the pillars under the thickest part of the slope must be in the order of 500-600 kg per sq. cm. Some of them have been wholly or partially removed in later periods, most recently for example by profiteering quarrymen. This is the major cause of regular roof-falls. Due to the way the quarry was worked, only part of it is free space in the form of passages, while the remaining, larger part is filled up with huge quantities of debris, mostly structured and not simply dumped. Thus only twenty of the pillars are directly visible, and the existence of as many again is apparent from small gaps in the upper part of the piles of debris. There must be over a hundred of them. Two descending passages link the quarry with the outside world. The southern one is ancient. On the left of the entrance is the well-known relief on the rock. The passages do not follow the steepest slope towards the east, but run in a diagonal direction towards the northeast, so that the slope is more moderate (almost 60% in the southern and 50% in the northern one); this was necessary as a safety margin for the movement of men and loads. The production of the quarry in antiquity must have amounted to nearly a hundred thousand cubic metres of useful marble.

Outside the quarry, on the southern extension of the two passages, the machine house for the winches still survives on top of a hill of debris; they belong to the last phase of the quarry's exploitation by the *Greek Marble Company of Paros*, which, as indeed is obvious, extended the quarrying (1881) much further on its northern side, almost completely obliterating the ancient features. On the other hand the original features of the most ancient phases are still nearly fully preserved on the south side.

Various other buildings, workshops, storerooms, etc., were built by the Society at that time in the area of the quarries and at Paroikia, the remains of which already belong among the monuments of industrial archaeology. There was a railway system some 6,900 m in length to carry the marble to Paroikia, and a revolving crane of 20 tonnes capacity mounted on the end of a new jetty to load it onto the ships. Some massive, well-hewn blocks of marble with a curved front, dumped into the sea at Paroikia, may be parts of the fine base of the crane.

Fig. 41 Plan of the quarry. Scale 1:800.

1 Open-air part and entrance to the quarry.
4 South passage.
5´ Machine house.
6 Relief dedicatory inscription (IG XII 5, 245).
7 Well preserved phases of the ancient workings: trenches.
7´ Inconspicuous areas of its continuation on the north and east.
7´´ New parts of the quarry.
9 Partly cleared ancient pillars.
9´ Completely cleared ancient pillars.
10 Debris strata graded into steps; channels, wedge sockets etc.
12 Pillars of virgin rock supporting the roof.
13-14, 20-23 Various passages.
16 Parts of the roof that have fallen.
18 New tunnel (1881) of the north passage (14).
19 Built inner walls of the north passage.

CONTENTS OF PARTS I AND II AND THEIR CORRELATION

	PART I			PART II			
	Title	Page	Pl.	Expl. of Pls.	Subject of explanation	Page	Figs.
1	*Athens and her quarries*	10	**Pl. 1**	**Expl. Pl. 1**	Topography	62	**Fig. 1-7**
2	*The Pentelicon quarry*	12	**Pl. 1**	**Expl. Pls. 2-5**	General rules of quarrying	74	
3	*The marble for the column capital*	14	**Pl. 3**				
4	*Sockets for wedges and levers*	16	**Pl. 4**				
5	*Splitting the block fi-om the parent rock*	18	**Pl. 5**				
6	*Preparation for cutting away excess marble*	20	**Pl. 6**	**Expl. Pls. 6-7**	Geological fabric and hardness of the marble	74	**Figs. 8, 9**
7	*Removal of more excess marble*	22	**Pl. 7**				
8	*Squaring of the block*	24	**Pl. 8**	**Expl. Pl. 8**	Definition of the initial shape	76	
9	*Overturning the block to work on the underside*	26	**Pl. 9**	**Expl. Pl. 9**	Turning the block over	76	
10	*Stages in the formation of the column capital*	28	**Pl. 10**	**Expl. Pl. 10**	Quarryman's and stonemason's tools	76	**Fig. 10**
11	*The assembly of the timber sledge*	30	**Pl. 11**				
12	*Hoisting the block to the quarry entrance*	32	**Pl. 12**	**Expl. Pl. 12**	The Pentelic quarries	78	**Figs. 11-25**
13	*Descent to the loading platform*	34	**Pl. 13**	**Expl. Pl. 13**	Sliding down the block	104	**Figs. 26-29**
14	*Loading the capital onto the large waggon*	36	**Pl. 14**	**Expl. Pl. 14**	Transferring the block	104	
15	*On the road to Athens*	38	**Pl. 15**	**Expl. Pl. 15**	Landscape and marble transport	104	**Figs. 3-6**
16	*On the eastern outskirts of the city*	40	**Pl. 16**	**Expl. Pl. 16**	Landscape and cityscape	105	**Figs. 3-6**
17	*Passing the south slope of the Acropolis*	42	**Pl. 17**	**Expl. Pl. 17**	Topography of the south slope	106	**Fig. 30**
18	*From the Ramp to the Propylon*	47	**Pl. 18**	**Expl. Pl. 18**	Topography of the west slope	107	
19	*At the work site to the east of the Parthenon*	50	**Pl. 19**	**Expl. Pl. 19**	*Older Parthenon - Surface plates*	107	**Figs. 31, 32**
20	*A dilemma: greater economy or greater security?*	52	**Pl. 20**	**Expl. Pl. 20**	Fissures and antisplitting reinforcements	110	**Fig. 35**
21	*The work site after the Persian attack*	54	**Pl. 21**	**Expl. Pl. 21**	Thermal fracture	111	**Fig. 34**
22	*The same site fifty years on*	56	**Pl. 22**	**Expl. Pl. 22**	Positioning and securing *acroteria*	113	**Figs. 35, 36**
23	*Time Future*	58	**Pl. 23**	**Expl. Pl. 23**	The half-finished capital (Acr. 2100)	114	**Fig. 37**
	Endnotes	60		**General Explanation of Pls. 4-7, 9, 11-14**		114	

LIST OF FIGURES

Fig. 1 The shore, Athens, Mt Pentelicon and the *lithagogia* 63
Orthographic projection. Scale of 1:5000
Printed here on a scale of 1:8000

Fig. 2 Ancient Attica and the *lithagogia* (stone transport) 64
Bimetric projection at a scale of 1:200,000/1:400,000

Fig. 3 Athens, Mt Pentelicon and the *lithagogia* (stone transport) 65
Bimetric projection at 1:50,000/1:100,000

Fig. 4 From Athens to Pentelicon a century ago 68-69
Section of sheets VI, V and XII of J. A. Kaupert's maps of Attica
(1881, scale 1:25,000)
Printed here on a scale of 1:30,000

Fig. 5 From Athens to Pentelicon, longitudinal section showing important 68-69
points of physical, historical archaeological topography
Scale 1:30,000

Fig. 6 From Athens to Pentelicon today (1992), historical map showing 68-69
features of physical, historical and archaeological topography
Scale 1:30,000

Fig. 7 Five-span marble bridge on the ancient quarry road 73
Present (1992) condition. Plan and east view (1:125)

Fig. 8 Crystalline structure (fabric) and stone-cutting 75

Fig. 9 Fabric and stone-cutting... 75

Fig. 10 The principal ancient and modern tools for quarrying................................. 77
and cutting marble (excluding those for sculpture)
Scale 1:10

Fig. 11 The *Spelia Quarry* (Λ1) and the large trench-shaped quarry Λ2 78
The situation until 1976

Fig. 12 The *Spelia Quarry* (Λ1) and the large trench-like quarry (Λ2).................... 80
Plan. Scale 1:800

Fig. 13 The relation of the shape of the quarry to the geological structure 83

Fig. 14 The *Spelia Quarry* (Λ1) and the large trench-like quarry (Λ2) 85
Scale 1:800

Fig. 15 The *Spelia Quarry* (Λ1, Λ2) and the large trench-like quarry (Λ2) 86
Cross section. Scale 1:800

Fig. 16 The *Spelia Quarry* (Λ1). Longitudinal section. Scale 1:800 87

Fig. 17 Half-worked marble objects from the *Spelia Quarry* 88

Fig. 18 Other half-worked marble objects 89

Fig. 19 Probable geological evolution of the *Spelia tes Penteles* 89-91
(*Spelia Quarry*)

Fig. 20 The quarries and *slipways*. Topographical map. Scale 1:5000 92-93

Fig. 21 The quarries and *slipways*. Longitudinal section. Scale 1:5000 92-93

Fig. 22 The quarry A 10. Scale 1:2000 94

Fig. 23,1 First phases in the development of quarry Λ1 96

Fig. 23,2 Final phases in the development of quarry Λ1... 97

Fig. 24 First and last phase in the development of quarry Λ1.................................. 97

Fig. 25 Pentelicon - Athens - Eleusis. Scale 1:4000 99

Fig. 26 The best preserved sections of the *slipway*. Scale 1:2000 102

Fig. 27 The construction of the *slipway* 103

Fig. 28 Special method of braking the sledge 103

Fig. 29 Special method of braking the sledge 103

Fig. 30 South slope of the Acropolis. The west end of the retaining wall 106
north of the Sanctuary of the Nymph. Scale 1:50

Fig. 31 Fragment of a large circular *surface plate* 109
(Acropolis Museum 3748)

Fig. 32 Reconstruction of the method of using a *surface plate* 109

Fig. 33 Anti-cracking clamps. Trimetric projection. Scale 1:20 110

Fig. 34 Thermal fractures in the steps and column drums of the Ill
Older Parthenon

Fig. 35,1 Older Parthenon, restoration of the plan. Scale 1:400 112

Fig. 35,2 Parthenon, restoration of the plan. Scale 1:400 112

Fig. 36 Sculptures on the north-east corner of the Parthenon 113
Scale 1:400

Fig. 37 The half-worked capital of the Older Parthenon. Scale 1:20...................... 115

Fig. 38 Ludwig Lange, *Quarry on Mt Pentelicon* (1836) 116

Fig. 39 Ludwig Lange, *Quarry on Mt Pentelicon* (1836) 117

Fig. 40 Paros. Section of the *Quarry of the Nymphs*. Scale 1:800 120

Fig. 41 Paros. Plan of the *Quarry of the Nymphs* Scale 1:800 121

SELECT BIBLIOGRAPHY

Abbreviations

AA. .... *Archäologischer Anzeiger*
ABSA .... *Annual of the British School at Athens*
ΑΔ .... *Ἀρχαιολογικόν Δελτίον*
AE .... *Ἀρχαιολογική Ἐφημερίς*
AJA .... *American Journal of Archaeology*
AM. .... *Mitteilungen der athenischen Abteilung des Deutschen Archäologischen Instituts*
BCH .... *Bulletin de Correspondance Hellénique*
JHS .... *Journal of Hellenic Studies*
Hesperia .... *Journal of the American School of Classical Studies at Athens*
IG .... *Inscriptions Graecae*
IstMitt .... *Istanbuler Mitteilungen*
Jdl .... *Jahrbuch des Deutschen Archäologischen Instituts*
RA .... *Revue archéologique*
ΦΕΚ .... *Φύλλον Ἐφημερίδος τῆς Κυβερνήσεως (Goverment Gazette)*

ANCIENT QUARRIES AND QUARRYING IN GENERAL

– J-P. Adam, A propos du trilithon de Baalbeck. Le transport et la mise en oeuvre des megalithes, *Syria* 54, 1977, 31-63.
– J-P. Adam, *La Construction Romaine*, 2nd ed., Paris 1989, 23-60.
– Γ. Ἀλευρᾶ-Κοκκοροῦ, Τά ἀρχαῖα λατομεῖα τῆς Νάξου, *AE* 1992, 101-127 (The Ancient Naxian Marble Quarries).
– P. Amandry, Chronique Delphique: Carrières, *BCH* 105, 1981, 714-721.
– D. Arnold, *Building in Egypt*, Oxford 1991.
– N. Asgari, Die halbfabrikate kleinasiatischer Girlandensarkophage und ihre Herkunft, *AA* 1977, 329-380.
– N. Asgari, Roman and early Byzantine Marble Quarries of Proconnesos, *Xth International Congress of Classical Archaeology*, Ankara-Izmir 1973 (Ankara 1978), 467-480.
– N. Asgari, Steinbrüche von Prokonesos, *Ist. Mitt*. 39, 1989, 48.
– A. Burford, Heavy Transport in Classical Greece, *The Economic History Review* 13, 1960, 1-18.
– A. Burford, *The Greek Temple Builders at Epidauros*, Liverpool 1969.
– Z. Cezari, The Unfinished Obelisk of Aswan: A Reappraisal of Egyptian Quarrying Methods, *AJA* 88, 1984, 245.
– K. Clinton, Inscriptions from Eleusis, *AE* 1971, 81-136.
– C. R. Cockerell et al., *Antiquities of Athens and other places in Greece, Sicily* etc., London 1830.
– J. J. Coulton, Lifting in early Greek Architecture, *JHS* 94, 1974, 1-19.
– J. J. Coulton, *Greek Architects at Work*, London 1977.
– W.B.Dinsmoor, *The Architecture of Ancient Greece*, 3rd ed., London 1950.
– E. Dolci, *Carrara, cave antiche*, Carrara 1980, Viareggio 1981.
– J. Durm, *Die Baukunst der Griechen*, 3rd ed., Leipzig 1910.
– A. Dworakowska, *Quarries in Ancient Greece*, *Bibliotheka Antiqua* 14, Wroclaw etc. 1975.
– A. Dworakowska, The Quarries in Ancient Greece, According to Ancient Scholars and Travelers, *Archeologia* 25, 1974, 1-9.
– J. Clayton Fant, *Cavum Antrum Phrygiae. The organization and Operations of the Roman Imperial Marble Quarries in Phrygia*, Oxford 1989.
– J. Clayton Fant, Ideology, gift and trade: a distribution model for the Roman imperial marbles, in *The Inscribed economy* (ed. W. V. Harris), Ann Arbor, MI 1993, 145-170.
– R. Ginouvès and R. Martin, *Dictionnaire méthodique de l'Architecture Grecque et Romaine* I, Rome 1985.
– R. Ginouvès, *Dictionnaire méthodique de l'Architecture Grecque et Romaine* II, Rome 1992.
– H. R. Goette, Die Steinbrüche von Sounion im Agrileza-Tal, *AM* 106, 1991, 201-222.
– E. Hansen, Emploi de pierres brutes dans les constructions, surtout à Delphes, in *Mélanges helléniques offerts à Georges Daux*, Paris 1974, 159-179.
– E. Hansen (G. Daux and E. Hansen), *Le Trésor de Siphnos*, *Fouilles de Delphes*, II, 4 Paris 1987, 25-48.
– Inscriptions : *IG* I^2 339-353, *IG* I^2 372, 373, *IG* I^2 24, 44, *IG* II^2 1668, 1673, *IG* II^2 3299, *IG* VII 3073, *IG* XI^2 199 B, 89, *IG* II^2 1673.
– Χ. Κανελλόπουλος, Τά λατομεῖα, *Ἀρχαιογνωσία* 5, 1987-88, 182-190, fig. 9, pl. 59, 60 (The Granite Quarries of the Iria Temple on Naxos).
– H. J. Kienast, Topographische Studien im Heraion von Samos, Steinbrüche, *AA* 1992, 206-213.
– G. Koch–H. Sichtermann, *Römische Sarkophage*, München 1982.
– W. Koenigs, Beobachtungen zur Steintechnik am Apollon-Tempel von Naxos, *AA* 1972, 280-285.
– M. Κορρές–Χ. Μπούρας, *Μελέτη Ἀποκαταστάσεως τοῦ Παρθενῶνος*, Athens 1983 (Study of the Parthenon Restoration).
– M. Korres, The Geological factor in Ancient Greek Architecture, *The Engineering Geology of Ancient Works*, *Monuments and Historical Sites* (P. G. Marinos and G. C. Koukis eds), Rotterdam 1988, 1779-1793.
– M. Κορρές, *Συμβολή στήν οἰκοδομική μελέτη ἀρχαίων κιόνων*, Athens 1991 (Construction of Columns in Antiquity).
– T. Kozelj, An Example of cutting Marble, using a Handpeack and a Chisel, *Studi Miscellanei* 26, 1985, 127-134.
– T. Kozelj, Les carrières des époques grecque, romaine et byzantine, in *Ancient Marble Quarrying and Trade* (ed. J. Clayton Fant), Oxford 1988, 3-10, pl. 1-34.
– A. Lambraki, Le cipolin de la Karystie. Contribution à l'étude des marbres de la Grèce exploités aux époques romaine et paléochrétienne, *RA* 1980, 31-62.
– M. K. Langdon, Hymettiana II: An Ancient Quarry on Mt. Hymettos, *AJA* 92, 1988, 75-83.
– H. Lattermann, *Griechishe Bauinschriften*, Strassburg 1908.
– M. W. Leak, *The Topography of Athens*, 2nd ed., London 1841, vol. 2, 47 (Ancient Quarries on Mt Hymettus).
– R. Lepsius, *Griechische Marmorstudien*, Berlin 1890.
– R. Lepsius, *Geologie von Attika*, Berlin 1893.
– Luciana and Tiziano Mannoni, *Marble*, *The History of a Culture*, New York–Oxford 1985.
– *Il Manno... ieri e oggi*, 3rd ed., Società Editrice Apuana 1978.
– R. Martin, *Manuel d'Architecture Grecque*, Paris 1965.
– W. Müller-Wiener, *Griechisches Bauwesen in der Antike*, München 1988.
– A. Ὀρλάνδος, *Τά ὑλικά καί οἱ τρόποι δομῆς τῶν ἀρχαίων Ἑλλήνων*, Athens 1959-60.
– A. K. Orlandos, *Les matériaux de construction et la technique architecturale des anciens Grecs*, Paris 1966.
– A. Ὀρλάνδος–I. Τραυλός, *Λεξικόν ἀρχαίων ἀρχιτεκτονικῶν ὅρων*, Athens 1986 (Dictionary of Ancient Architecture).
– J. Papageorgakis, Die antiken Marmorbrüche von Thessalien, *Πρακτικά τῆς Ἀκαδημίας Ἀθηνῶν*, 38, 1963, 563-572.
– J. Papageorgakis, Die antiken Brüche des karystischen Marmors, *Πρακτικά τῆς Ἀκαδημίας Ἀθηνῶν*, 39, 1964, 252-284.
– J. B. Ward Perkins, Marble in Antiquity (Collected Papers), *Archaeological Monographs of the British School at Rome*, 6, London 1992 (with a rich bibliography of marble studies).
– A. Peschlow-Bindokat, Die Steinbrüche von Milet und Herakleia am Latmos, *JdI* 96, 1981, 157-214.
– A. Peschlow-Bindokat, *Die Steinbrüche von Selinunt*, Mainz 1990.
– G. Raepsaet,Transport de tambours de colonnes, *L'Antiquité Classique* 53, 1984, 101-136A.
– A. Rehm, *Didyma* 2, Berlin 1958.
– J. Röder, Marmor Phrygium. Die antiken Marmorbrüche von Iscehisar in Westanatolien, *JdI* 86, 1971, 254-312.
– Sodini–Lambraki–Kozelj, Les Carrières de marbre d'Aliki à 1'époque paléochrétienne, *Études Thasiennes* 9, Paris 1980, 81-143.
– L. Tarr, *The History of the Carriage*, New York 1969.
– P. Tsoflias, Les Carrières antiques de marbre de 1'Eubée du sud, *Bulletin des Musées Royaux d'Art et d'Histoire* 53.2, 1982, 71-79.
– D. Vanhove et al., *Marmer in Hellas*, Brussels 1988.
– P. Varène, *Sur la taille de la pierre antique, médiévale et moderne*, 3rd ed., Université de Dijon, 1983.

– M. Waelkens, From a Phrygian Quarry, *AJA* 89, 1985, 641-653.
– M. Waelkens, P. De Paepe and L. Moens, Patterns of Extraction and Production in the White Marble Quarries of the Mediterranean: History, Present Problems and Prospects, in *Ancient Marble Quarrying and Trade* (ed. J. Clayton Fant), Oxford 1988, 81-116.
– M. Waelkens, N. Herz and L. Moens (eds), *Ancient Stones*, *Quarrying*, *Trade and Provenance*, Leuven 1992.

MT PENTELICON

– F. Aldenhoven, *Itinéraire descriptif de I'Attique et du Peloponèse*, Athens 1841, 46-47.
– A. Ἀραβαντινός et. al., *Γενική ρυθμιστική μελέτη ἀναπτύξεως Πεντέλης*, Athens 1975 (Pendeli Development Plan).
– H.-G. Bankel (ed.), *Haller von Hallerstein in Griechenland*, Berlin 1986, 108-109.
– A. N. Βερναρδάκης, *Περί τοῦ ἐν Ἑλλάδι ἐμπορίου*, Athens 1885, 61-62 (On the Trade in Greece).
– A. Γαλανόπουλος, Ἐξορυκτικές δραστηριότητες στην Ἀττική, κατάλογος ἐκθέσεως *Ἀττικό Τοπίο καί Περιβάλλον*, Ministry of Culture, 1989, 284-287 (Modern Quarrying in Attica).
– K. M. Γιαννουλίδου, Ἱστορικά σπήλαια τῆς ἀρχαιότητος, *Πλάτων* 1970, 195 (Historical Caves).
– R. Carpenter, The Unfinished Colossus on Mount Pendeli, *AJA* 72, 1968, 279-280.
– R. Chandler, *Travels in Greece*, Oxford 1776, 170; 1825, vol. 2, 210.
– E. Curtius–J. A. Kaupert, *Karten von Attika*, Berlin 1881-1900, pls. 4, 5, 12.
– E. Dodwell, *A classical and topographical Tour through Greece during the Years 1801, 1805 and 1806*, Vol. I, London 1819, 499.
– Evlia Çelebi, The itinerary, Attica: K. Μπίρης (ed.), *Τα Ἀττικά τοῦ Ἐβλιᾶ Τσελεμπῆ*, Athens 1959, 59. N. Χειλαδάκης (ed.), *Ταξίδι στήν Ἑλλάδα*, Athens 1991, 189-190.
– *Ὁ Ἑλληνικός Ταχυδρόμος* Α΄, 1836, 149 (ἀρ. 31, 5 Σεπτ.) Στατιστική. Λατομεῖα τῆς Ἀττικῆς, Τρόπος καθ' ὅν οἱ ἀρχαῖοι ἐλατομοῦσαν· σύγκρισις αὐτοῦ καθ' ὅν λατομεῖται σήμερον ὁ πεντελικός λίθος πρός οἰκοδομήν τῶν Β. Ἀνακτόρων (Ancient and modern quarrying in Attica).
– Π. Ζορίδης, Ἡ Σπηλιά τῶν Νυμφῶν τῆς Πεντέλης, *AE* 1977, Χρονικόν, 4-11 (The Cave of the Nymphs on Mt. Pentelicon).
– William Gell, *The Itinerary of Greece*, *containing one hundred routes in Attica*, *Beoetia*, *Phocis*, *Locris and Thessaly*, London 1819, 63-64.
– B. Καλλιπολίτης, *ΑΔ* 19, 1964, B΄ 72.
– M. Korres, The Geological factor in Ancient Greek Architecture, *The Engineering Geology of Ancient Works*, *Monuments and Historical Sites* (P. G. Marinos and G. C. Koukis eds), Rotterdam 1988, 1786.
– M. Korres, *Vom Penteli zum Parthenon*, Glyptothek München 1992.
– Π. Λαζαρίδης, Μεσαιωνικά Ἀθηνών-Ἀττικής, *ΑΔ*, *Χρονικά*, 1963 (1965), 54-55 (On the Byzantine Churches in the Ancient Quarry).
– Ludwig Lange, Two water colours : *Steinbruch zu Penteli*, June 1836 (Graphische Sammlung, München Inv. Nr. 35763 & 35764).
– Γ. Λαδᾶς, Ἡ Σπηλιά τῆς Πεντέλης, *Συλλέκτης* 1, 1947-1951 (Athens 1952), 137-168; *Συλλέκτης* 2, 1952-1958, 1-19 (The Cave and the Byzantine Churches in the Ancient Quarry).
– R. Lepsius, *Griechische Marmorstudien*, Berlin 1890, 11-23, *Geologie von Attika*, Berlin 1893, 55-60, 151-153.
– M. Μαγνήσαλη and Θ. Μπιλής, *Μελέτη ἀποκαταστάσεως τῶν ἀρχαίων λατομείων...*, National Technical University of Athens, 1991 (A Proposal for the Restoration of the Ancient Quarries).
– A. Milchhöfer, *Erläutender Text zu den Karten von Attika*, Heft III-VI (Berlin 1889), 32-35.
– K. Μπίρης, *Γιά τή σύγχρονη Ἀθήνα*, I, 1956, 39-41 (The Quarries and the hills of Athens).
– K. Μπίρης, *Αἱ Ἀθῆναι*, Athens 1966, 70-72, 394-397, 379-382.
– K. Μπίρης, *Αἱ τοπωνυμίαι τῆς πόλεως καί τῶν περιχώρων τῶν Ἀθηνῶν*, Athens 1971 (The Toponyms of Athens).
– Γ. Μπρόφας, Ἔρευνα γιά τήν ἀποκατάσταση τοῦ τοπίου στό λατομικό χῶρο Πεντέλης, *Δασική Ἔρευνα* 1987, 149-186 (Study for the restoration of the pentelic landscape).
– Ντ. Μουρίκη, *Δελτίον τῆς Χριστιανικῆς Ἀρχαιολογικῆς Ἑταιρείας* 7, 1974, 79-119.
– N. Μουτσόπουλος, Τό Ἀσκηταριό τῆς Σπηλιᾶς τοῦ Νταβέλη, *Ζυγός* 50 (1960), 34-36 (On the Byzantine Churches at the Ancient Quarry).
– A. Ὀρλάνδος, Μεσαιωνικά Μνημεῖα Πεδιάδος Ἀθηνῶν καί κλιτύων Ὑμηττοῦ, Πεντέλης, Πάρνηθος, Αἰγάλεω. Nr. 7, Ἀσκητήριον τῆς Σπηλιᾶς, *Εὐρετήριον τῶν Μεσαιωνικῶν Μνημείων τῆς Ἑλλάδος* Γ΄,1933, 196 (On the Byzantine Churches at the Ancient Quarry).
– A. Ὀρλάνδος, *Ὑλικά καί τρόποι δομῆς τῶν ἀρχαίων Ἑλλήνων*, vol. 2, Athens 1959-60, 80-81, 90-91, figs. 31-33.
– M. Πετροπουλάκου and E. Πεντάζος, *Ἀττική*, in the series *Ἀρχαῖες Ἑλληνικές Πόλεις*, Athens 1973, 190.
– Γ. Πετρόχειλος, Σπήλαια στό Πεντελικόν, *Δελτίον Ἑλληνικῆς Σπηλαιολογικῆς Ἑταιρείας* 1, 1951, 154-178.
– I. Παπαδημητρίου, Οἱ Νύμφες τῆς Πεντέλης, *Ἐκλογή* 9, 24 Aug. 1953, 17-22.
– I. Παπαδημητρίου, *BCH* 77, 1953, 202 (The Cave of the Nymphs).
– F. C. Penrose, *The Principles of the Athenian Architecture*, London 1851, 16.
– A. Philippson, *Die griechischen Landschaften*, Band I, Teil III, Frankfurt 1952, 792-802, particularly 797.
– S. Pomardi, *Viaggio nella Grecia* II, Roma 1819, 66-67.
– Prokesch von Osten, *Denkwürdigkeiten und Erinnerungen an den Orient*, vol. 2, Stuttgart 1836, 424-429.
– L. Ross, Das Pentelikon bei Athen und seine Marmorbrüche, L. Schorn's *Kunstblatt* 18, Tübingen 1837, 5-6, 10-11, 16.
– J. Spon, *Voyage d'Italie, de Dalmatie, de Grèce et du Levant*, II, Lyon 1678, 124.
– O. M. v. Stackelberg, *Vues pittoresques et topographiques de la Grèce*, Paris 1829-1838.
– Γ. A. Σωτηρίου, Ἡ Σπηλιά τῆς Πεντέλης, *Ἡμερολόγιον τῆς Μεγάλης Ἑλλάδος*, 1927, 45-59.
– Τεχνικόν Ἐπιμελητήριον τῆς Ἑλλάδος, *Ἐνημερωτικόν Δελτίον* 795 (29 June 1974), 6/ 832 (15 March 1975) 12-16/ 866 (8 Nov. 1975) 7-15 (Environmental aspects of the exploitation of Pentelicon).
– J. S. Traill, *Hesperia*, Suppl. 14, 1975, 92.
– J. J. Travlos, *Bildlexikon zur Topographie des antiken Attika*, Tübingen 1988, 329-334.
– D. Vanhove et. al., *Marmer in Hellas*, Brussels 1988, figs. 8, 10-11.
– George Wheler, *Journey into Greece*, London 1682, 450.
– J. M. Wickens, *The Archaeology and History of Cave Use in Attika*, Indiana Univ. Microfilms, Ann Arbor, MI 1986, 194-202.
– R. E. Wycherley, Pentelethen, *ABSA* 68, 1973, 349-353.
– J. Wiseman, An Unfinished Colossus on Mt. Penteli, *AJA* 72, 1968, 75-76.
– W. Wrede, Pentelikon, *Paulys Realencyclopädie der Altertumswissenschaft* XIX, 1 (1937) 535.
– *ΦΕΚ* 265, 1 Oct. 1957 (Declaration of an area, extending from the Spelia Quarry to the Cave of the Nymphs, as Historical Monument).
– *ΦΕΚ* 669, 30 Nov. 1968 (YA 22 323/ 23 Nov. 1968, Aesthetical Regulations for the pentelic landscape).
– *ΦΕΚ* 3432, 13 Nov. 1974 (Π.Δ. Nr. 758/ 8 Nov. 1974, Prohibition of quarrying in the area of the Spelia Quarry).
– *ΦΕΚ* 673/ B΄, 23 Oct. 1990.
– *ΦΕΚ* 810/ B΄, 28 Dec. 1990.
– *ΦΕΚ* 78/ B΄, 21 Febr. 1991.
– Ministry of Culture/ APX/ A1/Φ02/11 669/ 626 (Extension of the limits of the area under protection).
– Ministry of Culture, Central Archaeological Council, Session of 21 Febr. 1983.

PAROS

– X. Ἀγριαντώνη, *Οἱ ἀπαρχές τῆς ἐκβιομηχάνισης στήν Ἑλλάδα τόν 19ο αἰ.*, Athens 1986, 261 (The Beginning of Industrialization in Greece).
– A. N. Βερναρδάκης, *Περί τοῦ ἐν Ἑλλάδι ἐμπορίου*, Athens 1885, 59-61 (On the Trade in Greece).
– *Ἑταιρεία τῶν Παρίων Μαρμάρων*, *ἐν Ἀθήναις 1857* (ἐκ τοῦ Βασ. Τυπογραφείου), Ἔκθεσις τοῦ Σ. Κλεάνθους περί τῶν μαρμάρων τῆς Πάρου (S. Kleanthes and the Greek Marble Company of Paros).
– L. Ross, Archäologisches von den griechischen Inseln, L. Schorn's *Kunstblatt* 16, Tübingen 1836, 50-51.
– L. Ross, *Inselreisen* I, Stuttgart-Tübingen 1840, 49-50.
– *IG* XII 5, 245.
– N. Ἀλιπράντης, Ὁ Σταμάτης Κλεάνθης καί ἡ Πάρος, *Παριανά* 19, 1985, 116-122 (S. Kleanthes in Paros).

PARTHENON

– G. Beckel, Akropolisfragen, *Χαριστήριον εἰς Α.Κ. Ὀρλάνδον*, vol. 3, Athens 1967-68, 329-362.
– J. A. Bundgaard, *The Excavation of the Athenian Acropolis*, Copenhagen 1974.
– J. A. Bundgaard, *The Parthenon and the Mycenean city on the Heights*, Copenhagen 1976.
– A. Burford, The Builders of the Parthenon, *Greece and Rome*, Supplement 1963, 23-35.
– W. B. Dinsmoor, Attic Building Accounts, *AJA* 17, 1913, 53-80 and 25, 1923, 233-245.
– W. B. Dinsmoor, How the Parthenon was planned, *Architecture* 47, 1923, 177-180, 241-244.
– W. Doerpfeld, Die Zeit des Älteren Parthenon, *AM* 27, 1902, 379-416.
– W. Doerpfeld, Parthenon I, II, III, *AJA* 39, 1935, 497-507.
– B. H. Hill, The Older Parthenon, *AJA* 16, 1912, 556.
– P. Cavvadias, G. Kawerau, *Die Ausgrabung der Akropolis*, Athens 1907.
– M. Κορρές and Χ. Μπούρας, *Μελέτη Ἀποκαταστάσεως τοῦ Παρθενῶνος*, Athens 1983 (Study of the Parthenon Restoration).
– F. C. Penrose, *An Investigation of the Principles of the Athenian Architecture*, London 1851.
– Plutarch, *Pericles*.
– R. H. Randall Jr., The Erechtheum Workmen, *AJA* 57, 1953, 199-209.
– J. Travlos, *Bildlexikon zur Topographie der Stadt Athen*, Tübingen 1971.
– A. Tschira, Die unfertigen Säulentrommeln auf der Akropolis von Athen, *JdI* 55, 1940, 242-261.
– B. Wesenberg, Kunst und Lohn am Erechtheion, *AA* 1985, 55-65.

INDEX

abacus-abaci, 114
acroterion-acroteria, 113
actites, 63
Aegina,10, 105
Agora, 50
Aigaleo, 48
Akte of Piraeus, 62, 64
Andersen, H. C., 118
angles, *squares*, 28
aqueduct of Hadrian, 65, 70
aqueduct of Peisistratos, 71, 105
Arakli, 67
archaeological excavations, 58
architects, 7, 48, 52, 56
Ardettos, 62, 65
Areopagus, 62, 65
Aspra Marmara, 69, 71
Athena Polias, 65
balanced waggons, 47, 48
Barathron, 10, 62
Bareia, 18, 77
Bathyrema, 71
Biris, K., 119
Boulismene (*Thalassi*), 62
Braunonion, 106
bridge, 70, 72
building programs, 10, 43, 56,
Callimachus or Callimachos, 50
capitals, 28, 50, 56, 107
carving markers, 26
Cave of the Nymphs, 92, 95, 98
chiyselephantine, 60,113
colossus of Mt. Pentelicon, 66, 89
column drums, 50, 88
compasses, 28
crane, 7, 113, 120
crepidoma, *crepis*, 60, 107, 111
crystalline texture, 74, 75
Cyclades, 10, 24
Cyclopean walls, 43, 44
daktyloi, 110
Darius, 50, 52
Daveles, 71
descent from the quarry, 34
Dipylon, 62
drafted margins, 28, 52
Ducess of Plaisance, 70, 72,
echinus, 50
Eleusis, 98,104
engineers, 32
entasis, 107
euthynteria, 60
Evlia, 116
exploitation of Pentelicon, 8, 70, 82, 94, 118, 119
Fauvel, 79, 81, 83
Georgandas, A., 72
Gladstone, 119
Glyptothek Munich, 8
Gruben, G., 119
guidelines (channels as), 24
Halandri, 36, 70
half-worked sculptures, 88-89
Hallerstein, H., von 81, 94, 100, 102
Hekatompedon, 10, 46
Herodeion (Odeum of Herodes Atticus), 67, 98, 106
hexastyle, 113
Hill of the Mouses, 104
horos, *horoi*, 105
Hymettian marble, 10
hypotrachelion, 52
Ilissia, 72
Ilissos, 64, 65, 105
imantes (*annuli*), 52
kalos (thick rope), 48
kalostrophoi (rope makers), 32
Kambouroglou, D., 72
Kastella, 62
Kastro tes Athenas, 71
Kaupert, J. A., 69, 92, 94
Kephisias Ave., 67
Kephissos, 64
Koile, 62
kopeus (point), 28, 77
Koukouvaounes, 67
"Koupho Vouno", 62
Krene, 106
Krumbacker, K., 119
Kyklovoros, 64
Lefkes, 120
levers (crow bars), 16, 18, 30, 34
Limne, 62
lithagogia, 38, 62, 65, 67, 104
Lykabettos, 38, 62, 104
Lüth, Ch., 118
Marpissa, 120
Mentele, 71
Mesogeia, 64
Mesogeitike Porta, 71
metallurgy, 7
metopes, 113
Mona Lisa, 58
Mone Penteles, 70, 71, 92
Munichia, 62
Museum of Cycladic Art, 8
natural fissures, 22, 30, 52, 74
octastyle, 113
Old Temple, 43, 46, 50, 114, 120
Olympieion, 10, 40, 65, 71, 98, 100, 105, 106
Oros ton Ammon, 71
Pandion, 106
Parnes, 48
Paroikia, 120
Paros, 47,120
Parthenon, 50, 56, 82, 100, 104, 112-114
Parthenos, 60
Pausanias, 66, 94
Piraic coast, 10, 40, see Akte...
Piraic stones, 46, 47
Piraeus, 54, 104, 105
Peisistratos or Peisistratus, 10
Pentele, 64, 71
pentelethen lithagogia, 38, 67
Pentelicon, 63-66, 71
peripteral, 113
phalanges (rollers), 32, 50
Phaleron, 64, 11
Philopappos, 62, 104, 105
Phlya, 36
plane of reference, 76
Plataea, 56
Pnyx, 62
Polis (=Acropolis), 65
Preparthenon or Older Parthenon or first Marble Parthenon, 10, 98, 104, 107, 109, 112, 114
Proconnesos, 60
Prokesch, von Osten, 81, 116
Propylaia or Propylaea, 7, 67, 107, 110
Propylon, 43, 47
pulleys, 47
Quarry at Dionysos, 89
Quarry **A2**, 96
Quarry **A7**, 97, 98
Quarry **A10**, 94, 97, 98
Quarry *of the Nymphs* on Paros, 120
quarrying, 12,18, 74
quarrying channels, 20, 74
Ramp, 46, 47
reference surface, 28
road builders, 40
rollers, 26, 30, 77
ropes, 32
Ross, L., 60, 107, 101, 118
Sanctuary of Dionysos Eleuthereus, 42, 62, 71, 106, 114
Sanctuary of Nymphe, 42, 62, 67
Sanctuary of Pan, 64, 94, see *Cave of the Nymphs*
Santarosa, S., 118
Sarcophagus, 88
scaffolds, 10, 50, 108
"Schiste Petra", 62
Sepolia, 66
Hill of *Sikelia*, 62, 65, 105
sledge, 30, 32, 34, 36, 50
slipways, 92, 99-100, 102
Soulenari, 71
Spelaion ton Amomon, 71
Spelia, 89-91
Spelia Quarry, 66, 78-87, 98, 101, 116-118
Sphacteria, 118
squaring 24
Stackelberg, O. M., 81, 83
stades, 36
Stadium, 62, 98
Stoa of Attalus, 98
stone cutting, 74, 75
stone cutting tools, 76-77
Strephi, 62
surface plates, 108, 109
talants, 24, 28
Telesterion of Eleusis, 98, 100
tetrakykle, 36, 104
Themistocles, 54, 65, 105
thermal fracture, 107, 111
tiles, 88, 100
toichobate, 107
tykos, 76, 77
tumulus, 70
turning a stone over, 26, 76
waggon, 36, 67
waggon builders, 36, 40
wedges, 16, 18, 74
Winches, 26, 32
wooden posts, 34, 102, 103, 104
Xerxes, 52
zeugetrophoi, 60
Ziller, E., 105

NOTE on the size of the original drawings: The original drawings in Part I (Pls. 1-22) are 20 to 30 % larger than those printed, with the sole exception of Plate 17 which is 10% smaller than that printed. The original drawings of Part II are for the most part double the size of those printed. Figs. 5 & 6 are three times larger than the printed versions. Figs. 38 & 39 (watercolours by L. Lange) measure 54 x 70 cm. and 58.5 x 91.2 cm. respectively.

GLOSSARY

abacus (pl.: abaci) = the uppermost part of a capital.
acroterion (pl.: acroteria) = figures or ornaments standing on the extremities of a roof.
actites = hard limestone from the Akte of Piraeus.
agora = market place, political center.
anta(*e*) = pilaster-like projection of a wall.
apergon = preliminary surface (i.e. thickness in excess) protecting architectural elements before and during positioning and to ensure the perfect final fashioning of columns and walls, which is possible only after all components have been assembled.
chryselephantine = a statue in which a wooden core is overlaid with gold (for the drapery) and ivory (for the naked parts of the body).
crepidoma or crepis = stepped platform of a Greek building, particularly of a temple.
Cyclopean (-masonry, -wall, -building etc.) = built with large unhewn or partly hewn hard stones. The building system of Mycenaean fortifications in particular.
daktyloi = subdivisions of foot (1 dactylos = 1/16 foot).
entasis = slight convex curve given to the vertical lines of a column.
euthynteria = top course of a foundation defining exactly the contour and the levelling (eventually including the curvature) of a building.
hexastyle = a building with six columns at the front(s).
hypotrachelium = the neck of a capital.
imantes (*or annuli*) = projecting rings at the bottom of the echinus of a doric capital.
kalos = thick rope.
kalostrophoi = rope-makers.
kopeus = the modern point, one-pointed implement for the rough dressing of hard stones.
lithagogia = heavy transport of stone.
metopes = plain or decorated square panels above the architrave.
naiskos = small temple.
nymphaion = an architecturally arranged and decorated combination of fountain and plants.
oikos = small temple without columns.
orthostates (or *dado*) = course of large, upright stones forming the lower part of a wall.
peripteral = temple with colonnade on all sides.
poros = yellowish limestone, often with fossil shell inclusions; the commonest building material in ancient Greece.
pronaos = porch in front of the cella of a temple.
propylon = entrance, building.
pteron = exterior colonnade of a temple and the space behind it.
spelia or *spelaion* = cave.
stade (*stadium*) = ancient measure for long distances (1 s.= ca. 190 m).
stoa = long building with colonnaded front(s).
talant (*s*) = weight unit (= ca. 24 kg).
telesterion = hall for ceremonies.
tetrakykle = four-wheeled waggon.
toichobate = base of a wall.
tumulus = mound of earth on top of a grave or funeral chamber.
tykos = heavy implement for stonecutting; pick.
zeugetrophoi = owners of teams of traction animals.

SELECT GAZETEER

Akte = the west coast of the Piraeus peninsula.
Ardettos = the hill on the south side of the Stadium.
Areopagus = rock some 200 paces to the west of the Acropolis.
Asty = the city outside the Acropolis.
Brauronion = sanctuary of Artemis of Brauron on the Acropolis, to the SE of the Propylaea.
Cyclades = the central cluster of islands in the Aegean Sea.
Dipylon (two gates) = the main entrance on the NW of Athens and its vicinity.
Hekatompedon = building (a temple in particular) 100 feet long. The Archaic predecessor of the Parthenon.
Herodeion = the Odeion (Odeon) of Herodes Atticus at Athens.
Ilissia = (1) name of the Ilissos river area to the east of Athens. (2) The mansion of Sophie de Marbois.
Kastella = the tallest hill of Piraeus.
Kastro tes Athenas = the Acropolis as a medieval citadel.
Kifisia = suburb, formerly a village, 14 km to the north of Athens.
Kephissos = the main river of the Athenian basin.
Kerameikos = the northwestern part of ancient Athens.
Koile = district of ancient Athens on and between the hills some 800m to the west of the Acropolis.
Krene = fountain; the venerable fountain at the south foot of the Acropolis rock.
Kyklovoros = one of the seasonal tributaries of the Kephissos river.
Marousi = suburb, the ancient Athmonon, 11 km to the north of Athens.
Mesogeia = the plains to the south of Mt Hymettus.
Mesogeitike Porta = gate of medieval Athens on the road to Mesogeia.
Mouseion = the formal name of the so-called Philopappos hill to the SW of the Acropolis.
Munichia = the south harbour of Piraeus.
Old Temple = the temple of Athena whose *foundations* are visible close to the south of the Erechtheum.
Olympieion = the large sanctuary of Zeus at the east end of Athens.
Parnes = the high range (1413m) 20 km to the north of Athens.
Phaleron = shore and harbour SW of Athens.
Phlya = the modern Halandri, 8 km to the NE of Athens.
Plataea = ancient city 50 km to the NW of Athens. The battle of Plataea took place in 479 BC.
Pnyx = the large assembly place on the hill to the west of the Acropolis, where the citizens of Athens convened.
Podoniftis (modern name) = the main eastern tributary of Kephissos.
Polis (city) = originally the name of Acropolis.
Preparthenon = the Older Parthenon.

IMPORTANT NAMES

Athena Polias = one of the different attributes of the goddess: the protector of Athens.
Callimachus = famous leader of the Athenian army in the battle of Marathon (490 BC).
Nike = the goddess Victory.
Nymphs = female deities of the forests, the fountains etc.
Pandion = mythical King and hero worshipped on the Acropolis.
Philopappos = benefactor of the 2nd c. AD whose monument still stands on the Mouseion Hill.
Themistocles = Athenian statesman (ca. 524-459 BC). The father of the victory over the Persians.
Thucydides = the great historian (2nd half of the 5th c. BC).
Xerxes = King of Persia (ca. 520-465 BC).

MODERN GREEK PRONUNCIATION OF SOME NAMES
This guide is given to assist the visitor

e	pronounced as in	red	s	pronounced as in	sister
h	-»-	hill	**th**	-»-	they
i	-»-	machine	th	-»-	thin
o	-»-	corporal	y	-»-	yes

Aigaleos = e-yá-le-o	Herodeion = i-ró-**th**i-on
Akte = a-ktí	Hymettus = i-mi-tós
archaios = ar-hé-os	Ilissos = i-li-sós
Ardettos = ar-**th**i-tós	Ilissia = i-lí-si-a
Areopagus = á-ri-os pá-yos	Kephisia = ki-fi-siá
Asty = á-sti	Kephissos = ki-fi-sós
Athena Polias = a-thi-ná po-li-ás	Kerameikos = ke-ra-mi-kós
Barathron = vá-ra-thron	Koile = kí-li
Bathyrema = va-thí-re-ma	kopeus = ko-péfs
Boulismene = vu-lis-mé-ni	Koupho vouno = ku-fó vu-nó
Brauronion = vra-vró-ni-on	Krene = krí-ni
Callimachus = ka-lí-ma-hos	Lykabettus = li-ka-vi-tós
chryselephantine = hri-se-le-fán-ti-ni	Marousi = ma-rú-si
crepidoma = kri-pí-**th**o-ma	Mone Penteles = mo-ní pen-dé-lis
Cyclades = ki-klá-**th**es	Nike = ní-ki
cyclopean = ki-kló-pi-on	Olympieion = o-lim-bi-í-on
Daveles = da-vé-lis	Palaion Herakleion = pal-e-ó(n) i-rák-li-o(n)
Delos = **th**í-los	Parnes/Parnitha = pár-ni-tha
Delphi = **th**el-fí	Paroikia = par-i-kiá
Dipylon = **th**í-pi-lon	= pi-re-éfs
Eleusis = e-lef-sís	Pentele = pen-dé-li
Erechtheion = e-réh-thi-on	Pnyx = (pní-ka)
Hadrian = a-**th**ri-a-nós	Soulenari = su-li-ná-ri
Halandri = ha-lán-**th**ri	spelia = spi-liá
Hekatompedon = e-ka-tóm-pe-**th**on	

EPILOGUE

Acquaintance with the present state of the Pentele quarries' environment with its labyrinthine road network can only lead to speculation and painful conclusions: quarrying activities at Pentele in modern Greek times constitute in their entirety one of the finest examples of how such important sites can be ruined by the absence of proper planning and sheer profit-making greed. This shameful situation goes hand in hand with self-destructing urban development, in particular in the form of the bulky buildings gradually encroaching on much tried Mt. Pentelicon.

The extent of this sad phenomenon is accentuated when one, unavoidably, compares the ancient with the modern quarries and roads. The earlier period was characterised by perfect planning, sobriety, and the maximum quantitative and qualitative use of the noble stone. Human intervention on the site was governed by a fine sense of the aesthetic.

Today we are faced with the worst possible planning and robbing and waste of this irreplaceable stone; in short, an act of sacrilege that has totally destroyed the site's natural and aesthetic qualities.