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Stoneworking Techniques and Processes

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Focusing on which tool is or is not used and where can expose patterns of craft organization and the transmission of expertise both geographically and chronologically, but it reveals only part of the picture.[1] Stone carving tools are designed to be used in a particular sequence to achieve a specific end product. Successful carving is a methodical craft and as Rockwell puts it, 'stone is worked by a series of simple steps.'[2] Each of these steps builds on its predecessor, progressing from initial quarrying, through roughing-out of the overall form, to more and more detailed work and eventually polishing. How these stages of work are organised, the tools used for each of them and the way in which they are combined in sequence will impact significantly on the final result.

Sequence

There is no uniform method for stone carving, in the same way as there is no set series of tools. As a rule, carvers will progress from the general to the specific, but the exact processes that they undertake and the way they carry them out will vary depending on their personal preferences, their training, the material being carved or the desired effect. They might skip over certain stages of work, therefore, or miss out others altogether. And though different tools are adapted to suit different stages of work this relationship is far from fixed.

A typical sequence of carving on marble, then, might progress as follows: a carver will begin working on a block with a point, to remove large quantities of stone and rough-out the basic form required; they will then move on to a tooth chisel, which they use to create clear surfaces and give definition to the form; then they will use a flat chisel to eliminate the traces of the tooth chisel and add detail; and finally further smoothing will be applied with the rasp and, if required, increasingly finer forms of abrasives. A different carver, however, might not use the tooth chisel at all, moving instead straight from point to flat chisel, or might use it instead for surface finishing. Sometimes the roundel is used in place of, or in addition to, a true flat chisel, while the drill is routinely employed for detailed work where depth is required. Breaking down this sequence tells us not only which tools were employed in the Roman period but, more interestingly, how they were used, which in turn highlights more obscure differences in stone carving across this region and over time.

On fully-finished carvings, on which the final surface finish eradicates traces of the preceding stages of work, reconstructing this sequence of tool use is often impossible. In order to understand the progression from one tool to the next and the decisions made by the carver during these processes we are consequently reliant on part-finished objects. Three examples from our dataset illustrate how this sequence can be broken down.

First, the entablature block of the Temple of Vespasian, now in the Capitoline Museums, datable to the 80s AD {Fig. 1}.[3] Since the left end of this block appears to have been built into a wall, hidden from view, it was never finished and the visible toolmarks allow its working sequence to be reconstructed. Seven distinct processes can be identified:

[1] This essay and the others published on this website are intended to be read alongside and to complement the collection of images on the *Art of Making in Antiquity* website. References are made to images in on the *Art of Making in Antiquity* website throughout, and links provided directly to them.
[2] Rockwell 1993: 12.
[3] PR202_03_01, PR202_03_05; for further discussion of this monument, see Rockwell 1987–8.

1. The block was squared with the saw,
2. The stepped profile of the fasciae of the architrave and the line of the frieze and cornice were roughed-out with the point,
3. The edges of the fasciae, which would become lines of moulding, were chamfered with a flat chisel to indicate their eventual profile,
4. A narrow band of the roughed-out surfaces was carved back to the final surface with the flat chisel; this band appears to have acted as a guide, providing the intended profile of the architrave,
5. Within this band the surface of the fasciae was smoothed with the flat chisel,
6. The fasciae of the architrave on the right side of the block were carved using the flat chisel, the profile being transferred from the narrow band (4), presumably with the aid of callipers,
7. Detailed carving of the foliage in the moulding was carried out on the right of the block.

The individual stages of work that the detailed elements of the mouldings on the right of this block went through are impossible to identify because these parts were largely finished. However, the unfinished left end provides a remarkable insight into the preparatory stages of carving on this project.

A similar series of processes can be seen on a part-finished garland sarcophagus from Aphrodisias, probably datable to the late 2nd or more likely the 3rd century AD {Fig. 2}.[4] The chest of this example is fully-finished along its front side, roughed-out along its rear side, while both states of finish are visible on its short sides.[5] On its right short side, in particular, the sequence of tools employed is especially clear:

1. This end of the chest was first sawn, perhaps because it was felt a useable slab of stone could be removed, and the resulting smooth surface can be seen on the right hand side,
2. Into this flat surface the basic geometric form of the garland was then marked out with the point and the surrounding area carved back to the background plane. A centre point can be noted in the middle of the round boss from which measurements for the arrangement of the geometric form appear to have been taken,
3. The garland on the right remained in this condition but on the left the decorative details of the garland, the central flower motif and the corner support were defined with the tooth chisel (the marks of which can be seen on the background around the hanging grapes),
4. All of these details were then finely shaped with the flat chisel,
5. Further definition of the grapes was achieved with the drill, the marks of which can be seen in places though not all over the bunch.

Rasp marks are not clear on this side, though they can be identified in places on the front side of the chest. The carver responsible for this chest employed a fairly full range of tools for this project and structured his work in a highly methodical manner, entirely roughing-out the basic design before beginning on more detailed carving.

The fact that the sequence in which tools were used was by no means standardised and varied considerably according to the preferences of individual carvers and the project being undertaken is shown by a statue also from Aphrodisias, again datable to either the 2nd or 3rd century AD {Fig. 3}. On this part-finished, fragmentary statue of Hermes from the West Necropolis a different, altogether more fluid series of working stages can be identified.[6] From the toolmarks on this object we can identify the following sequence of processes:

1. The basic form of this figure was first roughed-out from an approximately rectangular block using the point chisel; the vestiges of this stage can still be seen down the figure's left hand side, on the cloak, tree stump support, as well as on the rear of the block,
2. A series of measuring points on both legs of the figure appear to have been applied during the roughing-out process, presumably to act as reference points to guide the carver,
3. Following this, rough shaping was carried out with a combination of the flat chisel and roundel on the torso, legs and arms of the figure,
4. Other details, like the decoration of his caduceus, were sketched in with the flat chisel but left for further definition later.

The tooth chisel is not used at all on this particular project, while the carver is quite happy to switch between rough work with the point and finer work with the flat chisel and roundel. There remains, in fact, a large amount of excess stone around the legs of this figure that still needed to be removed with the point. The presence of measuring points might indicate that the carver was working from a sketch or a maquette.

[4] Isik 2007: 113, Cat. No. 48.
[5] PR305_02_04, PR305_02_08, PR305_02_09.
[6] PR307_02_14.

These examples illustrate carving sequences, that is the way in which specific tools were used to undertake certain defined processes in order to achieve a particular result. However, the creation of a monument will involve a whole series of other processes, beyond carving, that also need to be considered. Most stone, for instance, is acquired via quarrying, which is in itself a form of carving designed to remove a block of stone from the bedrock. Once quarried, stone then needs to be transported to where it will be used. On building projects, stone blocks need to be lifted into place, a further process requiring specialist equipment and sometimes expert personnel. The different stages of carving can be undertaken at any point after the stone has been quarried: before it is transported, once it has been transported but before it is put in place, or even after it has been put in place. Finally, we should not forget that carving work often relies on precise planning or measuring carried out before any stone is removed and the desired effect is often only achieved via successive stages of finishing with abrasives, paint or even gilding. All of these processes together, deployed in a particular sequence dependent on particular circumstances or preferences, combine to make up the 'project'.[7]

Quarrying

The first stage of any carving project that is not using second-hand material involved the quarrying of a suitable piece of stone.[8] Quarrying in the Roman period was undertaken with the quarry pick, sometimes the point chisel, and wedges. Once a suitable section of rock was found, and any overburden cleared, separation trenches would be cut along the sides and rear of the block that was to be removed with the pick.[9] If the quarryman was using a long-handled pick then these trenches could be quite narrow but in the case of very large blocks they might have been wide enough for a worker to stand inside. The alternating bands of curved marks left by the quarry pick as the workmen moved to and fro are often visible on the walls of these trenches; the resulting traces on the stone are often described as festoon-shaped (*a festoni* in Italian) {Fig. 4}.[10] Once these trenches were cut, shallow holes would then be carved out with the point around the bottom of the block, where it was still attached to the bedrock.[11] Into these, iron wedges would be hammered to encourage the stone to split from the bedrock. Sometimes the holes for these wedges were carved quite deeply and wooden wedges inserted which, when soaked in water, would expand and split the rock.

The saw was occasionally also used for extracting material directly from a quarry face. In the Bacakale quarry at Iscehisar (ancient Dokimeion) there are traces left by a saw.[12] This was a long saw which must have been suspended from a wooden frame by a system of pulleys and weights. It would have been positioned above an outcrop of stone and operated by two quarryman standing at either end, perhaps in specially cut separation trenches. This would have been a useful tool for cutting thin panels of marble straight from the quarry face which would not then have needed much further working on their surfaces.

Most ancient quarries were opencast but occasionally, when particularly high-quality veins of stone were covered by a considerable overburden, stone was also extracted via underground galleries. Such galleries have been found at the quarries on Paros and tunnels leading to others are known in the Bacakale quarry at Iscehisar.[13]

In later periods explosives were used to dislodge material from the rockface. Modern marble quarrying is usually done with diamond wire saws allowing for enormous blocks to be extracted, which are then sawn into smaller panels.[14] Pneumatic drills are also employed to create holes into which edges are then hammered to split the stone.[15] At some modern quarries, however, more traditional methods of quarrying can still be seen. At the *peperino* tuff quarries near Marino, in the Alban Hills south-east of Rome, blocks are still extracted with specially-designed long versions of the point. The quarryman uses this tool to carve narrow separation trenches along the side and rear of the desired block.[16] The block is then split from the bedrock using numerous small flat wedges, or sometimes a bundle of point chisels,

[7] Rockwell 1993: 142–55.
[8] Rockwell 1993:156–65; Adam 1999: 20–9.
[9] The marks left by the pick on the sides and bottom of these trenches are common in Roman quarries. At Aliki on Thasos: PR114_03_21; at Aphrodisias: PR309_03_05, PR309_07_02, PR309_08_06, PR309_11_10, PR309_11_12; at Altintas: PR311_01_14 PR311_01_15; at Iscehisar: PR311_02_15, PR311_03_13, PR311_03_21; at Carrara: PR228_01_13, PR228_01_16, PR228_02_01. Separation trenches around blocks which was never extracted can be seen at Aphrodisias: PR309_11_03, PR309_15_16; and Altintas: PR311_01_04. Aborted trenches on which work had only just begun have also been documented, at Aphrodisias: PR309_09_10, PR309_09_12; and at Carrara: PR228_01_14.
[10] PR311_02_15.
[11] For wedge holes: at Aliki on Thasos: PR114_03_24; Aphrodisias: PR309_06_05-08, PR309_06_ 06, PR309_06_ 07, PR309_06_08, PR309_09_18, PR309_09_21, PR309_09_24; Bacakale: PR311_03_13; Saliara on Thasos: PR114_02_18.
[12] PR311_03_15, PR311_03_19.
[13] On Paros, see Korres 2000; on Bacakale, Waelkens, de Paepe, and Moens 1986: 114.
[14] Large modern quarry with diamond wire saw in use at Carrara: PR927_01_22.
[15] For an image of wedges used following pneumatic drilling, see PR316_02_13 from Marmara Adasi.
[16] PR932_01_10, PR932_01_11, PR932_01_13.

hammered into the stone along its base {Fig. 5}.[17] The block is then pulled off the quarry face with a rope down to a point where it can be loaded for transport.[18]

Transport

Where a particular stone outcrops is determined by the underlying geology and not all areas contain stones suitable for all types of project. As a result, stone, once quarried, usually has to be transported some distance to the site at which it is to be put to use. Transporting a material as heavy as stone is far from easy. Most hard limestones or marbles weigh between 2,500 and 2,800 kg/m^3.[19]

The first obstacle was to get quarried material out of the quarry. Quarries are often located in areas of steep terrain and ox-drawn carts suitable for the transport of stone blocks overland struggle on gradients of over 5%. In most cases, then, quarried material had to be slid out of the quarry on sleds or over rollers to a point where it could be safely loaded on to a vehicle. Slipways for sliding blocks along are common in Roman quarries.[20] At Mons Claudianus in the Eastern Desert in Egypt these slipways are simply compacted routes down the hillside from the numerous quarries to loading ramps on the valley floor.[21] Similar slipways are visible in the Pentelic quarries north of Athens.[22] On steeper slopes sleds carrying stone blocks would have to have been lowered using a winch system to stop them sliding away. This method is called the *lizza* and is well-documented in nineteenth-century Carrara.[23] The descent of the sled is controlled by ropes looped around upright posts, fixings for which are known from a number of Roman quarries.[24] This task is an art form in its own right and in large quarries would probably have been performed by specialised teams of workmen.

Once material had been brought to an area flat enough to allow access to vehicles it then had to be loaded. At Carrara, a railway was built in the nineteenth century for the transport of marble from the quarries but now large trucks are used.[25] In the Roman period, ox-drawn carts would have been the most common vehicles used for overland transport but Vitruvius talks about a series of purpose-built vehicles for the movement of stone.[26] The very largest blocks could not have been carried in carts and were probably just pulled over rollers by oxen or men. Cranes would have been needed to get blocks on and off these vehicles, both at the quarry and at the place where the material was needed.[27]

Quarries located immediately next to the sea had an important advantage in this respect. Long distance transport of stone is much cheaper by sea than by land and it is infinitely preferable to be able to load blocks directly from quarry to ship than to have to transport it overland first. This explains why some of the largest white marble quarries exploited in the Roman period were located on the coast. Particularly well-positioned from this perspective were the island quarries on Thasos, in the northern Aegean, and Prokonnesos (modern Marmara Adasi), in the Sea of Marmara. On Thasos, two types of white marble, one calcitic and one dolomitic, were quarried in vast quantities throughout antiquity but especially in the Roman imperial period.[28] The quarries of these lithotypes –at Salaria, Cape Vathy and Aliki– were all on the seashore.[29] The largest of these were at Aliki, where the traces of ancient extraction and the fixtures for cranes and other machinery to assist the loading of quarried material directly onto ships have been studied and mapped in detail {Fig. 6}.[30] The Prokonnesian quarries were not quite so well-appointed with regard to onward transport but most of the quarries were within 1–2 km of the harbour at modern Saraylar and quarried material could easily be slid down the hillside to waiting ships. This harbour remains the centre of the marble export industry on Marmara Adasi {Fig. 7}.[31]

[17] PR932_01_14, PR932_01_16.
[18] PR932_01_04.
[19] Meaning that a 1 m^3 block of marble weights roughly the same as large family car.
[20] PR103_01_17.
[21] Peacock and Maxfield 1997: 260–1, 267.
[22] PR103_01_11, PR103_02_02.
[23] Adam 1989: 30, fig. 31.
[24] PR103_01_12, PR103_01_13.
[25] PR927_01_24.
[26] Vitruvius, *De Architectura* X.2.11–12 .
[27] Adam 1999: 43–51.
[28] Herz 1988.
[29] PR114_01_07-08, PR114_01_19.
[30] Sodini, Lambraki and Koželj 1980. For images of these quarries: PR114_03_12, PR114_03_14, PR114_04_02, PR114_04_12, PR114_04_14.
[31] For an image of marble being loaded into a ship at Saraylar, see PR316_03_12, PR316_03_14.

Stone was certainly shipped around the Mediterranean in large quantities in the Roman period, both short and long distances.[32] At one end of the scale, local building stones were routinely moved by sea if this was an option. At the other end, fine marbles from the eastern Mediterranean were shipped to those areas where there was high demand for them, especially those regions lacking their own marble sources: the Levant, around the Adriatic, central and southern Italy, and much of North Africa. Our best evidence for this practice comes from shipwrecks.[33] A wide range of cargoes of stone have been recovered from these sites, comprising raw blocks, roughed-out architectural elements, statues and sarcophagi, and in some cases finished items, both new and second-hand.

Planning and measuring

Carving stone is a subtractive process and it is hard to put back stone that has already been removed.[34] As a result, most stone carving projects are carefully planned. When the finished product has to closely resemble a specific subject or match another product (as in the case of architectural elements), this planning process might also require close measuring. This process could be done before or after transport. In the case of major architectural elements, like monolithic columns, their precise proportions had to be carefully planned out before they were roughed-out and in some cases even before they were quarried. Certain columns found abandoned in Roman quarries had their entasis, the vertical curvature of their shafts, already carved.[35] Many of the marks left over from this stage of planning and measuring, however, were made once the stone arrived at its destination, whether a building site or a carver's workshop. They were intended to help the carver lay out their design and execute it correctly. For this reason, such guidelines are most common on architectural projects, where very specific dimensions and proportions were required to ensure that different elements fitted together into a unified structure.

Laying-out

Most guidelines were probably applied directly on to the surface of the stone with impermanent materials, like paint or charcoal, and have since vanished. Occasionally, though, more permanent guidelines are visible, engraved into the surface of the stone, especially on unfinished objects.

Guidelines for fluting are a case in point. Fluting is a delicate operation which has to be done once the column shaft or drums are upright and it is vital that the flutes are carved parallel to each other. To ensure that the spacing of the flutes, and the width of the fillets between them, was correct across each shaft, the carvers of the columns of the Temple of Vespasian used a series of guidelines {Fig. 8}.[36] First, the space between the flutes (i.e. the fillet) was marked out with pairs of circles, drawn from central compass holes, probably using callipers; one larger circle defined the roughed-out width of the fillet, a smaller one the final width.[37] Using these circles as a guide vertical lines were then engraved into the stone to mark the edges of each flute. On each flute one of these lines was drawn using a plumb line suspended from a nail, the hole for which can still be seen in places. While the circles could have been inscribed on the ground before the columns were erected, these vertical lines had to have been done after erection. To finish this guide framework horizontal lines were then added around the top and bottom of the flutes to mark out the maximum height of each flute and the point at which their upper curvature begins. These lines are invisible from the ground and so were often left in place but performed a vital role in directing the carver, who must have been operating high on scaffolding.

Other guidelines can be seen on fluted columns at Aphrodisias, though a slightly different approach was taken here. On two columns of the Sebasteion inscribed lines running down the middle of the central flutes can be identified, from which measurements for the rest of the design seem to have been taken.[38] On one of the columns of the Agora Gate, there are a pair of guidelines marking out the width of one flute, which was presumably meant to be used as a model for the others {Fig. 9}.[39] For the columns of the Temple of Zeus at Euromos the carvers responsible marked out the centre point of each fillet with small incised dashes around the top each shaft.[40] These were different solutions to the

[32] Pensabene 1994; Lazzarini 2004; Russell *forthcoming*.
[33] Russell 2011; 2013.
[34] Rockwell 1993: 10.
[35] Wilson Jones 2000: 131.
[36] PR202_01_13; see also Rockwell 1987–8.
[37] A similar method is used for the fluting of the pilasters in the porch of the Pantheon.
[38] PR301_07_23, PR301_07_24.
[39] PR302_07_15.
[40] PR313_01_11, PR313_01_13.

same basic problem and, though the more complex system used on the Temple of Vespasian in Rome resulting in an arguably more refined end product, they all worked satisfactorily.

Compass holes and guidelines similar to those used for the fluting of the Temple of Vespasian in Rome are also found on roughed-out garland sarcophagi, which are decorated with a combination of curved and straight forms. On the right short side of the example from Aphrodisias mentioned above, a compass hole can be seen in the centre of the right hand boss.[41] This point marked both the centre of the boss and the garland and an inscribed line drawn from this point using large callipers can be seen along the bottom of the garland. Similar incised guidelines can be seen on another garland sarcophagus from the city which also has a compass point in the same place.[42] Central measuring points from which measurements, especially of circular elements, could be taken can also be found on the volutes of Ionic capitals at Aphrodisias and elsewhere.[43] And sets of fairly standard guidelines are also common on the top surfaces of Corinthian capitals at various sites.[44]

Measurement

A different sort of guideline, but one which again was meant to act as a sort of model from which carvers could take measurements can be seen on the entablature block from the Temple of Vespasian now in the Capitoline Museums, which is described above.[45] The narrow guide strip carved into the roughed-out end of the block provides a model for the fasciae of the architrave that the carvers responsible for actually carving the design could continually refer to. Using just their callipers they could take basic measurements from this strip, itself probably planned out using accurate dimensions. There was no need for them to keep precise measurements in their head or have access to rulers or tape measures.

The extent to which models or drawings were used in this planning process remains much debated. For a complex architectural form, like the entablature of the Temple of Vespasian, which required careful planning, drawings (essentially architectural plans) must have been used. Models were certainly also employed, especially for statuary. Pliny the Elder, for instance, mentions small clay models produced by the famous sculptor Arkesilaos being in high demand among fellow sculptors.[46] Whether one-to-one models existed from which carvers created exact replicas remains unclear. Raised knobs are found on a small number of Roman statues which do appear to be measuring points of some sort {Fig. 10}.[47]

These knobs have been variously used to argue that the so-called pointing system was employed in the Roman period.[48] The pointing system uses a T-shaped frame with a jointed mobile arm to take measurements from one statue and then apply them to another. This frame needs to be first attached to the model, a point taken, and then moved across to the copy, on which it has to be fixed and the particular position of the point marked out.[49] On both model and copy in this system, knobs are used to hold the frame of the pointing machine and as basic reference marks, while the actual points that are being transferred are usually marked with small drilled holes. The knobs found on Roman statues, then, are quite different from the marks left by the pointing system.[50] They are different from the drilled holes which mark transferred points while most of the knobs do not have holes in the middle that could support the T-shaped frame of a pointing machine. There is, in fact, no convincing evidence for the use of pointing system prior to the mid to late eighteenth century.[51] Importantly, even if it could be proved that these knobs were related in some way to the pointing system this would not indicate that the sculptures on which they are found were copies. Sculptors often use the pointing system to transfer measurements from a model in clay or plaster to stone, even when dealing with completely original works.

Rather than marks left by the pointing system, then, these raised knobs were probably reference points that the carver used to check the proportions of their work and its overall arrangement against some form of drawing or perhaps

[41] PR305_02_08.
[42] PR305_01_02; see Isik 2007: 108, Cat. No. 20.
[43] At Aphrodisias: PR302_06_03, PR302_06_04. For examples from the Sile shipwreck, see Beykan 1988.
[44] For examples from Sabratha and Lepcis Magna, see Tomasello 1983: 87–103; Pagello 1992: 235–52.
[45] See Rockwell 1987–8; PR202_02_23, PR202_02_24, PR202_03_01, PR202_03_05, PR202_03_16.
[46] Pliny, *Naturalis Historia* XXXV.155; see Hollinshead 2002: 228–9.
[47] For a list of such knobs and one theory for their use, see Pfanner 1989. For examples: PR210_01_14, PR246_01_04, PR301_01_08, PR307_02_21, PR312_03_19.
[48] Blümel 1955: 44–56; Rockwell 1993: 119–23; Palagia 2003.
[49] For images of the pointing machine in use in the Studi di Scultura Nicoli at Carrara: PR918_01_09, PR918_01_10, PR918_01_13.
[50] Strong and Claridge 1976: 202–3; Rockwell 1993: 118–120.
[51] Rockwell 1993: 118–20.

smaller model. Skilled carvers, who are used to working in this way, can produce three-dimensional statues from two-dimensional drawings. This is how even large-scale sculptures have traditionally been produced in the Laboratorio Morseletto in Vicenza {Fig. 11}.[52] Working from small drawings and photographs the sculptors divide the block on which they are working into a grid and transfer these drawings to it. The arrangement of the figure is essentially planned in two dimensions on the front and then side of the block with certain set reference points used throughout the carving process to ensure that the proportions are correct. It is possible that the raised knobs found on Roman statues are reference points of this kind, used to check that that the overall proportions and orientation of key elements of the subject are correct. It is also possible that the carver used the distances between these knobs when scaling up designs from drawings. Since these knobs are not flush with the final surface of any of the sculptures on which they are found they were not used to mark the depth of the planned carving.

Planning and measuring are often preludes to carving but they also continue right the way through it. The carvers in the Laboratorio Morseletto continually draw on the surface of their statue as they work and sculptors carving portraits will repeatedly re-apply centre lines to their works right up to the final stage of finishing.[53]

Carving

How a carver goes about actually carving their work depends very much on the project in question, the desired final effect, and their own personal approach. Carving as a process can be divided into a whole series of lesser processes, each with their own specific goals and for each of which different tools are best suited. As with so much else in stone carving, these processes are not easily defined and many carvers see no obvious separation between them. Nevertheless, certain broad processes can be noted across a wide series of sculpture, both from the Roman period and later. The following discussion examines the most important of these, providing a description of each of these processes, in the order they were usually carried out, with reference to images in the *Art of Making in Antiquity* web resource.

Squaring

The rough squaring of newly quarried blocks so that they were approximately flat on all sides was a task usually undertaken in the quarry. Ashlar blocks for rough walls were often never carved beyond this stage and sometimes the rear sides of relief panels are left simply squared. This work would usually have been carried out with the point chisel, sometimes the quarry pick.

Squared blocks on which the marks of the quarry pick can be clearly seen are common finds at Roman quarries.[54] Sometimes this work was done with a point held close to the vertical. This was usually the first stage of work that these objects went through. In modern quarries where diamond saws have not been used, rough blocks are sometimes still squared using a pick, as at several places in Turkey.[55] At the tuff quarries near Marino, south-east of Rome, blocks are still squared by hand with the point.[56]

Occasionally rough blocks were sub-divided and squared using the saw, a process that leaves a distinctive flat surface on the block. Sawn blocks at known from the Bacakale quarry, where a saw was also used for cutting material straight from the quarry face.[57] The garland sarcophagus at Aphrodisias described at the beginning of this essay has one sawn end, perhaps from where a section of useable stone was removed for use elsewhere.[58] The entablature block from the Temple of Vespasian also seems to have been originally squared with the saw.[59] This tool helped to create a perfectly flat surface into which more detailed carving could be undertaken. Diamond wire saws are usually used for sub-dividing blocks nowadays but sometimes pneumatic drills in conjunction with plug-and-feathers wedges are also employed.[60]

[52] PR924_2_15, PR924_3_7.
[53] Observed during carving by Andy Tanser and Paul Jakeman.
[54] PR103_02_11, PR311_04_08, PR316_01_20.
[55] Bacakale: PR936_01_22-24; Marmara: PR316_02_10.
[56] PR932_01_17.
[57] PR311_04_08.
[58] PR305_02_04, PR305_02_08.
[59] PR202_02_23, PR202_02_24, PR202_03_01.
[60] Plug-and-feathers on Marmara: PR316_02_13, PR316_02_15.

Roughing-out

This is the initial stage of shaping the form in a very rough way. Roughing-out was often carried out at the quarry to reduce the weight of the object ready for onward transport. The basic forms of the final design are defined at this stage and as much excess material as possible removed. This is almost always undertaken with the point and results in the removal of the largest volume of stone of any stage of carving.

Curved forms, like column drums or shafts, were often roughed-out while being quarried. This is a practice that goes back at least to the Archaic period, as shown by the column drums in the Cava di Cusa quarries near Selinunte (ancient Selinus) in south-western Sicily {Fig. 12}.[61] In the quarries at Aphrodisias, a part-worked circular element, perhaps a drum or a large column base, can still be seen.[62] It was worked mainly with the point but eventually rejected, perhaps because of a fault in the stone. Once these objects were removed from the bedrock they were often then roughed-out further in the quarry before being transported elsewhere. This work was intended to reduce the weight of each object as much as possible before transport but it also helped to identify faults within the stone which could jeopardise any future project. Rejected roughed-out objects, especially column shafts, are a common find at the major Roman white marble quarries.[63] A set of large granite columns which were never put to use still lie in the Yedi Taslar quarries on Çigri Dâg in the Troad {Fig. 13}.[64]

Other architectural elements, such as entablature blocks were also sometimes roughed-out at quarrying sites.[65] A whole series of capitals, intended to be either Corinthian or Composite in their final state, have been found in the Roman quarries at Carrara and are now in the Museo del Marmo there. These capitals were roughed-out so that their basic form and dimensions were established without any detailed carving, which might be damaged during transport, being added.[66] Slightly more intricate roughed-out forms of Corinthian capitals are known from the Prokonnesian quarries, but again delicate decoration was left for carvers closer to the building site.[67] Bases and plinths are also found at both quarries, again generally just roughed-out with the point.[68] It made particular sense to rough-out sarcophagi before they were transported. Roughed-out chests are found in large numbers at the Prokonnesian quarries, sometimes with particular details of their design already sketched-out on them.[69] At the Dokimeian quarries, a particular form of sarcophagus lid type, the so-called *kline* lid, on which a reclining individual or couple is depicted, was also occasionally roughed-out before transport. Four of these lids have been found in the quarries to date {Fig. 14}.[70]

Roughing-out, however, was not a stage of work limited to the quarries; rather, it was simply the first stage of major shaping during which the overall form of the object was defined. Vestiges of roughing-out can be found on objects that were unfinished and on certain areas of completed objects which would have been hidden from view. The entablature block from the Temple of Vespasian discussed above, for example, was roughed-out at the building site.[71] Remains of a similar roughed-out scheme can be found on the corner of an entablature block from the Agora Gate at Aphrodisias.[72] The frieze and upper moulding here were never carved beyond simple roughing-out except on the front of the block, which was presumably more visible. Even the finished reliefs inserted into the Sebasteion at Aphrodisias have small areas of roughing-out left visible on them, especially around the feet of the figures, at the bottom of the panels, an area invisible from the ground.[73] These allow us to reconstruct the stage of work that all of these reliefs would initially have gone through.

[61] PR115_01_01; for more on these quarries, see Peschlow-Bindoket 1990.
[62] PR309_09_02, PR309_09_05, PR309_10_14, PR309_10_15; see also Rockwell 1996: 93–5, fig. 8.
[63] At Aliki: PR114_04_01, PR114_04_02, PR114_04_05, PR114_04_06; at Bacakale: PR311_01_03, PR311_04_03, PR311_04_05, PR311_04_06, PR311_04_07, PR311_04_08, PR311_04_09, PR311_05_16, PR311_05_19, PR311_05_20, PR936_02_01; at Kara Göl near Teos: PR318_01_04, PR318_01_06, PR318_01_07; on Marmara: PR316_03_24, PR316_04_01.
[64] PR940_01_01, PR940_01_02; on these quarries, see Ponti 1995.
[65] Curved and straight entablature blocks on Marmara: PR316_02_07, PR316_04_05.
[66] Large capitals: PR228_02_05, PR228_02_08, PR228_02_10, PR228_02_11, PR228_02_13, PR228_02_14; while a simpler format is also found at the quarries for smaller capitals: PR228_02_16. For more on these objects, see Dolci 1995; 2006.
[67] PR316_04_11, PR316_04_12, PR316_04_18, PR316_04_20; see Asgari 1988.
[68] At Carrara: PR228_02_16, PR228_02_17; on Marmara: PR316_03_21, PR316_05_03.
[69] PR316_05_06, PR316_05_08, PR316_05_10; see Asgari 1990: 112, fig. 3.
[70] Fant 1985: 659; see PR311_01_05, PR311_04_11, PR311_04_12, PR311_05_07, PR311_05_08, PR311_05_15, PR311_06_08, PR311_06_11, PR311_06_13, PR311_06_14.
[71] PR202_03_01, PR202_03_05, PR202_03_06, PR202_03_16.
[72] PR302_02_12, PR302_02_13.
[73] PR301_02_19, PR301_03_03, PR301_03_05, PR301_03_07, PR301_03_14, PR301_04_16.

Part-finished sarcophagi and other reliefs show how more complicated figurative designs were also initially roughed-out all over, usually with the point chisel. The relief of a youthful athlete holding a disc (modelled on the Polykleitan diskophoros) from Aphrodisias is a good example. Marks of the point, held at a range of angles, can be seen all around the figure, the form of which was roughed-out from the background before further work with finer tools was undertaken.[74] This practice of carving from the front plane of the stone into the background, defining any figures or other elements of the design roughly before carrying out more detailed work, is also visible on sarcophagi and is typical of Roman relief carving {Fig. 15}.[75]

Slightly different approaches can be noted on different sarcophagus types, however. Garland sarcophagi had the approximate, almost geometric form of their designs blocked-out with the point before detailed carving began.[76] Sarcophagus carvers in northern Italy, especially at Modena, though, preferred to leave any of the areas on which detailed figure carving needed to be added as roughly worked bosses.[77] In one case, the busts on the lid were also left simply roughed-out.[78] Detailed architectural work, like the finishing of the capitals in the background, was also left rough but all of the other surfaces were essentially finished.[79] In this case, it is possible that the whole design was roughed-out all over and then one specialist finished the architectural framework and smoothed the background before handing over to another who was meant to complete the more detailed work.

Roughed-out statues are rarer than either architectural elements or sarcophagi, perhaps because they could not be put to be put to use until they were finished. A colossal roughed-out statue, probably of an emperor, was found in a shipwreck of Sile in north-western Turkey.[80] This statue is worked all over with the point, its basic form blocked-out and only certain key details of the clothing marked in. It was probably roughed-out at the quarry to be finished at its destination. The roughing-out of this statue closely resembles the traces of this stage of work still visible on the unfinished Hermes from Aphrodisias discussed above.[81] Statues in a comparable state have been found in the limestone quarries near Xylophagou in southern Cyprus as well.[82] In all of these cases the overall form of the statue is essentially defined in two dimensions with work progressing from the front of the block to the back.

Hollowing-out

A sub-category of roughing-out, hollowing-out is a particular type of preparatory work often carried out at the quarry on vessels, basins and especially sarcophagus chests. This process was usually done with the point chisel, though for large spaces the quarry pick might have been used.

Hollowing-out of sarcophagi was almost always undertaken at the quarry before onward transport because it almost halved their weight.[83] Clear traces of this process can be seen on the inside of sarcophagi, both at the quarries and at those sites where they were put to use.[84]

Rough shaping

Following roughing-out a carver will normally begin to add more definition to the form, still working relatively quickly. Often this stage of work is skipped altogether as the carver goes straight from roughing-out to a finer level of shaping. This kind of rough shaping was done with the point chisel, tooth chisel, flat chisel or roundel. On architectural elements and some reliefs that were intended to be finely worked with the flat chisel or smoothed with the rasp or abrasives this first stage of shaping was often done fairly quickly with the point chisel. On a sarcophagus from Aphrodisias the row of figures on the front of the chest has been shaped almost entirely with the point chisel, the tool in this case being used quite carefully but close to the vertical.[85] On another sarcophagus depicting five figures standing in arched niches, the pose and dress of the figures was also modelled with the point.[86] This was not a practice

[74] PR307_02_03, PR307_02_07, PR307_02_09.
[75] On this point, Rockwell 1993: 107–11.
[76] For an example from Aphrodisias, see PR305_01_02, PR305_01_03, PR305_01_04.
[77] PR239_01_02, PR239_01_07, PR239_01_17; for more on the sarcophagi from Modena and other north Italian cities, see Gabelmann 1973.
[78] PR239_01_02, PR239_01_13.
[79] PR239_01_05.
[80] Asgari 1990: 125–6, fig. 28; PR246_01_06, PR246_01_07.
[81] PR307_02_14.
[82] Hollinshead 2002.
[83] Sarcophagus chest from the Saliara quarry on Thasos: PR114_02_06.
[84] Bacakale: PR311_05_08; marks on the inside of a chest from Ostia: PR223_05_10.
[85] PR305_04_06, PR305_04_08.
[86] PR305_03_22, PR305_03_24.

limited to Aphrodisias as two sarcophagi from Ostia show.[87] On both of these examples the point was used to roughly model the figures before they were finished with the flat chisel.

In general, though, this initial stage of careful shaping following roughing-out was done with the tooth or flat chisel. On the Sebasteion at Aphrodisias the tooth chisel was mainly used for this process, on both the reliefs and the fluting of the columns.[88] The tooth chisel was used in the same way on the part-finished statue of an emperor that was discovered in the Prokonnesian quarries on Marmara Adasi {Fig. 16}.[89] The aim of this stage of work was to define the form of the figures, leaving behind a surface that could be easily smoothed and detailed with the flat chisel. The tooth chisel, which is designed itself as an intermediate tool between rough and fine carving is well-suited to this task. Indeed, much later the tooth chisel was also used for rough shaping on the reliefs of Orvieto cathedral, though in this case the carvers alternated between this tool and the small sculptor's pick.[90]

The marks left by this initial stage of rough shaping are only visible on these monuments because they were left only part-finished. Most of the monuments in Rome, in comparison, were more finely finished, making it very difficult to work out the sequence of tools. Several sections of the exterior of the Column of Trajan, however, show that rough shaping was carried out with the flat chisel and indeed may well not have been distinguished from finer shaping by the carvers responsible.[91] Marks of the tooth chisel are not visible on the exterior of this monument but the tool was certainly in the carvers' repertoire, since its marks are found on the interior of the column shaft.[92]

Fine shaping

This is the careful definition of the planned form, usually carried out with a flat chisel but sometimes with a roundel or tooth chisel. This could be a final level of finish if no further smoothing was required. Numerous figures on Roman reliefs were never carved beyond this stage, which could follow immediately on from roughing-out or perhaps as an intermediate stage of rough shaping.

Only very occasionally in the Roman period was the tooth chisel used for fine shaping, though this was a favoured technique of Michelangelo's, many of whose carvings were left with clear tooth chisel marks all over their surfaces.[93] The Sebasteion at Aphrodisias is unusual because the tooth chisel was occasionally used delicately for fine shaping on it but even in this case most of this work was done with the flat chisel or roundel {Fig. 17}.[94] These tools were generally better suited to creating the smooth surfaces required of finished surfaces.[95] When a particularly undulating or rugged texture was needed then the roundel, with its curved end, was a popular choice. On the Column of Trajan and other monuments in Rome this tool was often used for carving leaves or the bark on trees, and sometimes for water or for hair.[96]

Detailing

A sub-category of fine shaping is detailing, which involves the carving of specific minutiae of the form picked out for visual effect. Detailing might include the addition of depth to facial features, drapery or hair with the drill followed by the channelling tool or the use of the corner of a flat chisel to decorate armour or add patterns to clothing, hair or beards. This is work usually only undertaken once the overall form of the carving is basically complete.

Numerous examples can be highlighted where the flat chisel was used to incise decoration into the surface of an already finished surface. This was often done on clothing, especially on chain mail or decorated shields, and on background structures on the Column of Trajan {Fig. 18}.[97] Other examples can be found on the Arch of Constantine,

[87] PR223_01_02, PR223_05_13.
[88] On the reliefs: PR301_01_07, PR301_01_13, PR301_01_14, PR301_01_15, PR301_05_13, PR301_05_14, PR301_05_15, PR301_05_16, PR301_05_17; on the architecture: PR301_07_22, PR301_07_24, PR301_08_02.
[89] Asgari 1990: 126, fig. 29; Attanasio 2003: pl. 28.1; see PR316_05_13, PR316_05_15.
[90] For tooth chisel use: PR500_03_14, PR500_03_15; for the sculptor's pick: PR500_03_03, PR500_04_05.
[91] PR205_1_08_05, PR205_1_10_20, PR205_1_21_01.
[92] PR205_1_16_19, PR205_1_16_20.
[93] Rockwell 2003; PR670_04_18, PR670_05_20.
[94] PR301_01_06, PR301_01_07, PR301_01_11, PR301_01_15, PR301_02_13, PR301_04_23, PR301_05_22, PR301_06_06, PR301_07_03.
[95] For flat chiselling at Aphrodisias: PR303_02_04, PR303_03_02, PR303_03_04, PR303_02_09, PR307_10_19.
[96] PR205_1_02_20, PR205_1_06_20, PR205_1_07_10, PR205_1_11_08; for similar use on the Arch of Constantine: PR210_01_15, PR210_01_16.
[97] PR205_1_02_10, PR205_1_04_09, PR205_1_04_10, PR205_1_15_07.

on both the Trajanic and Constantinian reliefs.[98] On later portraits, especially from the third century AD onwards, the corner of the flat chisel was also used to incise the lines of stubble or short hair in an impressionistic manner.[99]

For detailing that required depth, such as holes in nostrils, ears and eyes or grooves in drapery, the favoured combination of tools in the Roman period was the drill followed by a narrow flat chisel or channelling tool. On architectural decoration, this combination of tools was used especially on foliage, on Corinthian capitals, or lines of moulding.[100] In relief sculpture, drillwork is commonly found in the folds of drapery,[101] and to outline complex forms, such as the fruit and leaves of a garland, as on numerous sarcophagi from Aphrodisias, or the leaves on a tree, as on the Column of Trajan and Arch of Constantine.[102] On other occasions the drill was used simply to create single holes, either to add depth, and thus shadow, to an area or to create a particular pattern. Single drill holes are used in the corner of the eyes and mouth of both Gaius and Lucius on the relief from the Sebasteion.[103] On the Column of Marcus Aurelius, drill holes are used to create the texture of chain mail.[104] In places, drill holes are used to indicate lines of hair and to add depth to curls {Fig. 19}.[105]

Outlining

Outlines around figures and other details when they are set against a flat background are a common feature of Roman reliefs. These outlines are usually carved with the corner of a flat chisel, a roundel or sometimes a channelling tool. Deep outlines are a particular feature of Late Antique relief carving. On reliefs it was important that the figures or other subject matter stand out from the background and to do this outlines were often carved around them, or at least part of them. This practice is attested to a limited degree on the Column of Trajan but is much more apparent on the later Column of Marcus Aurelius, where the massed ranks of figures needed to be distinguished from each other to be legible.[106] An extreme form of outlining can be found on the relief depicting a heroic scene from Ephesos on which all of the figures are deeply delineated to separate them from the rocky background. In this case, the drill may well have been used to achieve substantial depth {Fig. 20}.[107]

Flattening

All of the processes discussed so far (except squaring) were intended to shape particular forms but flat surfaces also had to be carved. Flattening here is defined as the rough working of a surface to provide a flat finish rather than a smooth one. Ashlar blocks in rough walls might be flattened on all sides without being smoothed, and often the bottom of relief panels which would have been hidden from view are simply flattened off.

This kind of rough flattening was usually achieved with either a tooth chisel or flat chisel. Even on large and ornate monuments like the Arch of Titus at Rome or the Arch of Trajan at Benevento, the undecorated surfaces were often fairly roughly flattened rather than smoothed. On both of these structures, the surfaces beneath the main relief panels of the passageway were worked over with the tooth chisel.[108] The surviving original fasciae of the entablature block of the Temple of Vespasian were also flattened with just the tooth chisel.[109]

At Rome, the backgrounds of reliefs were usually smoothed further than this state, but at Aphrodisias it was common for these areas to be roughly flattened with the tooth chisel. This resulted in a surprisingly rough texture against which the smooth surfaces of the figures stood out and was evidently a deliberate stylistic choice. This practice is especially clear on the reliefs of the Sebasteion {Fig. 21}.[110]

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[98] PR210_02_12, PR210_03_09.
[99] PR312_03_11.
[100] On the Temple of Vespasian: PR202_02_07, PR202_03_04; on pilaster capitals from Aphrodisias: PR302_06_20, PR302_06_23. On the Arch of Trajan at Benevento: PR225_02_09. For similar use of the drill on a sarcophagus: PR305_05_16.
[101] On a sarcophagus from Ostia: PR223_01_15; on the Sebasteion: PR301_07_03.
[102] Aphrodisias: PR305_03_08, PR305_03_12; Column of Trajan: PR205_1_05_13, PR205_1_15_06; Arch of Constantine: PR210_01_16, PR210_04_09.
[103] PR301_04_24.
[104] PR208_01_02, PR208_01_05, PR208_01_12; for drill holes on armour on the Arch of Constantine: PR210_01_16.
[105] PR210_05_04, PR221_03_01, PR225_02_15.
[106] Column of Trajan: PR205_1_03_13, PR205_1_05_13, PR205_1_08_14, PR205_1_14_03; Column of Marcus Aurelius: PR208_01_03, PR208_02_02.
[107] PR312_03_13, PR312_03_14.
[108] PR204_04_20, PR204_06_07, PR225_03_24.
[109] PR202_03_14.
[110] PR301_01_24, PR301_02_13, PR301_03_06, PR301_04_06, PR301_06_21.

In Britain, and other areas where soft limestones and sandstones were the usual materials of sculpture, flat surfaces were often worked over with wide flat chisels, so-called droves or bolsters, or sometimes flat-headed axes.[111]

Smoothing

Smoothing, on either flat areas or more complicated forms, was achieved in a variety of ways in the Roman period. Sometimes careful flat chiselling was all that was required but in most cases a rasp, or sometimes a scraper, was used. Rasping, in fact, is the most common finish on Roman relief sculpture in marble, especially on drapery and the flesh of figures. A rasped finish also seems to have been the preferred surface for the application of paint.

Rasp marks can be identified on most of the major imperial monuments at Rome, as well as on large-scale public reliefs elsewhere, such as the Sebasteion at Aphrodisias. In most cases, the rasp was used to smooth drapery or skin surfaces. It was used systematically on these areas on the Column of Trajan at Rome and Arch of Trajan at Benevento {Fig. 22}.[112] The rasp was also used for smoothing skin surfaces on the Sebasteion at Aphrodisias, though in practice a range of finishes are found on these areas: some figures were worked with the flat chisel or roundel, others were left roughly tooth chiselled, and a couple were polished with abrasives.[113] On flat surfaces, smoothing was usually done with the flat chisel. In general the background on the Column of Trajan is flat chiselled, though there are areas of rasping.[114] On the Arch of Trajan at Benevento the background is systematically flat chiselled.[115] Marks of the scraper are also found on various Roman monuments, notably the Ara Pacis and Column of Trajan. This tool was used as an alternative to the rasp but produced a slightly coarser finish.[116] On the Ara Pacis it has been argued that the scraper marks are later, signs of post-Augustan restoration, however scraper marks are found on much pre-Augustan sculpture so there is no reason to assume its use is late.[117]

Further surface finishes

All of the carving processes discussed up to this point could have been done with a small selection of tools and completed by most carvers. Further levels of finishing, especially polishing and painting, however, required different equipment and have, throughout history, often been carried out by specialist craftsmen.

Polishing

Polishing is distinct from smoothing because it is not done with a chisel or rasp but instead involves abrasive stones or powders. There are different gradations of polish, ranging from a basic matt one to an extremely high gloss finish, which require progressively finer abrasives to achieve. A matt polish, for instance, can be achieved by rubbing emery, sandstone or pumice over the surface of the stone, usually with water to help lubricate the process. Higher grades of polish can then be achieved by using finer substances, like sand and burnt and crushed animal bones mixed into a paste with water.[118] Only certain stones can be polished, among them marble, various hard granites and porphyries, and certain types of limestone.

Matt polishes are common on high-quality Roman sculpture and high gloss finishes are also found, though these are rarer on ancient works than on Baroque and modern sculpture. Gloss polishing is typically limited to high-end portraits, of either emperors or members of the elite. The Flavian or early Trajanic portrait of a woman in the Capitoline Museums is a good example, though it should be noted that the authenticity of this as ancient polish cannot be verified –polish was sometimes added to ancient statues in the Baroque period.[119] At somewhere like Aphrodisias the genuine antiquity of the polish can be more easily verified since most of the statues here were excavated recently. The polish on the head of a goddess from the Hadrianic Baths, therefore, is certainly Roman.[120] The same can be said for the male head from Ephesos {Fig. 23}.[121]

[111] Blagg 1976: 161–2.
[112] Column of Trajan: PR205_1_08_11, PR205_1_08_12, PR205_1_08_15; PR205_1_11_08, PR205_1_14_03; Arch of Trajan at Benevento: PR225_02_16, PR225_02_23, PR225_03_06.
[113] For rasp marks: PR225_04_14.
[114] PR205_1_01_07, PR205_1_07_17; for rasping: PR205_1_06_18, PR205_1_07_02.
[115] PR225_02_14.
[116] PR205_1_06_18; PR205_1_07_10.
[117] On this point, Conlin 1997: 49–50.
[118] Rockwell 1993: 48–50.
[119] PR222_03_02.
[120] PR307_03_02, PR307_03_04, PR307_03_08.
[121] PR312_03_08, PR312_03_09, PR312_03_11.

Gloss polishes are much rarer on Roman reliefs than free-standing statuary. On most of the major imperial monuments at Rome the flat chisel or rasp was used to apply the final level of finish to the stone. At Aphrodisias, however, sections of the Sebasteion were worked with abrasives to create a matt polish.[122] And marble sarcophagi were occasionally polished, at Rome and elsewhere.[123] Polishing is a time-consuming process and in the post-antique period a short cut was often turned to which involved rubbing the surface of the stone with wax. This was often done to Roman statues to make them look smoother or newer.[124] Over time this wax finish tends to discolour, explaining the yellowish hue often found on sarcophagi and statues in museum collections or churches in Rome.[125]

Lettering

Inscriptions are common features of many Roman monuments, used to record those who paid for them, the occasion on which they were erected, what they depict and their date. The addition of inscriptions is usually a stage of work undertaken once all other carving on a monument has been completed.

Letter-carvers are sometimes specialist craftsmen but this work could also be done by an ordinary carver if they were trained in it. In the Roman period most letters were carved with the corner of a narrow flat chisel. The style of the letters varied considerably by region but also by period. Dedicatory inscriptions on architectural projects were often very formally arranged.[126] But other types of inscribed label are also found on carvings. Sometimes these are carved on to reliefs to identify the figures or other subject matter represented.[127]

On other occasions small inscriptions or *graffiti* are found which had a completely different function to the inscriptions on the facades of monuments. Hastily composed examples are found on raw blocks extracted at quarries under imperial oversight, for example.[128] These recorded the individual responsible for quarrying the block, where it came from within the quarry and the date (given by the name of the consuls of that year). Such inscriptions were part of a widespread accounting system attested, with some variations, at most imperially-controlled quarries.[129] Not all *graffiti* were administrative. Most, in fact, were used by carvers or builders simply to label where blocks should be placed or what they were used for.[130] Sometimes *graffiti* are attested which appear to be actual graffiti in the modern sense, idle doodles or the names of people who were bored; gaming boards are common in Roman cities, especially on the paving of public spaces.[131]

The letters of inscriptions were often painted; traces of red paint are common.[132] On large monuments in Rome and elsewhere metal letters were also used, inserted into the facades of buildings to make up the major dedicatory inscriptions. These metal letters rarely survive but the marks left by them can still be seen on these monuments and their content reconstructed.[133]

Painting

A large proportion of the sculpture produced in the Roman period, and the earlier Classical and Archaic periods, was painted. This is true of free-standing statues, reliefs and architectural carvings. Very little of this paint has survived and even where it can still be seen with the naked eye it is clear that ancient pigments deteriorated rapidly. The study of the painting of statuary has been boosted relatively recently by the development of a host of new analytical techniques, chemical, physical and photographic.[134] These can be used to identify what pigments were used even when they are no longer visible and are beginning to show that Roman sculpture painting was extremely sophisticated. A

[122] PR301_06_06.
[123] PR222_06_13
[124] PR222_01_06.
[125] Personal observation, Peter Rockwell.
[126] See Grasby 1996; 2002; also PR301_08_15, PR301_08_17, PR301_08_18.
[127] PR303_01_18.
[128] PR228_02_16, PR228_02_23, PR311_04_08, PR311_06_05.
[129] For more on these inscriptions, see Fant 1989; Pensabene 1994; Hirt 2010.
[130] PR302_07_14.
[131] See, for example, Trifilò 2011.
[132] See Pliny the Elder, *Naturalis Historia* XXXIII.40; Keppie 2001: 15.
[133] Fixing points for the metal letters survive, for example, on the Arch of Septimius Severus, see Brilliant 1967: 74, pl. 16a-b.
[134] On recent developments in this field, see Bradley 2009a; 2009b; Verri, Opper, and Deviese 2010; the various contributions in Brinkmann, Primavesi, and Hollein 2010; Brinkmann and Scholl 2011; Liverani 2004; and the website and preliminary reports of the Tracking Colour project at the Ny Carlsberg Glyptotek in Copenhagen: www.trackingcolour.com.

wide colour palette was achieved using a range of minerals, ground down and mixed together to create a spectrum of pigments which were then combined with various binders to help them adhere to the stone.

Traces of paint can be seen on the details of numerous well-known Roman statues, perhaps most famously the Prima Porta Augustus.[135] Paint residues tend to survive in the deep grooves of clothing or hair, where they are protected from weathering. A red-brown colour was applied to the hair of the goddess from the Hadrianic Baths at Aphrodisias and her pupils and irises were also painted in {Fig. 24}.[136] Similar colouring can be seen on the statue of a young male from Ephesos.[137] A female head which is probably also from the Hadrianic Baths at Aphrodisias and which is now in the Ny Carlsberg Glyptotek in Copenhagen has been carefully analysed as part of the work of the *Tracking Colour* project.[138] On the hair of this statue a base layer of carbon black was identified on top of which red paint had been applied, as well as some gilding. Several shades of red were used, one made of ochre, umber, lead and copper and another also including cinnabar. VIL imaging techniques also identified scattered particles of Egyptian blue in the hair, suggesting that a range of colour tones and shades were used. The statue's lips were painted red and carefully shaded while the skin of the face seems to have been given a light flesh colouring using a complex mix of pigments.

Work by the *Tracking Colour* project has also demonstrated that even high-gloss polished surfaces of marble statues were painted over. One example of this is a head of the young imperial prince Gaius Julius Verus Maximus, dated to AD 235–8, in the Ny Carlsberg Glyptotek.[139] The skin of this figure is polished to a high gloss and recent analysis suggests that it was then painted with skin tones made up of red, yellow and even blue pigments. The hair, eyebrows, lips and eyes were also painted. Precisely why the skin surface was polished before painting has yet to be ascertained but the researchers responsible have proposed that this polish might have helped enhance the luminosity of the final work, a theory they hope to test by experiment.

Less work has been completed to date on the painting of architectural elements in the Roman period, although Stephan Zink's study of the Temple of Apollo has shown the potential of this line of research.[140]

Insertion

The growing body of evidence for the polychromy of Roman carvings, whether sculptural or architectural, suggests that most, if not all, works in stone were painted. However, this was not the only way in which Roman artists used additional media to enliven their works. Particular effects were sometimes achieved through the combination of different materials. A particular class of sculpture, known as chryselephantine, made use of gold and ivory together.[141] Certain statues, known as acrolithic, had bodies made of wood with only their heads, arms and legs in stone, while coloured marbles were used in combination with white marble to create elaborate decorative ensembles.[142]

Metal inserts were also used. Holes for the addition of metal jewellery, crowns or solar rays are found on Roman portraits, especially those depicting emperors or Hellenistic kings.[143] And metal weapons were added to large-scale relief sculpture. The best evidence for this comes from the Column of Trajan. Numerous figures on this monument were depicted fighting or chopping wood with empty hands and drill holes in some of these hands, as well as traces of metal, show that they were meant to be provided with metal weapons {Fig. 25}.[144] This addition of metalwork was clearly a second stage of work, perhaps following painting, and the instructions given to those responsible seem to have differed from those given to the carvers. As a result a large number of the figures designed to have metal weapons never received them.[145] These weapons, in combination with the colouring on the monument, would probably have contributed to its legibility or at least its overall decorative impact. Why so few of the planned metal attachments were actually inserted is unclear but it might have been felt that too many weapons would have been distracting or even obscured too much of the relief.

[135] Spada 2004.
[136] PR307_03_02, PR307_03_04, PR307_03_08.
[137] PR307_10_17.
[138] Therkildsen 2012.
[139] Skovmøller and Therkildsen 2011.
[140] Zink 2009.
[141] Lapatin 2001.
[142] Despinis 2004.
[143] On this point, see Bergmann 1998: 112, 242, 249–52, and for examples, pl. 24.1–6, 44.3–6, 47.1–3, 48.2–3; also Johansen 1995: 40 (no. 9), 54 (no. 15).
[144] PR205_1_07_01, PR205_1_07_03, PR205_1_09_10.
[145] PR205_1_07_11, PR205_1_07_12.

Building and additional work

Every carving project is achieved by a sequence of processes. The relative order of most of these is fixed. Quarrying, therefore, takes place before carving, and rough carving before surface finishing. Which processes are undertaken will impact significantly on the form and appearance of the finished work. Where these different processes are carried out is much more flexible. Normally in the Roman period roughing-out, sometimes also rough shaping, was done close to the quarry, prior to transport, with finer carving taking place near to where the object was to be used. Sometimes, however, more detailed carving could also be undertaken at the quarry, as shown by the imperial statues from Marmara Adasi (Prokonnesos).[146] Finished carvings were certainly transported, even if this was generally avoided.[147]

Even on a building site there was some flexibility as to where different stages of work were undertaken. Many of the objects in our dataset, indeed most extant carved Roman artefacts, were originally part of larger, multipart monuments. This is especially true of the reliefs on major public monuments, such as the Sebasteion at Aphrodisias, Arch of Titus or the Column of Trajan at Rome. At least the final stages of carving on these monuments and their constituent elements –reliefs as well as architectural elements– would have been done on the building site and would, therefore, have had to fit into the wider construction project. There are several different ways in which material arriving on the building sites might have been handled. Blocks could arrive unworked, be shaped just enough to allow them to be put in place on the structure and then fully-finished, in most cases with the carver working on scaffolding. Alternatively they could be completely carved on the ground before being put in place. Since it would have been difficult to ensure that decoration passed uninterrupted between blocks a compromise between these two systems can be imagined, whereby carvers finished most of their work on the ground but left a strip of rough stone along the edge of any blocks with continuous decoration which could then be carved in place.

Placement

The solution adopted probably varied through the course of a project as structural work progressed and the carvers adapted to new demands. When the object is a self-contained element, like a capital, then working it on the ground is generally easier for a carver. If it had to be erected so that the building could progress, however, then it would have to have been finished in place, and there is little a carver could do about this. More complex carvings, however, that passed across multiple blocks were perhaps always easier done in place, so that the carver did not have to worry about lining up details across blocks or worry about causing damage to the edge of blocks.

Close examination of the carving across the juncture of blocks can provide an insight into which of these approaches was most common. This has been done by Rockwell for the Column of Trajan and by Beckmann for the Column of Marcus Aurelius.[148] In both cases these authors argue that the carving of the relief on these monuments was done in place since the details of the design cross the juncture between column drums without disturbance and no effort was made to avoid delicate details overlying these divisions {Fig. 26}.[149] Furthermore, they argue that the carvers were working from the bottom to the top of their respective shafts since the decoration on each spiral seems to respond to that on the spiral below.

The evidence from other monuments in Rome and Italy suggests that this was a common approach. On the Arch of Titus the main reliefs on the interior of the passageway are carved across multiple large blocks. Several of the largest block lines pass right through figures.[150] The scene depicting the apotheosis of Titus in the soffit of the arch, meanwhile, is carved across at least five blocks.[151] In theory all of this decoration could have been carved on the ground with strips of rough stone left around the edges of blocks for finishing in place, to ensure that details of decoration lined up correctly across these junctures. However, in these cases one would expect the design to be planned in such a way that crucial details, such as the heads of figures or their delicate hands, were kept away from block edges. This is demonstrably not the case on the Arch of Titus reliefs. In fact, since the whole monument is composed of blocks in a range of sizes, and sometimes even forms, it seems most likely that the structure was essentially built before any of the decorative carving began. Similar conclusions can be drawn from comparable monuments, notably the Arch of Trajan at Benevento.

[146] PR316_05_11.
[147] Russell 2013.
[148] Rockwell 1981–3; Beckmann 2011.
[149] As can be seen on the following images: PR205_1_04_05, PR205_1_12_06, PR205_1_09_15, PR208_01_08.
[150] PR204_03_18, PR204_05_08.
[151] PR204_04_15, PR204_04_16, PR204_04_17.

The alternative approach can be seen on several monuments at Aphrodisias. The mask and garland frieze from the South Agora appears to have been mainly carved on the ground before being put in place.[152] Work was clearly divided in this case between carvers who completed the garland and others who finished the masks since the finish differs markedly between them. However, several of the blocks of this frieze also seem to have rough margins along one or both ends which look very much like areas to be finished in place, at which point the carvers could make sure the various strands of motifs lined up satisfactorily {Fig. 27}.[153] The famous reliefs of the Sebasteion could also have been largely completed on the ground since they are carved on single blocks. However, in this case the place where these reliefs were carved depended on the speed with which the rest of the project was progressing. The Sebasteion panels are built into the architectural framework on the parallel porticoes that constitute the complex. The panels on the first storey, in other words, had to be put in place before work could proceed on the second and third storeys.

Securing

Whether these blocks were inserted into the monument part- or fully-carved they also had to be secured in place, a key part of the construction process. In the Roman period, most stone blocks in large monuments were fixed to their neighbours using a combination of metal clamps and pins.[154] Iron clamps were usually used but tended to be wrapped in lead to prevent them rusting and then set in molten lead to hold them in place. Small channels leading to clamp sockets are a common feature on Roman monuments and were used either for pouring molten lead into or draining it out of the gaps around iron clamps.[155] Metal clamps and pins were also employed on statues to piece together different blocks of stone and on sarcophagi to secure lids in place and prevent their contents being robbed.[156]

Removal

In later periods these metal clamps and pins were often removed by people looking for metal to recycle. Most of the major Roman monuments in Rome and other cities are consequently covered in deep gouges where their metal fittings have been removed.[157]

Re-use

Few major Roman monuments, particular those located in major cities, have survived from antiquity untouched. The removal of metal elements discussed above is one aspect of a wider pattern.[158] Throughout the post-antique period there was demand for both metal and materials that could be burned to make lime, in particular marble and limestone. Many of the monuments in the Forum Romanum at Rome were demolished or stripped of their marble to feed this demand and the same fate befell structures elsewhere. One of the reasons why Aphrodisias is so well-preserved is that the city was never re-settled in any significant way and this kind of on-site recycling remained limited.

As well as the removal of material for recycling, blocks of stone, carved or otherwise, from Roman monuments were often taken for re-use in other structures. This was a practice that went on throughout the Roman period itself, as refurbishment and demolition projects generated salvageable material, but it was especially widespread in Late Antiquity and later.[159] Many of the largest Medieval buildings in central Italy were built almost entirely out of material spoliated from ancient structures. Churches in Rome are full of earlier Roman columns given a new lease of life. The façade of Orvieto cathedral was almost entirely built out of re-used ancient marble blocks, many brought from Rome and Ostia for this purpose. A wide range of block sizes were employed including some that had clearly been columns previously.[160] Newly-quarried stone, from quarries local to Orvieto, was generally limited to structural uses behind the façade.

[152] Although for a different interpretation, see De Chaisemartin 1999.
[153] PR320_01_22.
[154] Adam 1999: 54–8.
[155] On the Column of Trajan: PR205_1_16_13; on the end of a column in Aphrodisias: PR301_08_11.
[156] Statues: PR307_04_11, PR307_04_12; sarcophagi: PR305_02_08, PR305_02_13.
[157] PR203_01_07, PR204_05_03.
[158] Rockwell 1993: 187–97.
[159] On salvaging in the Roman period, see Barker 2012.
[160] PR500_05_13, PR500_05_14.

Other objects were re-used for different purposes. Sarcophagi were useful containers and were often re-used as tombs. At Aphrodisias some sarcophagi were employed in the Ottoman period as containers for the fermentation of grapes to make pekmez, a sort of molasses.[161]

Restoration

Signs of repair and restoration are common on Roman monuments. Most are post-antique, though there is plenty of epigraphic evidence for the repairing of monuments throughout the Roman period.

Several forms of restoration can be identified, some beginning surprisingly early. An interesting sarcophagus in the collection of the Capitoline Museums bears traces of early restoration attempts, perhaps datable to as early as the fourteenth century.[162] Several of the figures on this sarcophagus, depicting Meleager hunting the boar, had clearly been damaged and attempts were made to repair them. A female figure in the middle of the chest had a new face added and the nude male figure on the right end had his entire head re-carved.[163] Various attempts were also made to give some new emphasis to the scene. Drill holes were added to the dogs, therefore, and also the boar, perhaps in imitation of the original drilling in these areas.[164]

Large metal clamps dating from the Medieval and early Modern periods can also be identified on a number of monuments. These include large structures, like the Column of Marcus Aurelius, as well as smaller statues and sarcophagi which were repaired when they were re-used.[165] One of the earliest monuments in Rome to be substantially restored was the Arch of Titus. This arch was built into the fortified palazzo of the Frangipani family in the Medieval period, a fact which helped to preserve its central section. In the early nineteenth century this palazzo was demolished and attempts made to restore the arch to its original state by Raffaele Stern in 1817 and then Giuseppe Valadier in 1821.[166] As part of this process the sides of the arch were re-built in travertine to distinguish them from the original white marble, a deliberate differentiation of materials that is still employed in restoration projects today.[167]

As well as this kind of large-scale rebuilding project, many statues and reliefs, especially at Rome, have been more subtly restored. Replacement noses, hands or other projecting details are a common addition, while fig leaves were commonly added, especially in European collections, to cover up genitalia. Restoration of this kind was very widely undertaken throughout the eighteenth and nineteenth centuries but more recently many later replacements have been removed from Roman monuments. The marks left by this activity are especially clear on the Ara Pacis, where most of these later addition were removed towards the end of the twentieth century and the pin holes that attached them filled in.[168]

Conclusions

As Rockwell puts it, "Methods are frameworks that a stoneworker applies in order to organise the work process… [They] help the stoneworker to arrive at the finished product."[169] A project, whether building a monument or carving a sculpture, requires a structure, planned out in advance, to ensure its proper completion. The organisation of work processes can be read, or deduced, from the surviving evidence and from that a sequence of actions, either general or highly specific, can be proposed. This should, however, take into account the variety of approaches available at each of the different stages in making which are effected by the individual(s) involved or the problem that needed to be solved, both of which might be further modified by time and place. Recognising these differences, and extrapolating data from them, is crucial to understanding stoneworking on a macro and micro level. In order to assess exactly this sort of variety in the organisation of work, the next essays focus on a series of specific monuments, from both Rome and the Roman provinces. In the final essay, the individuals involved in this process are then considered in more detail, so as to strike the balance between the production of large monuments and the role of the artist-craftsman within them.

[161] PR305_01_02.
[162] La Rocca and Presicce 2010: 196-199, Cat. No. 21.
[163] PR222_06_20, PR222_07_11.
[164] PR222_06_20, PR222_07_08.
[165] On the Column of Marcus Aurelius: PR208_01_06, PR208_01_12, PR208_03_03, PR208_03_04; on a sarcophagus from Modena: PR239_01_12.
[166] Pfanner 1983: 9–12.
[167] PR204_03_01, PR204_03_02, PR204_03_04.
[168] PR201_01_14, PR201_01_18, PR201_01_20, PR201_02_01.
[169] Rockwell 1999: 69.

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Figures

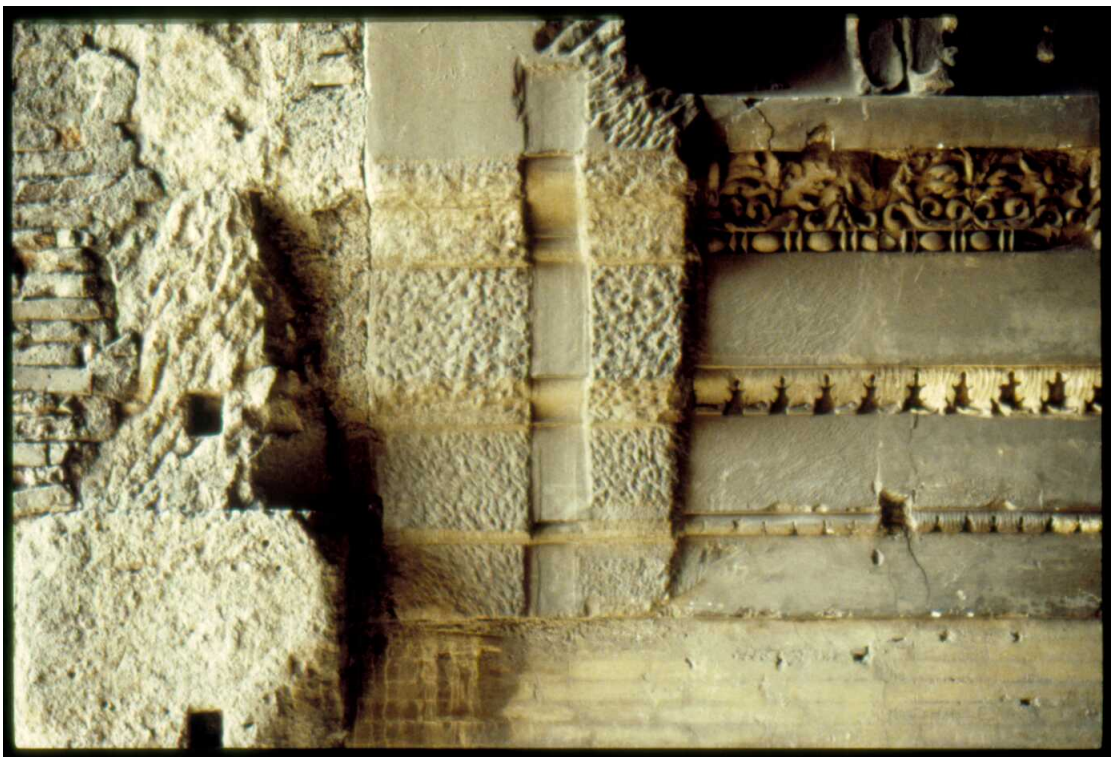

Figure 1: PR202_03_01: Entablature block from the Temple of Vespasian, Rome

Figure 2: PR305_02_04: Short side of a part-finished garland sarcophagus, Aphrodisias

Figure 3: PR307_02_14: Roughed-out statue from the West Necropolis, Aphrodisias

Figure 4: PR311_02_15: Quarry-face at Iscehisar (ancient Dokimeion), Turkey

Figure 5: PR932_01_14: Quarrymen using chisels as wedges in the tuff quarry at Marino, Italy

Figure 6: PR114_03_15: Quarries at Aliki, Thasos

Figure 7: PR316_03_13: Marble blocks being loaded on to a ship at Saraylar, Marmara

Figure 8: PR202_01_13: Guidelines on a column of the Temple of Vespasian, Rome

Figure 9: PR302_07_15: Column from the Agora Gate, Aphrodisias

Figure 10: PR246_01_04: Dacian prisoner in the collection of the Vatican Museums, Rome

Figure 11: PR924_2_15: Carving in progress at the Laboratorio Morseletto, Vicenza

Figure 12: PR115_01_01: Roughed-out column drums in the Cava di Cusa, near Selinunte, Sicily

Figure 13: PR940_01_01: Column shafts in the Yedi Taşlar quarries, Turkey

Figure 14: PR311_01_05: Roughed-out sarcophagus lid in the quarries at Iscehisar, Turkey

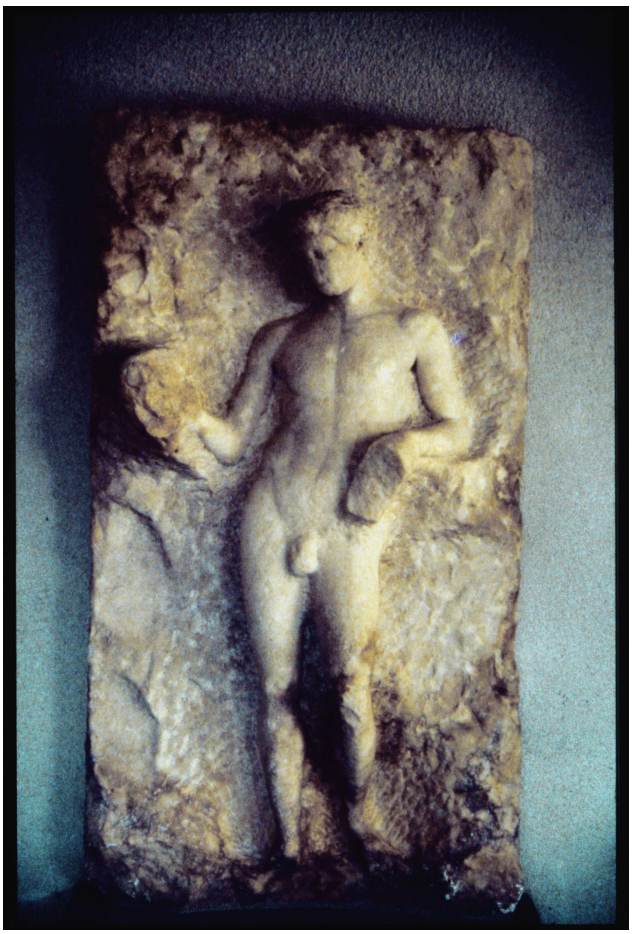

Figure 15: PR307_02_03: Roughed-out relief of an athelete, Aphrodisias

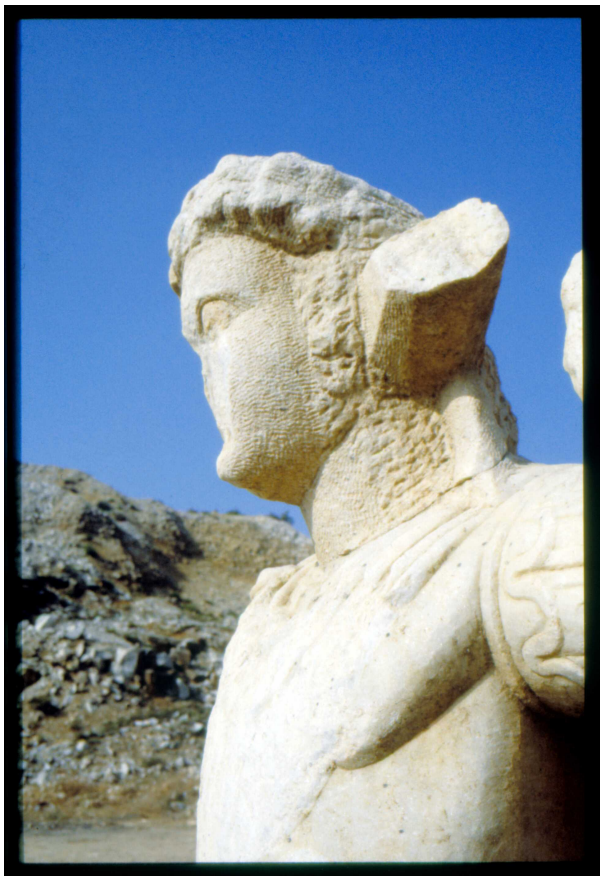

Figure 16: PR316_05_15: Roughly shaped head of an imperial statue from the Prokonnesian quarries, Marmara

Figure 17: PR301_05_22: Detail of flat chiselling on the panel depicting Claudius with personifications of Land and Sea from the Sebasteion, Aphrodisias

Figure 18: PR205_1_04_09: Detail of a soldier's chainmail worked with the flat chisel on the Column of Trajan, Rome

Figure 19: PR208_01_05: Detail of drill holes on the Column of Marcus Aurelius, Rome

Figure 20: PR312_03_13: Relief from Ephesos with deeply drilled outlines

Figure 21: PR301_04_23: Detail of the panel depicting Gaius and Lucius from the Sebasteion, Aphrodisias

Figure 22: PR225_02_16: Rasped surface on the Arch of Trajan, Benevento

Figure 23: PR312_03_11: Male portrait head from Ephesos with a polished face

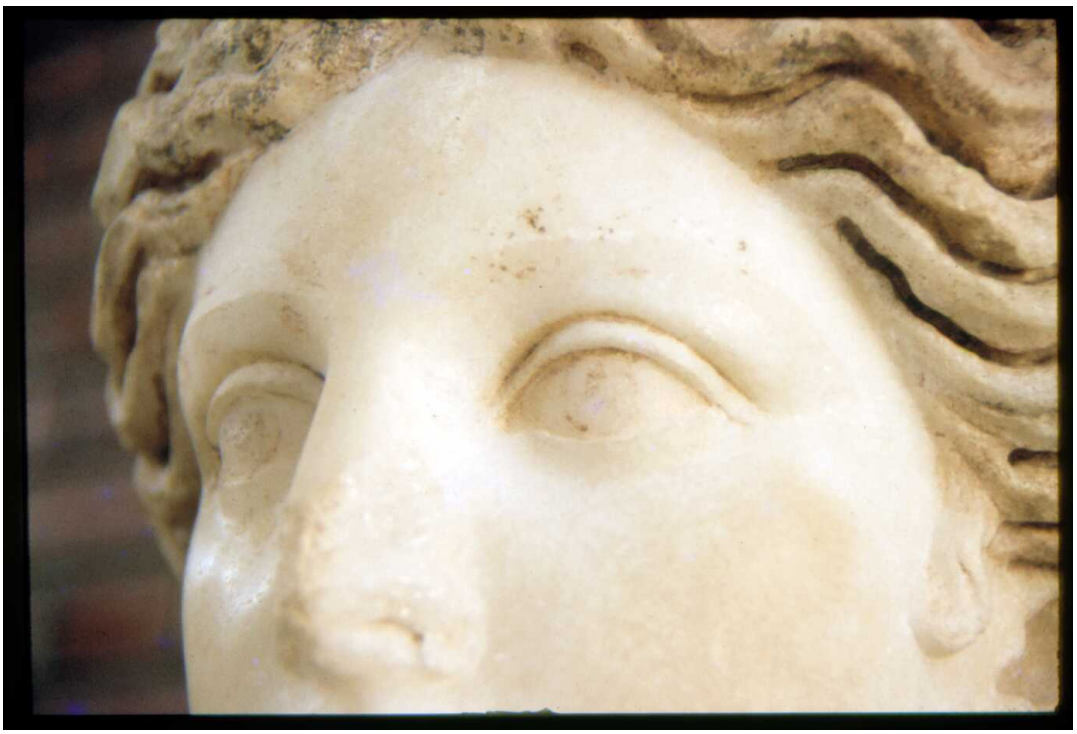

Figure 24: PR307_03_08: Female head from the Hadrianic Baths, Aphrodisias

Figure 25: PR205_1_09_10: Detail of the Column of Trajan showing a drilled hole for a metal insert

Figure 26: PR205_1_04_05: Detail of the Column of Trajan showing carving across a joint between drums

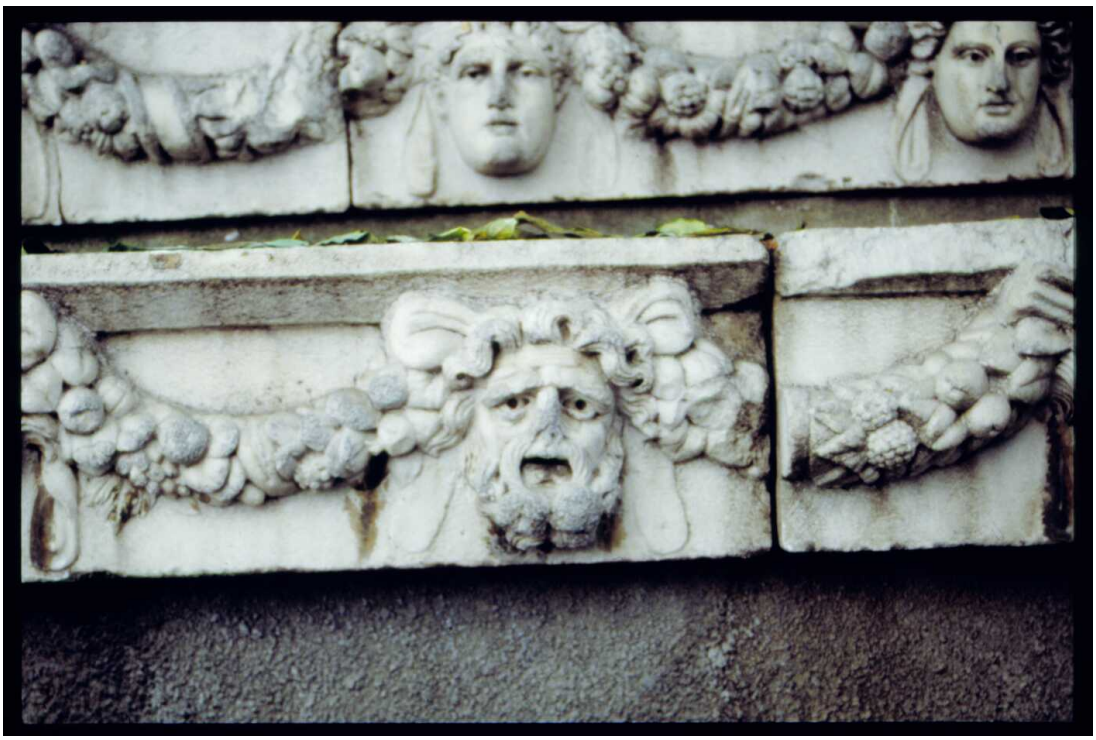

Figure 27: PR320_01_22: Blocks from the mask and garland frieze of the South Agora, Aphrodisias