

MORTIMER WHEELER ARCHAEOLOGICAL LECTURE

QUARRYING IN ANTIQUITY  
TECHNOLOGY, TRADITION AND  
SOCIAL CHANGE

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*Apart from the minor changes needed for adapting the spoken word to print, I have left the text of this lecture substantially as it was delivered. As I remarked on that occasion, the debt which archaeology owes to Sir Mortimer Wheeler is not one that can be easily measured in words: si monumentum requiris, circumspice. I will only add that the text which follows is a small token also of deep personal gratitude to Sir Mortimer for forty years of friendship, guidance and generous support—another debt for which words are sadly inadequate.*

QUARRYING in antiquity. The subject at any rate has a sweep appropriate to the occasion, embracing as it does a large part of the inhabited world and over four millennia of human history. Within this broad perspective my object is to survey the methods of production and supply of what is, in many parts of the world, one of the basic materials of civilized life, and in particular it is to see whether one can draw any useful general conclusions about the relative roles of technological practice and of political and economic organization in that production. For a subject of such potential importance for archaeologist, art-historian, and historian alike it is one which until recently has received surprisingly little systematic attention. A great deal of the work to which I shall be referring is work still in progress; and though this is neither the time nor the place for lengthy acknowledgements, I should make it clear that I am indebted to a number of colleagues for the use of material which is as yet still partly or wholly unpublished.<sup>1</sup>

It only remains, by way of introduction, to say that I shall be talking principally, but by no means exclusively, about the classical period and that, like the classical authors and inscriptions, I shall be using the word 'marble' in a very loose sense, to cover a whole range of geologically different stones: marbles, porphyries, granites, basalts, breccias, and even on occasion certain fine limestones and travertines. Each of these stones has its own particular characteristics. The fact which they have in common is that they were all in varying degrees the stones in widespread commercial use for the finest monumental building and sculpture.

Let us begin, then, with the methods of production. Here we are greatly helped by the extraordinary conservatism of quarrying practice throughout antiquity and down to quite recent times. For all the magnitude of some of its undertakings, this was essentially a craft industry, dependent more on the inherited skills of its workmen than on the elaboration of its tools and equipment. These by any modern standards were in fact remarkably simple. In Pharaonic Egypt, for example, a great deal of the work of freeing a block of granite from the parent rock was done by the fantastically laborious method of pounding the surfaces or the joints with balls of an even harder stone, usually dolerite.<sup>2</sup> With somewhat softer stones, such as quartzites or hard limestones it was possible to use a heavy quarryman's pick. This too was a crushing rather than a cutting implement, the characteristic traces of which are either a series of oblique pick-marks on the vertical faces (Plate VII*b*) or else, where the stone is really compact, a series of shallow horizontal ledges or grooves down the quarry face, each groove marking the extent of a single deepening operation within the quarry trench (Plate I).<sup>3</sup>

For softer stones again, such as the tufas of central Italy, there was a whole range of quarryman's axes and adzes.<sup>4</sup> In this case one really could cut the stone, and very much the same tools might be used to dress it after quarrying. In Malta within my own memory the implements for dressing a moulded block were a set-square, a template, and a broad-bladed axe. Our concern, however, is mainly with the harder stones, and here the subsequent dressing of the surfaces was regularly done with a coarse metal point similar to that used by the contemporary mason or sculptor. The little votive relief illustrated in Plate II*a* was in fact probably dedicated by a Greek sculptor, but it might almost equally well have been a quarryman or a stonemason.<sup>5</sup> It shows what have always been the basic tools of the marble worker's craft: a wooden mallet and an iron or bronze point, or punch. Even today a mason or a sculptor would use something very like this to rough out the first stage of his work, and the remarkable thing is how much of the finest Greek classical sculpture was in fact not only roughed out but actually carved almost to its finished form with these very simple tools.<sup>6</sup> A piece such as the head illustrated in Plate II*b*, from the Temple of Asklepios on Paros (*c.* 480 B.C.), had been brought to this stage with nothing more elaborate than a fine point, and all that it needed for completion was the

smoothing of the flesh surfaces and their polishing with pumice or abrasive sand. The same is true of architecture. Plate III*b* illustrates a limestone terrace wall at Delphi, most of the blocks of which have been first dressed roughly to shape with a coarse point and then drafted round the edges with a finer point at the moment of actual use. In a few cases the preliminary dressing has been omitted and the blocks used just as received from the quarry; on others the handling bosses again represent the quarry state. Plate III*a*, which illustrates an unfinished marble capital at Lepcis Magna, shows the same two stages; on the upper surfaces of the four corners the preliminary dressing with a coarse point, and on the central disc (the bearing surface for the architrave) finer dressing with a claw chisel.

Certain hard stones, such as the granites of Egypt, could also be split along a prepared line by means of metal or wooden wedges. Plate IV*a* illustrates the marks of such splitting in the quarries of Mons Claudianus, the quarries which produced the magnificent grey Egyptian granite (*granito del foro*) of the columns of Trajan's Basilica Ulpia and of Hadrian's Pantheon.<sup>7</sup> The same technique is still in use today in the red granite quarries of Sardegna (Plate IV*b*).

Finally one must mention the abrasive sand which played so large a part in the sculptor's work but which also had (and still has today) a considerable role in the processes of quarrying. Without it, it is very hard to believe that the tools could ever have stood up to the very heavy work which they were called on to perform.

The methods of extraction were as simple as the tools. Except in the final stage, when with some rocks it was possible to use wedges, the only way to obtain a block was to isolate it laboriously from the parent rock by cutting narrow trenches all round it. Plate V*a* illustrates one of the most celebrated examples, the great unfinished obelisk in the quarries at Aswan,<sup>8</sup> but one could document the same process quite literally from China to Peru. Plate V*b* shows an example of such quarrying on the fore-shore of the island of Tonga.<sup>9</sup>

The method was basically the same whatever the size of the block. The principal difference was that a really large object like a column, or like the obelisk at Aswan, could only be taken from a piece of rock that had been very carefully selected so as to avoid cracks or flaws. The Roman Mons Claudianus quarries employed an architect specifically for this purpose.<sup>10</sup> Such large stretches of unflawed rock are few and far between, and as a

result the cavities left by the extraction of such outsize pieces tend to be scattered all over the quarry area. In the green marble quarries of Thessaly, for example, one can still see the trenches left by the quarrying of some of the big late antique sarcophagi, and the scars left by the extraction of columns are quite a common feature. Abandoned columns and others not yet detached from the parent rock can still be seen in several of the ancient quarries—at Karystos in Euboea, for example (Plate VI), at Mons Claudianus, and in the great Phrygian quarries of Dokimeion.<sup>11</sup>

For smaller pieces, where any loss through cracks and flaws could be offset by the resulting saving of time and labour, the processes could be simplified by establishing a systematic quarry face, with a horizontal working floor. Plate VII*a* illustrates a typical example of such a face in the quarries at Aphrodisias in Caria, Plate VII*b* another in the great limestone quarries of El Medol which supplied Roman and medieval Tarragona.<sup>12</sup> One achieved this result by working downwards and outwards against a sloping hillside as systematically as the flaws in the stone permitted (Fig. 1). Substantially one reduced thereby

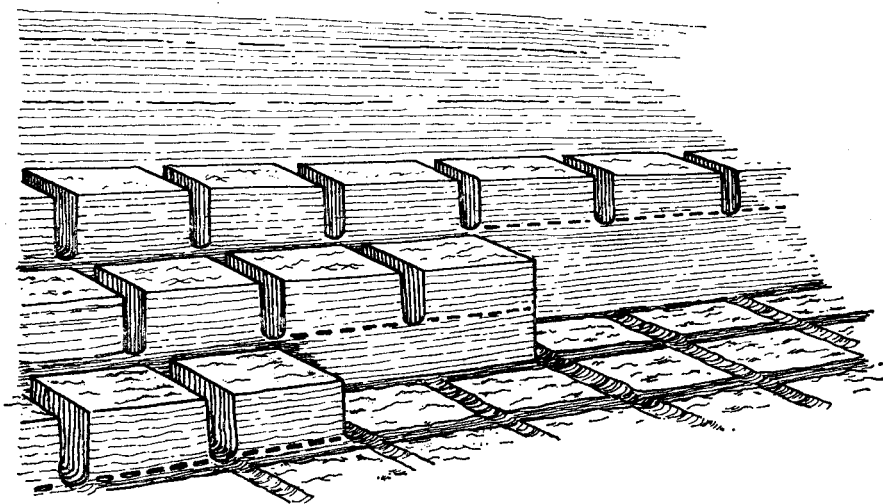


FIG. 1. Schematic diagram of quarrying by means of separation trenches and wedges. the number of separating trenches for each block from four to three, and at the same time one established a convenient working and loading platform. For precisely the same reasons it is still the preferred pattern today for those stones which, like the tufas of Latium and Campania or the soft limestones of Apulia, are uniform for large stretches and can be cut directly from the parent rock in substantially their finished form.<sup>13</sup>

Working in this way to a steadily rising quarry face was a simple, functional answer to a practical problem, and it is small wonder that quarries of this sort, of all sizes and dates, are to be found all over the Mediterranean, wherever there is suitable stone. The detail varies inevitably with the particular geological and topographical circumstances, but the broad pattern is clear and consistent, stamped with the conservatism of generation after generation of patient, practical craftsmanship.

Such in essence were the tools and methods of quarrying throughout antiquity; and such they remained until barely a century ago. It was not until 1854 that a Belgian engineer named Eugène Chevalier invented an ingenious device for cutting marble directly from the parent rock by means of a moving wire of twisted metal, fed liberally with abrasive sand and water and drawn through the stone like the blade of a saw; and it was only in 1895 that the new method began to be introduced in the great quarries of Carrara (Plate VIII).<sup>14</sup> Chevalier's system still called for the initial excavation of narrow trenches at right-angles to the working face in order to accommodate the two ends of the wire saw (this is nowadays done with explosive, preferably following a natural line of fracture); but within the limits imposed by a material that calls for an intimate knowledge of the rock in order to secure the best results, it represents a mechanization of the methods of quarrying, with all the advantages and disadvantages that such mechanization entails. Among the disadvantages it is interesting to remark that with these methods it is today no longer profitable to work the narrow veins of top-quality marble from which, traditionally, Michelangelo drew his material. The reasons for this are instructive. For one thing, the new methods cannot easily be adapted to the tunnelling that is needed for following up the finest veins of statuary marble, as was done also in antiquity in the famous *lychnites* quarries of Paros. For another, the mechanization of transport and the ever-rising costs of handling make it uneconomic to exploit any quarry to which one cannot drive a road direct. There is still quarrying near the Michelangelo quarries at Serravezza (Plate IX), but it is of a marble which, though of lesser quality, can be made accessible by heavy lorry. It was presumably as a result of similar economic pressure that the mountain-top quarries of imperial porphyry finally ceased production about the middle of the fifth century A.D. Its place was taken by the green marble of Thessaly, which lay within easy reach of the sea, possibly even by way of a canal running

from the foot of the low slopes on which the quarries lie. The really profitable quarries in antiquity must have been those like Thasos and Proconnesus, from which one could load directly on to sea-going vessels.

That Michelangelo's methods should find no place in our twentieth-century world is sad, but not surprising. What is in the context more to the point is that right down to the end of the nineteenth century Michelangelo would have felt perfectly at home in the quarries of Carrara or Serravezza. There is a fine set of drawings of the Carrara quarries made by Salvioni at the beginning of the century, now in the State Archives at Massa.<sup>15</sup> Plate X illustrates one of these drawings. On the left is a tall vertical quarry face, with workmen suspended near the top of it on narrow platforms. At the foot of it other workmen are dressing the fallen blocks against a characteristically stepped background of secondary working faces. Around 1800, and for nearly a hundred years thereafter, Carrara was still using substantially the methods devised four thousand years ago in Pharaonic Egypt.

Almost exactly the same could be said of the methods of transporting the stone after extraction. Smaller pieces could be loaded on an ox-cart, but any sizeable monolith had to be dragged on a sledge, a very rudimentary device consisting of two heavy longitudinal timbers, lashed together and eased along the quarry path by means of wooden rollers. At Carrara this sledge was known as a *lizza*, and except that the hauling was normally done by teams of oxen (as in another of Salvioni's drawings, Plate XVIa), the method was still that which we see portrayed on the tomb of a high Egyptian official shortly before 1800 B.C. (Plate XVIb).<sup>16</sup> This particular statue, of alabaster, is stated in the accompanying inscription to have been nearly 25 feet high and it must have weighed over 50 tons. The only unusual circumstance is that in this case the statue was evidently fully carved at the quarries. It was normal practice to transport it in rough, for the completion of the fine detail after arrival. In other respects moving a load of this size was a commonplace event. Some of the granite columns from the Roman Mons Claudianus quarries weighed over 200 tons and had to travel nearly 100 miles overland before being loaded on to barges on the river Nile.

For obvious reasons much depended on water transport. One would hardly have needed the evidence of the monuments to be sure that the Egyptians made every possible use of the Nile,<sup>17</sup> nor is it an accident that many of the best-known quarries of

classical antiquity were situated in easy reach of the sea or of a navigable river. Some of the rarest and most highly prized varieties, however, were only to be found on mountain-tops, and to bring the quarried stone down to the loading ramps, use was again made of sledges, this time operating down prepared runways. Nowadays, as we have already remarked, it is found more economical to bring the road right up to the quarry; but until a few years ago a number of such *lizzae* were still to be seen in use at Carrara (Plate XI). The only substantial difference from antiquity was that the load was paid out by a steel rope and a mechanical windlass. In antiquity, and down to quite recent times, it was manœuvred down by ropes attached to heavy wooden bollards on either side of the *lizza* track. One can still see the sockets for such bollards beside the track that brought the marble of the Parthenon down the slopes of Mount Pentelikon (Plate XII). At the porphyry quarries, where timber was scarce, cairns of stone served as bollards.<sup>18</sup>

I need not labour the point. It will already be abundantly clear that until surprisingly recent times the actual techniques of quarrying and handling the stone after quarrying had changed remarkably little since the Egyptians first started using large blocks of stone for building or for statuary, some 4000 years ago. This is not, of course, to say that these practices were everywhere in continuous use. The Greeks, for example, who inherited them directly from Egypt, at quite an early stage lost interest in the characteristically Egyptian element of sheer size. The few monolithic colossi (like the unfinished giant, 34 feet long, in the quarries of Naxos)<sup>19</sup> are all very early. It was left to the Romans, after the annexation of Egypt, to resurrect the Egyptian taste for the colossal and to reintroduce the techniques for handling the large masses of stones represented, for example, by the columns of the Pantheon or by the great granite obelisks. When one recalls the sensation caused by Domenico Fontana's removal and re-erection of the Vatican obelisk in 1586, or in far more recent times the difficulties encountered in transporting Cleopatra's needle to the Thames Embankment, it is well to be reminded that the transport of two of these monsters to Augustan Rome was a notable but far from exceptional event. Fontana's enterprise was a nine days' wonder. We do not even know the name of Augustus' architect—unless indeed he was the same Pontius who signed his work on the claw of one of the four great bronze crabs which supported the Augustan obelisk at Alexandria.<sup>20</sup>

In their techniques and tools the Romans were, then, the heirs to a long tradition. In the uses to which they put them, on the other hand, they emphatically broke fresh ground. Both the Egyptians and the Greeks were essentially supplying local markets. The later Hellenistic age, it is true, was beginning to feel its way towards new tastes and new situations—wider markets, greater use of coloured marbles, the first tentative introduction of monolithic column shafts; but, as so often, it was left to the Romans to push these trends to their logical conclusions. Since the middle of the second century B.C. the wealthy Roman of cultural pretensions had been erecting minor public monuments of Greek marble in Rome itself;<sup>21</sup> but there was considerable prejudice to be overcome, and even as late as the fifties of the first century Caesar's plan to rebuild in marble a major public monument, the *Saepta*, was a matter for critical remark. It was only with the re-establishment of the *Pax Romana* and the institution of the great Augustan building programme that the dam broke. Coloured marble columns, pavements, and veneers began to flood in, and by the turn of the century they were part of the standard vocabulary of fashionable building in the capital.

It very soon became evident that the existing sources and existing methods were insufficient to meet the vastly increased demand. One answer was to open up new quarries. The far-sighted Caesar had already anticipated an important aspect of the problem by opening up the quarries at Carrara,<sup>22</sup> which for the next two centuries were to be Rome's principal source of white building marble. Augustus' own surveyors were busy in Egypt. But this was only a partial answer to the problem. The potential market was nothing less than the cities of the whole Mediterranean basin and beyond. To produce and to deliver the marbles of the Aegean and Numidia or the granites of Egypt anywhere from the Atlantic to the Syrian desert called not only for technical skill but also for a highly sophisticated commercial organization. It is this organization that was Rome's outstanding contribution to the marble trade in antiquity.

Of what did the new organization consist? It is nowhere specifically described, but we can piece together its broad outlines and much of its detail from odd references in the written sources, from the remains of the quarries themselves and of their products, and from the scattered but cumulatively very considerable body of epigraphic evidence relating to it.<sup>23</sup>

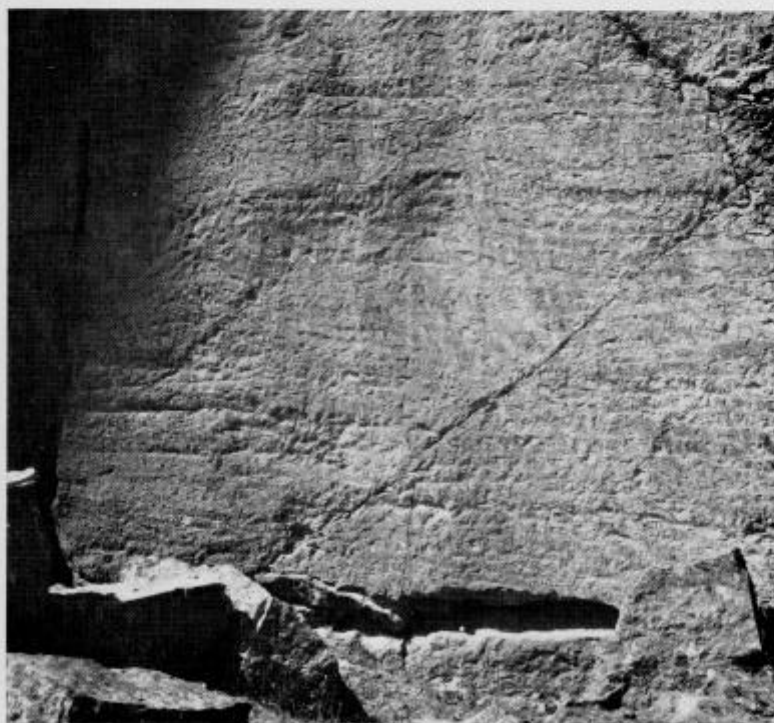
It was precipitated by the great Augustan building programme





a. One of the main quarry faces

J. B. W. P.

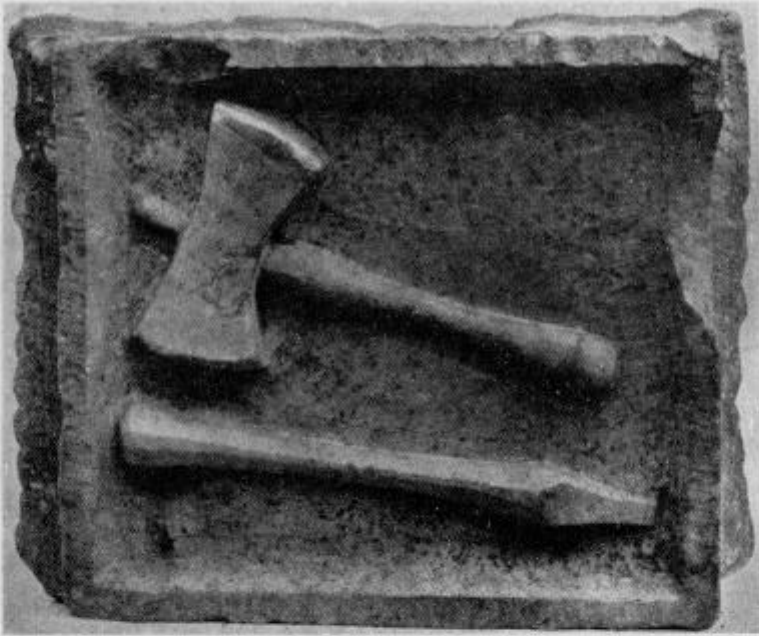


b. Detail of a quarry face, showing the tool-marks left in cutting the separation trench

J. B. W. P.

The green marble (*verde antico*) quarries near Larisa, Thessaly

PLATE II



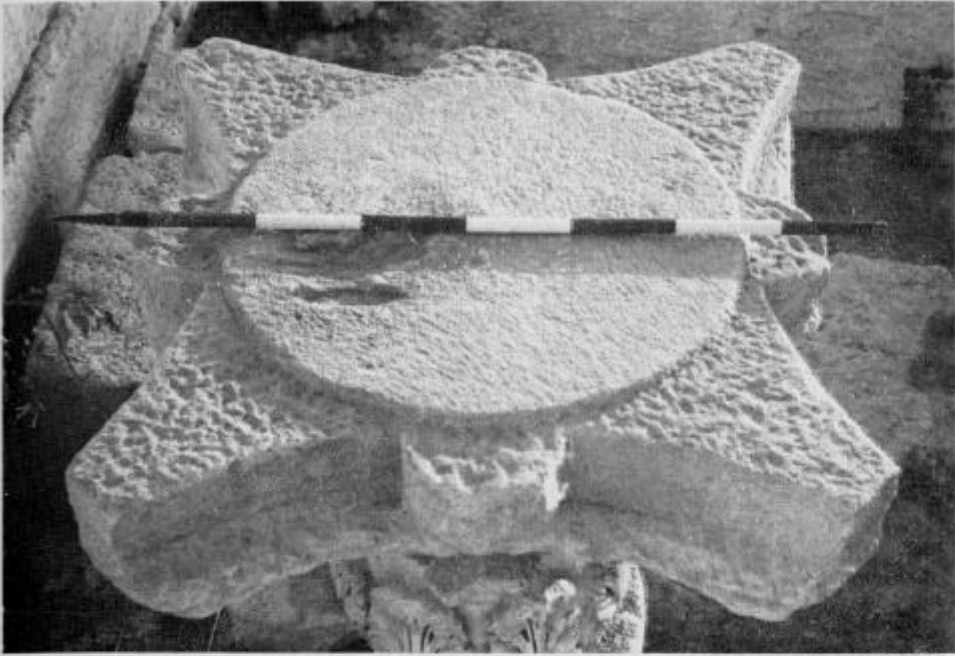
*After Blümel*

a. Greek votive relief in the Metropolitan Museum, New York:  
a marble-worker's mallet and point



*After Blümel*

b. Unfinished head, c. 480 B.C., from Paros



*a.* Unfinished capital, *c.* A.D. 200, at Lepcis Magna

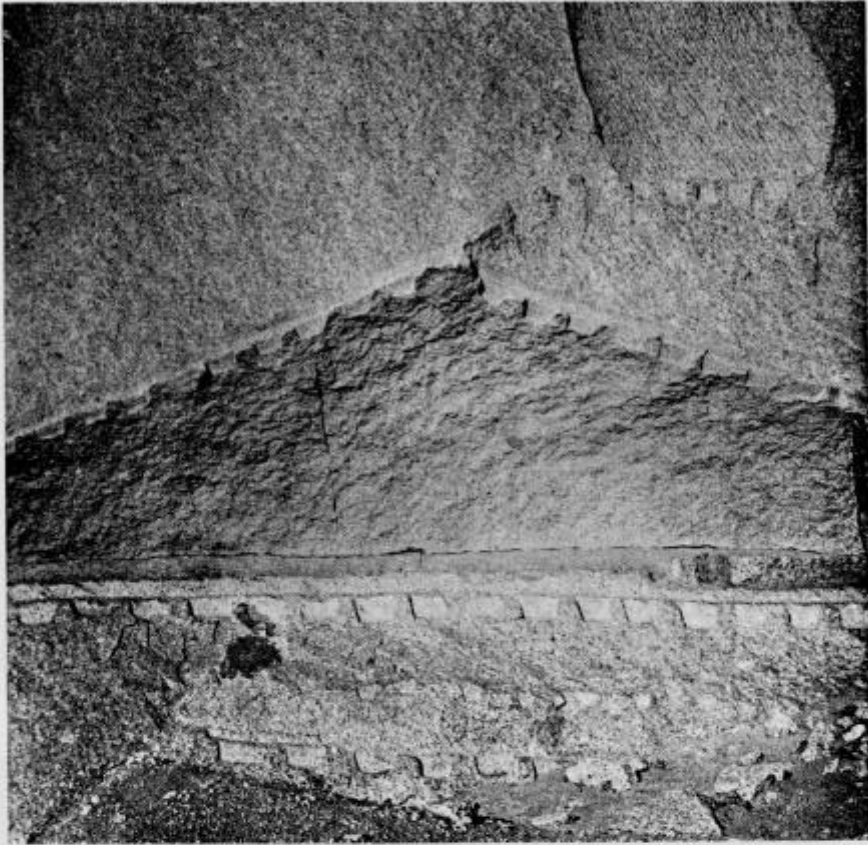
*J. B. W. P.*



*b.* Terrace wall at Delphi

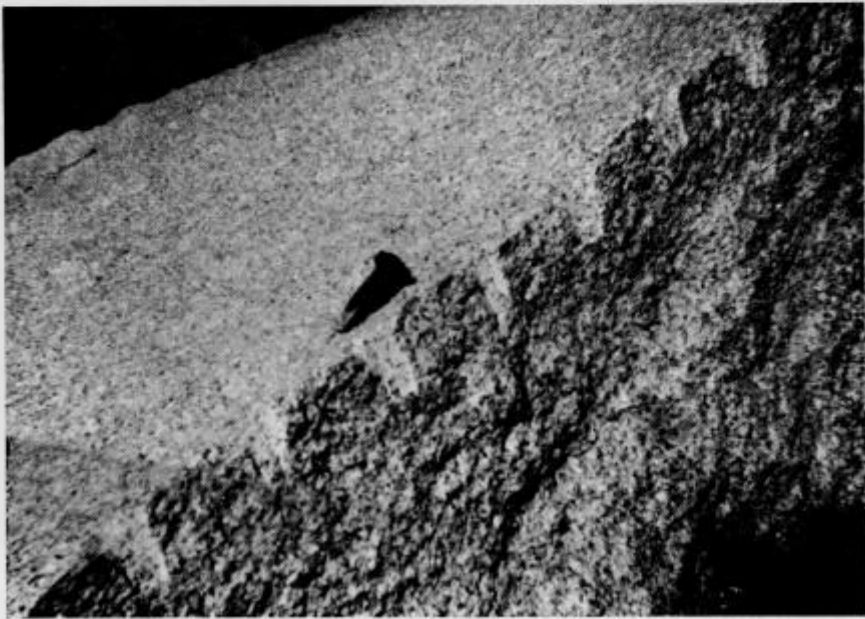
*J. B. W. P.*

PLATE IV



*After Krouw and Röder*

a. Use of wedges in the Roman granite quarries of Mons Claudianus, Egypt



*H. S. W. P.*

b. Wedge holes and an iron wedge in a modern granite quarry in northern Sardegna



*After Clarke and Engelbach*

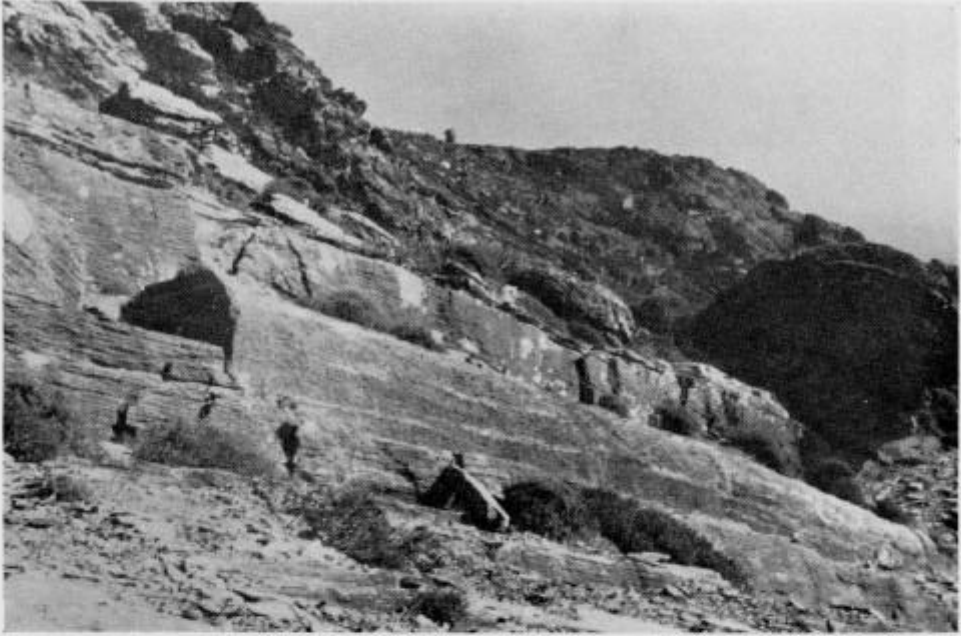
a. The unfinished Pharaonic obelisk in the granite quarries at Aswan



*Janet Davidson*

b. Quarrying coral rock on the foreshore of Tonga

PLATE VI



a. An unfinished column, still partly attached to the parent rock

*Miranda Buchanan*



b. Columns abandoned in the quarry

*Miranda Buchanan*

The green (*cipollino*) marble quarries above Karystos, Euboea

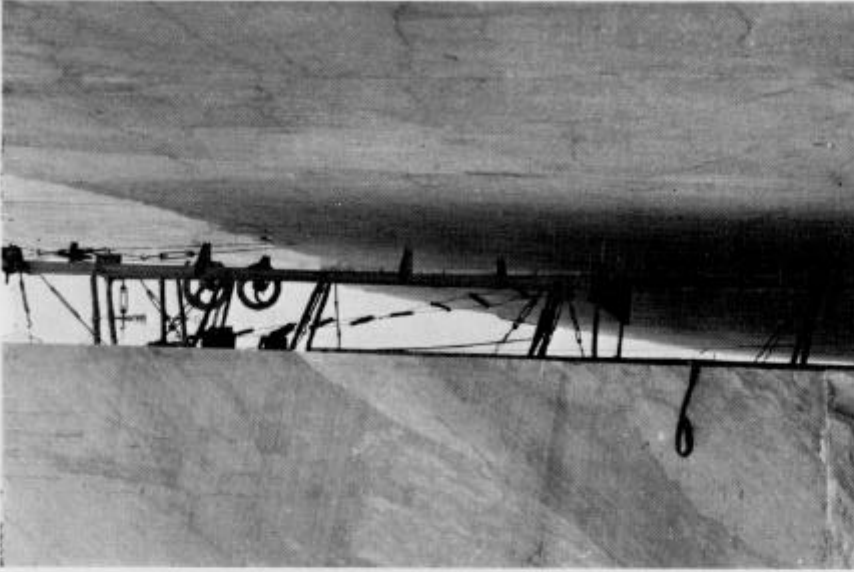


*C. Bager*  
*b.* The Roman limestone quarries of El Medol, near Tarragona: working face, showing traces of the extraction of successive layers of blocks



*J. B. W. P.*  
*a.* The white marble quarries at Aphrodisias, Caria: a typical Roman working face

PLATE VIII



J. B. W. P.

b. Running wire saw at work

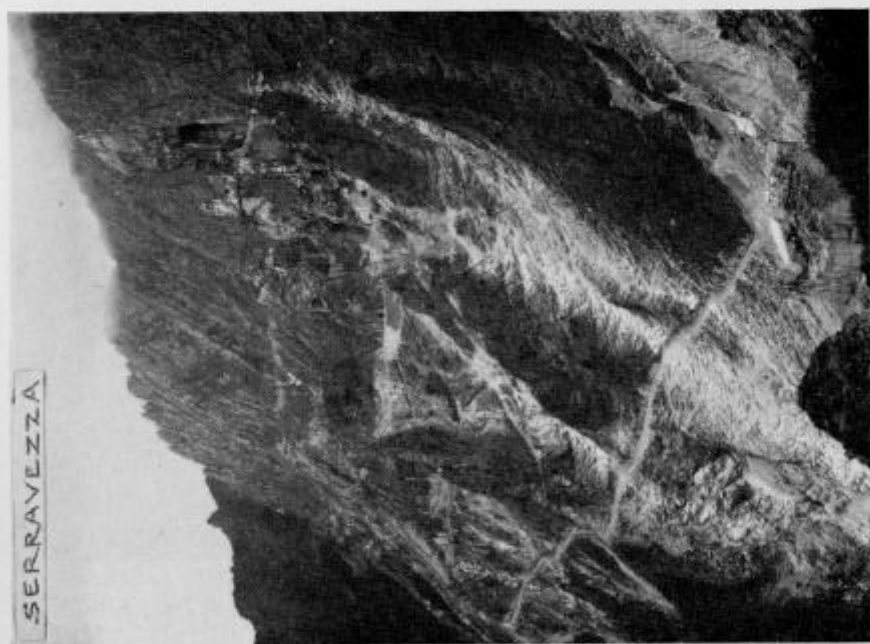
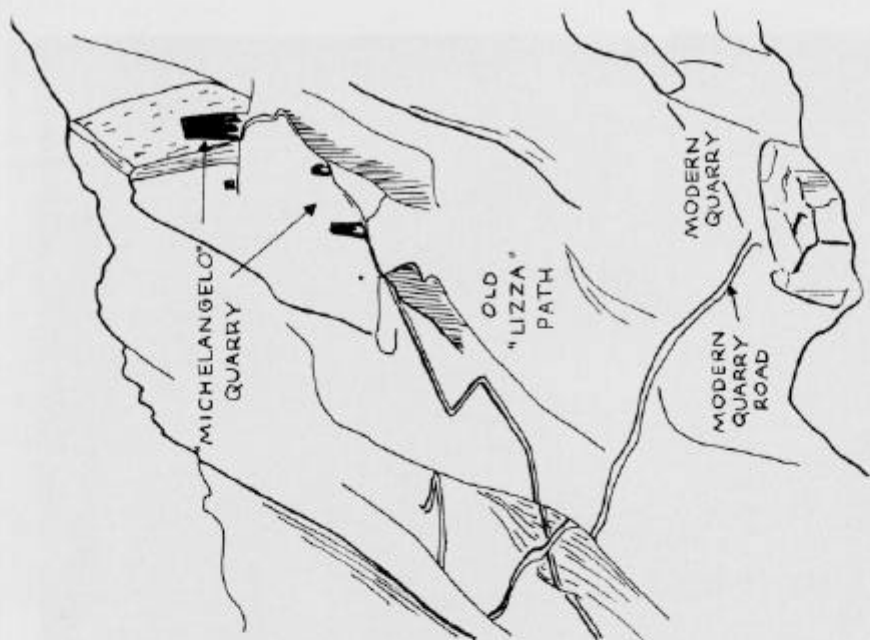


J. B. W. P.

a. Large block, the result of primary extraction by means of a running wire saw. It comes from the sloping platform above and behind it

Modern marble quarry at Serravezza, near Carrara





J. B. W. P.

The abandoned 'Michelangelo' quarries at Serravezza

PLATE X

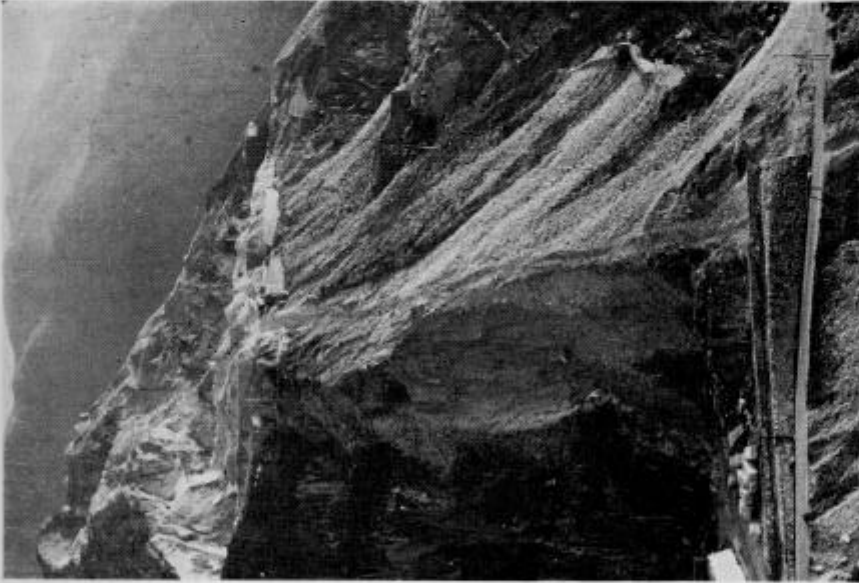


Marble quarry at Carrara, c. 1800, after Salvioni. Above left, workmen on light platforms attack the main quarry face; below, other workmen dress the fallen blocks with heavy picks or with mallet and point

*Stair Architet, Mass*



*J. B. W. P.*  
b. Carrara: loads of marble awaiting transport from the  
foot of a *fiZZa* track



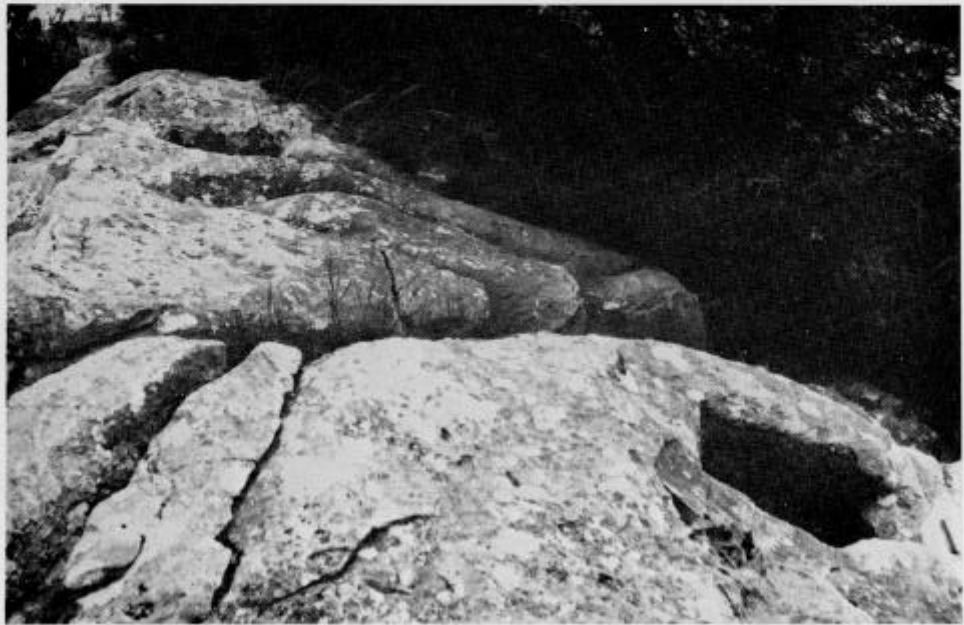
*J. B. W. P.*  
a. Carrara: a modern quarry (c. 1960) still using a  
short *fiZZa* track down to the loading ramp below

PLATE XII



*J. B. W. P.*

*a.* The great quarry face, traditionally the source of the marble of the Parthenon. Note the figure, bottom centre, marked by an arrow



*J. B. W. P.*

*b.* Sockets for wooden bollards beside the quarry path

Mount Pentelikon, Attica



*Vatican Museums*

Quarry inscription on the underside of the Column of Antoninus Pius, formerly in the Campus Martius, now in the Vatican Museums. It is of red Egyptian granite and was quarried in A.D. 106

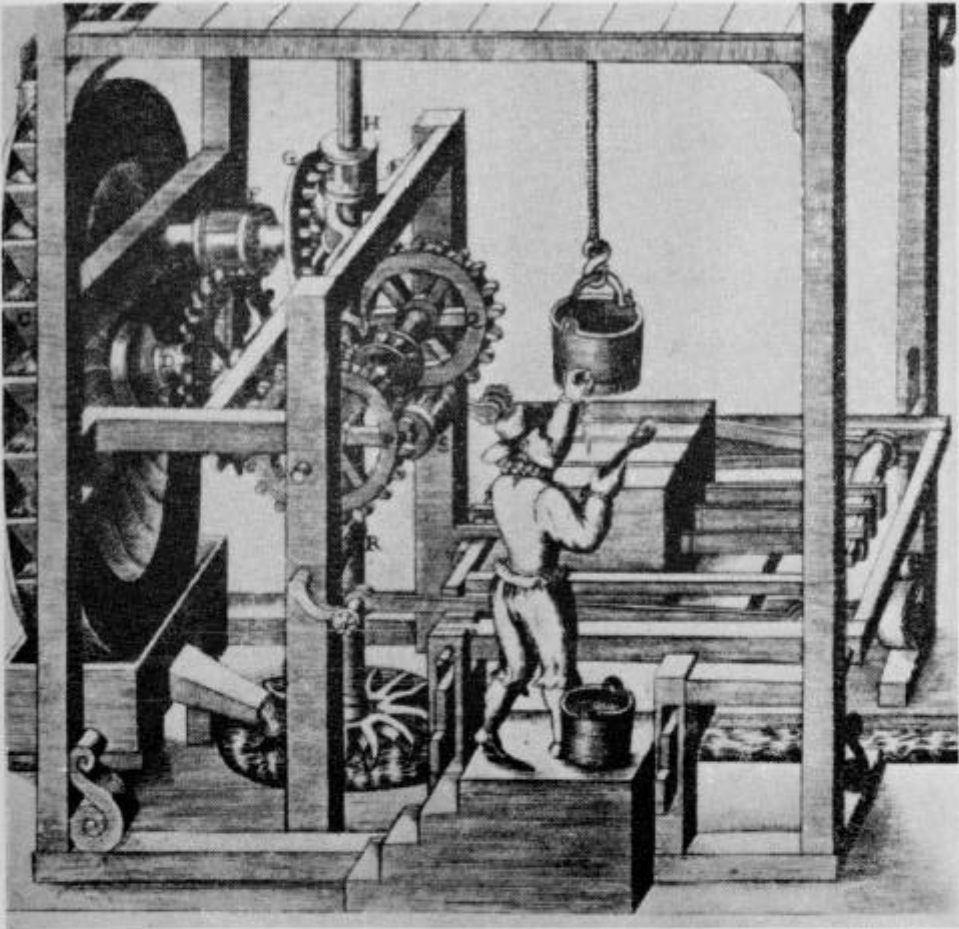


*Superintendency of Antiquities, Ostia*

DOMINIAN<sup>N</sup>  
EX FELICIS RAT<sup>AVO</sup>  
SER

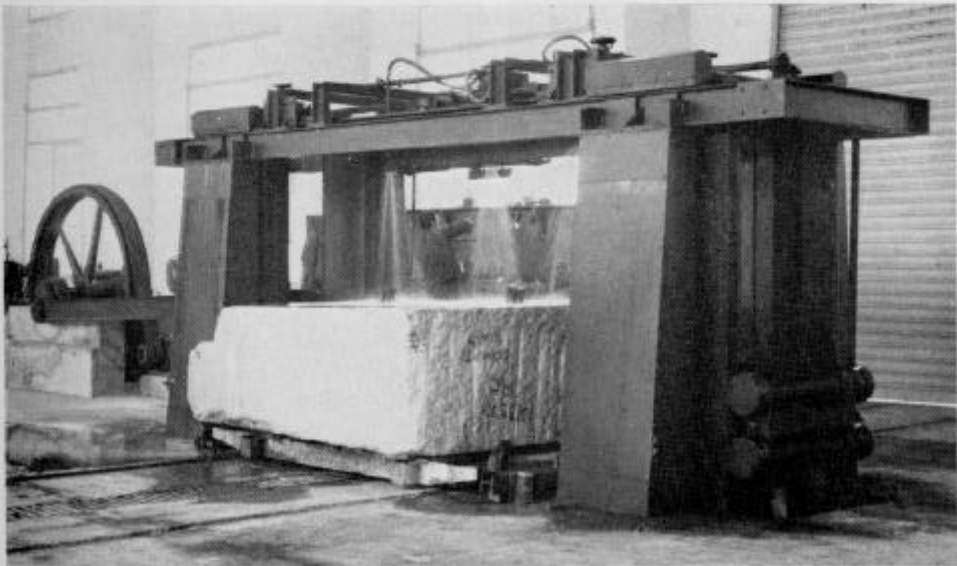
AGURINCOS  
LDCCLXXIX R  
DINTRISE R

Quarry inscriptions on a block of Numidian marble found at Ostia, where it was being used in a building that was destroyed in A.D. 394, during construction. The upper text records its extraction under Domitian (d. A.D. 96); the lower text is a control mark, added after shipment, probably in A.D. 132



*After Klaptisch-Zuber*

a. Design by A. Ramelli (1588) for a water-powered marble sawmill, with three parallel blades; above (not illustrated) is a flourmill, powered by the same shaft



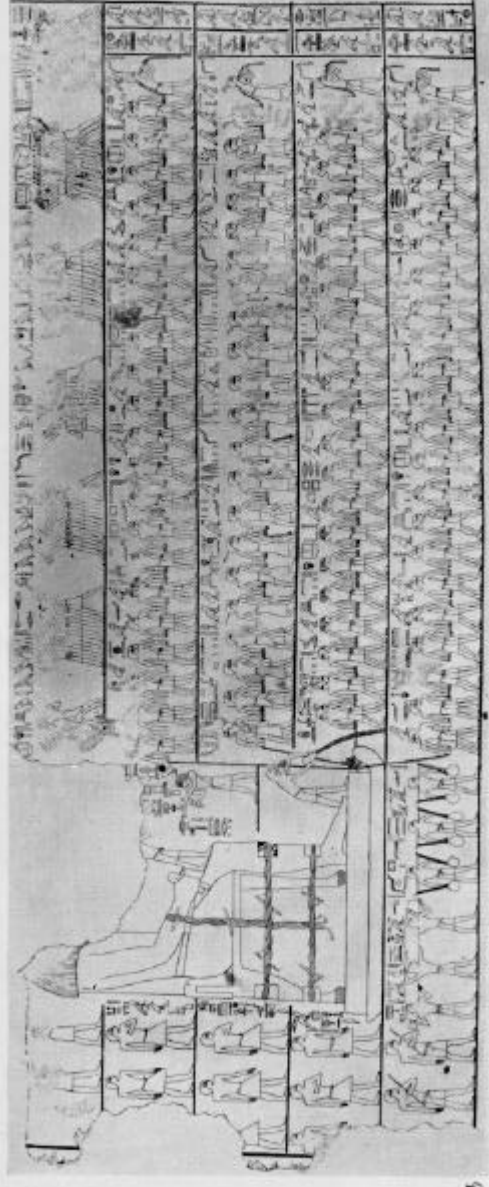
*J. B. W. P.*

b. Modern marble sawmill with three parallel blades, near Tunis; the two groups of wedges in the upper surface mark the position of the blades



State Archives, Massa

a. The transport of a large block of marble from the quarries at Carrara, from a drawing by Salvioni, c. 1800



After Nimburtt

b. The transport of an alabaster statue, as illustrated on the tomb of an Egyptian noble shortly before 1800 B.C.



in Rome, but it seems to have been left to Augustus's successor, Tiberius, to draw the logical conclusion from the situation so created. It is not true that Tiberius annexed all quarries and mines throughout the Empire: a great many did undoubtedly continue to operate in private or municipal hands. But it is true that a great many of the best-known quarries were, in modern terminology, nationalized.<sup>24</sup> Those of Egypt were already imperial property; those of Carrara passed into imperial hands at some date between A.D. 22 and 27. Unfortunately the quarry-mark system of accounting, our best source of information about ownership, does not seem to have been adopted before the middle of the century. But we do know that most of the best-known types of marble were reaching Rome in time to be used in Nero's two palaces, and that by A.D. 79 the left-overs were already filtering down to Pompeii and Herculaneum. We know, moreover, that by the second half of the century, at latest, the bulk of this commerce in fine marbles originated in a limited number of imperially-owned quarries, most of them in the Aegean world and in Egypt, but a few of them also in the West, notably in North Africa, in the Pyrenees, and at Carrara.

Far more important, however, than the mere fact of imperial ownership was the opportunity which this new situation afforded for a massive reorganization of the whole system of production and marketing. Once again the terms that spring to mind are those of modern commerce: mass-production, standardization, and even a certain measure of prefabrication.

How new all this was will be appreciated by anybody familiar with classical Greek practice. A number of Greek building accounts have come down to us, and a feature that almost all have in common is the extraordinarily hand-to-mouth arrangements which they presuppose for the supply of materials. With the quarry only a few miles away the system no doubt worked, and even in the Roman period one gets glimpses of something very similar in some of the municipal architecture of the provinces. In the great imperial quarries, on the other hand, the resources involved, the scale of operation, and the radius of distribution were all vastly different. Instead of casual piece-work, the only method of production that made economic sense was to build up, both at the quarries and in the marble yards of the various importing centres, large stocks of ready-quarried stone upon which the customer could draw for any normal order. Much of this stock was quarried and held, as it would be today, in all-purpose blocks of roughly rectangular shape and varying size,

to be used as needed, either architecturally or sculpturally, or else sliced up for paving or veneer. But some of it was already partially prepared before shipment. There is a growing body of evidence, for example, to show that columns were regularly quarried not only to shape but also to certain standard lengths;<sup>25</sup> and from the second century onwards several of the major centres of production, notably Attica and Proconnesus (the island of Marmara), were producing sarcophagi of which the designs were already roughed out at source.<sup>26</sup>

There is a great deal more that could be said about the organization that handled this very large body of material. I must be content to mention two aspects only.

One of these is the series of painted or incised inscriptions which for convenience we may refer to as 'quarry marks'. They range from simple numbers or symbols up to texts of some complexity, recording the names of the official or officials responsible, the date and the serial number of the block in question. Not all can be interpreted with certainty; and modern analogy suggests that some may have been connected with the processes of dispatch. The great majority however were evidently part of an imperially-controlled accounting system, operating in the first instance at the quarries themselves and again in some cases after shipment, at the marble yards of Rome and possibly of other importing centres (Plates XIII, XIV).<sup>27</sup>

The other aspect of this organization which I want to call to your attention is the abundant evidence that in many cases there were workshops in the importing provinces which operated as agencies for the parent quarries. There was no marble either in Egypt or Cyrenaica, and the white marble sarcophagi found there were all imported. But whereas every single one of the thirty-odd marble sarcophagi found in and near Alexandria are of Proconnesian marble, and of a type that was partly carved at the quarries before dispatch, in Cyrenaica there are precisely two such pieces;<sup>28</sup> all the rest (about three dozen in all) came from Attica. In such a situation taste clearly played second fiddle to the exigencies of a tightly-knit commercial organization. Elsewhere, in the Adriatic for example, Attica and Proconnesus shared the market, with agencies respectively at Aquileia and (almost certainly) Ravenna.<sup>29</sup>

Since these agencies in many cases must have dealt also in workmen as well as in materials, they were an important factor in the dissemination of motifs and styles. The best known such group is that of the *Aphrodisienses*, working out from Aphrodisias

in Caria. Another important group was that of the Bithynian marble workers, based on Nicomedia and operating (I suspect) principally in the marble of Proconnesus. They have been the subject of a valuable preliminary study, based on the epigraphic evidence, by Monsieur Louis Robert,<sup>30</sup> and their handiwork is everywhere apparent in what I have in another context described as the 'Marble Style' architectural ornament of the second and third centuries.<sup>31</sup> At Lepcis Magna, for example, there is a bilingual dedication to Aesculapius made by one of these sculptors, a certain Asclepiades, who describes himself as 'marmararius Nicomedia', and who could well have been one of the workmen engaged on the great Severan Forum and Basilica, most of the white marble for which did in fact come from Proconnesus.<sup>32</sup>

Yet another group of sculptors that calls for re-examination in similar terms is that of the Attic sculptors working abroad. Here again Lepcis supplies a conspicuous example of a closely-knit organization. The graceful lotus capitals and bases of the Forum are of Attic marble; the form is distinctively Attic; and at least one of the craftsmen employed bears the no less distinctively Attic name of Eleuseinios.<sup>33</sup> There is a mass of such evidence to show that the quarries regularly shipped workmen as well as materials and that the relationship of the agencies abroad to the parent quarries was close enough to determine the production of specific types of object for specific markets. To quote a single example, a ship which foundered near Taranto<sup>34</sup> in the early third century was carrying 24 large sarcophagi of a marble identifiable as coming probably from south-west Asia Minor, possibly from Aphrodisias itself; and yet half of the sarcophagi were already roughed out ready for completion in a form which is hardly found outside Italy, namely the form with rounded ends, often embellished with two projecting lion's heads. In this and other similar cases the quarries were producing to the precise specifications of a particular market.

All of this indicates a highly sophisticated commercial organization. Initially it was created to supply the capital, but by the early second century two things had happened. One was that, architecturally at any rate, the metropolitan market was near-saturated. There were still special orders to be filled for special needs; but for most ordinary purposes the marble yards were full. A few years ago at Ostia, the excavators came upon a building that had been destroyed during construction in 394. When destroyed it was still being paved and veneered in marble,

and in it, standing on the floor, the excavators found two of the blocks of yellow marble that were to be sliced up for the purpose. They came from the quarries of Chemtou in Numidia, and they had been quarried under Domitian 300 years before (Plate XIV).<sup>35</sup>

The Ostia find is unusually explicit in its testimony, but it is very far from unique. When the Marmorata quarter, beside the Tiber just below the Aventine, was cleared in the nineteenth century, several hundreds of blocks and columns were found that had been lying there since the first and second centuries<sup>36</sup>—very much as (I am told) the Istituto delle Pietre Dure at Florence still has in store today blocks of precious marble that go back to the time of the Medicis. By the second quarter of the second century the marble yards of the capital had built up enormous stocks of some of the commoner marbles. Shipments to Rome did not cease altogether, but the emphasis henceforth was to be on quality rather than on sheer bulk. Simultaneously, however, a vast new market was coming into being. This was the golden age of the provincial municipalities, in which public munificence was one of the accepted responsibilities of the wealthy citizen. The magistrate who could afford a handsome marble sarcophagus for himself and his family could afford also to embellish his city with a monument in the new prestige material. At Sabratha in Tripolitania (to cite a single example) the Forum, the Basilica, the main public baths, the theatre, a number of fountains, and all but one of the seven known major city temples were built or rebuilt in marble during the second century. Sabratha was a well-to-do but by no means exceptionally wealthy city. What happened here was happening in varying measure up and down the length of the Mediterranean world. Increased production, rationalization of supply, lowered prices, a large new consumer market—it all has a very familiar ring today and, *mutatis mutandis*, I am sure the analogy is a sound one.

An organization such as I have just been describing was almost wholly dependent on the stable conditions created by the Pax Romana, and with the collapse of central authority it too was almost bound to collapse. Not necessarily overnight. The impact of world events was to some extent cushioned by the fact that so many of the principal quarries lay within the orbit of Constantinople, which continued to afford not only relatively peaceful conditions but also an assured market. In the sixth century the quarries of Proconnesus were still able to supply a

large part of the briefly reunited Roman world with the white marble needed for Justinian's great building programme. Elsewhere too, under favourable conditions, something of the Roman system might for a time be maintained. As late as the early seventh century the quarries of Numidia, which had for a while returned under Byzantine control, were still in production, and, rather more surprisingly, the Pyrenean quarries were still supplying large parts of south-western Gaul with sarcophagi, and perhaps even for some time thereafter with smaller objects such as capitals and colonnettes.<sup>37</sup> But this was exceptional. In Egypt, for example, the porphyry quarries seem to have ceased production in the middle of the fifth century, nearly a hundred years before the Arab invasions.<sup>38</sup> Over large parts of the central and western Mediterranean world the Roman marble trade was by that time already a thing of the past.

What replaced it? In a great many places we can only guess. Martyn Jope's study of the building-stone industry of Southern and Midland England in Saxon times<sup>39</sup> is a shining example of what could be and all too rarely has been done. It is a safe assumption that such quarrying as there was reverted largely to piece-work, undertaken as local requirements called for it. However, the Saxon evidence alone would suffice to show that we do not have to look to Constantinople for the survival into the Middle Ages of the basic techniques of classical quarrying. If even in far-off Britain the builders of Bradford-on-Avon, around or very soon after 700, could quarry and dress large blocks of an excellent Bath-type limestone, there was certainly somewhere within reach a continuous tradition upon which they could draw. Furthermore, it was not long before the better-quality stones were serving a considerable local market, 40 or 50 miles afield and exceptionally even further. The distribution of the so-called 'featherbed' limestone from the later Saxon quarries at Quarr in the Isle of Wight will serve to illustrate both the extent and the limitations of this sort of commerce (Fig. 2).<sup>40</sup> The highly specialized commercial organization of Roman times had gone, and the elements of it were only slowly being pieced together again under royal and monastic patronage. But the essential techniques of quarrying and handling the stone and, within limits, of transporting it, had all survived.

In many parts of the former Roman world there was also the almost inexhaustible alternative source of supply represented by the buildings of classical antiquity. When at the end of the seventh century the nuns of Ely wished to translate the body of

Saint Etheldrida they knew just what to do. Some of the brethren (so Bede tells us) took ship and 'came to a certain little city left uninhabited, the which was not far from thence and in the

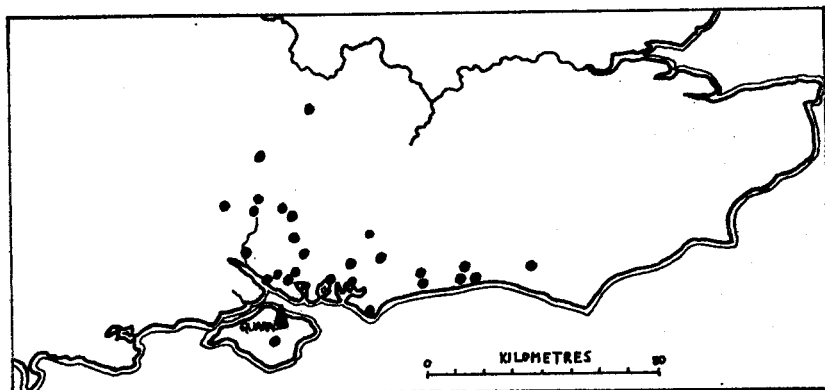


FIG. 2. Distribution of Quarr stone in late Saxon buildings.

English tongue is called Grantacaestir: and by and by they found by the walls of the town a coffin of white marble, very fairly made . . .'.<sup>41</sup> The good brothers knew exactly where to look, and this is just one of countless such stories. Naturally the documents tell us mostly of people in high places—Charlemagne, Abbot Desiderius of Monte Cassino, the abbot of Moissac, Saint-Germain of Auxerre, the cathedral builders of Modena and of Pisa. But it must have been going on all down the line. In many parts of this country it is a lucky excavator who finds even the foundations of a Roman building still in place. Building stone, columns, coffins, slabs for carving: all over the Roman world they were there for the taking.

It is not until the twelfth century that one begins to detect a significant new element in the pattern. In many parts of western and Mediterranean Europe the preconditions of a stable commercial organization were slowly being re-established, and with them the supply of fine stones begins, locally at any rate, to take on once more something of its former Roman aspect. This is a subject about which it is still very hard to generalize. Circumstances might vary so greatly from one region to the next, and almost everywhere we lack any really systematic study of the basic evidence, both documentary and archaeological. Once again we seem to be rather better served in this respect in north-western Europe than in the western Mediterranean or, be it added, Constantinople. So far as I know no serious attempt has been made to document the later history of the Roman

quarries under Byzantine rule. The ornament of Middle Byzantine churches such as Kariye Camii and the Pantocrator (Zeyrek Camii) suggests that there was still a production of certain local coloured marbles for decorative use; but for most architectural purposes the ruins of the classical cities of the Propontis were too rich and tempting a source to encourage fresh quarrying. At Cyzicus, for example, thirty-one of the original sixty-two columns of the great Temple of Hadrian had already gone when Cyriacus of Ancona first visited the site in 1431.<sup>42</sup> In the thirteen years before his second visit two more had been removed, together with many architraves and most of the cella walls, taken to build the mosques of Mudania and Broussa. Today the site is a barely identifiable mound of scrub-covered rubble.

In the West the days of such rich, upstanding treasure-trove were past. Fresh materials were of course constantly coming to light as earlier buildings were demolished or rebuilt; and there were many places where one could still burrow profitably for the remains of antiquity, as in Rome itself the *marmorari romani* did for the porphyries and precious marbles of their craft. But the great romanesque and gothic cathedrals demanded steadier, more dependable sources of supply. Good freestone was beginning to be quarried on a very substantial scale and shipped for considerable distances: in our own country, for example, at Barnack or, just across the channel, at Caen. With this traffic came an increasing number also of decorative stones. The first to achieve a national reputation in this country was the dark Purbeck stone which, starting about 1170, we find being shipped all over England and even on occasion abroad. This held the field until replaced, at first sporadically and locally by a number of equivalent local stones and ultimately, in the fourteenth century, by the development of the alabaster quarries of the northern Midlands. With the alabaster trade we move into a world of highly organized, explicitly commercial production, reaching as far afield as the Iberian peninsula, Italy, the Rhineland, and Iceland, and well documented in the sources. Before this the documentation is far more fragmentary and it is not always easy to assess either the scale of output of a particular quarry or the organization under which it operated. But it is surely significant that Purbeck and several of the other early quarries did deal in products (colonnets, for example, or decorative strips) which were already prepared in the quarry workshops before dispatch. Little by little we see ourselves slipping back into Roman ways.

It is much the same story on the continent. In the Pyrenees, after several centuries of abandon, the quarries came to life again in the twelfth century to serve the romanesque cathedrals and monasteries on either side of the frontier. At the same time Tournai, favoured by its position on the river Escaut, was laying the basis of a commerce which for the better part of two centuries was to dominate a wide market in Flanders and northern France, with substantial links across the channel towards England.<sup>43</sup> The fine black limestone of Tournai, like Purbeck stone, was exported not only in the form of rough blocks but also of ready-carved colonnettes and capitals, and in this instance we know that the trade was concentrated very largely in the hands of a merchant guild, the Charité Saint-Christophe, which had links with the Hansa in London.

Tournai stone had already been extensively worked in Roman times. Other medieval centres were new, or had been worked previously only on a very modest scale. One such centre that cries aloud for systematic study is the familiar red-brown or creamy-pink marble from the hills to the north-west of Verona, beside the Adige.<sup>44</sup> Here is a stone which had already found its way to most of the major romanesque monuments of the middle and lower Po valley, from Piacenza, Cremona, and Brescia to Padova and Venice, and which later on was to find an even wider market. By comparison, Carrara seems to have been rather a late starter. It is not until the very end of the twelfth century that we hear once more of quarrying activity, with certain *marmorari* of Carrara undertaking deliveries of material, including a column, to Genoa.<sup>45</sup> Once launched, however, this commerce rapidly gained momentum. A single example must suffice. In 1265 we find Niccoló Pisano contracting to deliver to Siena, for the new pulpit, a consignment of Carrara marble consisting of eleven columns, sixteen colonnettes, fifteen blocks, and seven slabs; this was evidently to be worked at Pisa and paid for in Pisan currency.<sup>46</sup>

At this point we must leave the story; but in any case we are already moving into familiar country. There is only one last point which I should like to stress, one which, with the masterpieces of the Quattrocento and the Cinquecento before us, it is very easy to forget. Contemporary writers and architects, nurtured on Vitruvius, might design all sorts of ingenious equipment; but a great deal of this was theory, or at best of very limited application. When Scamozzi, writing in 1615, tells of the water mills used for sawing large marble slabs in the Duchy of



Milan, he no doubt had in mind something akin to the double-purpose mill devised and published by Ramelli thirty years before (Plate XVa).<sup>47</sup> Such mills did exist, and the recent excavations at Chemtou have shown that the Romans had them too.<sup>48</sup> But they were a marginal luxury, where water-power was abundant. At Carrara they did not come in until the eighteenth century. Domenico Fontana had the technical knowledge to raise the Vatican obelisk; but its application was a *tour de force*, not a reflection of everyday practice. We know that in fact, before the advent of mechanical transport, ten tons was a normal maximum load. We know too that right down to the nineteenth century the ordinary method of loading a ship with marble was to drag the individual blocks up a shallow ramp and to suspend them from a windlass over a dock into which the ship itself was manœuvred. This was substantially the Egyptian method, employed by Hatshepsut in the fifteenth century B.C. to move her obelisks from Aswan to Karnak. Incidentally these obelisks weighed, not ten tons, but three hundred and twenty.

\*       \*       \*       \*       \*

I have tried in the time at my disposal to paint a rather large picture on a rather small canvas. This has only been possible because the central theme is in fact one of great simplicity. During the four thousand-odd years since large-scale quarrying was first developed in Pharaonic Egypt there was astonishingly little advance in the actual processes of quarrying and handling the stone until barely a century ago. The availability of fine stone did vary greatly from one period to another; but such variations must be measured in terms not so much of the stores of traditional skills available at any given time as of the political and social conditions within which those skills were free to operate.

This is hardly a very profound conclusion. And yet, for all that the pattern is a familiar one, there are a surprising number of fields in which its implications have still to be systematically explored, fields moreover that have much to offer. For the economic historian an expensive, prestige material such as this is an unusually sensitive index of the fluctuations of contemporary prosperity; and because the handling of it poses logistic problems that do not apply to other more mobile luxury goods, the art-historian too can see, reflected with unusual clarity, something of the practical considerations which lie behind so

many of the stylistic and iconographic phenomena which are his own especial concern. As for the archaeologist pure and simple—if indeed there is any such animal—it is fascinating to watch the development of such a broadly continuing situation through the distorting mirror of the successive sources of our knowledge about it: in ancient Egypt, largely though not exclusively, through those of archaeology; in the classical world through archaeology matched and controlled by a growing body of literary and epigraphic evidence; and by the later Middle Ages through the documents, supplemented—and obviously capable of further supplementation—by archaeology.

And what of prehistory? What would we have made of all this archaeological information in a situation where there were no documents at all? I ask the question, not to offer any answers but because I believe it to be the sort of question we can all usefully be asking ourselves today. At a time when so many of the traditional concepts of archaeology are being called in question, I am sure there is value in any inquiry that carries discussion backwards and forwards across the arbitrary line that divides prehistory from history, or again across that which so often seems to divide the conclusions of archaeology from those of documentary history.

In all of this, I am only repeating a lesson which over the years the distinguished scholar in whose honour this lecture is given has on innumerable occasions enunciated with a vigour and an eloquence that I cannot hope to match. There is no living archaeologist who has done more to keep these broader perspectives clearly before us. It is good that this, the first Mortimer Wheeler Archaeological Lecture, should afford an opportunity to express, however inadequately, the deep debt of gratitude which we all owe to him.

#### NOTES

<sup>1</sup> I am indebted above all to my colleagues on the International Committee for the Study of Marbles in Antiquity. A short bibliography of relevant books and articles published since 1960 has been prepared by the Committee and will appear in volume xxxix of the *Papers of the British School at Rome*.

I have used the following bibliographical abbreviations in the notes that follow:

Blümel = C. Blümel, *Greek Sculptors at Work* (English translation of *Griechische Bildhauer an der Arbeit*, 4th ed., 1953), London, 1955.

Bruzza = L. Bruzza, 'Iscrizioni sui marmi grezzi', *Annali dell' Instituto*, 1870, pp. 106–204.

Clarke and Engelbach = S. Clarke and R. Engelbach, *Ancient Egyptian Masonry*, London, 1930.

Klapisch-Zuber = C. Klapisch-Zuber, *Les Maîtres du marbre. Carrare, 1300-1600*, Paris, 1969.

Kraus and Röder = T. Kraus and J. Röder, *Mitteilungen des Deutschen Arch. Inst., Abt. Kairo*, xviii (1960), pp. 80-120, and (with W. Müller-Wiener) xxii (1967), pp. 109-205.

<sup>2</sup> Clarke and Engelbach, p. 27 and figs. 26-8.

<sup>3</sup> *Ibid.*, pp. 31-2, figs. 31-3.

<sup>4</sup> G. Lugli, *La Tecnica edilizia romana* (Rome, 1957), fig. 36.

<sup>5</sup> Blümel, fig. 16, after *Bull. Metrop. Mus. New York*, xxi (1926), p. 260, fig. 6.

<sup>6</sup> Blümel, pp. 18-33.

<sup>7</sup> Kraus and Röder (1960), pls. XVIII, XIX, XXI, and (1967), pls. XLII-XLIV; cf. pls. LXI, LXIII, LXIV, in the porphyry quarries of Mons Porphyrites.

<sup>8</sup> For the methods used in separating this obelisk, nearly 300 feet long, from the parent rock see R. Engelbach, *The Problem of the Obelisks* (London, 1923); summarized in Clarke and Engelbach, pp. 27-30.

<sup>9</sup> The photograph reproduced on Plate Vb was taken on the occasion of the Cook Bicentenary Expedition by Miss Janet Davidson, to whom I am indebted for permission to use it. The rock in question is a hard coral which was used in several parts of the Tonga group to face the house platforms of the nobility and also for sepulchral monuments. Dr. G. Blake-Palmer, to whom I owe this information, adds that, as in the Mediterranean, there is clear evidence of the use of water transport. The lintel of the trilithon of Haaminga-a-mani on Tonga, estimated at upwards of 15 tons in weight, appears to have been brought from Urea or Wallis Island, several hundred miles from Tonga by sea.

For information about Peruvian quarrying and building practice I am indebted to Dr. Warwick Bray and to Ann Kendall. J. H. Rowe, *An Introduction to the Archaeology of Cuzco* (Cambridge, Mass., Peabody Museum, 1944), gives a good short summary of Inca stone-working traditions. For a description of the great Inca quarries of trachitic rock at Andahuaylillas, 22 miles from Cuzco, see E. George Squier, *Peru* (London, 1877), pp. 418-19.

For a convenient summary of what is known of Mexican practice see *Handbook of Middle American Indians*, ed. G. R. Willey (Austin, Texas, 1965) ii, p. 397. This indicates a combination of separating trenches and, wherever the rock formation permitted, splitting by means of poles or wedges; the tools include pick-like implements, hammerstones, stone hatchets or adzes and chisels. I owe this reference to Dr. Geoffrey Bushnell.

<sup>10</sup> *CIL* iii. 24 = *ILS* 5741; *IGRR* i. 1254 = *CIG* 4713e; and particularly *IGRR* i. 1260 = *CIG* 4713d, naming the architect Herakleides (temp. Trajan), whose name has since been identified on the rock face of the quarries in circumstances which suggest that he was marking the site selected for the extraction of a column (T. Kraus, 'Zu einer neugefunden Inschrift am Mons Claudianus', *Acta of the Fifth International Congress of Greek and Roman Epigraphy, Cambridge, 1967* (Oxford, 1971), pp. 391-5). Doubtless to be identified also with the architect [ . . . ]eides who figures on the underside of the Antonine Column in Rome (see note 27 and Plate XIII).

<sup>11</sup> For the Karystos quarries, see J. Papageorgakis, τὰ ἀρχαῖα λατομεῖα τοῦ καρυστίου μαρμάρου (Die antiken Brueche des karystischen Marmors), *Praktika*, xxxix (1964), pp. 263–84; also V. Hankey, *Bulletin du Musée de Beyrouth*, xviii (1965), pp. 53–61.

<sup>12</sup> I owe my knowledge of these quarries, which lie near the Via Augusta about half-way between Tarragona itself and the Arch of Sura, to Dr. Christoph Rüger, who kindly supplied the photograph illustrated on Plate VIIb.

<sup>13</sup> Although such soft stones are cut nowadays with a rotating metal saw and removed from the quarry-face by truck, the same principles of accessibility and economy of labour still apply.

<sup>14</sup> For information about modern methods of quarrying at Carrara I am indebted to Dr. Carlo Caleo, President of the Provincial Chamber of Commerce, and to Professor G. Citi of the Ditta Henraux of Serravezza, owners of the quarries illustrated in Plate VIII. For quarrying practices there prior to the introduction of the running-wire saw, see Klapisch-Zuber, pp. 61–7; and for the evidence (now destroyed) of ancient quarrying, L. Banti, 'Antiche lavorazioni nelle cave lunensi', *Studi Etruschi* v (1931), pp. 475–97.

<sup>15</sup> Among those illustrated by Klapisch-Zuber (figs. 7–13) are ones showing the use of wedges to detach a sloping mass (fig. 9), the sawing of a large block by two men using a single-bladed rocking saw (fig. 10) and the foot of a *lizza* path (fig. 11).

<sup>16</sup> P. E. Newberry, *El-Bersheh I: The Tomb of Tehuti-hetep* (*Archaeol. Survey of Egypt*, iii, no date). Reisner (*Catalogue général du Musée Égyptien, Cairo: Models of Ships and Boats*, p. 89) illustrates the twelfth-dynasty wooden sled, 14 feet long, on which a royal barge had been transported; cf. Clarke and Engelbach, fig. 85. The obelisks of Queen Hatshepsut were shipped lashed to the wooden sleds on which they had been transported from the quarries (cf. following note).

<sup>17</sup> The great barge that carried Queen Hatshepsut's two obelisks from Aswan to Karnak is illustrated on the walls of the Temple of Deir el-Bahari (E. Naville; *The Temple of Deir el-Bahari* (Egypt Explor. Fund, 1908), Pls. CLIII and CLIV; cf. Clarke and Engelbach, fig. 39). It must have been a very large vessel.

<sup>18</sup> Kraus and Röder (1967), pl. LXIIa.

<sup>19</sup> S. Casson, *Annual of the British School at Athens*, xxxvii (1940), 21–5, pls. 2–5; Blümel, figs. 2–4.

<sup>20</sup> *CIL* iii, 6588 = *ILS* 5483a. Now in the Metropolitan Museum, New York.

<sup>21</sup> The first of these was some part of the Porticus Metelli, built soon after 146 B.C. by Q. Caecilius Metellus Macedonicus; Velleius, i. 11. 3 ff. *hic idem primus omnium Romae aedem ex marmore . . . molitus*. The Round Temple in the Forum Boarium, a building probably of the first half of the first century B.C., is of Pentelic marble (*Papers of the British School at Rome*, xxviii (1960), pp. 7–32).

<sup>22</sup> The quarries were already in production on a scale sufficient to supply the rebuilding of the Regia in the Forum Romanum in 36 B.C.

<sup>23</sup> For a convenient summary of this aspect of the Roman marble trade (a subject which badly needs a fuller study) see the writer's article 'Marmo, uso e commercio a Roma' in *Enciclopedia dell'arte antica*, iv (1961), pp. 866–70; cf. *Journal of Roman Studies*, xli (1951), pp. 89–104. For the coloured marbles in particular see R. Gnoli, *Marmora romana*, Rome, 1971.

<sup>24</sup> Suetonius, *Tib.* 49: *plurimis etiam civitatibus et privatis veteres immunitates et ius metallorum ac vectigalium adempta.*

<sup>25</sup> Much of the evidence comes from the measurement of actual surviving columns, which regularly approximate closely to an exact number of Roman feet. Those of the porch of the Pantheon, for example, measure 50 feet; columns of 16, 20 and 24 feet are a standard feature of the Severan buildings at Lepcis Magna. See also the evidence of inscriptions: e.g. *CIL* xiii, 38, *columnae vicenariae*, from the quarries of Saint-Béat in the Pyrenees; *J. Öst. Arch. Inst.* xlvii (1964-5), Beiblatt 30, from Ephesus, recording a donation of twenty 5½-foot columns of Dokimian (Phrygian) marble; *Annali dell'Inst.* 1839, pp. 192-3, Tav. d'agg. D = Bruzza no. 338, a porphyry column found in Rome near the church of SS. Apostoli (from the Temple of Serapis?), inscribed on the underside ΠΟΔ'Θ (9 feet). Cf. also note 27.

<sup>26</sup> Attica: *Journal of Roman Studies*, xlvi (1956), pp. 10-16. Proconnesus: *Report of the Smithsonian Institution for 1957* (Washington, 1958), pp. 455-67; *Archaeology* 11 (1958), pp. 98-104. See also the writer's articles, 'The imported sarcophagi of Roman Tyre', *Bulletin du Musée de Beyrouth*, xxii (1969), pp. 109-45, and in *Enciclopedia dell'arte antica*, Supplementary volume (forthcoming).

<sup>27</sup> The standard account of these quarry marks remains that of Bruzza (op. cit.), describing the discovery of the vast Tiber-side depots of classical marble in the Marmorata quarter, just below the Aventine. Plate XIII illustrates one of these quarry inscriptions (*IGRR* i, 529) cut on the underside of the red granite Column of Antoninus Pius, which is shown to be one of a pair of 50-foot columns quarried at Aswan in A.D. 106, half a century before it was put to use in or soon after 161. The damaged underside is preserved in the Vatican Museums, to which I am indebted for the photograph here reproduced.

<sup>28</sup> A Proconnesian garland sarcophagus was seen, together with two Attic sarcophagi, by Pacho in a rock-cut tomb at Cyrene (M. J. R. Pacho, *Relation d'un voyage dans la Marmarique et la Cyrenaique* (Paris, 1817) p. 379, pl. LVI; reproduced by A. L. Pietrogrande in *Africa Italiana*, iii (1930), p. 119, fig. 16). At Ptolemais part of a large gabled lid is now placed near the amphitheatre.

<sup>29</sup> J. B. Ward-Perkins, 'Il commercio dei sarcofagi in marmo fra Grecia e Italia Settentrionale', *Atti del I Congr. Int. di Archeologia dell'Italia Settentrionale*, Torino (1963), pp. 119-24.

<sup>30</sup> Cf. Louis Robert, *Hellenica*, xi-xii (1960), 21-39, where a fuller epigraphic study of these Bithynian *marmorarii* is promised. They were active as far afield as Nikopolis-ad-Istrum, in the modern Bulgaria (G. Mihailov, *IGBulg* ii. 764), and in Rome, where we find a Bithynian marble-dealer (λιθέμπορος) with a *statio* in the Horrea Petroniana (*SEG* iv. 106 = *Ann. Ep.* 1926, 16).

<sup>31</sup> A. Boethius and J. B. Ward-Perkins, *Etruscan and Roman Architecture* (1970), pp. 408, 411.

<sup>32</sup> *IRT*, 264.

<sup>33</sup> *Journal of Roman Studies*, xxxviii (1948), 66-70 (capitals). *Proc. Brit. Acad.* xxxvii (1951), 269-304, pl. III, 4 (the Eleuseinos inscription = *IRT*, Addenda, p. 274, no. 799t).

<sup>34</sup> *Archaeology*, xviii (1965), pp. 201-9.

<sup>35</sup> *Scavi di Ostia*, vi (1969): G. Becatti, *Edificio con opus sectile fuori Porta Marina*, pp. 22–5. The upper text records the original extraction of the block in the time of Domitian (i.e. before A.D. 96), under the charge of the imperial slave Felix (*ex rat(ione) Felicis ser(vi)*), who was still in charge in A.D. 107 (*CIL* viii, 14560). The lower text probably refers to a stock-taking of the marble yards of Rome undertaken in A.D. 132 (*Augurin(o) co(n)s(ule)*).

<sup>36</sup> Bruzza, *op. cit.*

<sup>37</sup> For the commerce in Aquitanian sarcophagi and its chronology see most recently Brigitte Briesenick, 'Typologie und Chronologie der südwestgallischen Sarkophage', *Jb. des R-G Zentralmuseums Mainz*, ix (1962), pp. 76–182. For the commerce in colonnettes and capitals, Denise Fossard, *Cahiers archéologiques*, ii (1947), pp. 69–85.

<sup>38</sup> According to the list compiled by Constantine Porphyrogenitus (*de Ceremoniis*, 42) the last emperor to be buried in a sarcophagus of the traditional Imperial porphyry was Marcian (d. 457); see A.A. Vasiliev in *Dumbarton Oaks Papers*, iv (1948), pp. 3–26, and Philip Grierson, *ibid.* xvi (1962), pp. 3–63.

<sup>39</sup> E. M. Jope, 'The Saxon building-stone industry in Southern and Midland England', *Medieval Archaeology*, viii (1964), pp. 91–118.

<sup>40</sup> *Ibid.* pp. 101–2 and Appendix, pp. 115–18; distribution map, fig. 26. From quarries near Binstead, I.O.W. Used extensively in Saxon buildings in the Hampshire basin and coastal Sussex, as far afield as Laverstoke and Lewes, which are distant about 60 miles, much of which could have been covered by water.

<sup>41</sup> Bede, *Eccl. Hist.* iv. 19.

<sup>42</sup> B. Ashmole, *Journal of the Warburg and Courtauld Institutes*, xix (1956), pp. 179–81; cf. *Proc. Brit. Acad.* xiv (1959), pp. 35–6.

<sup>43</sup> For information and bibliography about the Tournai quarries (which await systematic study) I am indebted to Professor J. Mertens.

<sup>44</sup> F. Rodolico, *Le pietre delle città d'Italia* (Firenze, 1953), pp. 81–4, 111–18.

<sup>45</sup> Klapisch-Zuber, pp. 52–3, citing documents from the notarial archives of Genoa.

<sup>46</sup> G. Milanese, *Documenti per la storia dell'arte senese*, vol. i (Siena, 1854), p. 145, no. 8 (1265); cf. pp. 150–1, no. 10 (1267); Klapisch-Zuber, p. 57.

<sup>47</sup> Klapisch-Zuber, p. 74, citing V. Scamozzi, *Dell'idea dell'architettura universale* (Venezia, 1615) and A. Ramelli, *Le diverse e artificiose macchine* (Paris, 1588), whence Plate XVa. The two buckets are for water and sand. The essential mechanism, a battery of parallel blades driven by a crank and lubricated with water, is still in use today, as in the sawmill near Tunis illustrated in Plate XVb.

<sup>48</sup> The water-power was supplied by means of two vertical, cylindrical, rock-cut shafts. My informant, Dr. Friedrich Rakob, now tells me that it is very doubtful whether it was used for sawing marble.