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Roman Artillery Balls from Qasr Ibrim, Egypt

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Reprinted with additional plates, labelled alphabetically, from the original PowerPoint presentation of this paper at the British Museum. Original page numbering in red.

Plate A. Egypt Exploration Society base camp 2004. Surviving top layers of Qasr Ibrim, now an island in Lake Nasser (Barnard).

Plate B. The towering eminence of Qasr Ibrim in 1856, photographed by Francis Frith.

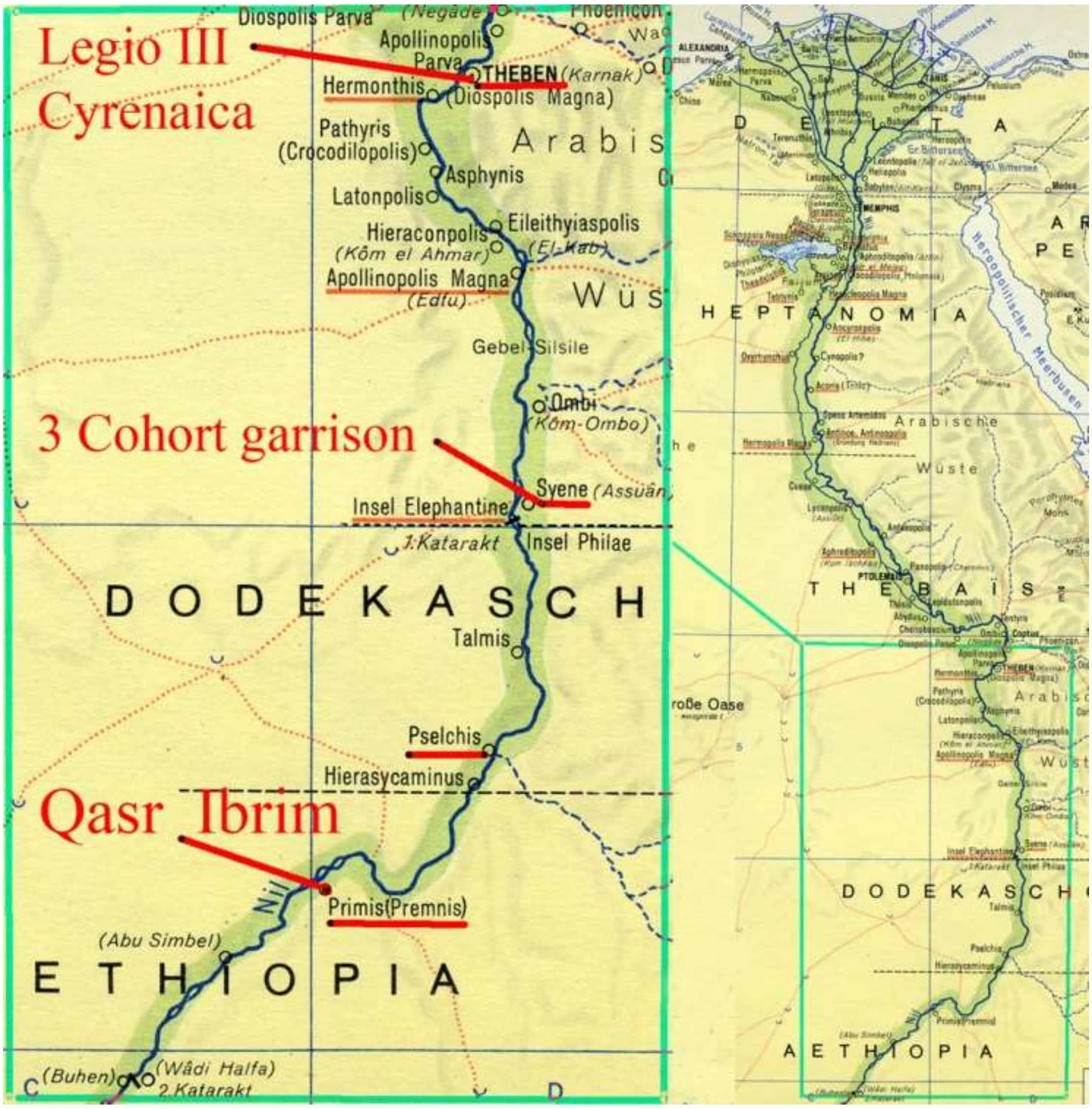

Plate C. From *Grosser Historischer Weltatlas* (Munich 1854, pl. 26).

1. The Roman occupation of the fortress

> "*The Ethiopians who extend towards the south and Meroe are not many in number and are a scattered population because they inhabit a long, narrow, winding river bank. They are not well prepared for warfare or for any other kind of life*." (Strabo 17.1.53).

Strabo's dismissive remarks are disproved by the bold and successful Meroitic attack on the Roman three-cohort garrison at Syene (Aswan) during the absence of Aelius Gallus on his campaign in Arabia in 25/24 BC.. The Ethiopians struck unexpectedly, capturing Syene, Elephantine and Philae, enslaving the inhabitants, and pulling down the statues of Caesar Augustus. In retaliation the Roman governor Petronius set out with fewer than 10,000 infantry, and 800 cavalry, and forced them to withdraw to Pselchis (Dakka). Asked by Petronius' envoys why they had begun a war, they said they had been unjustly treated by the Nomarchs, the tax collectors (Török 1997, 452). They probably repeated such complaints some three years later to Augustus when they met him on Samos (Strabo 17.1.54). Petronius forced them out to battle and routed them "*because their battle lines were poorly drawn up and they were poorly armed*".

During the ensuing pursuit he captured "*the generals of Queen Kandake, the ruler of the Ethiopians in our day, a masculine sort of woman, blind in one eye*." After taking Pselchis, he then "*reached Premnis* [Qasr Ibrim], *a fortified city, taking it at the first attempt*". On his way back from sacking Napata[2] ,the royal capital, he "*fortified Premnis better, installing a garrison and food for two years for 400 men*." In 22/21 BC Kandake marched to attack this small Roman garrison with an army of many thousands (Strabo 17.1.54).

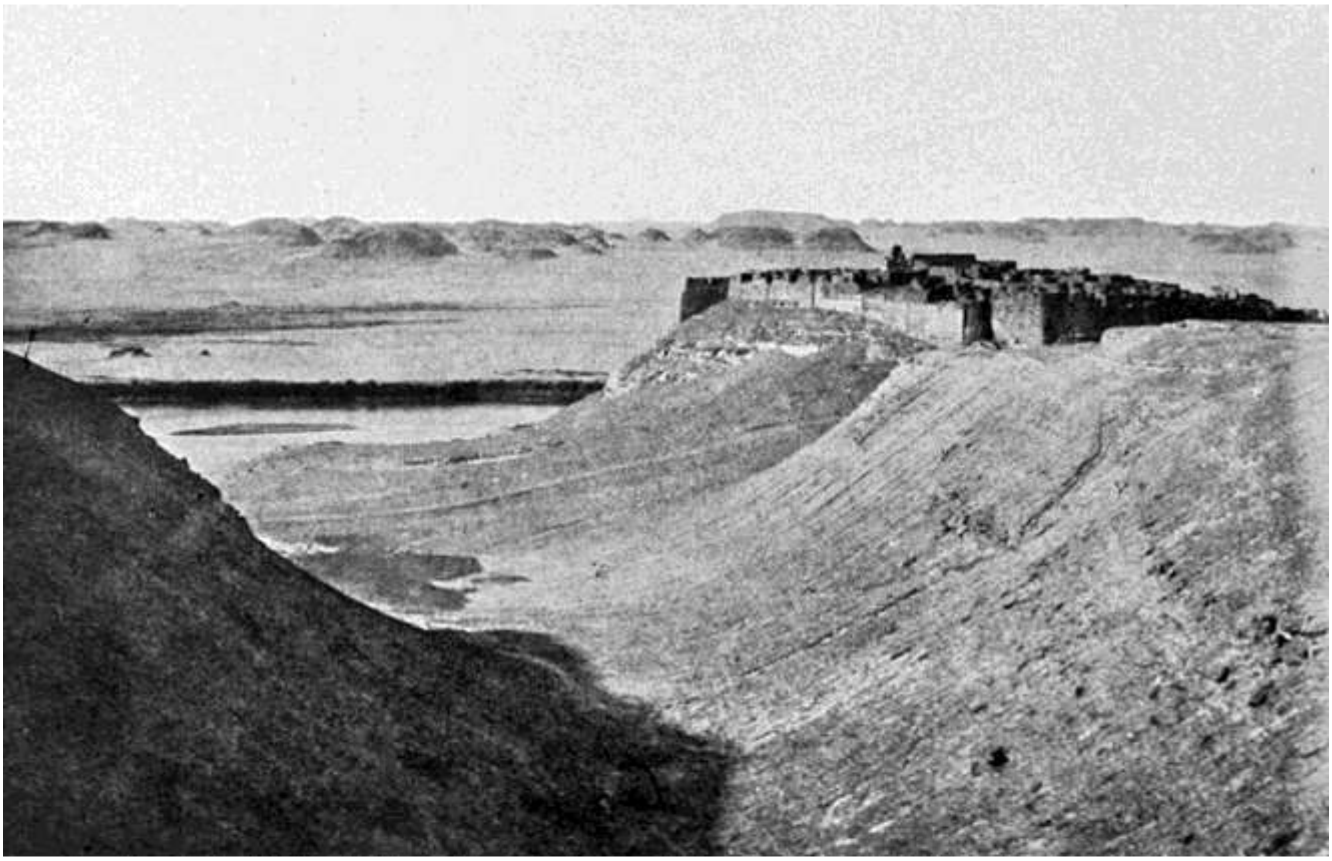

Plate 1. The fortress photographed from the desert in 1851-52, looking north-north-west (Teynard n.d., pl. 142).

It is only from photographs (Plates 1 and 2) that the commanding eminence of Qasr Ibrim can be appreciated; its riverside screes inviting comparison with Herod's fortress city of Masada. However, Petronius' success in taking the fortress at the first attempt proves that the similarity is superficial, and that Qasr Ibrim lacks the immense height and all round towering cliffs of the Judaean site, which was only taken after a siege of some eight months and the construction of a spectacular siege ramp.[3] There is no siege ramp at Qasr Ibrim, and it is probable that Petronius employed the tactic of a heavy artillery barrage before assault, as when Vespasian used his three legions' firepower to clear the battlements at the siege of Jotapata (Palestine) in AD 69, described by eyewitness Josephus (Jewish War III, 1668):'*Vespasian ordered his artillery, numbering a total of 160 machines, …to fire at the defenders on the wall. In a coordinated barrage the catapults sent long bolts whistling through the air, the stone-throwers shot stones weighing one talent, fire was launched and a mass of arrows. This made it impossible for the Jews to man the wall or even the area behind it that was strafed by the missiles. For a mass of Arabian archers, spearmen and slingers was in action along with the artillery*.' Under cover of such a murderous barrage Petronius' legionaries could force an entry, perhaps at the South Gate or at several points, by employing the tortoise formation[4].

[1] *Section 2 is by Pamela Rose, Section 3 by Hans Barnard, the others by Alan Wilkins. We would like to thank the Egypt Exploration Society (London) for making this study possible. Alan Wilkins would like to acknowledge extensive help from Pamela Rose, and valuable suggestions from Professor Lawrence Keppie, Dr Duncan B. Campbell, and Mark Hassall.*

[2] *Török 1997, 453-54 sums up the arguments as to whether Petronius would have had the time to reach Napata. The reference may be a Roman propagandist addition to the text.*

[3] *Most recently discussed by Campbell 2005, 42-5.*

Old photographs, the 1894 sketch by Somers Clark,[5] and [page 67] the aerial photograph (Plate 10) are the only evidence now of the contours of the surrounding terrain, relevant to planning defence or attack. They confirm that the landward approach along the saddle leading to the South Gate is the only one which avoids a steep and disastrously exposed climb up to the walls. In 22/21 BC, if Kandake was intending to cross the Nile out of sight of Qasr Ibrim, she would probably have to advance on the site using an eastern desert route that would lead to the top of the saddle. The west bank of the Nile is easier terrain all the way along and the usual way that later travellers journeyed. However, this approach would lose the element of surprise, because the fortress commands a view of the Nile bank stretching many kilometres.[6] The totally exposed, steep approach across the wide valley to the south can be appreciated from Plates 1 and 2b. This paper will show that Petronius' catapults could outrange the Meroitic light arrows and lay down a deadly hailstorm of heavy missiles, rendering any attack by the Meroitic unarmoured warriors suicidal.

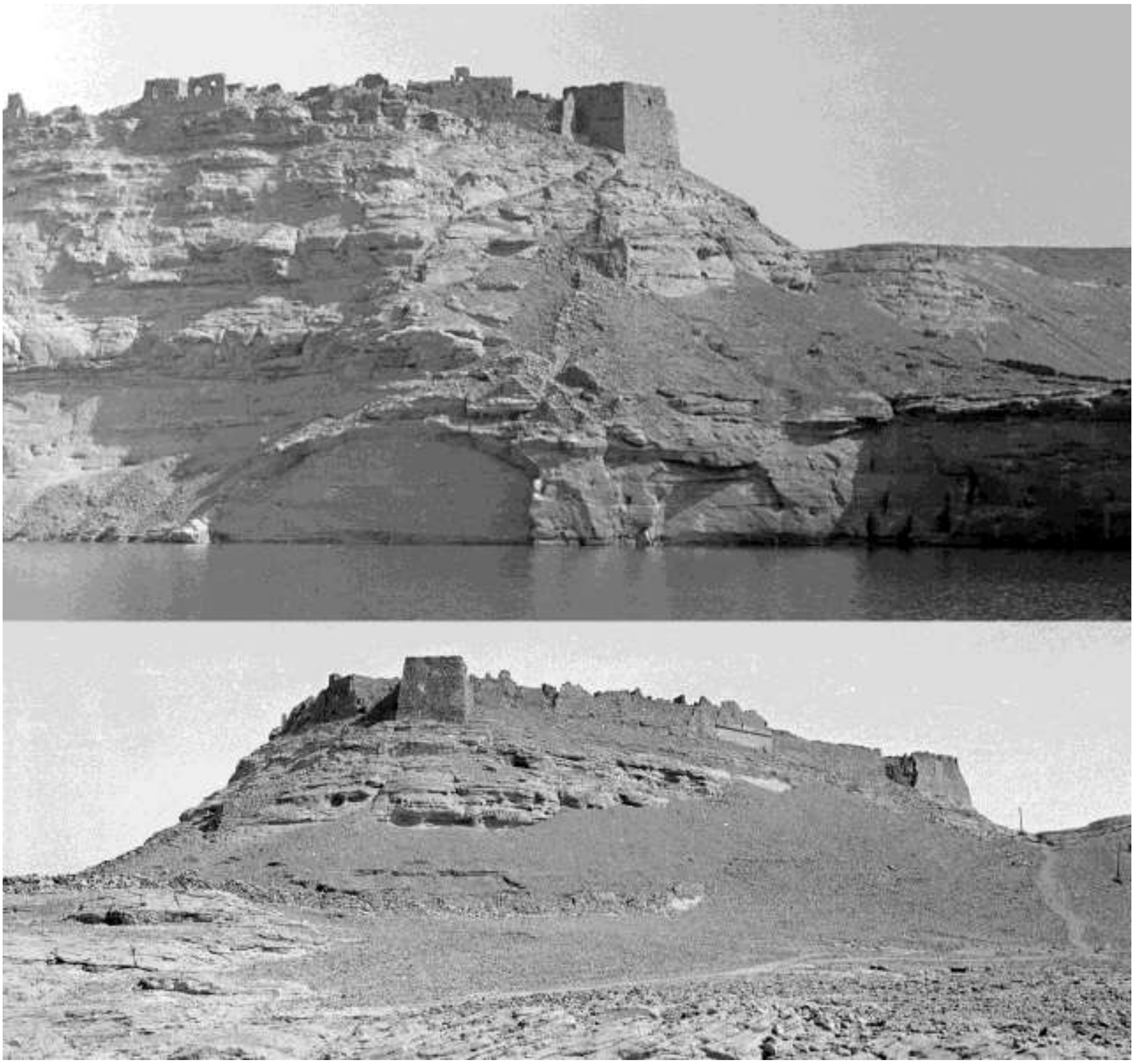

Plate 2. Photographs taken in the early 1960s at the start of excavations. (a) The riverside cliffs, the Northwest Bastion and the wall running next to the probable water stair. (b) The western defences, from the west.

2. Review of excavation results (Pamela Rose)

Roman-period fortifications have been explored along the south-western and south-eastern edges of the site, between the Northwest Bastion and South Rampart Street (Plate 3 and Figure 1).[7] The Roman girdle wall, which for much of its length seems to have been based on repairs or alterations to pre-existing walls, stood at the edge of the hilltop, where the rock was cut back into a series of steps on which the walls were based. Elsewhere around the line of the later fortifications, the appearance of unconnected areas with cut stone blocks in the lowest courses may indicate the presence of Roman walls enclosing most of, or the entire hilltop.

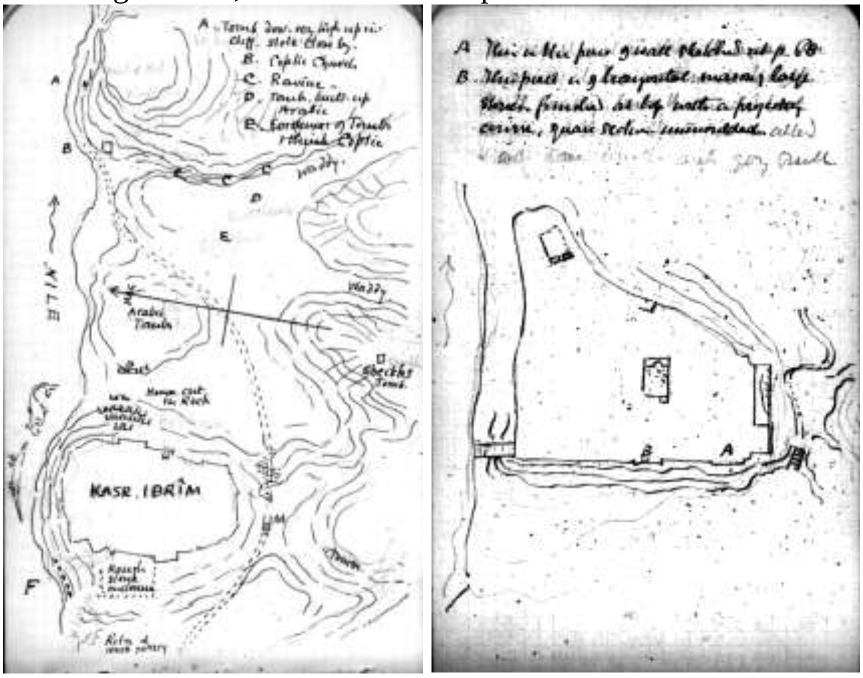

Plate D. Somers Clark sketches, 1894.

The excavations have revealed multiple phases of construction associated with the Roman occupation (Adams 1983; 1985). The first of these was, presumably, the repair of any damage done to the walls and gate(s) in the course of taking Ibrim. Further modifications included heightenings of the walls in response to the accumulation of debris inside them, particularly in South Rampart Street. It is only towards the end of the Roman occupation that major defensive works, the construction of the Northwest Bastion and the deposition of clusters of *ballista* stones took place.

The Northwest Bastion

The Northwest Bastion was one of the most spectacular Roman constructions at Qasr Ibrim. It was a later addition to the fortifications, built against the exterior of the Roman girdle wall on the steeply sloping hillside some 4m from its northwest corner, at some time after Roman-period occupation debris had already begun to accumulate there. It was a parallelogram in shape, of which the outer wall was some 9m in length and preserved to a height of over 8m. The interior of the bastion was infilled to a height of 4.5m with stones and earth to create a solid platform. Its position, and the odd angle at which it was built, suggest that it was carefully sited to command the adjacent girdle walls, the approach to the South Gate, and the probable water stair leading up from the river (Rose 2004, 72-73).

On the debris outside the girdle wall, and underlying the bastion, a deposit of ‘pebbles’ (perhaps the same as the ‘cobbles’ found elsewhere around the fortifications, see below) was found piled against the girdle wall, along with three ballista balls of 25cm diameter. The pebbles were described as water-worn, 5 to 10cm in diameter, and some 425 of them were found in an area of just under 2m square,

[4] *Trajan’s Column LXXI, cast 181 (Lepper and Frere 1988, 109). See Sallust Jugurtha 94.3 for Marius’ use of the tortoise backed by long range fire from catapults, archers and slingers.*

5 In the Griffith Institute, University of Oxford.

[6] *Clearly shown by the Breasted Expedition photograph P2532. Chicago University URL : http://oi.uchicago.edu/OI/MUS/PA/ EGYPT/BEES/IMAGES/BEES_QASR_IBRIM.html*

[7] *Preliminary reports of these excavations appeared in Anderson and Adams 1979, 33-35 and Adams et al. 1983, 57-59. Other material cited here comes from unpublished field notes compiled by Dr J. Alexander (North-west Bastion) and Prof. W. Y. Adams (West Rampart, South Bastion and South Rampart Street).*

deepest at the wall face but extending some 3.5m from it. The *ballista* balls were close to the outer edge of the deposit. The excavator thought that the material was deliberately dumped into the area immediately prior to or during the [page 68] initial construction phase of the bastion, although it is possible that the *ballista* balls represent spent ammunition from the original attack on the fortress by the Romans. It is worth noting that there is no evidence as to where a *ballista* for throwing the stone balls could have been located prior to the construction of the bastion, since the area inside the wall was taken up for some distance with buildings. Excavations in 1974, which trenched outside the girdle wall immediately south of the bastion, encountered Roman debris including Latin papyri of a military nature (Frend 1976; 1980), but did not record any form of missile.

Access to the fortress

The South Gate, approached by rock-cut steps from the neck of land joining the hilltop to the scarp to the east, remained in use throughout the Roman occupation. It had undergone many modifications to its structure since its first construction, including, perhaps early in the Roman period but prior to the construction of the cobblestone enclosure (see below) the drastic narrowing of the gateway from c. 4m to c. 1.25m wide, at which time there is also the first evidence for the presence of a door opening inwards.

Other entrances to the fortress may also have been open at this time. The East Gate, a narrow entrance at the lowest and most vulnerable point of the girdle wall may be of Roman construction, although, since it was flooded before any excavation took place, no further information can be adduced. There were however, domestic buildings of Roman date on the hill slopes immediately behind the girdle wall both north and south of the gate, suggesting that the area lay within the Roman fortifications. The gate and the length of girdle wall to its south would have been protected by a walled bastion-like feature which also appears to have been of Roman date. Little excavation took place here before it was flooded, but neither cobbles nor *ballista* stones were noted in the limited area exposed.

Along the western fortifications, the Podium Gate, a narrow opening between the girdle wall and the south end of the Podium, seems to have been created when the fortification wall was built prior to the Roman occupation. It was [page 69] reached by steep steps cut into the bedrock, and was closed with a wooden door. No evidence remains to indicate whether it was open or blocked off in the Roman period.

The West Rampart

The main accumulation of *ballista* stones found at Qasr Ibrim lay in the entrance ramp which ran from the South Gate northwards towards the Podium. It ran inside the western girdle wall, and on the east side was bounded, at the south end, by the gate structure, and further north by the massive western wall of Temple 5, an earlier stone structure at the edge of the hilltop in which masonry was only preserved to the level of the bedrock forming the top of the hill. Within the ramp, floor levels of the Roman period accumulated prior to the construction of a wall which ran northwards from the north face of the east side of the gate, roughly parallel to the western girdle wall but at an angle to the Temple 5 wall. The enclosure thus formed to the east of the wall was wider at its southern end than at the northern end, and roughly halved the width of the entrance ramp. The wall extended over 17m before disappearing, either destroyed by later overbuilding or at a genuine termination to the feature; a possible continuation of the wall was noted further north, where it joined a line of stones continuing the alignment of the Temple 5 wall. The enclosure wall was made of rough irregular stone blocks set in thick mortar, mud plastered and whitewashed on its western face. The latter was much damaged at its base, presumably by passing traffic. The wall retained a fill of cobblestones in its upper part (Level 2), giving way to sandstone chunks of about the same size as the cobbles in the deeper part of the enclosure at the south end (about 3m in depth); the depth of deposit thinned further up the ramp to a depth of less than 20cm at the northern end. The stone fill was inserted as the wall was built in a single construction episode. Although the top of the retaining wall was damaged, it appears to have reached the same level as the top of the Temple 5 wall, and provided a flat-topped platform extending its area, presumably for the stone-throwing machines. The cobbles were described by the excavator as ‘round stream cobbles of quartzite and other materials’, not native to the site. On top of and slightly bedded into them were the deposits of *ballista* stones.

Plate 3. Aerial photograph (1959) of the Ottoman levels of Qasr Ibrim before the start of excavations. The area covered by Figure 1, and the positions of sites referred to in the text, are marked in: WS = wall next to the probable water stair; NWB = Northwest Bastion; PG = Podium Gate; EG = East Gate.

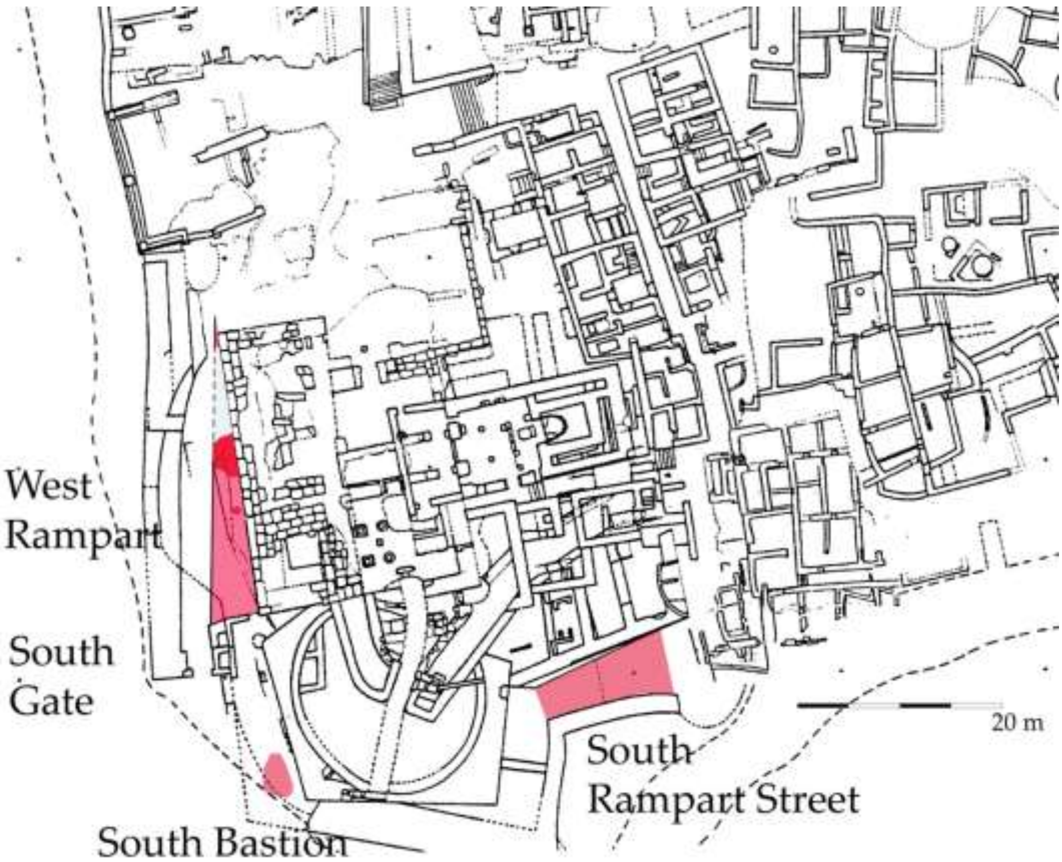

Figure 1. Plan of the areas, shaded red, where the balls were found (Rose).

Excavations in 1978 revealed two clusters which contained more than 50 balls; others had [page 70] been removed for reuse in the walls of an overlying house. Continuation of the excavations in 1980 revealed a concentration of more than 630 shaped *ballista* balls at the north end of the enclosure, and about 24 small granite hammerstones, possibly from their manufacture, were mixed with them (Plate 4). The balls were in a layer c. 16cm deep at the north end and 40cm deep to the south, and extended over an area of about 4m from north to south. A smaller concentration of about 100 stones was located near the west face of Temple 5, about 11m north of its southwest corner. One ball (from which cluster is unknown) was of grey granite. The balls were 13 to 18cm in diameter, with an average of 16cm. Forty of them were inscribed, two with incised markings. The location of the heaps suggests that machines for firing the stones were located above the West Rampart, at least partly on the hardcore platform which extends the available flat surface of the hilltop area above the entrance ramp. The 10 and 20 *librae* machines (p. 77 below) would each have required an operating space about 5m wide by 4.75m deep, and 5.75 x 5.5m respectively. A 10 *librae* ballista would stand about 3.4m high, and a 20 *librae* size 4.2m.

Plate 4. View of the West Rampart cobble deposit, with two clusters of *ballista* balls in the foreground. The gap between the clusters may represent the position of a *ballista*. [The rising waters of Lake Nasser allowed the expedition boats to moor alongside.]

The South Bastion

The South Bastion was already a conspicuous feature of the fortress by the time of the Roman occupation. It consisted of a substantial round tower of large stone blocks filled with sandstone chippings, enclosed in a pentagonal mud-brick casing, the latter itself repaired and buttressed to reinforce the corners of the pentagon. The whole feature was at its widest point some 19m across. There is some indication that the mud-brick casing rose to a higher level than the stone-chip-filled tower, and might have contained rooms, so that whether the bastion ever functioned as a platform overlooking the South Gate is unclear. No evidence of structural remains of the Roman period has been recovered on top of it.

The girdle wall enclosed the South Bastion leaving a walkway to its west and east. Whether the walkway continued around the south face of the bastion in the Roman period is unknown. A cobblestone deposit was found lying along the south part of the western face of the bastion, in which were 'only a few *ballista* stones scattered throughout the deposit'. They were apparently laid as a fill in an underlying pit, so that the deposit had a maximum depth of c. 1.5m and tapered away rapidly to the north and south; it may be redeposited material placed to even up the ground surface for later activity. No cobbles or *ballista* stones were found adjacent to the eastern face of the South Bastion despite the continuation of underlying and overlying layers of the South Rampart Street cobblestone deposit into this area (see below).

Plate 5. View of the South Rampart Street cobble deposit, looking west, with the South Bastion at the end.

South Rampart Street

The girdle wall continued eastward beyond the South Bastion to enclose an area, South Rampart Street, lying between it and an earlier revetment wall built as terracing for part of a temple complex. The area was filled with deep deposits of rubbish, the upper levels of which accumulated during the Roman occupation and seem to have necessitated repeated heightenings and thickenings of the girdle wall. The last of these events preceded the laying down of a thick deposit of cobblestones (Level 2), almost 1m in thickness close to the western end of the area, but thinning out somewhat to the east, and sloping from north to south (Plate 5). The deposit seems to have extended more or less to the top of the earlier revetment wall on the northern side. To the south, the base of the layer extended to the inner face of the girdle wall, but the upper parts of the deposit were lost through collapse. It is likely that, as in the West Rampart, the cobbles were the remains of the hardcore fill of a platform immediately behind the girdle wall for the stone-throwing machines.

The cobblestone deposit lay on a thin layer of densely packed stone chips resulting from the heightening of the girdle wall, and material from a midden deposit immediately below the cobbles and stone chips has a C^{14} date (OxA 14813) of 45 BC - AD 25 (67.5% probability), 100 BC - AD 70 (95.4% probability). See also the discussion of dating of the midden level in Anderson et al. 1979, 126. In 1978, the excavator noted finding in Level 2 ‘small clusters of deliberately shaped, round sandstone balls, each c. 16cm diameter, nested within the cobblestone deposit’. The [page 71] precise location of this deposit is not known. Further excavation the following season noted a cluster towards the east end of the street of 40 balls partly overlain by the cobble filling (Plate 6), and perhaps, therefore, the remains of an earlier missile deposit. Adams noted, ‘Except for this last group there were only a very few isolated *ballista* stones scattered along the South Rampart’.

Plate 6. Cluster of *ballista* balls in South Rampart Street. Scale in 10cm increments.

Plate E. The same cluster. There are 34 balls visible in these photographs. If this is not a random group, but the ammunition for one catapult, then the variation in the size of the missiles backs up the evidence from the inscribed balls that a *ballista* was capable of hurling balls smaller than the maximum diameter for which it was designed. See my discussion in Section 5 on the design of the launching channel.

3. The re-examination of the 1978 and 1980 stone balls (Hans Barnard)

The large spherical stone objects found in 1978 and 1980 were correctly interpreted as ammunition for the *ballista*, the Roman stone-throwing catapult. Thirty-eight of these had carbon-ink inscriptions, and two had engraved markings. These 40 were removed for safe keeping, seven to the British Museum, the remainder to Cairo Museum. The rest of the balls were retained on site. A detailed study of these was undertaken in February 2004, and is presented here.

Five hundred and sixty-nine balls were described, measured and weighed (Table 1). All but two appear to have been manufactured of the local Nubian sandstone, a rather friable sedimentary rock striated with red (most likely iron oxides) and white (possibly calcite or gypsum). The remaining two were made of a darker and much denser rock that can be found in many places in the immediate vicinity of the site.[8] As sandstone easily breaks along the sedimentary layers only 285 (50%) of the balls were found intact. Of these, no more than 27 (5%) were well rounded, the rest were in a variety of shapes ranging from roughly round to cubic and hemispherical. Most of these shapes can be explained as the result of an attempt to carve a sphere rapidly out of a material that breaks preferentially along parallel surfaces. There was obviously a favoured shape and size, as can be inferred from the relative uniformity of the collection, but no need, or time, to finish each ballista ball perfectly. The denser, and much more uniform, darker rock would have been easier to shape but at the same time much harder to work. This is most likely the reason that only a very small number (less than 0.5%) of them were made, even though it must have been clear that the much stronger ball was able to cause greater damage on impact.

Shape	Number	Average diameter	Average weight	Average Index
Rough	153	14.2	2.6	0.88168
Well rounded	27	14.6	3.0	1.01840
Flattened	27	14.7	2.6	0.86991
Irregular	26	14.3	2.3	0.78955
Hemispherical	20	14.8	2.6	0.81170
Cubic	18	13.3	2.4	0.98434
Ovoid	9	15.5	3.1	0.82284
? Complete	3	13.5	2.2	0.82431
Greywacke/dolerite*	2	13.3	2.1	1.11526
All**	569	14.3	3.1	1.01840
Standard deviation		1.86539	1.24145	0.16908

Tabel 1. Details of the 569 *ballista* balls. All diameters were measured, the weight of incomplete *ballista* balls was reconstructed (see Figures 2 and 3) (Barnard).

Upon measurement of the diameter and weight of the complete *ballista* balls these data were entered into a simple spreadsheet, which calculated the averages presented in Table 1 and produced the bar-graphs presented in Figures 2 and 3. It also computed an index for each *ballista* ball, relating its weight to its volume, according to the formula below.

$$\text{Index} = \frac{\text{weight (in g.)}}{\text{diameter (in cm.)}^3}$$

Fragments that did not preserve a complete, measurable diameter were excluded from this study. For the remainder of the incomplete *ballista* balls a weight was reconstructed by taking the average of two different approximations. The first method estimates the weight of the complete *ballista* ball by estimating what percentage is missing, and assuming that a proportional weight has also been lost. The second reconstructs the weight of each incomplete *ballista* ball by multiplying the cube of the measured diameter with the average index of all complete *ballista* balls (see the formula for calculating the index above).

The combination of both methods, by taking their average, is reflected in the formula

$$\text{Reconstructed weight} = \tfrac{1}{2}\ \text{x} \left[\frac{\text{measured weight}}{\text{percentage preserved}} + (\text{measured diameter}^3\ \text{x index})\right]$$

The former method appeared to yield [page 72] consistently higher results than the latter. This results in higher averages, which must be one of the reasons, if not the single reason, for the skewing of the distribution of the weights represented in Figure 3. Given the relatively good shape in which most of the *ballista* balls were found in Qasr Ibrim, with half of them still intact, it seems safe to assume that they were never used, but discarded by the legionaries on their withdrawal. That no remains of a *ballista* have been found at Qasr Ibrim can be explained by the fact that the Romans would never have left such a war machine behind. The metal parts in particular and the windlass were too valuable to discard, even if the machines were stripped for easier transporting.[9]

[8] *This may be greywacke, or a similar looking rock, from the pre-Cambrian basement (more than 500 million years old) which is most famously quarried in Wadi Hammamat in the Eastern Desert, or stone from the dolerite intrusions or basalt flows that occurred in Egypt in the late Oligocene (25 million years ago), most famously quarried from Gebel Qatrani near the Fayum. Both formations extend into Lower Nubia and surface near Qasr Ibrim.*

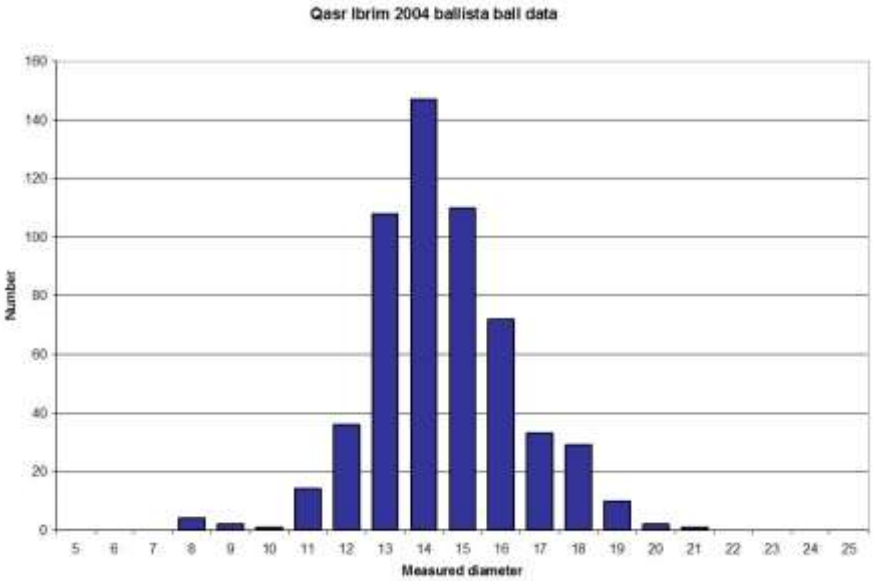

Figure 2. Bar-graph 1, showing the distribution of the measured diameters (7.5 – 20.5cm; average 14.3cm) of the 569 *ballista* balls; 147 are between 13.5 and 14.5cm (Barnard).

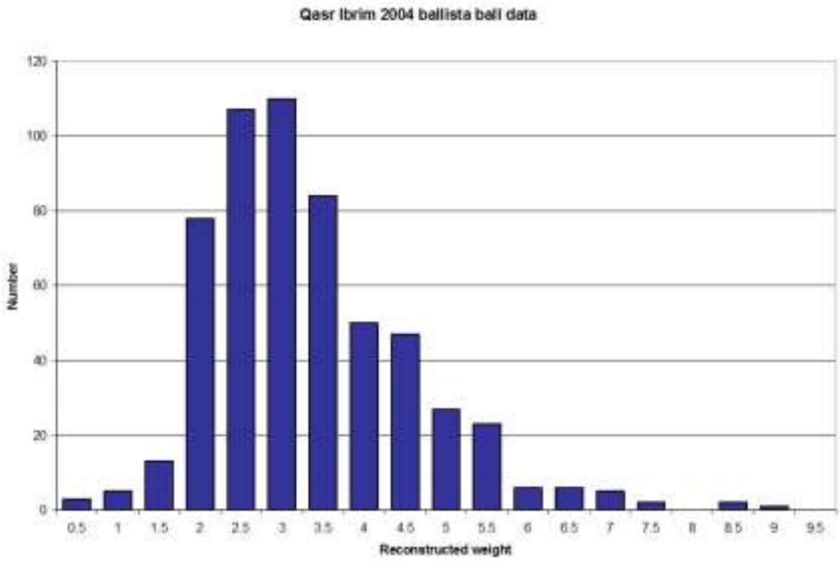

Figure 3. Bar-graph 2, showing the distribution of the measured and reconstructed weights (0.3 – 8.8kg; average 3.1kg) of the 569 *ballista* balls; 110 are between 2.75 and 3.25kg. Note that the distribution seems positively skewed, with a tail to the right (Barnard).

Plate F. The seven balls at the British Museum. See Section 3 for Hans Barnard's discussion of their geological origin and variety of shapes (photo A.W., by kind permission of the British Museum).

Ball 3E (EA 71837) 3.9 kg
Ball 1G (EA 71838) 2 kg
Ball 4F (EA 71839). 2.8 kg (Kandaxe)
Ball 3B (EA 71834) 1.75 kg
Ball 2C (EA 71836) 3.25 kg
Ball 2F (EA 71833) 2 kg
Ball 3F (EA 71835) 2.3 kg

4a. Stones with carbon ink inscriptions

Among the Hellenistic and Roman caches of stone ammunition discovered to date, many stones are inscribed or painted with their weight (Campbell 2003, 19-21). The ink writing on the Ibrim balls is unique in that it contains much more information than just the weight. Several are ascribed to a particular centurion, some have the initials M·V, perhaps another centurion; one is even marked as a missile for the enemy queen. Furthermore, the fact that the weights are recorded in both Greek[10] and Latin script makes it likely that the troops involved were from one of the legions originating from the Greek-speaking eastern Mediterranean stationed in Egypt in 23BC, possibly Legio III Cyrenaica or Legio XXII Deiotariana. [11] The stones are the earliest to be discovered with their weights recorded in Roman *librae*, rather than the Greek *minai* marked on earlier stone shot. This is evidence of the imposition of the Roman army system in Egypt, which was now under the strict personal control of Augustus. After discovery, the 40 inscribed stones were listed on five sheets dated 15 February 1980. They were photographed in black and white, their approximate diameter was measured, and sketches made of the ink inscriptions. Unfortunately, they were not weighed. The following discussion lists balls by the page and reference letters on the 1980 sheets. All are recorded as having been found at the west end of the West Rampart in Level 2. The approximate diameters are those given on the sheets, except for the seven stones in the British Museum which have been measured by the staff there.[12]

[9] Heron *Belopoiika*, 102 says that "they must be easily dismantled for transportation" (in Marsden 1971, 35).

[10] In the alphabetical rather than the acrophonic system which was more common on Hellenistic balls (Campbell, *ibidem*).

[11] Speidel (1984) for the positioning of the Roman forces in Egypt. For the origins of these legions see Keppie 1984, 134, 136, 206 and 212.

[12] The photographs from the Qasr Ibrim archives have been supplied by Dr Rose. Alan Wilkins took colour photographs of the seven balls in the British Museum during their weighing by the staff of the Department of Ancient Egypt and Sudan.

Balls with centurial inscriptions and stated weights

Ball 2H Diameter ±12cm (Plate 7)

The vertical arrow appears to be the Greek sign for weight, perhaps standing for the point of balance of weighing scales.

is a digamma, the sixth letter of the very early Greek alphabet. It only survived as the numeral letter for 6.

Plate 7. Inscribed balls: 2H, 3F, 1A, 2E, 3D, 3E.

The second line repeats the weight in Latin script: **P**[onderis] **VI** "of six [*librae*] weight". That the weight is in Roman *librae*, not Greek *minai*, is proved by the two balls in the British Museum, 3E and 3F. In line three ⅂ is the sign for *centuria*, commonly cut as a reversed capital C on building inscriptions to mark the work of a particular legionary century: **OKTAVI** "century of Octavius". The spelling OKTAVI confirms that the name is written in Greek script, [page 73] as with centurion Pompeius on Ball 2E. Lawrence Keppie and Mark Hassall suggest (pers. comm.) that Octavi might also be short for Octaviani, the genitive of the cognomen Octavianus.

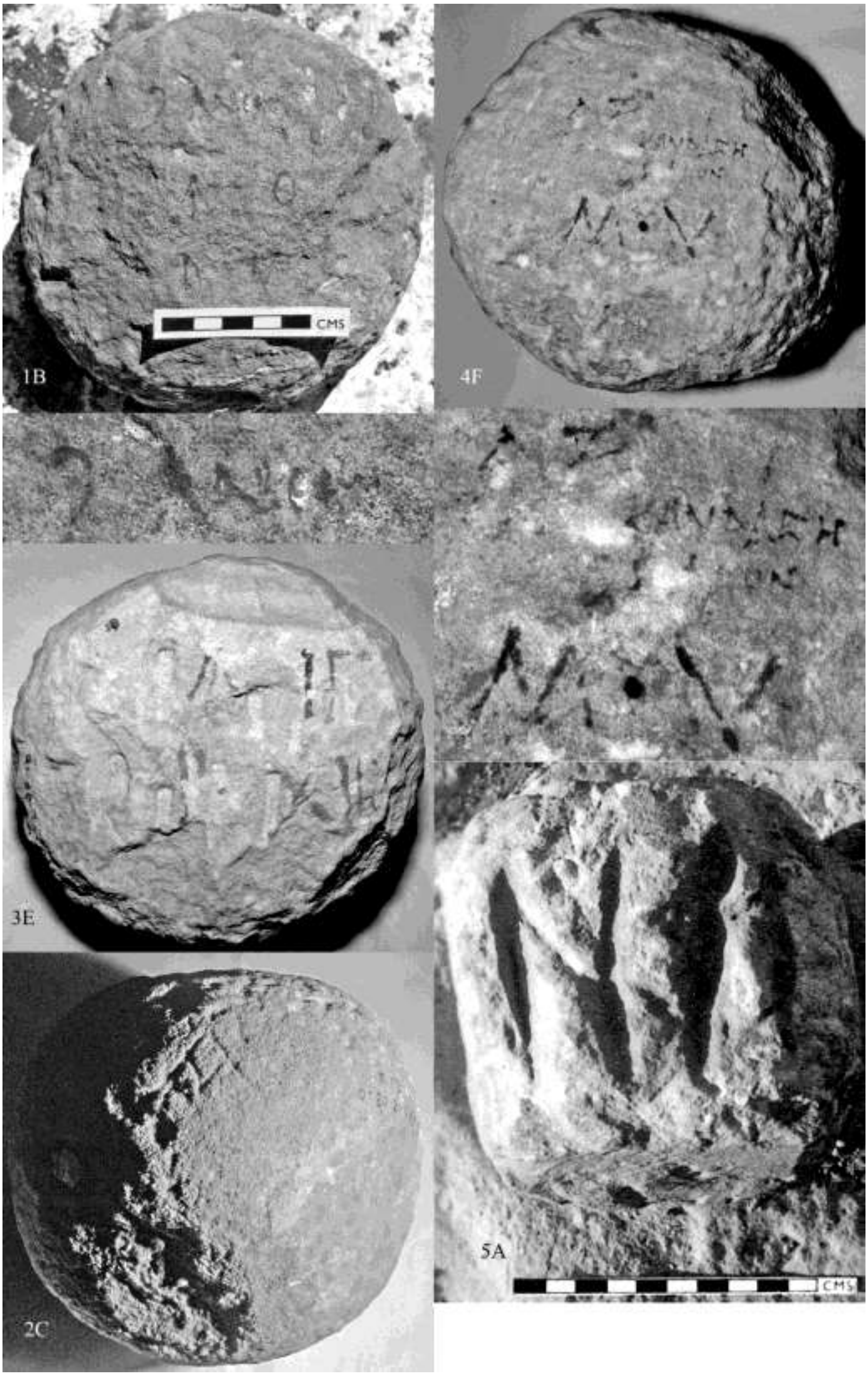

Plate 8. Inscribed balls: 1B, 4F, 3E, 2C, 5A.

Ball 3F = British Museum EA 71835 Diameter min. 11.8cm max. 12.7cm (Plate 7)

Line 1 ⌝ **OKTAVI** "century of Octavius". Line 2 ᛦ **H** (Greek Eta) "weight eight [*librae*]"
Line 3 **P VI**[II] **"**of eight [*librae*] weight"
Eight *librae* = 8 x 0.327 kg = 2.6 kg, but the ball now weighs 2.3 kg. The slight discrepancy is also found in Ball 3E, and may be explained by the drying out of the porous stone.

Ball 1A Diameter ± 15 cm (Plate 7)

Line 1 **[**⌝] **OKTA . .** "century of Octavius". Line 2 ᛦ **Θ** (Greek theta) "weight nine [*librae*]".
Line 3 **P IX** "of nine [*librae*] weight".

These three balls (2H, 3F, 1A) afford the vital information that centurion Octavius was shooting balls of three different weights.

Ball 2E Diameter ± 15 cm (Plate 7)

Line 1 ᛦ **I** (Greek iota) "weight 10 [*librae*]". Line 2 **P X** " of ten [librae] weight" Line 3 ⌝ **ΠΟΜΠΗΙΙ** "century of Pompeius"

Ball 3D Diameter ± 14 cm (Plate 7), and Ball 1B Diameter ± 14 cm (Plate 8)

Balls 3D and 1B both display a weight of nine *librae*, ᛦ **Θ** (Greek theta) **P IX** . Their first lines list two more centurions. Ball 3D seems to start with a blotchy iota **I**, second letter **V, "**century of Iu**….."**but after that the ink marks make no clear letters. However, this is certainly a different centurial name, and the obvious possibilities are IVLIVS or IVNIVS.

I read the name in line 1 of Ball 1B as: **AN** (the scribe has had two attempts at the last upright stroke of the N), followed by a tau (, then **ONI :** **"**century of Antonius".

If these two are Julius and Antonius, then three centurions bear the *nomina* of Caesar, Pompey, and Antony. This striking result raises the suspicion that centurions in the legions created in the recent civil wars might have claimed such famous names for themselves, rather than receiving them by formal grant of citizenship[13].

Other balls with weight signs

Ball 3E = British Museum EA 71837. Diameter min. 13.1 cm max. 17.3 cm (Plate 7)

Line 1 ᛦ **IΓ** (iota=10, gamma=3). Line 2 **P XIII "**weight 13 [*librae*]"**.** 13 *librae* = 4.25 kg. The actual weight today is 3.9 kg. As with Ball 3F, the discrepancy may be explained by the drying out of the porous stone.

This ball illustrates the problems of writing on an uneven stone surface. The pen skids over bumps and hollows, resulting in loss of ink contact. However, because they are written on a large scale with a thick instrument the letters are clear. The difficulty in reading the centurions' names on Balls 3D and 1B above is caused by the increasingly small size of the letters, and by the use of a fine pen on a craggy surface, causing the pen's point to be pulled off course by the contours.

Ball 3H Diameter ±18 cm

The upper line reads **XV** preceded by a mark that may be a **P**. There could have been further strokes making this **XVI** and so on, but nothing is visible on the photograph, and nothing was noted on the 1980 sketch of the lettering. Indecipherable marks above the lower **M·V**, very faintly discernable on the photograph, are recorded on the 1980 sketch. They may represent the weight in Greek script, possibly ᛦ **IE** (iota=10, epsilon=5). I think it likely that this is a 15 *librae* stone, the extra large diameter lending support to this conclusion.

The letters **M·V** are found on twelve of the 38 ink lettered stones. This is the only M·V stone with a weight.

Ball 4F = British Museum EA 71839. Diameter min. 11.5 cm max 16.6 cm (Plate 8)

This weighs 2.8 kg, and was possibly a 9 *librae* missile. Line 1 **Λ Ζ.** I interpret the many occurrences of Λ (lambda) followed by a second letter such as Γ (gamma), Ε (epsilon), Ζ (zeta), Η

Plate G. The Kandaxe ball (A.W., by kind permission of the British Museum. BM ref. no. 71839).

(eta), as standing for λόχος (lochos) the Greek equivalent of *centuria*, followed by a letter numeral. **ΛΟΧΟΣ Ζ** means Number Seven Century[2]Footnote 14, not 2.

Line 2 **ΚΑΝΔΑΞΗ** (Kandaxe) Strabo (17.1.54) describes the ruler of the Ethiopians in his time as Queen Kandake. He, and from the evidence of this ball the Roman garrison, took the Meroitic royal title *kdke* as the personal name of the monarch. The penultimate letter on the ball is xi, not kappa, possibly the way the name was pronounced by the legionaries.

Line 3 **Ι ? Α ? Ο Ν** Surface damage has removed two of the six letters. Only one word fits in: ἱκανὸν (hikanon) the neuter of the adjective ἱκανός meaning "befitting", "sufficient" etc.. With things it can mean "large enough".   Here the unexpressed noun it describes is probably βέλος (belos) meaning missile, or δῶρον (doron) meaning gift, present.

So lines 2 and 3 are a personal message to the enemy Queen, with her name in the Vocative Case: "**JUST RIGHT FOR YOU, KANDAXE !**"

This makes it by far the most interesting Roman *ballista* [page 76 because 74-75 were photos] ball found to date, because its wording reveals the attitude of mind of the artillerymen, encouraged to focus their hatred on the enemy leader. It has immediate parallels with the graffiti on bombs and shells of both World Wars: a veteran of 28 raids over Germany writes: "We would chalk on the bombs,

[13] For evidence of the small numbers of men from Italy and the West in the Egyptian legions see Keppie 2000, 58. The four centurions and M.V could, of course, be experienced westerners brought in to stiffen standards.

[14] This would be a rare example of the sequential numbering of centuries in a legion. Century 7 would be the senior century in the Second Cohort; in that case M·V would be the senior centurion of that Cohort.

'**Here's one for you, Adolf**,' and so on."[3]Footnote 15, not 3. The only Roman missiles with messages discovered to date are lead sling bullets, such as the group from Perusia.

Line 4 **M·V** in large bold letters. The stop, clearly visible on all M·Vs in the photographs, is standard in Roman inscriptions on stone to mark an abbreviated *praenomen*, usually Marcus. These letters occur on 11 other ink lettered balls, nine of which have M·V and nothing else. I suggest that this is another centurion, perhaps the senior one in the garrison, anxious to establish his ownership of this ammunition, and regarding his initials as having priority over vital information such as weight. Only Ball 3H above has weight as well as M·V. The **V** could stand for several *nomina*, such as Vipsanius, Valerius, Velleius, Ventidius, and others. On Ball 1G there is a feint λε above a clear M·V. It would appear that the λε has been erased and the ball reallocated to the assertive M·V.

Plate H. Gunner loading a missile with a message for Hitler. Second World War, North African campaign. By kind permission of the Imperial War Museum (IWM negative E20258).

<u>Balls with Λ (lambda)</u>

Under the interpretation suggested for Ball 4F above, Balls 3A, 4A and 5G marked ΛΓ (lambda gamma) would belong to Century Three. Balls 3B and 5D have ΛE indicating Century Five. Balls 1C and 1H have ΛZ marking Century Seven. Ball 2B has ΛH marking Century Eight.

<u>Ball 3B = British Museum EA 71834. Weight 1.75 kg Diameter approx. 11.5 cm</u>

λε, "Century Five". This is probably a 6 *librae* stone, if we allow for a slight underweight discrepancy, as with Balls 3F and 3E.

4b. Balls with incised markings

<u>Ball 2C = British Museum EA 71836. Diameter max. 16.6 cm min. 13.8 cm Weight 3.25 kg (Plate 8)</u>

[15] For examples from the Second World War see Imperial War Museum photographs A22640, A24252, A25502, B15220 (Churchill chalking a message on a shell), E20258 "A smashing Xmas, Adolf" on a 25 pounder shell, and E18557.

The British Museum catalogue entry describes this mark as "a Greek uppercase Λ with a V set within it". However I think that it may be a combination of Λ and M[4] Footnote 16, not 4, with M being short for the *praenomen* M…., and the same person as on the **M·V** ink-inscribed stones. Lochos Marci, "Century of Marcus". If so, this is M·V's thirteenth ball out of the 39.

The weight makes this a 10 *librae* missile. M·V's missiles with known weights are 3H (marked as 15 *librae*), 1G (weighing 2.0 kg, a 6 or 7 *librae* stone), and the Kandaxe ball 4F (weighing as 9 *librae*).

Stone 5A Diameter ± 11.5 cm (Plate 8)

The flat top and bottom rules this out as a missile. The inscribed marks were interpreted in 1980 as the Greek letters ΝΛ. However the diagonal cut is shallow in comparison with the four deep vertical cuts, and it continues well past the supposed N. I propose that this is to be read as IIII, the Roman numeral 4, and that it is either a marker stone, say for the position of a particular catapult, or, as Lawrence Keppie suggests (pers. comm.), a weight, presumably 4 *librae* (1.3 kg), rather than 4 *minai* (1.75 kg). The stone, now in the Cairo Museum, must be weighed.

Plate J. Reconstruction of the 10 *librae* size of *ballista* used at Qasr Ibrim (computer upscaling of the model by A.W.), and the Three-span *scorpio maior*, the catapult most likely used to launch the special Qasr Ibrim bolts (see Plate L). Full-size Three-span constructed by Len Morgan.

5. The importance of the find: the *ballistae* and the *ballistarii*.

As discussed in Section 2, the structural improvements that Petronius made in the defences can only be partly reconstructed. So we tentatively suggest that Petronius may have blocked off all but the South Gate, and followed the standard Roman disposition of artillery platforms, as laid down in the

[16] Lawrence Keppie considers the mark to be a letter A, as found on inscriptions such as RIB 2197, 2198 and 2199 (Antonine Wall); but the crossbar of the A on such inscriptions is only slightly bent.

manual on camp fortification, the *De Munitionibus Castrorum* (Pseudo-Hyginus 58): "*In enemy country you must remember to…construct platforms for catapults around the gates, and at the angles in place of towers.*" Assuming that the balls were manufactured not far from the machines, their findspots, (Plate 4), provide the only clue to the siting of *ballistae*.

The Qasr Ibrim balls will always be one of the most important finds of Roman catapult ammunition because of the quite exceptional amount of information that can be extracted from them. In addition to the 569 stones examined by Barnard, a further 43 balls from the 1978 and 1980 excavations were recorded separately in the 1990s. With the 40 inscribed ones the total of recorded balls comes to 652. The total of those encountered in excavations (pp. 69-70) comes to more than 780. The discrepancy between the two totals is probably because some have been lost over time due to disturbance to the site. Similar large groups of stone ammunition have been found at the Roman sieges of Jerusalem, Gamala, and Masada. However the details of only 50 of the many hundreds found at Masada have been published, and only a selection of the 200 from the site of Herod's Palace in Jerusalem. The Ibrim balls provide the first detailed analysis of any of the large caches of Roman Imperial *ballista* balls.

Unlike other groups of ammunition, these stones were intended for defensive use, though the three 25 cm diameter ones found in the Northwest Bastion, and those found west of the South Bastion, could well be "spent" missiles from Petronius' assault, reused as filling. Fortuitously, the balls date to within one or two years after the publication of [page 77] Vitruvius' authoritative description (*De Architectura* X, 11) of the *ballista*. Famous since the Renaissance as the sole surviving ancient writer on architecture and engineering, Vitruvius was in fact an artillery specialist appointed by Augustus to supervise the construction and repair of *ballistae*, scorpions (bolt-shooters) and other types of artillery (*De Architectura* I, 2) . Vitruvius (*De Architectura* X, 11. 3 in Wilkins 2003, 7) published a list of ascending weights of stone shot, each matched to the calibre of catapult best suited to shoot them. The sizes of the components of the catapult were all calculated from the diameter of the rope springs. Following lengthy practical experiments the Greek engineers had devised the following formula for calculating this diameter, based on the weight of shot that the catapult was intended to throw: $D = 1.1\ \sqrt[3]{(100\ M)}$, where D = the diameter of the rope spring in dactyls and M = the weight of the proposed stone shot in Attic *minai.* The precision of the *ballista* design, worked out to cope with the enormous torsional and compressive stresses involved, is amply proved by this use of a decimal point and a cube root, reputedly the first known appearance of a third degree equation in the history of Western mathematics.

Attempts to reconstruct the *ballista* described by Vitruvius began in the 19^{th} century, although to date no parts have been identified. The most difficult practical problem to solve is ensuring secure contact between the bowstring and the stone ball throughout the launch. That this was a major problem for Roman operators is made clear by the Alexandrian engineer Heron's advice on bowstrings (*Belopoiika* 111-2 in Marsden 1971, 38-9). He says that whereas the bolt-shooter's bowstring is round and close to the surface of the slider, the stone-thrower's is flat like a belt and further away from the slider, "*so that it will strike the stone half way up…. If it is positioned a little too high or low it will either slip under or jump over the stone*". We experienced the latter effect with the giant BBC *ballista* (Wilkins 2003, 58-9), when the 26 kg stone plopped harmlessly out of the machine. The slipping of the bowstring under the missile is a potentially lethal problem which can launch the missile upwards. Such an event almost changed the course of 20^{th} century history when Major Schramm demonstrated his version to Kaiser Wilhelm II: the Kaiser had to be pushed out of the way of the descending missile (Wilkins 2003, fig. 8). Dr Barnard's valuable information about the variety of shapes – rough, well rounded, flattened, irregular, hemispherical, cubic and ovoid – confirms that a semicircular launch channel, suggested for round profile missiles, would be unable to keep the missiles at the required constant height to meet the bowstring in their centre.

The solution is a rectangular section channel, where the missiles sit on the flat base throughout the launch (Fig. 4). The width of this channel limits the size of missile that can be used. Barnard's record of the maximum diameter of each Ibrim ball enables an estimate to be made of the minimum width of the channel for each shot, and hence the size of the machines used by the garrison. By the above formula the size of machine for every weight of shot can be calculated. However, to apply this rule rigidly to the enormous variety of Ibrim shot weights would result in a ridiculously large number of machines. It has long been obvious that each *ballista* was designed for a shot of a certain weight and

Plate K. Major Schramm about to demonstrate his *ballista* reconstruction to the Kaiser, with near fatal consequences when the bowstring slipped under the missile. See Section 5 text.   From Schramm-Baatz *Die Antiken Gechütze der Saalburg* 1918-1980 Abb. A).

maximum diameter, but that it was required to launch stones of lesser diameters. These balls would have to be raised to allow the bowstring to contact them half way up. The solution here proposed is a packing plank to slip onto the base of the slider's channel (Fig 4). Stones of 6, 8, and 9 *librae*, of diameters 12, 14 and 15 cm, are ascribed to Centurion Octavius. A 10 *librae* stone, Ball 2E, is also about 15 cm. Since there is only a maximum of 3 cm difference, I suggest that Octavius was using a 10 *librae* machine, one of the standard sizes on Vitruvius' list, with a packing plank 1.5 cm thick to raise the 6 *librae* missile.

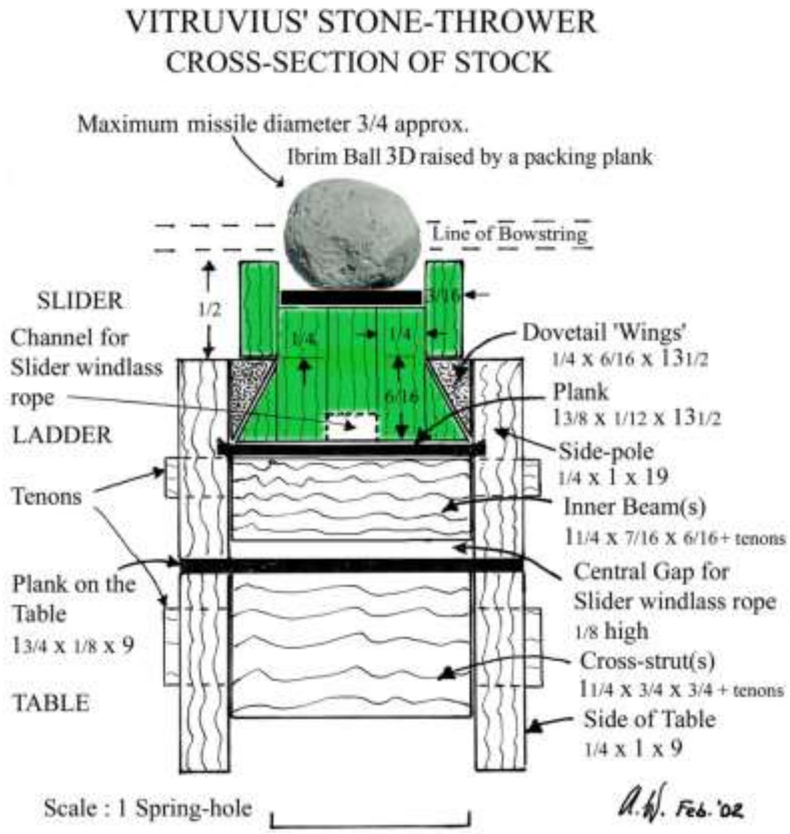

Figure 4. Cross-section of *ballista* stock from Vitruvius' description, with ovoid Ibrim Ball 3D raised by a packing plank. See Section 5 text.

If we apply such an approach to the 285 complete balls recorded by Barnard[5]Footnote 17, not 5 plus the additional 43 and the seven in the British Museum, 81% could be launched by 20 and 10 *librae* machines, 17% would be suited to a smaller 6 *librae* stone-thrower, and the three 25 cm diameter stones (above [page 78] p 67) and nine of the additional 43 balls would require a 25 *librae* catapult.

These are small to lower-medium calibre catapults on Vitruvius' list; the heavy stones of up to 80 *librae* (26 kg) were only needed for battering the walls of cities like Jerusalem (Josephus V, 270). In any case the height above the surrounding terrain and the Nile would have increased the range and the force of impact of both the stones and the catapult bolts[6] Footnote 18, not 6.

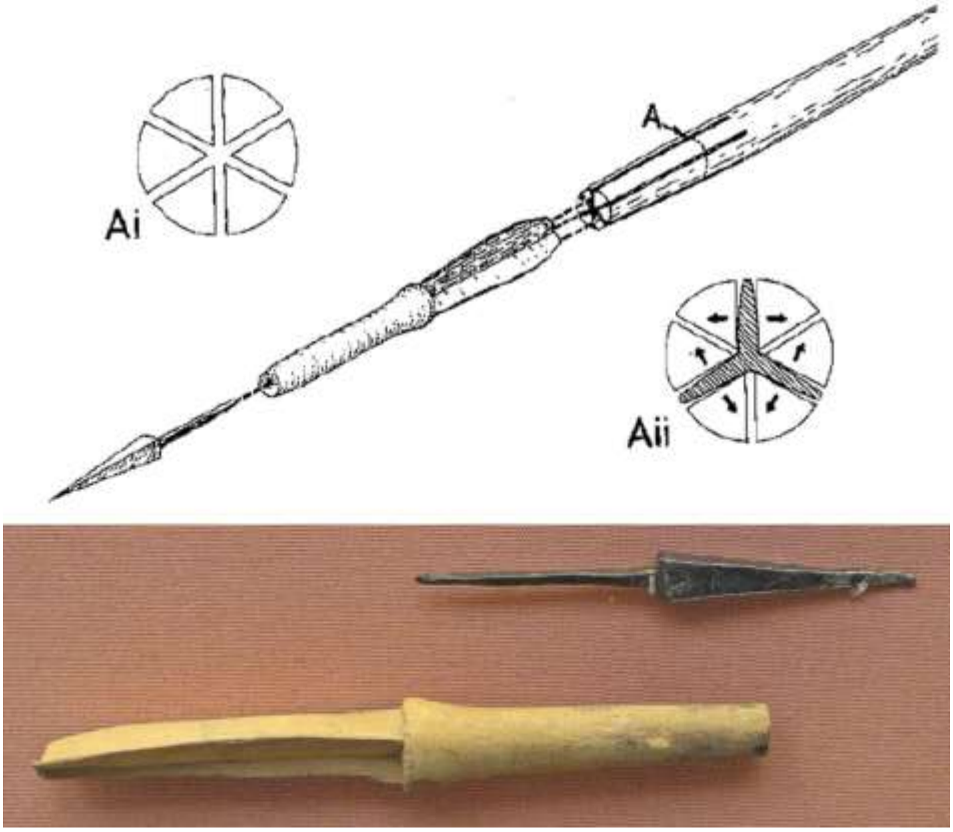

Plate L. Tanged bodkin bolthead (90mm long) and hardwood foreshaft (133mm long) from Qasr Ibrim (British Museum). Above: reconstruction by James and Taylor of the method of fixing the bolthead and foreshaft onto an 18.5mm diameter softwood mainshaft. The latter would have had the customary three flights of a Roman catapult bolt. See Section 5 text and footnote 18. For the size of Vitruvian bolt-shooter most likely used at Ibrim see Plate J above.

Launching lighter missiles than a machine's designed calibre would also extend the range. Valid calculations of these two advantages, rather than computer estimates, will only be available when trials are completed on the 2 *librae ballista* at present under construction by engineer Len Morgan from the writer's interpretation based on a revision of Vitruvius' text (Postscript Plate 2 below). The friable nature of the sandstone balls (Barnard, above p 71), and the fact there were no soft surfaces to cushion them, would mean that they would ricochet on impact and fragment into shrapnel.

It is impossible to establish the number of catapults stationed at Qasr Ibrim by Petronius, because at that date it is unlikely that the ratio of machines per legion[7] Footnote 19, not 7 had been fixed. Moreover there would be masses of artillery pieces left over from the two long civil wars, and Alexandria, one of the centres of catapult engineering, was now under Petronius' control. The ratio of bolt-shooters to stone-throwers may have been about 5 to 1, as became regular later.

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[17] These calculations are based on Barnard's lengthy Excel lists which describe every single one of the 569 balls.

18 James and Taylor 1997 discuss the finds of boltheads from the catapults that shared the defence of Ibrim. They consist of a tanged iron bodkin head inserted into a hardwood foreshaft which would originally have been slotted onto a softwood mainshaft. The addition of this hardwood foreshaft would have guaranteed extended penetration of the iron point before the mainshaft snapped, and any attempt to pull the shaft out of its target would leave the foreshaft and head behind.

[19] Vespasian's three legions, quoted above, had 160 catapults. For how this ties in with Vegetius' figures see Marsden 1969, 179.

Petronius "*fortified Premnis better, installing a garrison and food for two years for 400 men*." If the technical information that can be extracted from this ammunition is valuable, it is the human story revealed by the inscriptions that is fascinating and far more important. The legions' speed in constructing fortified camps had impressed Polybius (VI, 41. 5) as long ago as the 2nd century BC. With their technical skills Petronius' legionaries would have completed initial repairs and modifications to the girdle wall in a matter of days rather than months. One of the secrets behind the rapidity and high quality of Roman military engineering was the fostering of unremitting inter-centurial rivalry. Vegetius (I, 25) states that on campaign even the daily digging of defensive earthworks by centuries ended with a herald announcing which centuries had been the first, second and third to complete their tasks, followed by an inspection by the centurions who awarded punishments for inferior work. The largest group of Roman inscribed stones proudly recording construction by rival centuries is that of the centurial stones originally set into the face of Hadrian's Wall. Unlike such centurial stones, the Qasr Ibrim *ballista* balls were made to be disposable, intended to be hurled to destruction. The insistence on marking the names of the centuries on them is the most striking of all proofs of the importance of this use of competitive rivalry to extract the maximum effort. It should be set alongside the scene on Trajan's Column[20] where two legionaries are comparing their respective success at ditch digging, with expressive hand gesture.

Plate M. Trajan's Column Scene LXV, Cast 182. Competitive rivalry enhancing performance: two legionaries comparing their performance in ditch digging, with expressive hand gesture. "We cannot indeed here reconstruct the rough and sturdy phrasing of the *sermo castrensis*; but there will be many … who can achieve a translation, even if their version would not pass the Lord Chamberlain." Sir Ian Richmond (Richmond 1969, 196). (photo A.W. from the cast in the Museo della Civiltà Romana, EUR Rome).

The four centurions and the dominant M·V, commanding five 80-strong centuries, could account for Strabo's figure of 400 men. They are the first artillery officers to be known by name in the early Imperial period[8], and the only ones recorded on *ballista* ammunition. It was their responsibility to create a large, unending supply of ammunition by keeping their men at the slow, physically exhausting and tedious task of shaping sandstone blocks. Rather than thrashing the legionaries with their centurial rods, one of the main complaints of the mutineers in the legions in AD 14[9], there is evidence that they decided to achieve the long term output of ammunition by attending to the wellbeing of their [page 79] stonecutters. This may be inferred from the "many thousands of wine-

[8] For *ballistarii* named on later monuments see Marsden 1969, 193-4

[9] And the complaint to Hadrian in Vindolanda tablet 344 by an anonymous individual, beaten with rods until he bled. Birley 2002, 116-117.

amphora sherds"[10] found amongst the stone chippings and occupation debris filling the Northwest Bastion. Amphorae in general form *c.*75% of the total ceramic assemblage from the Roman levels. They are all resinated, implying liquid contents, and are almost entirely Egyptian made; so the wine was most probably Egyptian, which was not noted for its quality. Nevertheless wine was very freely available, and would have provided the same reward or palliative as the rations of rum issued by captains in the British navy for uncongenial tasks, like chipping the casting flaws off cast-iron cannonballs.

6. The end of the campaign

Kandake's march on Premnis was anticipated by Petronius who "*approached the fortress ahead of Kandake*"[11]. Strabo's use of προσελθὼν "*approaching*" rather than εἴσελθὼν "*entering*" would imply that the Meroitic army was also close to Qasr Ibrim, and so Kandake would know that her army was facing Petronius' field force in addition to the well-armed garrison. Earlier[12] Strabo describes the Meroitic weaponry: "…*they had large rectangular shields, and those made of raw oxhide, and their weapons were axes, with some having spears and others swords as well."* Later he adds that "*the Ethiopians also use bows of fire-hardened wood, four cubits long, and they arm the women as well…"* However, the Ethiopians, like the Britons[13] and the majority of those who faced Roman armies, did not wear body armour. Kandake's wise decision to negotiate rather than attack was based on a shrewd assessment of the superiority of Roman arms and armour, and in particular the destructive power of Roman artillery. At about 500 metres from the girdle wall a Meroitic attack would have met the edge of a hailstorm of heavy bolts, at 300 metres the lighter bolts of the smaller scorpion bolt-shooters, and at about 250 metres ricocheting *ballista* balls. From 200 metres (Plate 10) the balls would be striking them on first bounce[14], and the storm would be swollen by archers' arrows, by sling bullets, and eventually by hundreds of spears and rocks.

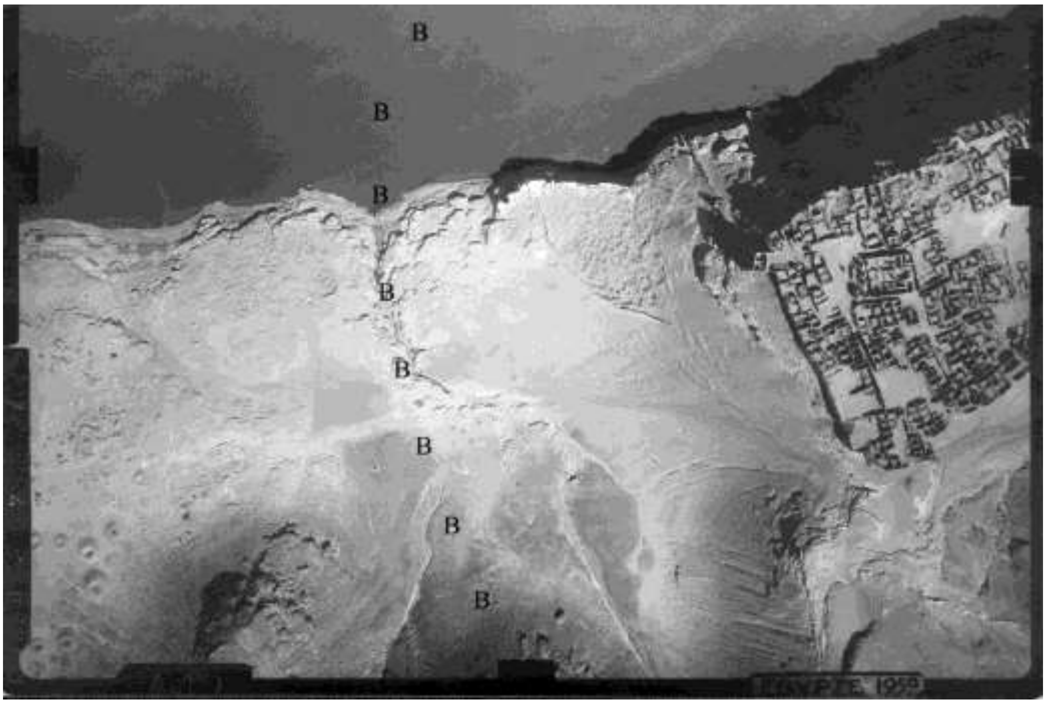

Plate 10. Aerial photograph (1959) of the western approaches. The line of Bs marks the estimated first bounce range of *ballista* balls launched from machines positioned just behind the western girdle wall. See also Plates 1 and 2b.

[10] Adams, Alexander and Allen 1983, 59.
[11] Strabo 17.1.54
[12] *ibidem*
[13] Vindolanda Tablet 164. Birley 2002, 95-96.
[14] Calculated in Wilkins 2003, 64.

"*and when Petronius had made the place secure with a greater number of armaments* (πλείοσι παρασκευαῖς), *envoys arrived*." The Loeb edition blurs this phrase by translating "*with sundry devices*", but παρασκευή in the plural is regularly used for military armaments. The extra armaments probably included more catapults. Stratigraphically, it is likely that the construction of the Northwest Bastion and the building of the cobble-filled platforms with their heaps of *ballista* ammunition belong to a later phase of the Roman occupation, such as this refortification of the site.

"*…envoys arrived, but he told them to take their delegation to Caesar… he gave them escorts. They went to Samos: Caesar was there… When they had obtained everything they asked for, he even cancelled the tributes which he had imposed*." Their reported treatment, if not another instance of Augustan propaganda, contrasts sharply with Augustus' ruthless suppression of the 45 Alpine tribes, in particular the Salassi[15].

Plate N. A last view of Qasr Ibrim, taken in the 1960s before the completion of the Aswan Dam and the rise of Lake Nasser.

Postscript

This reprint allows me to give credit to several people whose help and hard work are entirely responsible for this paper being published. First, I was only made aware of the existence of these balls when Carol van Driel Murray referred to them during a lecture, and urged me to look at them. Second, Pamela Rose generously agreed to devote valuable on-site expedition time to the examination of the balls, and then spent a long period searching out the 1978, 1980 and other QI records and analysing them for Section 2. It will be obvious that I have depended entirely on her advice to enable me to write about a site that I have never visited.

As mentioned in Section 4b, there is as yet no full publication of the important large caches of *ballista* balls found at Jerusalem, Masada and Gamala. This may be because no one has been prepared to undertake the very hard labour of handling, weighing, recording and analysing them. This is exactly what Hans Barnard has done, in the heat and the many other discomforts of the expedition camp (Plate A). The result is the only full record to date of a large group of Roman artillery balls, in this case associated with a documented historical incident, and uniquely retaining very remarkable ink inscriptions recording the activity and rivalry of several centurions.

Third, the staff of the Sudan and Nubia Department of the British Museum kindly allowed us to examine their seven QI balls and have them weighed. Most importantly, Dr Derek Welsby offered the chance of prompt publication and of presentation to the Sudan Archaeological Research Society's annual conference.

[15] Commemorated on the monument at La Turbie. Brunt and Moore 1967, 70-1.

Postscript Plate 1. A group of the heavy balls (scale in 10cm increments). Inset: Dr Hans Barnard surveying.

Postscript Plate 2. (left) In 2009 Len Morgan completed this very impressive full-size reconstruction of a Vitruvian ballista for a 2 *librae* (0.655kg) stone shot, the smallest *ballista* on Vitruvius' list. It is based on my revision of Vitruvius' Latin text and the model in Plate J. The improved Mk II version is likely to be ready in August 2011. (right) Appropriately, one of the first test shots was aimed and released by Dr Pam Rose, without whose enthusiastic cooperation this survey of artillery missiles would never have been written.

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For more information on Roman artillery go to the website www.romancatapults,co.uk , and read the new book by Alan Wilkins *Roman Imperial Artillery* described on that website and available by emailing the author at contact@romancatapults.co.uk .