

ANDREA VANNI DESIDERI

UNIVERSITY OF FLORENCE

Notes on Two *Manjanīq* Counterweights from Mamluk Shawbak

The Site and the Finds

The castle of al-Shawbak is located in Jordan, a few kilometers to the north of the homonymous town, along the road connecting Tafleḥ to Wadi Musa. A first archaeological campaign was conducted by Robin Brown in the 1980s in order to investigate the Late Islamic horizon of the settlement.¹ New research in the area, under the University of Florence's archaeological mission "Medieval' Petra: Archaeology of the Crusader-Ayyubid Settlement in Transjordan," started in 2000.² The results gathered since then show that the Crusader installation was preceded by a Late Roman-Byzantine fortified settlement whose curtain wall is partially preserved in the inner part of the castle. Baldwin I, king of Jerusalem, apparently taking advantage of the remains of the previous fortification, built the castle in 1115 as part of the defensive apparatus of the eastern frontier of the Latin Kingdom of Jerusalem, protecting the southern part of Transjordan and the road towards the Red Sea. Mentioned in Western written sources as Montréal due to its royal foundation, the castle became the political and military center of southern Transjordan and its success in this role is also expressed by its urbanistic development. After its fall into Muslim hands in 1189 as an aftermath of the defeat at Hattin (1187), the regional political importance of the castle was strengthened under the Ayyubids, who added monumental and productive buildings. According to written, epigraphic, and archaeological sources, a few years after the dismantling of the fortifications by the Mamluk sultan al-Ashraf Khalīl, his successor Lājīn

¹R. Brown, "Summary report of the 1986 excavations in Late Islamic Shobak," *Annual of the Department of Antiquities of Jordan* 32 (1988): 225–45.

²The research at al-Shawbak is part of the wider project "Medieval' Petra: Archaeology of the Crusader-Ayyubid Settlement in Transjordan" started in 1986 by the University of Florence. On the goals, method, and results of the whole project see *Archeologia dell'insediamento crociato-ayyubide in Transgiordania: Il progetto Shawbak*, ed. G. Vannini (Florence, 2007); *Da Petra a Shawbak: Archeologia di una frontiera*, ed. G. Vannini and M. Nucciotti (Florence, 2009); G. Vannini and M. Nucciotti, "Shawbak: strutture materiali di una frontiera," in *La Transgiordania nei secoli XII–XIII e le frontiere del Mediterraneo medievale*, ed. G. Vannini and M. Nucciotti (Oxford, 2012), 135–44.



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built a strong, new defensive apparatus, including new bastions and towers, in 1297–98 (Fig. 1).³

In the 1990s, prior to the start of the “Medieval’ Petra” mission, the Department of Antiquities of Jordan undertook a clearance campaign in the area of the major monumental buildings in the northeastern part of the castle. During this work a quantity of stone elements was unearthed, which were stored in the vaulted halls underneath the upper church of Saint Mary (Fig. 2). Among epigraphic fragments, decorative architectural elements, millstones, and many spherical stone projectiles of various diameters, a particular element carved into a limestone block was recognized. Being conventionally indicated as “A” type (Fig. 3), it has a trapezoidal shape, with a convex base and a dovetail mortise carved on both faces with a square hole pierced through the thickness of the block (Fig. 4).⁴

Around 2000–2002 the Ministry of Energy and Mineral Resources completed a new clearance campaign for consolidation works in the southern part of the castle. During this campaign a second element of the same kind came to light. It is conventionally indicated as “B” type and although lacking a small fragment in the upper part, the general shape is quite similar to the “A” type, though smaller and thinner, every dimension being about half of those of the previous specimen (Fig. 5). It differs from the latter in the extension of the mortise, which goes from the top to the base of the element and is carved only on one face. The most evident difference with type “A” is the absence of the square hole and the presence of four holes drilled through the thickness of the block and located laterally to the central mortise (Fig. 6).

Discussion

If we consider the two specimens from al-Shawbak, although the archaeological context has been lost and a preliminary search for published archaeological comparisons did not succeed, their apparent similarity with drawings of counterweight artillery guided our research attempting to specify the type of engine to which the artifacts belonged, and to propose a reconstruction of the coupling system and of their chronology, starting from a concise review of Arab military treatises and related iconography.⁵

³M. Nucciotti, “Analisi stratigrafiche degli elevati: primi risultati,” in *Archeologia dell’insediamento crociato-ayyubide in Transgiordania*, 45, 48; B. Walzer, F. Dotti, and M. Nucciotti, “Shawbak e la Transgiordania mamelucca,” in *Da Petra a Shawbak*, 126–31.

⁴A. Vanni Desideri, “Un contrappeso da manĵaniq dalle fasi mamelucche del castello di Mont Réal (Shawbak): Considerazioni tra archeologia e iconografia,” in *Da Petra a Shawbak*, 122–25.

⁵A preliminary bibliography on Arabic military literature was provided by Rahman Zarky in 1965. On Islamic military technology see also: A. Y. al-Hasan and D. R. Hill, *Islamic Technology: An Illustrated History* (Cambridge, 1986), 93–120; D. R. Hill, *Studies in Medieval Islamic Technol-*



The hurling engines to which the elements most probably belonged are indicated by the Arabic terms *‘arrādah* and *manjanīq*, perhaps reflecting their different sizes, with the *‘arrādah* being the smaller of the two.⁶ More recently, it has been suggested, on the basis of the description by al-Ṭarsūsī, that the *‘arrādah* was a pole-framed and the *manjanīq* a trestle-framed engine.⁷

This weapon, which probably originated in China as a traction-powered engine, appeared in the Mediterranean area with the Byzantine army in a hybrid design, combining human traction with gravity power.⁸ Quickly reaching the Islamic milieu, it was used increasingly often during the Islamic conquest, from the siege of Mecca (683) to Baghdad (865).

A more advanced and effective counterweight type, the *trabuchium* or *biffa* of Western written sources, was developed in the Mediterranean area by the end of the twelfth century.⁹ From this type, rapidly disseminated by Arab engineers toward the Far East, there evolved around the mid-thirteenth century the pivoting counterweight engine, or *biffa*, as it was called by Egidio Colonna in the *De re militari veterum ad mores praesertim medii aevi*.¹⁰ Paul E. Chevedden recognized a relationship between the effectiveness of this new design and changes in the planning of passive (fortifications) and active (weapons deployment) defense of castles and cities starting with the renovation of the Islamic fortifications in the Latin East.¹¹

It was in the Latin West that a new engine, powered by twin pivoting counterweights and therefore called *bricola*, originated. Its fortune spread in a relatively

ogy: From Philo to al-Jazarī, from Alexandria to Diyār Bakr (Norfolk, 1998), 99–115, specifically dedicated to trebuchet. See also the recent work by A. Tami, “L’art de la guerre au temps des Croisades (491/1098–589/1193): Du theocentrisme irrationnel aux influences mutuelles et adaptations pragmatiques dans le domaine militaire: Histoire” (Ph.D. diss., Université Michel de Montaigne, Bordeaux III, 2012) dedicated to the cultural and technical aspects of warfare during the Crusades on both sides.

⁶J. F. Finò, “Machine de jet médiévales,” *Gladius* 10 (1972): 25–43.

⁷P. E. Chevedden, “The Invention of the Counterweight Trebuchet: A study in Cultural Diffusion,” *Dumbarton Oaks Papers* 54 (2000): 95.

⁸P. E. Chevedden, “Fortifications and the Development of Defensive Planning in the Latin East,” in *The Circle of War in the Middle Ages: Essays on Medieval Military and Naval History*, ed. D. J. Kagay and L. J. A. Villalon (Woodbridge-Rochester, 1999), 36; idem, “The Invention of the Counterweight Trebuchet,” 71–116. On the evolution of medieval artillery see M. S. Fulton, *Artillery in the Era of the Crusades: Siege Warfare and the Development of Trebuchet Technology* (Leiden-Boston, 2018).

⁹For a discussion on the terminology see Chevedden, “The Invention of the Counterweight Trebuchet,” *passim*.

¹⁰E. Colonna, “De re militari veterum ad mores praesertim medii aevi,” cap. XVIII, in *Collectio monumentorum, veterum et recentium, ineditorum*, ed. S. F. Hahn (Brunswick, 1724), 1:1–69.

¹¹Chevedden, “Fortifications and the Development of Defensive Planning in the Latin East.”



short time eastward and lasted until the Renaissance when Francesco di Giorgio Martini gave two of the most famous and detailed, although latest (1472–77), descriptions of this engine in his *Opusculum de architectura* (Fig. 7).

Tracing the diffusion of the *bricola* from the western Mediterranean toward China, three main steps have been recognized. It seems that technical and practical knowledge of this design was first transmitted from the Latin West to the eastern Mediterranean thanks to the emperor Frederick II, who, according to Caffaro's *Annales*, sent some engines to the Near East in 1242.¹² Later on the new and more efficient artillery, since then called *manjanīq ifranjī* or *manjanīq firanjī* (mangonel of the Franks) because of its origin, was introduced as an updated ordnance in the Mamluk army.¹³ The third step eastward was accomplished by Muslim artillerymen serving in the Mongol army who transmitted the *bricola* to China where its name was changed into *hui-hui pao*, or Muslim trebuchet.¹⁴

From the iconographic point of view, the most complete description and the earliest available illustration of a counterweight *manjanīq* is the one displayed in *Tabṣirat arbāb al-albāb fī kayfīyat al-najāh fī al-ḥurub* (Instructions of the masters of the skills of the methods of salvation in wars) by Marḍī ibn 'Alī ibn Marḍī al-Ṭarsūsī, written around 1187 and dedicated to Saladin.¹⁵ The author specifies the details of the designs used among different peoples, including the Europeans, but the drawing is scarcely useful because of its overly schematic representation of the engine (Fig. 8). As to the transmission of this design, al-Ṭarsūsī attributes it to an Armenian master of weapons captured by the Fatimid army who offered his collaboration in exchange for his life and explained the principles of the new machine in Alexandria.¹⁶

The *Kitāb al-furūsīyah wa-al-manāsib al-ḥarbīyah* (Book of military horsemanship and ingenious war devices), written by Najm al-Dīn Ḥasan al-Rammāh

¹²Chevedden, "The Invention of the Counterweight Trebuchet," 110, n. 143.

¹³Ibid., 109.

¹⁴On the diffusion of the counterweight trebuchet see P. E. Chevedden, "Black Camels and Blazing Bolts: the Bolt-Projecting Trebuchet in the Mamluk Army," *Mamlūk Studies Review* 8, no. 1 (2004): 102–6. A preliminary look at the throwing engine in medieval and post medieval China was provided by J. Needham, "China's Trebuchets, Manned and Counterweighted," in *On Pre-Modern Technology and Science: Studies in Honor of Lynn White Jr.*, ed. B. S. Hall and D. C. West (Malibu, CA, 1976). For an overview on China's medieval military technology see J. Needham and R. D. S. Yates, *Science and Civilisation in China*, vol. 5, *Chemistry and Chemical Technology*, part 6, *Military Technology, Missiles and Sieges* (Cambridge, 1995).

¹⁵The treatise was first edited and translated into French by C. Cahen, "Un traité d'armurerie composé pour Saladin," *Bulletin d'Etudes Orientales* 12 (1947–48): 1–61 and more recently edited as Marḍī ibn 'Alī ibn Marḍī al-Ṭarsūsī, *Tabṣirat arbāb al-albāb fī kayfīyat al-najāh fī al-ḥurub*, ed. K. Sander (Beirut, 1998).

¹⁶Quoted in Chevedden, "The Invention of the Counterweight Trebuchet," 104–5.



around 1280, contains a drawing of a launching engine (Fig. 9) recognizable as a pivoting counterweight *manjanīq*.¹⁷ The counterweight has a nearly trapezoidal shape with a reinforced base connected to a vertical central element coupled to the beam, possibly indicating a wooden structure with a reinforcing metal frame.

The *Ĵāmi' al-tawārikh* (Collected histories) by Rashīd al-Dīn Ṭabīb, composed around 1306, provides more detailed and abundant representations of *manjanīq*.¹⁸ The plate depicting the siege of a town by the Mongol army gives a very interesting description of an engine ready to shoot (Fig. 10). The trestle frame appears particularly strong and is provided with several buttresses, giving the idea of a *manjanīq* of great size, able to project the round shells visible on the left. The hanging system of the triangular pivoting counterweight is very similar to the one it is possible to imagine for our “A” type. A keyhole-shaped plate, possibly metallic, is clearly visible and is coupled by means of a cylindrical joint pin provided with a cotter. On the other hand, the distance between the counterweight and the fulcrum of the beam as represented in the drawing is not realistic, being too short to be effective, but that could be explained by the author’s general tendency to *horror vacui*, trying to fill the illustrations of the manuscript with as many details as possible.

A drawing included in the *Kitāb anīq fī al-manājanīq* (An elegant book on trebuchets) composed by Aranbughā al-Zaradkāsh in 1462–63 depicts a *manjanīq* with details similar to those in the latter document (Fig. 11). The beam is supported by the same kind of frame, and the counterweight, whose shape is similar to the two elements from al-Shawbak, is sustained by a presumably metallic element with an upper joint pin functioning as pivot point.

The last two documents are the most useful for the interpretation of the mortises and holes on the two counterweights from al-Shawbak and the reconstruction of their coupling system. In particular, the supporting system represented in Rashīd al-Dīn’s manuscript helps us to understand the functional purposes of some details.

Taking into consideration the mortises and the holes carved into the trapezoidal-monolithic counterweights and comparing it with the illustrations of *manjanīq*, their different coupling system could be reconstructed as follows. In the “A” type, two (probably metal) plates with a keyhole shape were placed into the corresponding dovetail mortises, where a joint kingpin with a square section, passing through the thickness of the block, was fastened by cotter pins. A second

¹⁷Najm al-Dīn al-Rammāh, *Kitāb al-furūsīyah wa-al-manāsib al-ḥarbīyah*, ed. A. Y. al-Ḥasan (Aleppo, 1998).

¹⁸For a recent study on the manuscript see S. Kamola, “Rashīd al-Dīn and the Making of History in Mongol Iran (Ph.D. diss, University of Washington, 2013).



joint pin with a round section passing through the round holes in the upper ends of the plates would have hung the counterweight to the beam (Fig. 12).

In the case of the “B” type, the presence of only one dovetail mortise reveals that for its correct coupling and use at least one more element was necessary, while the four holes were needed to facilitate the transport of the heavy counterweight but also allowed the assembly of the two elements (Fig. 13).

Defense Planning, Ordnance Deployment, and Effectiveness

When comparing iconographic and archaeological sources, a difference must be noted: while the manuscript by Rashīd al-Dīn does not show a connection between the keyhole metal plate and the counterweight, the “A” type artifact has a square hole in the middle of the mortise. Apparently the difference can be explained by the different materials of the two counterweights, i.e., the monolithic limestone element from al-Shawbak and the probable wooden box structure described in al-Zaradkāsh’s and Rashīd al-Dīn’s manuscripts. Actually, a wooden box counterweight was the simpler and more convenient solution as it made it possible to rapidly and easily increase the propelling mass using any available material, obviously an advantage during siege activities when specific materials might not be available.¹⁹ Such considerations show that engines using two solid limestone or similar counterweights were not meant as offensive weapons to be used during an attack or siege, which would have required a certain flexibility of use, but were probably meant for defensive deployment.

The *manĵanīqs* were installed on the bastions of the castle, on the basis of detailed reconnaissance and knowledge of the surrounding landscape. The limited possibility for adjustment provided by solid stone counterweights meant that the performance and the locations of the two *manĵanīqs* were carefully planned and specifically designed. In fact, combining the possible direction of an attack, the necessary range, and the more suitable positions of the engine, it was possible to precisely plan the performance of the artillery while avoiding the construction of a more versatile but larger engine.

Based on comparison of iconographic sources, it is clear the counterweights from the castle of al-Shawbak belong to the more advanced gravity artillery, i.e., the pivoting counterweight type. If we take into consideration how the two counterweights are made, however, we can see that their mass could not be easily increased and, as a consequence, it would not have been possible to adjust their

¹⁹In this regard see the different raw materials identified during the archaeological survey in the surrounding area of the battlefield of Arsūf. In particular, most of the projectiles, since limestone was not available at the site, were made out of limestone blocks brought from the Samarian hills, some 15 km from Arsūf (K. Raphael and Y. Tepper, “The Archaeological Evidence from the Mamluk Siege of Arsūf,” *Mamlūk Studies Review* 9 (2005): 87–88.



performance. For both artillery pieces only limited adjustments were possible, such as moving the counterweight along the beam or modifying the size of the missiles, consequently changing the range. Still, their masses were not sufficient to hurl effective projectiles, since counterweight “A” weighed around 450 kg and “B” only about 62 kg. This problem could only be explained if we consider the two counterweights as parts of a different and more advanced kind of engine. In the case of a *manjanīq firanjī*, the *bricola* of Western origin, twin counterweights (of about 450 kg each for the “A” type and around 150 kg each for the “B” type) could have provided more adequate gravity power, granting balance and stability to the engines at the same time, thus increasing their accuracy.

Such a reconstruction at the castle of al-Shawbak, with two different kinds of *manjanīq* of the *bricola* design (with different performance characteristics) deployed, could be explained as follows. A rapid survey of the topographical features of the area around the castle indicates that the most threatening elevations are located along a north/northeast-south/southwest axis (Fig. 14). Two major heights of around 1200 meters above sea level are located nearest, around 200 meters away, on both sides of the castle. Since these locations are the most suitable for the positioning of enemy artillery pieces they had to be covered by the defensive artillery. Other elevations to the west and northwest are also suitable for artillery attacks but they are too far from the castle curtain walls. The whole eastern sector is naturally protected by the slope.

Accordingly, the fortifications built by the Mamluk sultan Lājīn at the end of the thirteenth century included two large bastions, one facing northwest and the other against a possible attack on the south/southwest flank, each with a large, flat roof suitable for operating the engine and each provided with batteries of arrow slits arranged in multiple rows. Combining the locations with the hypothetical range deduced from the average different features of the engines (mass of counterweights and projectiles, lengths of the beams, etc.) it is possible to propose a reconstruction of the effective coverage of such artillery.

Judging from the place where the two elements may have been found, the engine provided with the “A” type counterweight would presumably have been placed on the northwest bastion, and the engine with the “B” type counterweight on the south/southwest bastion.

The whole defensive plan of al-Shawbak, based on perfect knowledge of the logistics, together with an evaluation of the possible locations of siege engines, fits perfectly with the advice included in the treatise by al-Anṣārī at the beginning of the fifteenth century. In book twenty he writes that once the siege take place, because of the limited resources of the defenders, they should know with



maximum precision the weapons to be used and how to have the maximum effect on the enemy.²⁰

The use of hurling engines as defensive weapons mounted on bastions or towers is well known from written sources: Anna Comnena quotes a *helepolis* (a kind of traction trebuchet) mounted on towers or ships²¹ and Eustathios, bishop of Thessalonica, in *The Capture of Thessaloniki* remembers how in 1185 artillery deployed on the curtain walls defended the town against siege by the Normans.²² In 1148 the *manjanīqs* of the Saracens defended the town of Tortosa, throwing missiles of around 60 kg.²³ Apart from these early examples, the major developments in the use of artillery as a defensive weapon coincide with the introduction of the counterweight trebuchet, which was much more threatening to fortifications than the traction version. The increased effectiveness of the new design of trebuchet led to a new way of planning the defenses of castles and cities, combining larger fortifications with the defensive use of artillery. A new system of defenses including thicker curtain walls and larger bastions combined with the deployment of artillery developed by the sultan Sayf al-Dīn al-Malik al-Ādil was later also used by the Crusaders.²⁴ The clearest and most complete expression of this new defensive plan is the citadel of Damascus—later extended to Bursa (1218) and Mount Tabor (1215)—but reinforcements based on the same concept are to be found in many Ayyubid strongholds.²⁵

A good but late representation of this new role of artillery is provided by al-Zaradkāsh's manuscript, which shows three different types of artillery (torsion, traction, and rotating counterweight) defending a fortified gate (Fig. 15). More than three decades earlier the curtain walls of Orléans were protected by an out-of-date trebuchet located on top of the tower of Saint Paul, which was soon replaced by a more effective cannon.²⁶

In this regard, for the understanding of the castle's active defense system, the numerous limestone *manjanīq* missiles found during the excavation of area 6000 assume further importance. On the back of the apse of the lower church of the castle, next to the inner gate, at least two stratigraphic units (US) contained

²⁰ Al-Anṣārī, *Tafrij al-kurūb fī tadbīr al-ḥurūb*, ed. G. T. Scanlon (Cairo-New York, 2012), 121.

²¹ G. T. Dennis, "Byzantine Heavy Artillery: the Helepolis," *Greek, Roman and Byzantine Studies* 39 (1998): 108–9.

²² Chevedden, "The Invention of the Counterweight Trebuchet," 94.

²³ A. A. Settia, *Rapine, assedi, battaglie: La guerra nel Medioevo* (Bari, 2002), 126.

²⁴ Chevedden, "Fortifications and the Development of Defensive Planning in the Latin East," 38–43.

²⁵ *Ibid.*, 33–43.

²⁶ J. F. Finò, "Machines de jet médiévales," *Gladius* 10 (1972): 40, n. 52.



manjanīq missiles, both included in Period 8.²⁷ The earlier stratigraphic unit 6079 contained a quantity of roughly spherical missiles with diameters of approximately 35 to 85 cm, obtained by processing limestone blocks (Fig. 16), which could be interpreted as an ammunition deposit *in situ*. In a later moment, evidently after such artillery had become obsolete, the floor (US 6040) underneath a vaulted ceiling (US 6052) was paved using a quantity of *manjanīq* missiles as mere building material. The study of these projectiles, still in progress, will furnish important information concerning the different sizes and weights of the projectiles that can help determine the performance of the counterweight artillery. At the moment, their average weight, estimated at about 60 kg, can be compared with the data recovered during the excavation at the site of Arsūf, where the battlefield of the siege led by Baybars has been archaeologically investigated. Given that the raw material is the same, the average diameter and weight of the missile stones from Shawbak correspond to the maximum used by the defenders of the fortress against the besieging Mamluk army, which mostly weigh between 16 and 35 kg—noticeably less than the 45 kg stones hurled by the *ifranjī manjanīq* used by the Mamluk army besieging Acre.²⁸

As for the effectiveness of these bastion engines—usually hurling smaller projectiles as can be deduced from the description given by William the Breton of the siege of Bôves by king Philippe August: “nunc mangonellus, Turcorum more, minor saxa rotat”²⁹—Jean Froissart writes in his *Chroniques* that in 1340 the defenders of Montagne destroyed the great trebuchet of the enemy with three shots.³⁰ The author of the *Itinerarium peregrinorum et gesta Regis Ricardi* describes how the defenders of the town of Acre used *manjanīqs* to destroy the attacking trebuchets of Henry of Champagne,³¹ and the defense of the castle of Chinon, at the time of king Philippe August, also relied on a “petraria turquesia.”³² Artillery of the same type was also located on movable towers during offensive activities, as reported by Jean Froissart during the siege of Bergerac by the French in 1377.³³

The reconstruction of the active defense of Mamluk Shawbak, as far as can be deduced by material sources, apart from the quantity of arrow slits arranged

²⁷C. Molducci and E. Pruno, “Shawbak: lo scavo dell’area 6000,” in *Archeologia dell’insediamento crociato-ayyubide in Transgiordania*, 56–69.

²⁸Raphael and Tepper, “The Archaeological Evidence from the Mamluk Siege of Arsūf,” 87, 99–100 (Arsūf) and 90 (Acre).

²⁹D. J. Cathcart King, “Trebuchet and other Siege-Engines,” in *Chateau Gaillard 9–10: Actes des Colloques Internationaux tenus a Basel (1978) et a Durham (1980)* (Caen, 1982), 460.

³⁰P. Contamine, *La guerra nel Medioevo* (Milan, 2000), 270–71.

³¹Chevedden, “The Invention of the Counterweight Trebuchet,” 96.

³²Finò, “Machines de jet médiévales,” 40, n. 49.

³³*Ibid.*, 41–42.



in multiple rows in the bastions, can now be completed with the deployment of a number of updated artillery pieces as part of a wider plan accomplished in 1293–94 under the rule of Sultan Lājīn. In particular, the new bastions and their locations, if intended as a consequence of the study of the surrounding landscape and the recognition of the main direction of a possible attack, seem to support this interpretation.



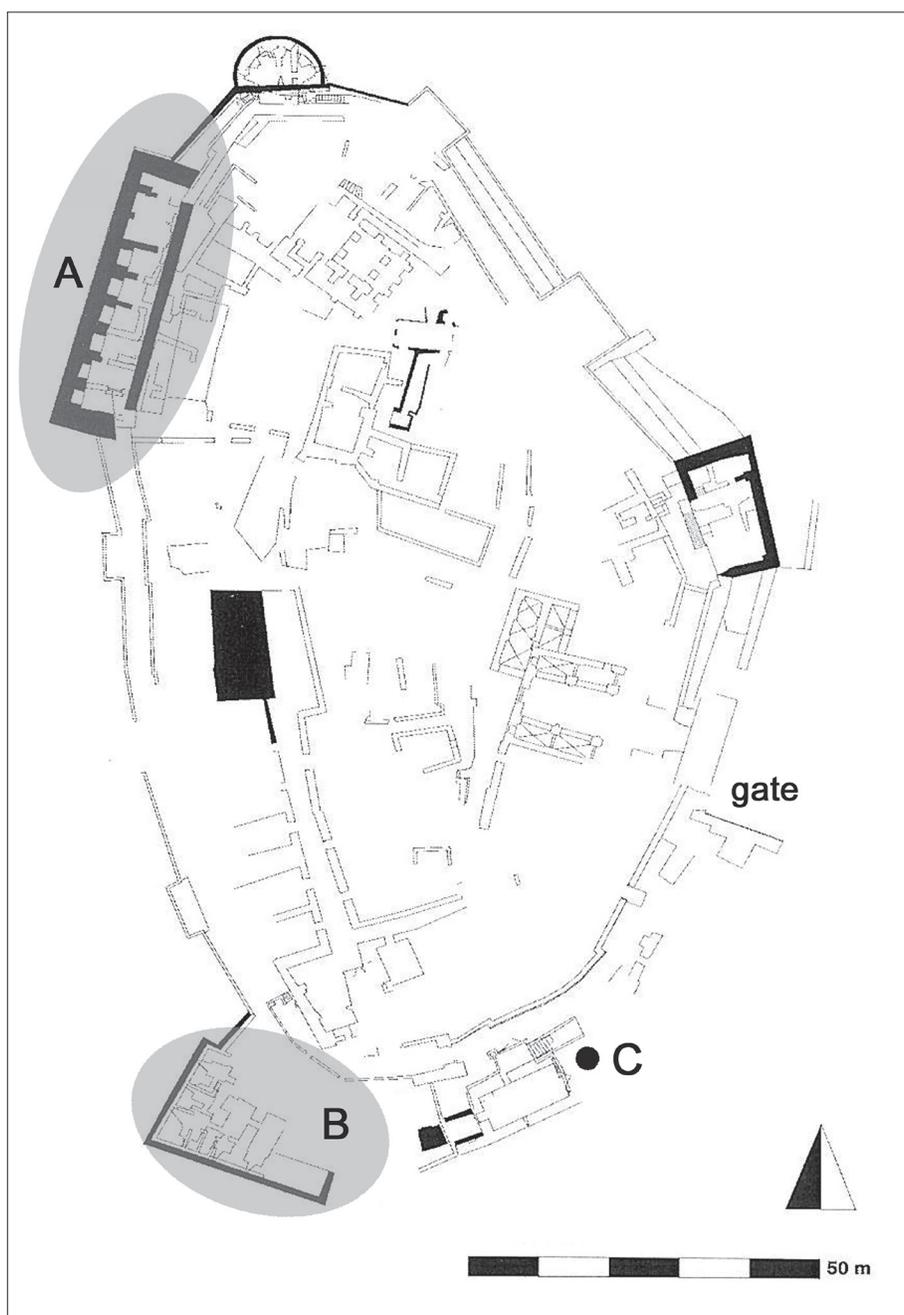


Fig. 1. Plan of the castle of al-Shawbak with the main Mamluk reinforcements of the late thirteenth century as indicated by the archaeological analyses (after Nucciotti, “Analisi stratigrafiche degli elevati: primi risultati”). Letters A and B show the probable areas of provenance of the two counterweights.



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Fig. 2. The *lapidarium* where the stone elements were stored after the first campaign of clearance. Among them the “A” type of counterweight is visible with projectiles of various size in the background. Photograph by the author, summer 1999.



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Fig. 3. The “A” type of counterweight. Photograph by the author, summer 1999.



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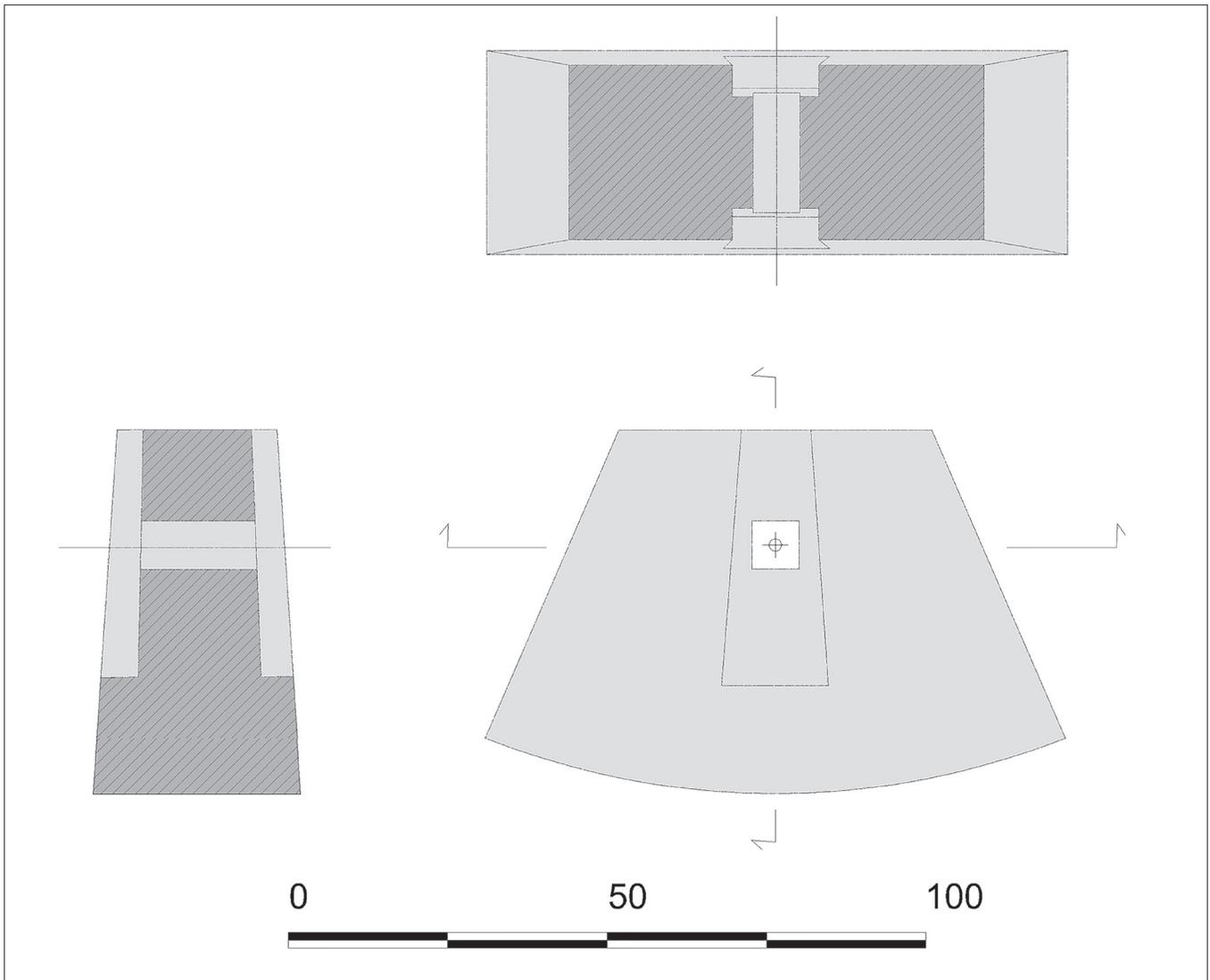


Fig. 4. The “A” type of counterweight. Drawing by the author.





Fig. 5. The “B” type of counterweight. Photograph by the author, November 2012.



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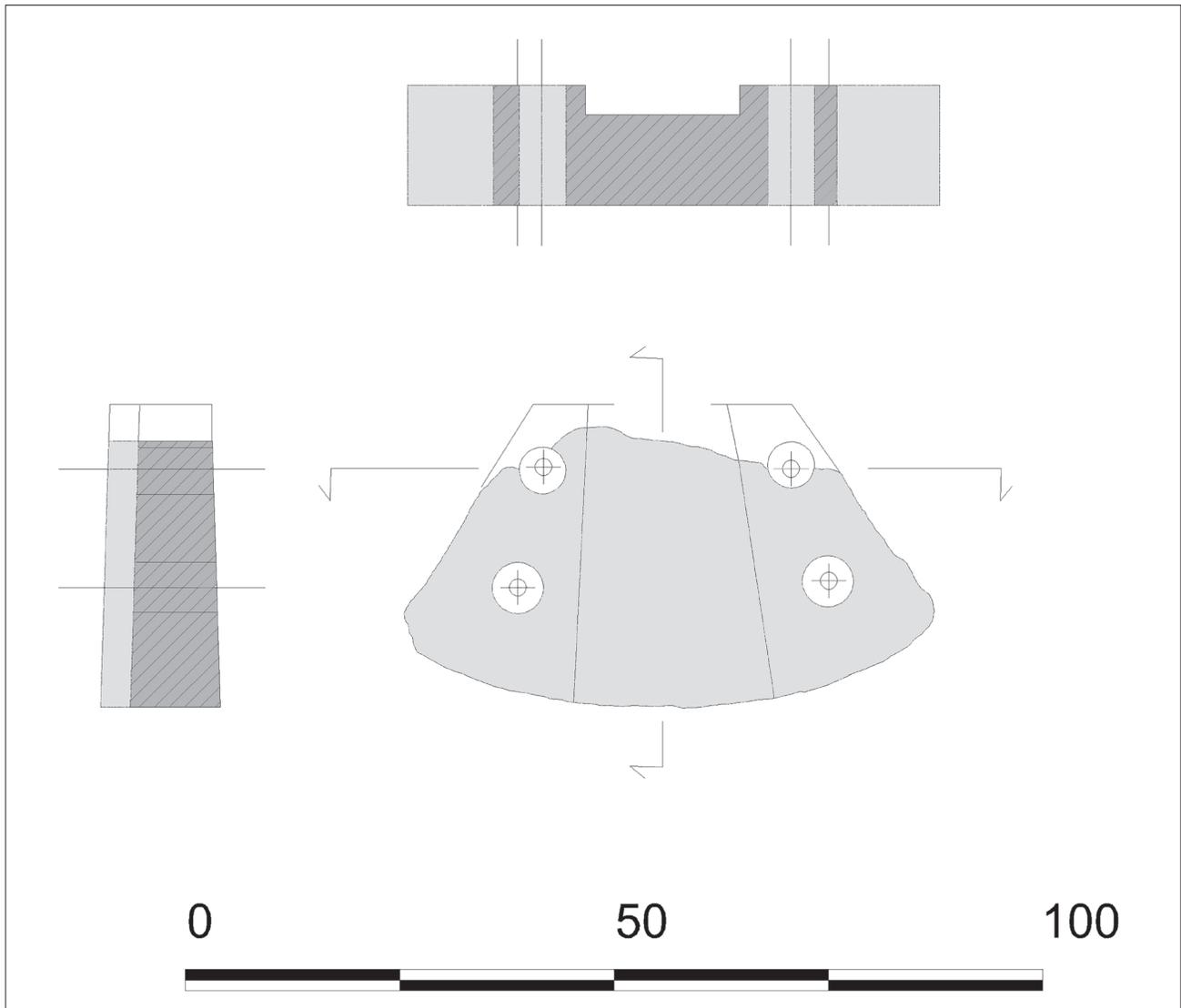


Fig. 6. The “B” type of counterweight. Drawing by the author.



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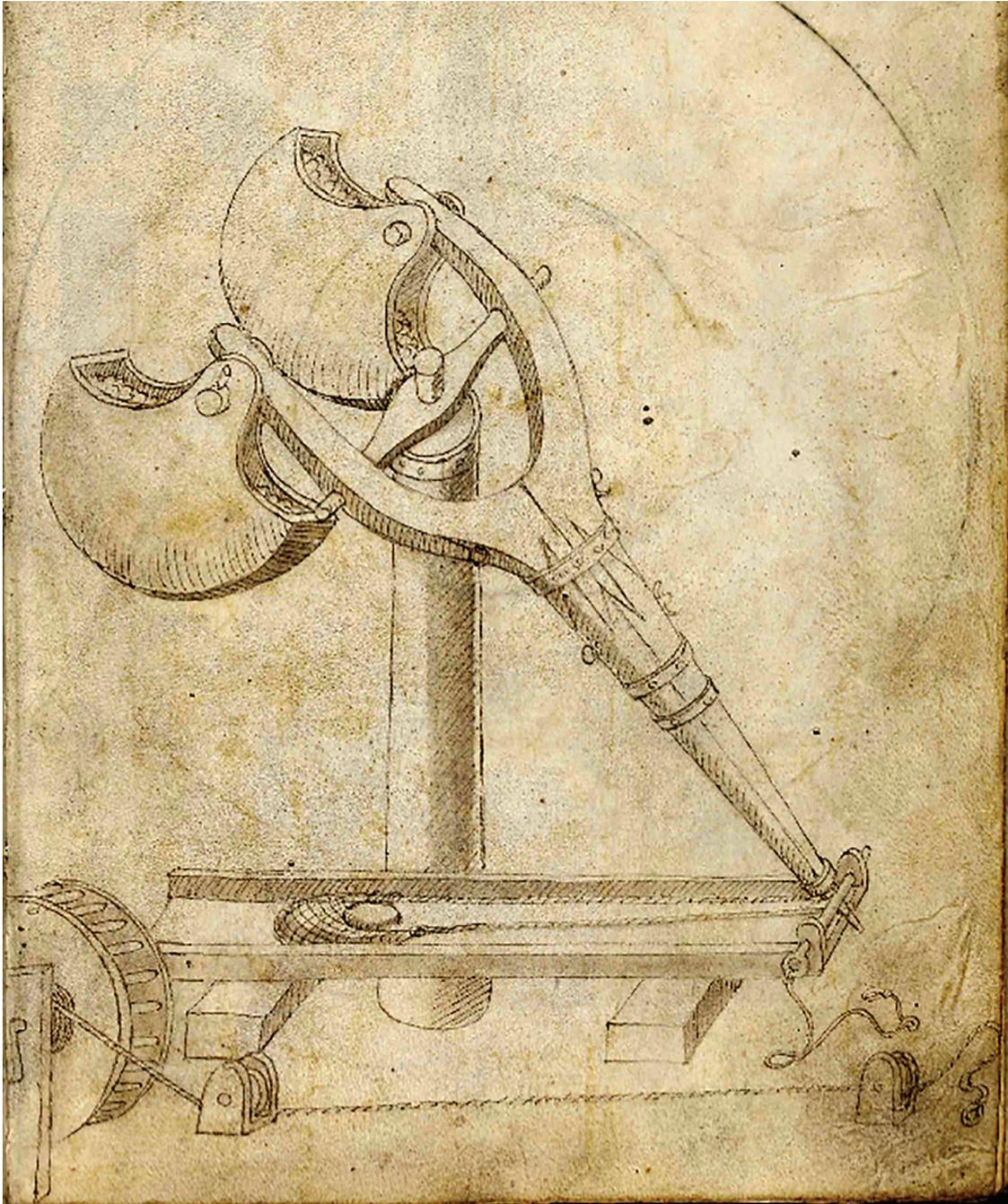


Fig. 7. Francesco di Giorgio Martini drawing of a *bricola*.



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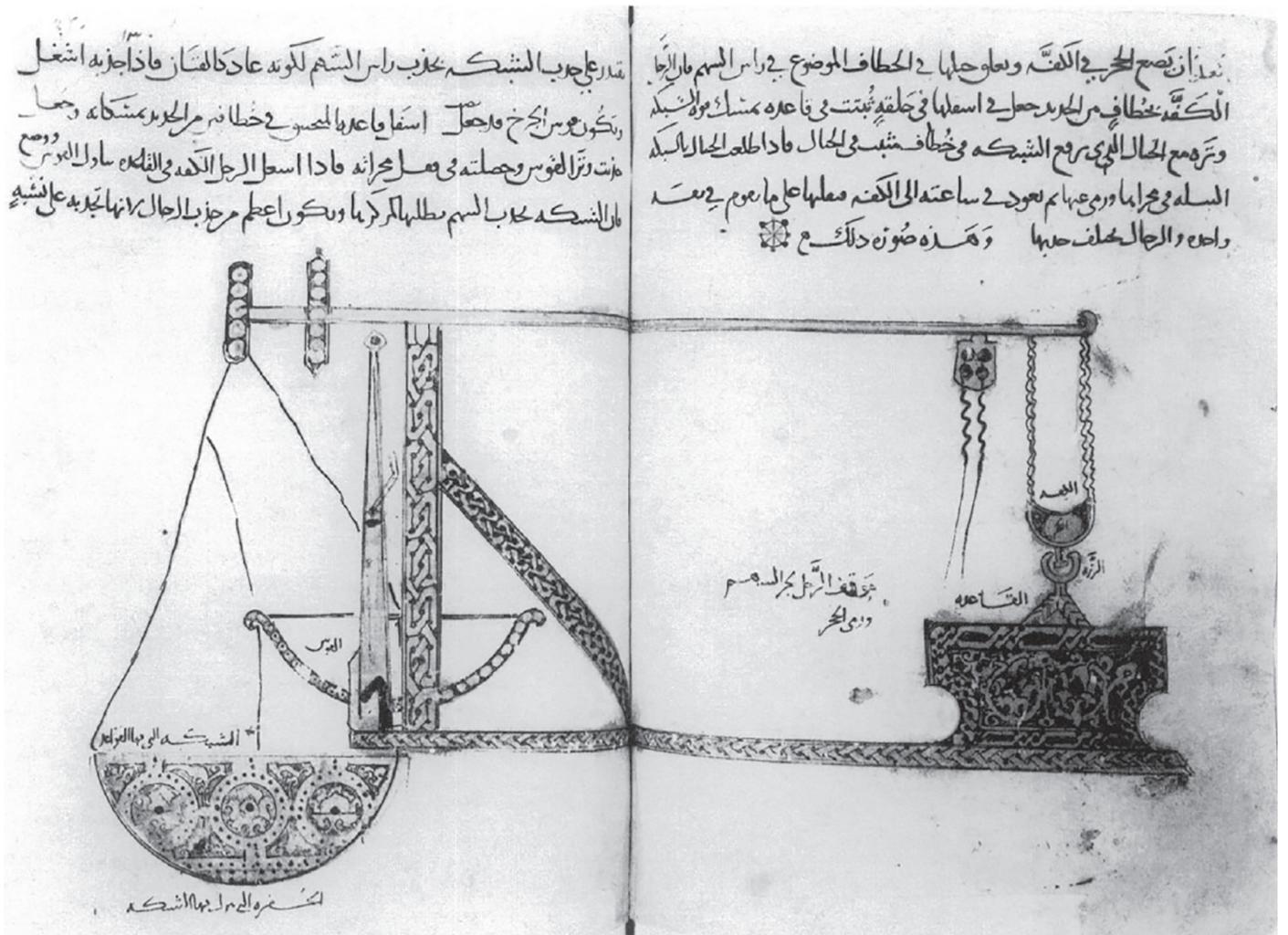


Fig. 8. The counterweight *manjanīq* represented in al-Ṭarsūsī's *Tabṣirat arbāb al-albāb fī kayfīyat al-najāh fī al-ḥurūb*, circa 1187.



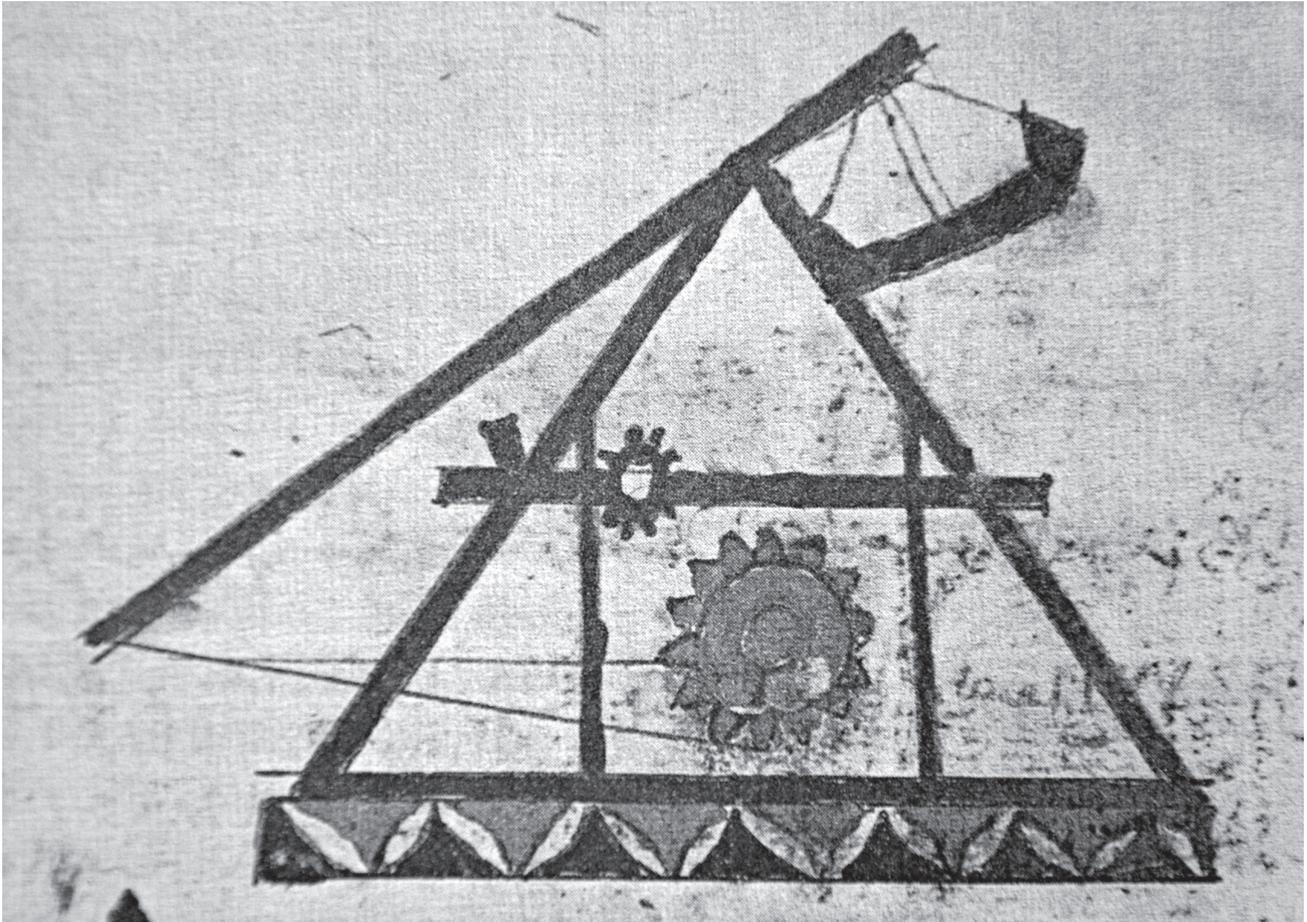


Fig. 9. A counterweight *manjanīq* in al-Rammāh's *Kitāb al-furūsiyah wa-al-manāsib al-ḥarbīyah*, 1280 (after al-Ḥasan and Hill 1986, p. 110, Fig. 4.15).



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Fig. 10. A Muslim counterweight *manjanīq* firing against the curtain walls of a town as represented in Rashīd al-Dīn Ṭabīb's *Jāmi' al-tawārīkh*, 1306 (after Kamola 2013).



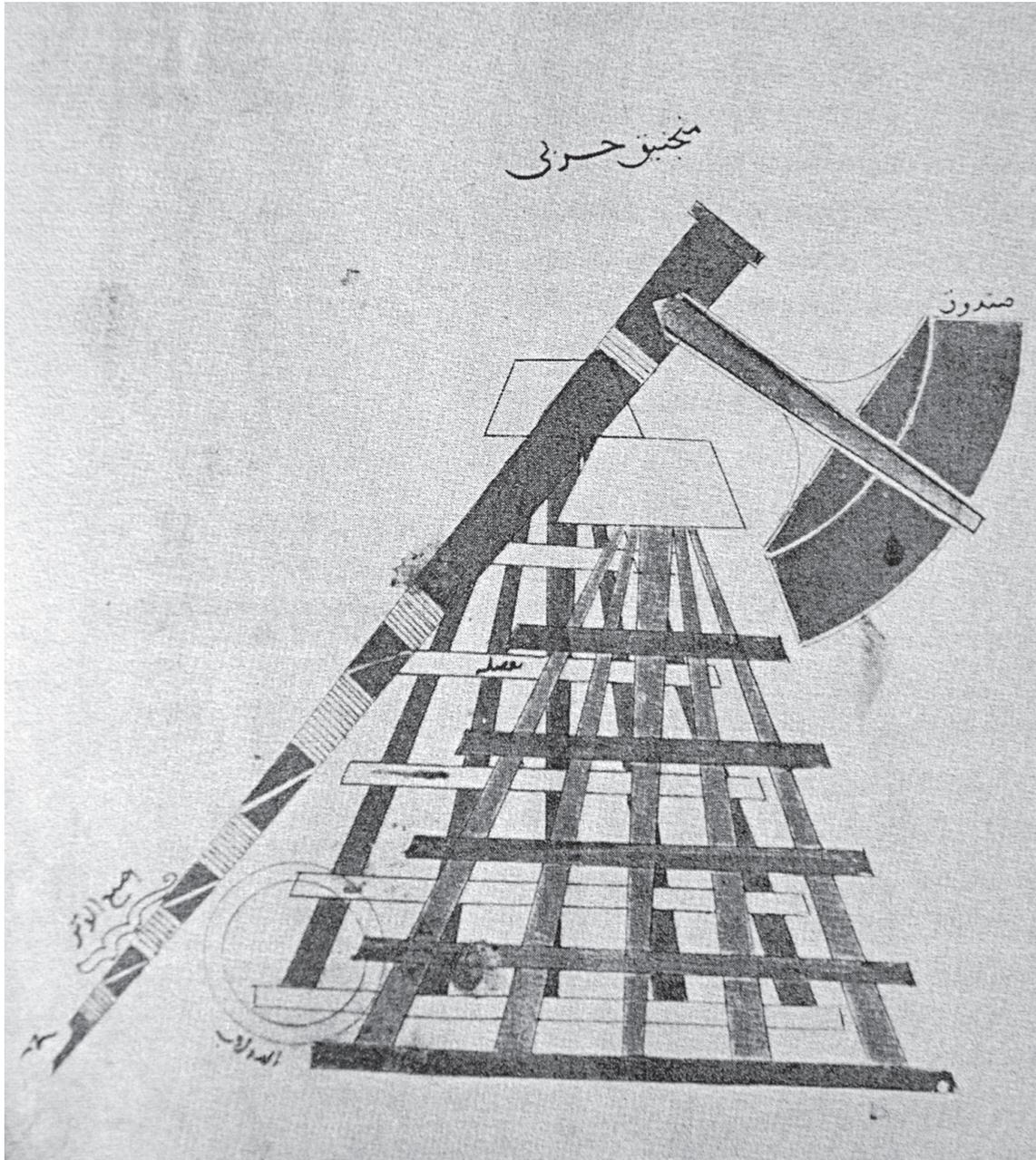


Fig. 11. A *manjanīq* represented in al-Zaradkāsh's *Kitāb anīq fī al-manājanīq*, 1462. Topkapı Sarayı Müzesi, İstanbul (after al-Ḥasan and Hill 1986, p. 101, Fig. 4.7).



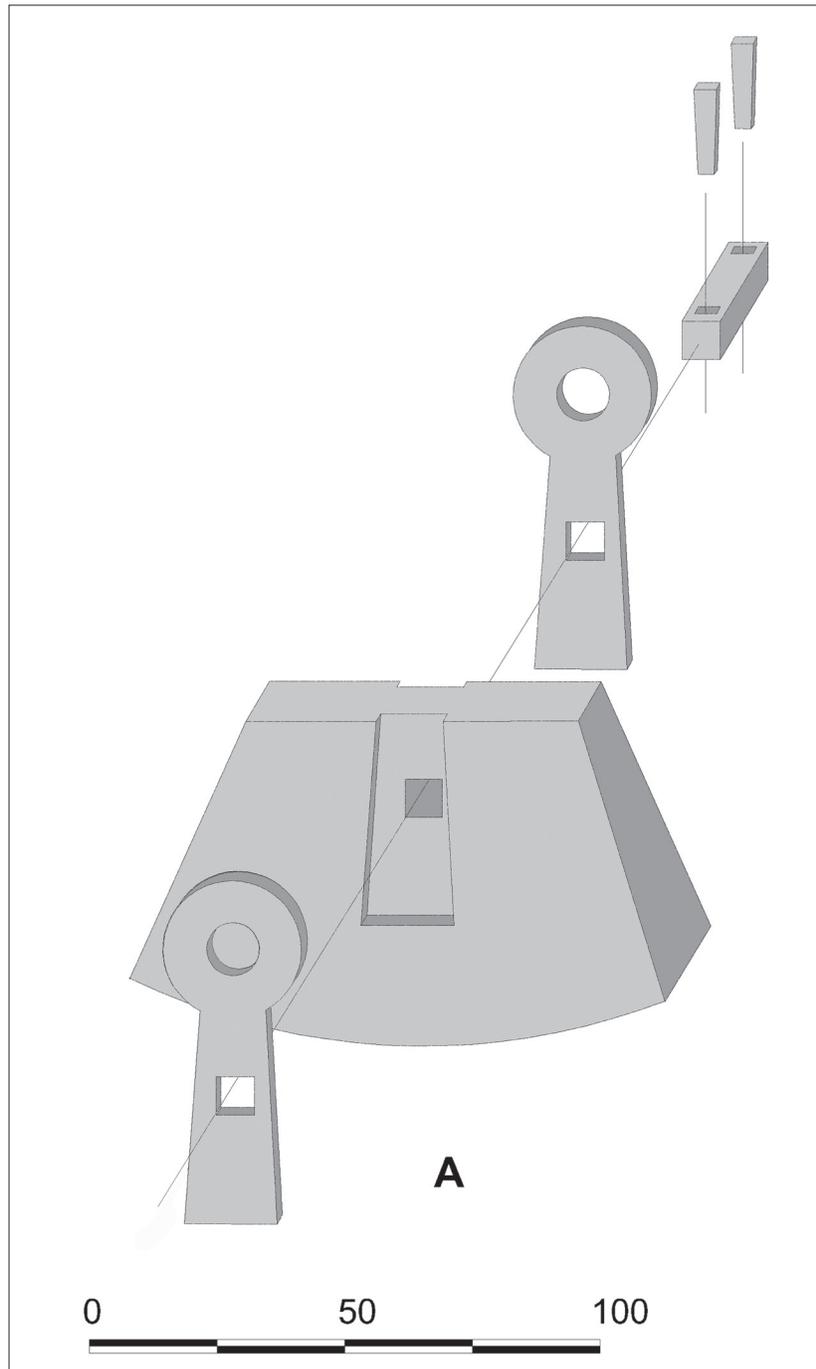


Fig. 12. Reconstruction of the hanging system of the “A” type of counterweight. Drawing by the author.



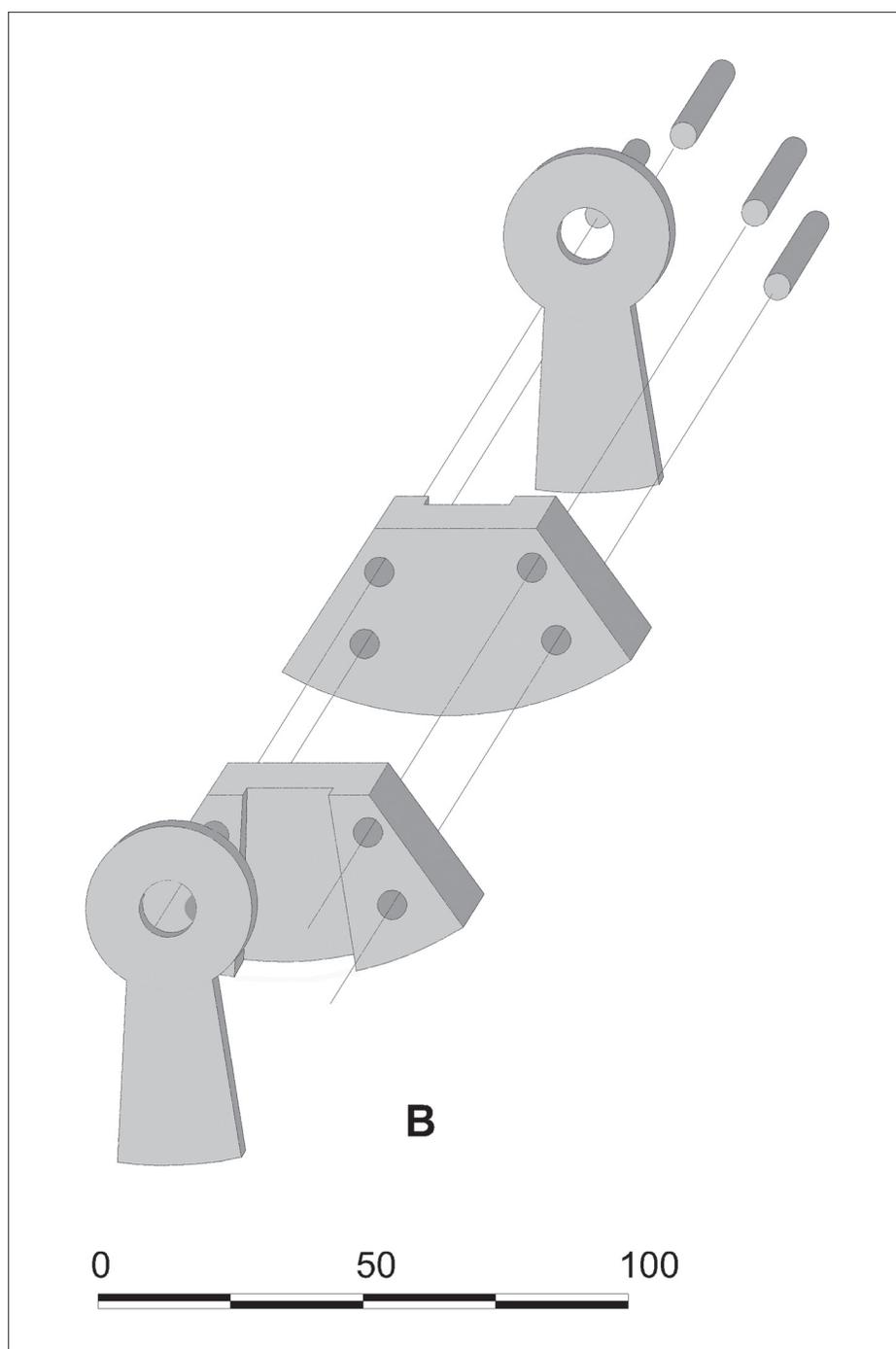


Fig. 13. Reconstruction of the hanging system of the “B” type of counterweight.
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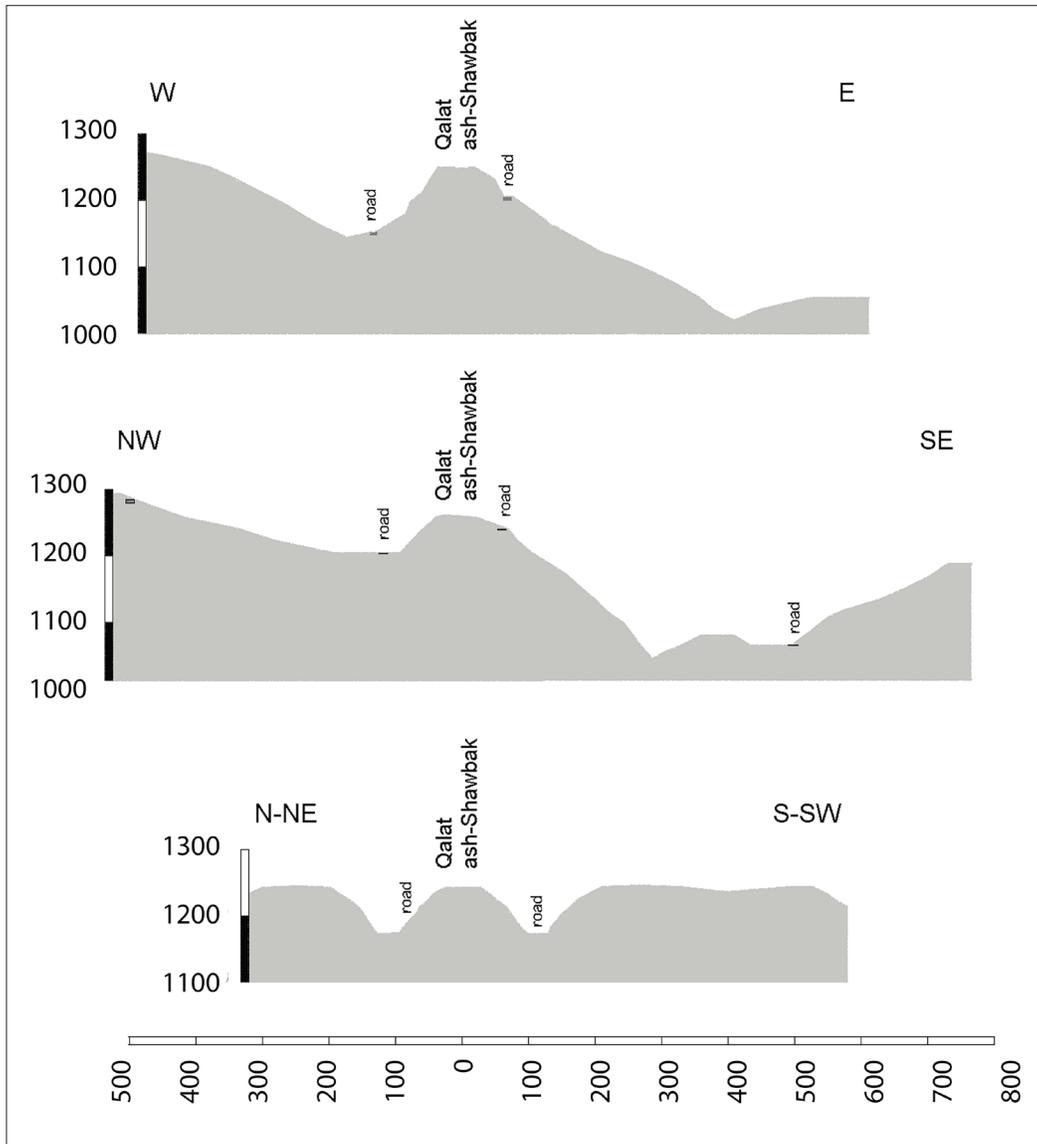


Fig. 14. Topographic sections of the area of Shawbak showing the more suitable elevation for an artillery attack. Elaboration by the author from the 1:25,000 “Maʿān” map by the Royal Geographic Centre.



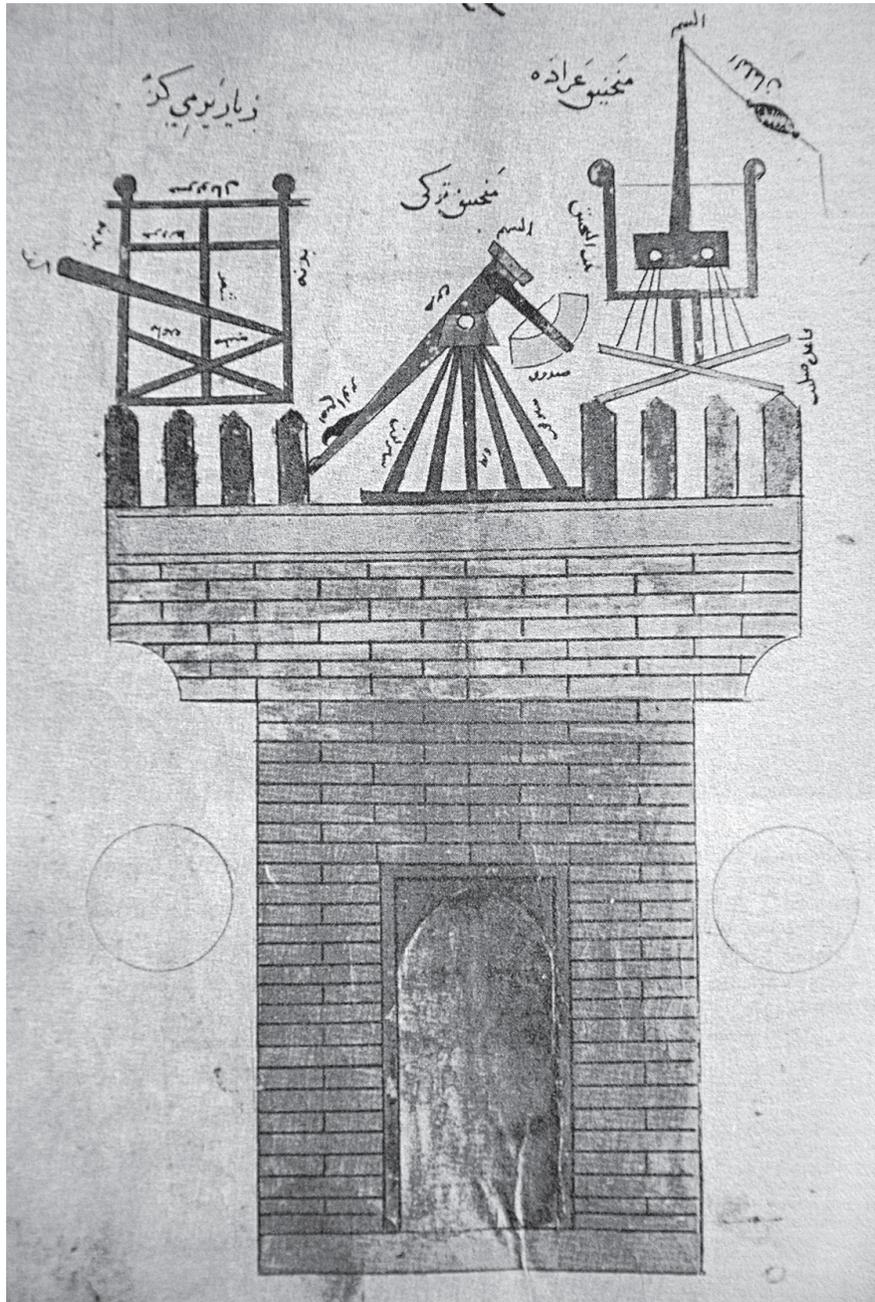


Fig. 15. Different types of artillery pieces defending a fortified gate: a torsion engine, a *manjanīq* and a traction engine. Al-Zaradkāsh's *Kitāb anīq fī al-manājanīq*, 1462. Topkapı Sarayı Müzesi, Istanbul (after al-Ḥasan and Hill 1986, p. 104, Fig. 4.9).





Fig. 16. Area 6000, US 6079 under excavation (after Molducci and Pruno 2007).



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