
ESTUDIOS / STUDIES

The Retractable *Maqṣūra* Screen and Mobile Minbar of the Kutubiyya Mosque of Marrakesh

La maqṣūra retráctil y el minbar móvil de la mezquita Kutubiyya de Marrakech

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ABSTRACT

The Kutubiyya Mosque of Marrakesh, built under the Almohad Caliph ʿAbd al-Muʿmin from 1158 to 1163, was fitted with a mechanical system for raising and lowering the *maqṣūra* screen, plentifully described in the chronicles of the time. Excavations in 1947 shed some light on the mechanisms of this system; this paper looks at how it might have worked based on the description provided by the documents and the material remains.

Key words: maqṣūra; minbar; Almohad; capstan; windlass; block-and-tackle; rope.

RESUMEN

La mezquita Kutubiyya de Marrakech construida por el califa almohade ʿAbd al-Muʿmin entre 1158 y 1163, contó con un sistema móvil para el cierre del recinto de su *maqṣūra*, ya descrito por las crónicas de la época. Las excavaciones realizadas en 1947 pusieron de manifiesto la infraestructura de este sistema. En el presente artículo se estudia cómo pudo ser el funcionamiento de este artificio en base a las descripciones documentales y a los restos materiales conservados.

Palabras clave: maqṣūra; minbar; almohade; torno; cabrestante; trócola; cuerda.

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INTRODUCTION

The Kutubiyya Mosque of Marrakesh was built under the Almohad Caliph ʿAbd al-Muʿmin from 1158 to 1163. It was constructed in two phases (Fig. 1) (Deverdun 1959: 172-194; Almagro and Jiménez, forthcoming), the first comprising a prayer hall of 17 aisles of six bays perpendicular to another aisle running along the *qibla* wall. To the north of this hall was a courtyard surrounded by a prolongation of the four outer aisles on each side, each of four bays. Shortly after this first building was constructed it was enlarged beyond the *qibla* wall by the addition of another almost identical building, slightly skewed to suit the Almohad's revised direction of prayer. In time the initial part of the building fell into ruins; all that remains standing and still in use today is the enlargement. In its initial phase this mosque boasted a very special *maqṣūra*, but it is not known whether this *maqṣūra* was moved when the mosque was enlarged.

A *maqṣūra* is an enclosure standing near the *miḥrāb*, traditionally closed off by a wooden screen, open at the

top, usually slightly higher than a man. It was designed to protect the caliphs or governors while they prayed in the mosque, because from the early years of Islam, these individuals ran the risk of assassination while they prayed, especially when the congregation was prostrating themselves on the floor. At this time, they would have been defenceless against any potential assassin who was behind them, and some died as a result. For this reason, the custom was adopted of building an enclosure with its own access, wherein the person of authority and his entourage were kept safe and separate from the rest of those at prayer (Pedersen *et al.* 2012: I-D-2b).

This arrangement, introduced by the prophet Muhammad's first successors, might also be bound up with the ceremonial custom of hiding the Caliph from his subjects, whereby he showed and displayed himself on very few, special occasions (Barceló 1995: 155-156). This was a way of showing his might and position as empowered representative of God before the Muslim community (Chalmeta 2001: 148). This practice, time-honoured in the eastern courts of both Byzantines and Sassanians, were taken up by the Umayyad caliphate of Damascus and thereafter by Abbasid and Fatimid caliphates. Even as late as the sixteenth century, the Saadian Sultan Ahmad al-Manṣūr hidden behind a curtain, received certain people as a way to claim the caliphal title (García-Arenal 2009: 118-119).

In the early twelfth century the Almohads, loyal to their own beliefs of equality, had initially been reluctant to take up the *maqṣūra* (Ghouirgate 2014: 366), but they soon began using it, particularly in the great mosque they built in their capital, Marrakesh. Several reports and chronicles, both contemporary and later, refer to this *maqṣūra*, stressing that it was moveable. In other words, the screen could be raised and lowered, hidden or displayed as needed.

The device was accompanied by a minbar, a pulpit from which the *imām* would deliver the *khuṭba* or sermon during Friday prayers; this minbar could likewise be displayed or hidden at will. These furniture-like items were present in all congregational mosques, derived from the original two-step pulpit on which the Prophet Muhammad would lecture his followers or preside over his judgment-giving and consultation assemblies (Fierro 2007: 156). Later, the pulpit was heightened with six further steps to make the preacher more visible. Apart from its usefulness, the minbar symbolized too the presence of the prophet, so the Imams usually preached two or three steps down from the top as a sign of humility and respect. Being also the place from which the name of the ruler was invoked in the sermon, it became a symbol of authority as well.

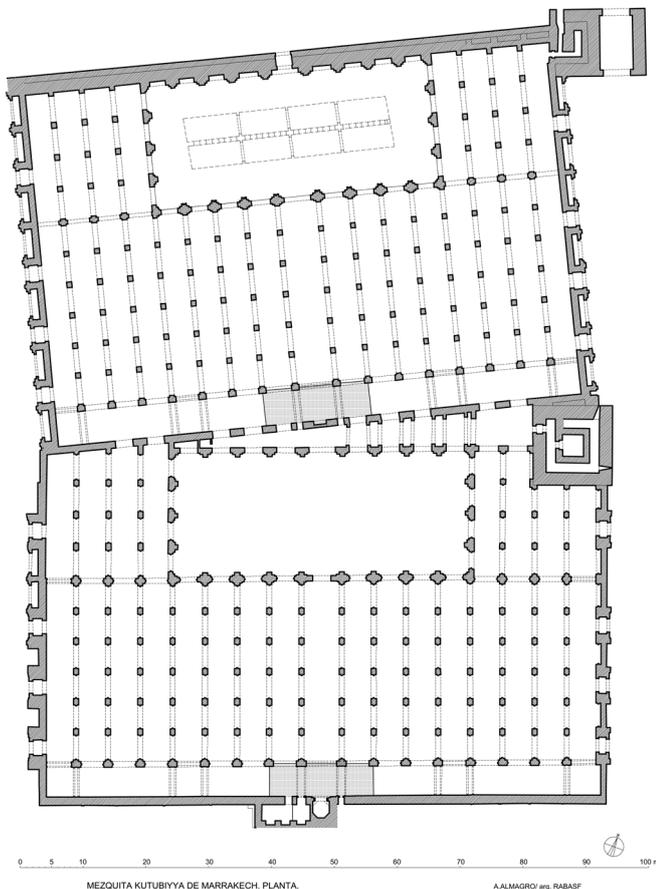


Figure 1. Reconstructed ground plan of the original Kutubiyya Mosque, showing the location of the *maqṣūra* in each phase. Author: A. Almagro.

The first minbar used by the Prophet was made of wood and moved about to wherever it was needed. In medieval times, in the central and eastern lands of Islam, minbars were sometimes made of masonry or stone and were always fixed in place. In the mosques of Muslim west, however, minbars took their cue from the one constructed by al-Hakam II (915-976) for the Cordoba Mosque, and they were made of wood and mounted on wheels so they could be kept in a storage chamber next to the mihrab. Storing the minbar away in a special room had a practical reason; they were usually made, after all, from valuable materials such as precious woods and ivory and featured a great deal of artistic workmanship, so it was necessary to protect them from theft and deterioration. The aforementioned symbolic character is again important here; the alternate appearance and concealing of this object was intimately bound up with manifestations of power (Fierro 2007: 159-161). There were also people that believed that since the Prophet didn't use the minbar all the time, it was wrong to have it always in the mosque.

The area set aside for a *maqṣūra* in both phases of the Kutubiyya Mosque measured 18.80 × 5.80 m (Fig. 1); opening onto it were the niche of the mihrab and two adjacent doors. Facing the *qibla*, the door on the right opened to the closet for storing the minbar. The one on the left gave onto a room and from there to a corridor whereby the caliph could enter the mosque without having to mingle with the rest of the faithful. This remarkable *maqṣūra* was almost twice the area of the oldest surviving one, ca. 1036, which is preserved in the mosque of Kairouan in Tunisia. Many medieval authors described or referred to the Kutubiyya *maqṣūra*, however, probably because of its unique mechanism. Fortunately, sufficient archaeological remains have survived, and together with the texts they make it a worthwhile and fruitful object of detailed study.

THE TEXTS

The first known reference to this device comes from Abū Bakr Muḥammad ibn ʿAbd al-Malik ibn Muḥammad ibn Ṭufail (died 1185 in Marrakesh) in a letter quoted by the seventeenth-century author al-Maqqari:

While this work, a pearl of the time and eternal source of light, was underway it was ordered – may Most High God continue to help them – that the Main Mosque be built in the capital Marrakesh, may Most High God protect it. The construction work began in the month of Rabīʿ II of

the year 553 [May 1158] and was brought to conclusion midway through the blessed month of Shaʿban of the same year [September 1158] in the most perfect manner, with the most extraordinary art, the most ample dimensions and the most belief-defying carpentry and workmanship. The glass windows and the movements of the minbar [pulpit] and the *maqṣūra* there contained would be astonishing even if it had taken many years to build the mosque; even more amazing are they in view of the speed of the work, unimaginable for any craftsman, especially when the edification work is also considered. The Friday prayer was made in the mosque on midway through the aforesaid month of Shaʿban (al-Maqqarī 1988: 615).

The start date of the work on the new Mosque of Marrakesh, given among others by the twelfth-century chronicler ʿAbd al-Malik b. Muḥammad b. Ṣāhib al-Ṣalāt, coincides with the bringing to this city of the *muṣḥaf* (manuscript of the Qurʾān), said to have belonged to the Caliph ʿUṭhmān and to have been kept until then in the Cordoba Mosque. It is possible that the mobile *maqṣūra* also bore a relation with the mechanical lectern in which the precious book was kept (Bennison 2007).

The most coherent and detailed description of this *maqṣūra* is given in the anonymous chronicle *al-Ḥulal al-Mawshīya*, finished in 783 AH (1381-1382 CE), which describes it within the Kutubiyya Mosque:

When Abd al-Mumin finished his construction [of the mosque], he made therein a *sabat* (high covered corridor) allowing passage to and from the alcázar without being seen. A large minbar made in al-Andalus [by the Almoravid dynasty ...]² was moved thereto and a wooden, six-sided *maqṣūra* with an extension of over one thousand³ feet was made. The master builder charged with the work was a man from Málaga called al-Hajjaj Iʿis, who also built Gibraltar in the times of Caliph Abd al-Mumin, as it still stands today. The idiosyncrasy of this *maqṣūra* screen is the mechanism allowing it to be raised on entry and lowered on exit. To this end a door was made to the right of the mihrāb, behind which is the minbar; to the left another door gives onto a room containing the mechanism of the minbar, whereby Abd al-Mumin also entered and left. When the time came on Friday to go to the mosque, the mechanism was activated after raising the carpets cove-

² On this *minbar* see Bloom 1998.

³ This figure seems an error or an exaggeration that does not match reality.

ring the floor of the maqşura. The side pieces were then raised at the same time without even so much as a minute between their respective appearances. The door of the minbar was kept closed, but when the preacher rose to mount the minbar, it was kept open, whereupon the minbar slid out noiselessly and apparently of its own accord⁴.

The maker of this device was a man from Malaga named al-Ḥajj Yaʿīsh al-Mālaqī (Jiménez Martín 1996: 22) who is also cited in 1159 in a letter from Caliph ʿAbd al-Muʿmin on the foundation of Gibraltar:

... he has solved construction of a city in Jabal Tariq, where the Mediterranean and Atlantic meet, serving as nexus to the regions situated on each side of the Strait; it is proposed to endow the newly founded city with advances of all kinds and make it impregnable. He has sent for that purpose sheikh Abu Ishaq Barraz b. Muhammad and the engineer al-Ḥajj Yaʿīsh (Lévi-Provençal 1941: 275).

Further information on the man of Malaga's role in this endeavor is given by the always well-informed chronicler Ibn Ṣāhib al-Ṣalāt:

There came the illustrious order to build a great city with the most complete permission of God and his help [...] the architect al-Ḥajj Yaʿīsh, during the time he was supervising the construction, as we have already said, made in the highest point of Gibraltar a mill using wind-power to grind the grain, which was watched over by trustworthy men during the construction work. But after he had returned to Marrakesh, upon completing his remit, the windmill fell into ruins for lack of care (Ibn Sahib al-Salat 1969: 21-23).

The mastermind of these inventions then turns up next in Seville, the other capital of the Almohad empire, in 1172, when the last known information on him is given:

Outside the port of Carmona, on the road leading through the plain to Carmona, lie ancient traces, hitherto buried, of an old canal. The earth on top was removed, revealing a line of stones, of unknown significance. The engineer al-Ḥajj Yaʿīsh went there and dug around the aforementioned remains, whereupon there appeared the traces of an aqueduct that took water to Seville in ancient times

[...] water was carried there on Saturday 15 of the month Jumada al-Akhira of the year 567 (13 February 1172) (Ibn Sahib al-Salat 1969: 190).

This information makes it clear that the al-Ḥajj Yaʿīsh mentioned in the *Hulal al-Mawshīya* was the same engineer from Malaga who designed the mechanism at the Kutubiyya Mosque.

Later authors also repeated this information. Even as late as the seventeenth century, Aḥmad b. Muḥammad al-Maqqarī al-Tilimsanī (1578-1632) explained that

When al-Manşūr made the maqşūra of the Main Mosque of Marrakesh in the city's Royal Residence [...] his mosque connected with his palace in the capital Marrakesh. This maqşūra had been fitted with engineering movements (ḥarakat handasiyya) that raised it for [al- Manşūr] to leave and lowered it for him to enter. All the literati and poets at that time in the court of al-Manşūr composed poems about it and recited them before him [...]. The mechanisms of this maqşūra have fallen into disuse, but there are still remains thereof as I could see for myself in the year 1010 AH. (=1601/2) (Zaglül 1985: 239-240).

This account probably confuses information about the Kutubiyya Mosque with the new mosque al-Manşūr built in the Qasba of Marrakesh, although it is also possible that the same mechanism was copied there despite the fact that there is no other reference to another mobile *maqşūra*.

The poet Abū Bakr b. Mujbar al-Himyarī al-Fihri (1139/40-1191/92) also refers to this *maqşūra* in a long poem, from which the following two verses come:

At times [the maqşura curtain] surrounds wall-like
That which it contains within,
At others the same as a secret hidden.
It is as though human beings proceed
In keeping with this conceit:
When the Imam and his court are about to visit it
Before the beholders it rises up.
He appears and it is revealed,
He is absent and it disappears,
Just like the Moon-engendered auras.⁵

⁴ Author's version after the translations of Huici Miranda (*Al-Hulal al-Mawshīya...* 1951: 171-172) and Deverdun (*Al-Hulal al-Mawshīya...* 1936: 119).

⁵ Quoted by Meunié, Terrasse and Deverdun 1952: 47, note 1. The poem is included by Ibn al-Khatib (1977, vol. IV p. 418-421) and al-Maqqarī (1988, vol. III, p. 239). The former of these authors speaks of a curtain or backdrop. Translated into English from a version into Spanish by Prof. Puerta Vilchez.

THE MATERIAL REMAINS

J. Meunié's 1947 excavations in the site of the first phase of the Kutubiyya Mosque brought to light the remains of what has been identified by different authors as the infrastructure of its retractable screen (Fig. 2); this was found in the space corresponding to the *maqṣūra* (Meunié, Terrasse and Deverdun 1952: 45-50), in the three central sections of the aisle running parallel to the *qibla* wall. As well as the Meunié's original drawings of the dig, dated 1949 and 1952 and published together with a brief description, we also have a more recent floor plan, published twice in 2015 together with fairly unintelligible descriptions (Marcos 2015: 146, fig. 41; Villalba 2015: 138; fig. 16.). In 2018 we conducted a photogrammetric survey of the remains as they are currently conserved (Figs. 3 and 4).

The infrastructure we see today proves without any doubt that the five spans that delimited the three cen-

tral bays of the aisle running parallel to the *qibla* wall were once closed with screens (Fig. 1). These spans correspond to the two sections crossing the *qibla* aisle (Fig. 5A) and those across the three central aisles of the prayer hall (Fig. 5B and 5C). The *maqṣūra* screen was supported by four cruciform pillars and the *qibla* wall itself. As the chronicle *Al-Ḥulal al-Mawshīya* says that the *maqṣura* had six "sides," it can be thought that it refers to six screens. This means that the central screen was divided in two halves, in this way making the whole system symmetrical. For it to work, a series of trenches had to be dug under the five spans to be screened off, as well as two somewhat circular holes under the two side bays and a rectangular pit in front of the closet housing the *minbar*. Finally, in the more recent drawing are recorded the foundations of four small pillars in front of the *mihrāb*, which have not survived; they bear no ostensible functional relation with the mechanism.

We are now going to make a detailed analysis of these remains, with the caveat that they have gone through many restorations since being excavated and have also suffered some deterioration. The five pits dug to house the *maqṣūra*'s screens beneath the ground are of different shapes and sizes; this was not originally visible because the floor hid them. All are about 2.6 m deep as measured from the mosque's assumed ground level at that time. They are the same length as the spans they cross, about 5 m for the axial aisle (Fig. 5C), a similar measurement for the *qibla* aisle (Fig. 5A) and 3.7 m in the lateral aisles (Fig. 5B). They vary most in their width, differing at top and bottom and from one end to the other. The three pits running parallel to the *qibla* wall (B, C, B) have a trapezoidal plan, the base more or less coinciding with the line of the screen. The screens were not located on the center of these pits but rather displaced towards the outside of the area they enclosed. In contrast, the two pits on either end have a very long hexagonal shape, due to the fact that the pits, from 1 to 1.6 m wide at the top, became narrower as they approach the pillars and *qibla* wall, tapering to only 20 or 30 cm. One can still see the vertical grooves which once housed the screens running down the pillars and wall. In the wall, the only place where the ancient elevation is visible, they reach a height of 1.35 m, running down in all cases below the paving level to the bottom of the pits. These channels are semi-circular in the jambs of the transverse arches but have square cross sections in the jambs at both ends. All are about 20 cm wide and from



Figure 2. Current view of the *maqṣūra* site in the first phase of the Kutubiyya Mosque. Author: A. Almagro.

10 to 15 cm deep. It should be noted that in the jambs of the transverse arches, these grooves are not located in the center of the pillars but rather displaced towards the *qibla* (Figs. 3-4). The pits are edged in brickwork, although in the lower areas it is the natural earth that is visible, notably reducing their width.

Two irregular circular pits (Figs. 2-4) coincide approximately with the point where axes of the two lateral aisles cross the aisle along the *qibla* wall; they have a radius of about 1 m and descend about 1.25 m below the

original floor of the mosque. They were also edged in brickwork though with visible earth edges in some parts of their vertical faces. The centres of these pits approximately coincide with the axes of the two pits across the *qibla* aisle and the two across the adjacent lateral aisles. We will see later that this provides a crucial clue to how the whole system worked.

At the bottom of both circular pits there are some H-shaped channel-like traces. Looked at more closely, they turn out to be the impressions left by timbers once

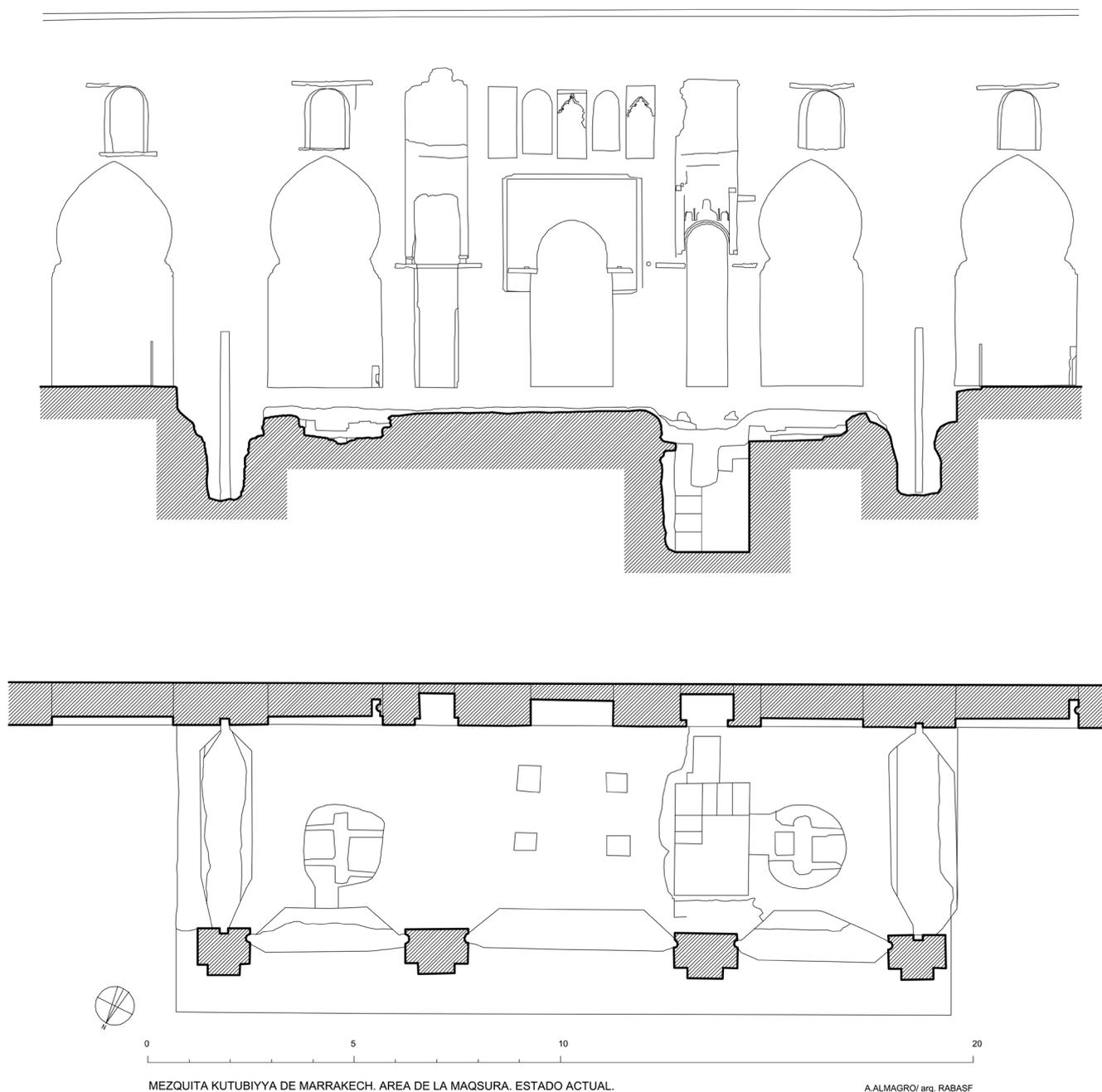


Figure 3. Cross section and ground plan of the *maqşūra* zone of the first phase of Kutubiyya Mosque in its current state. Author: A. Almagro.

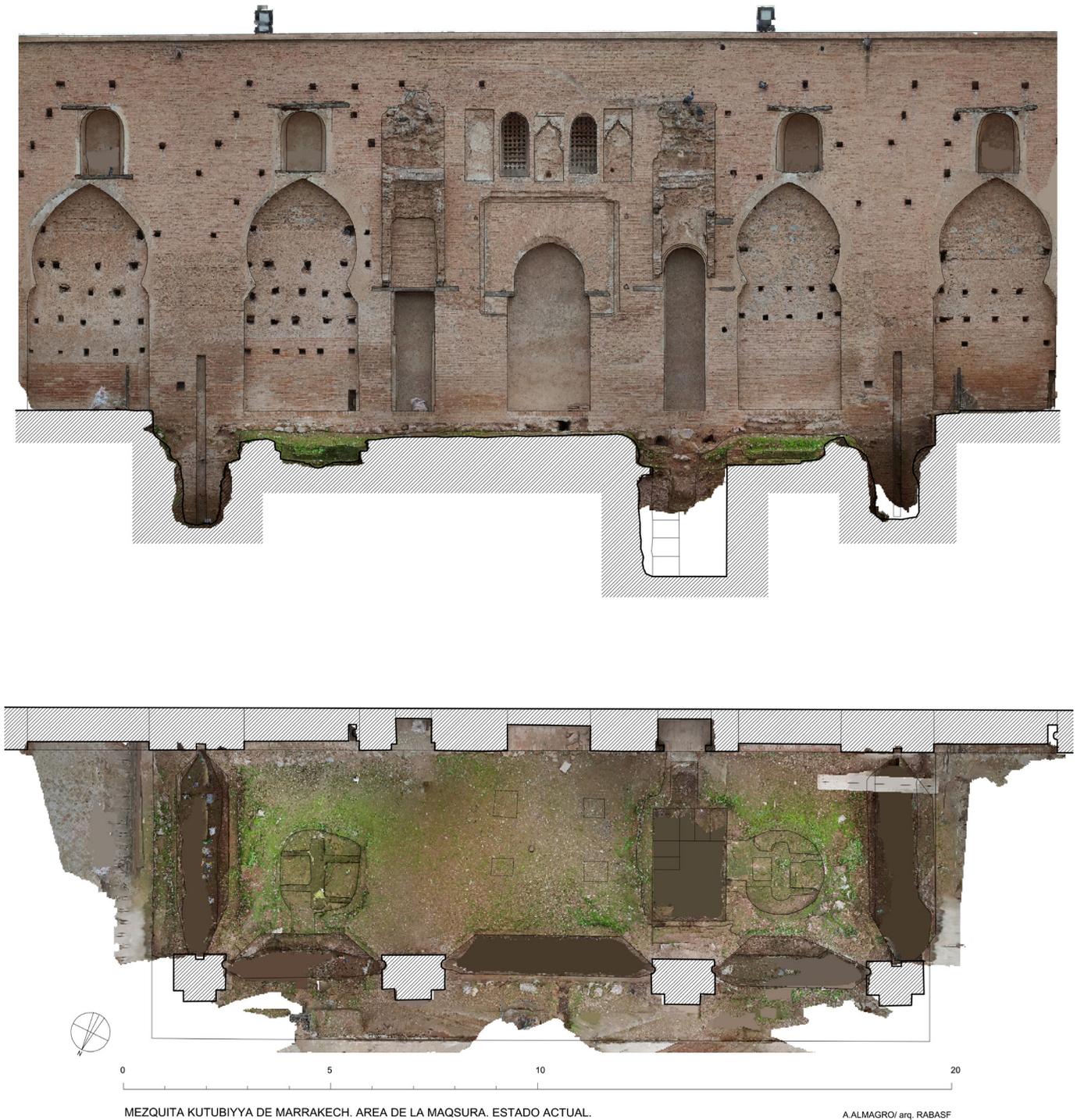


Figure 4. Orthoimages of the elevation and ground plan of the *maqṣūra* zone of the first phase of Kutubiyya Mosque in its current state. Author: A. Almagro.

anchored in the ground by means of bricks and mortar (Fig. 6). The vertical walls of these circular holes are not continuous; they are marked by notches where they linked up to other cavities.

Finally, in front of the door giving onto the closet where the minbar was stored, there is an oblong pit

2.75×1.78 m and 4 m deep. This was fitted with a stair built into two of its sides; its steps are remarkably high, between 0.3 and 0.45 m. These would have afforded access to the bottom of the cavity to maintain the system. On the side facing the door of where the minbar was stored, at 1.4 m from the edge of the pit,

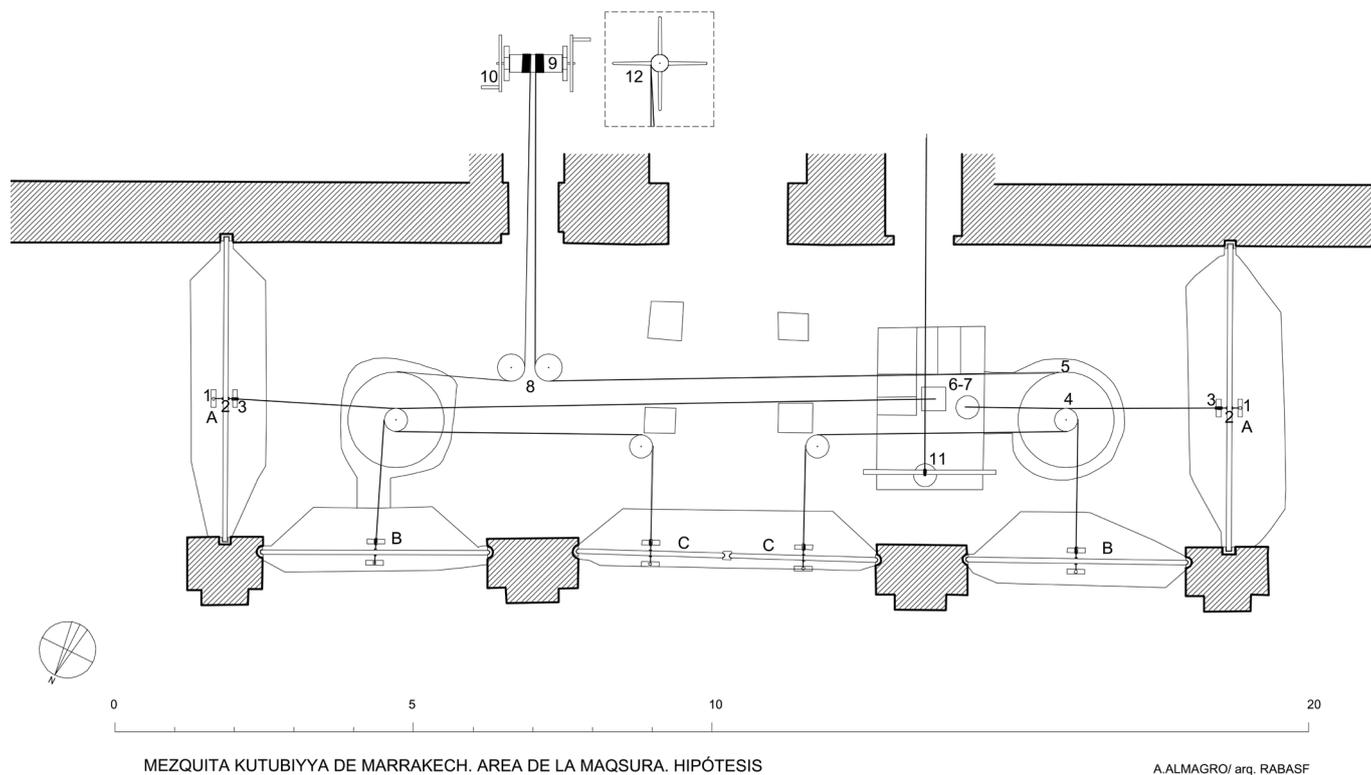


Figure 5. Hypothetical ground plan of the *maqşūra* showing the screen-raising and -lowering mechanism. Author: A. Almagro.



Figure 6. The pit for housing the capstan of the eastern side with the traces of the anchorage beams of its vertical axis. Author: A. Almagro.

there was an eastwards-facing depression in the upper part. Another depression appears on the side contiguous to the westernmost circular hole.

The current level of this *maqṣūra* zone, besides the holes described above, lies about 0.5 m below the assumed original level of the mosque floor.

All these features suggest their purpose was to house a complex, wooden mechanism undocumented elsewhere that was moved by pulleys and ropes and hidden below the level of the pavement. It was closely related to the minbar, whose concealment was common for this type of mobile pulpit (Fierro 2007: 155-156).

INTERPRETATION AND OPERATING HYPOTHESIS

Although many authors have referred to these remains, identifying them as infrastructure of the *maqṣūra*'s mobile screen as described in the abovementioned chronicles, no one has specifically tried to explain how this device might have worked, merely speaking vaguely of winches and pulleys without trying to delve into how the mechanism really functioned. Although we certainly lack specific data on the shape and dimensions of the different moving parts that made it up, here we outline our hypothesis about how the device might have worked (Figs. 5 and 7).

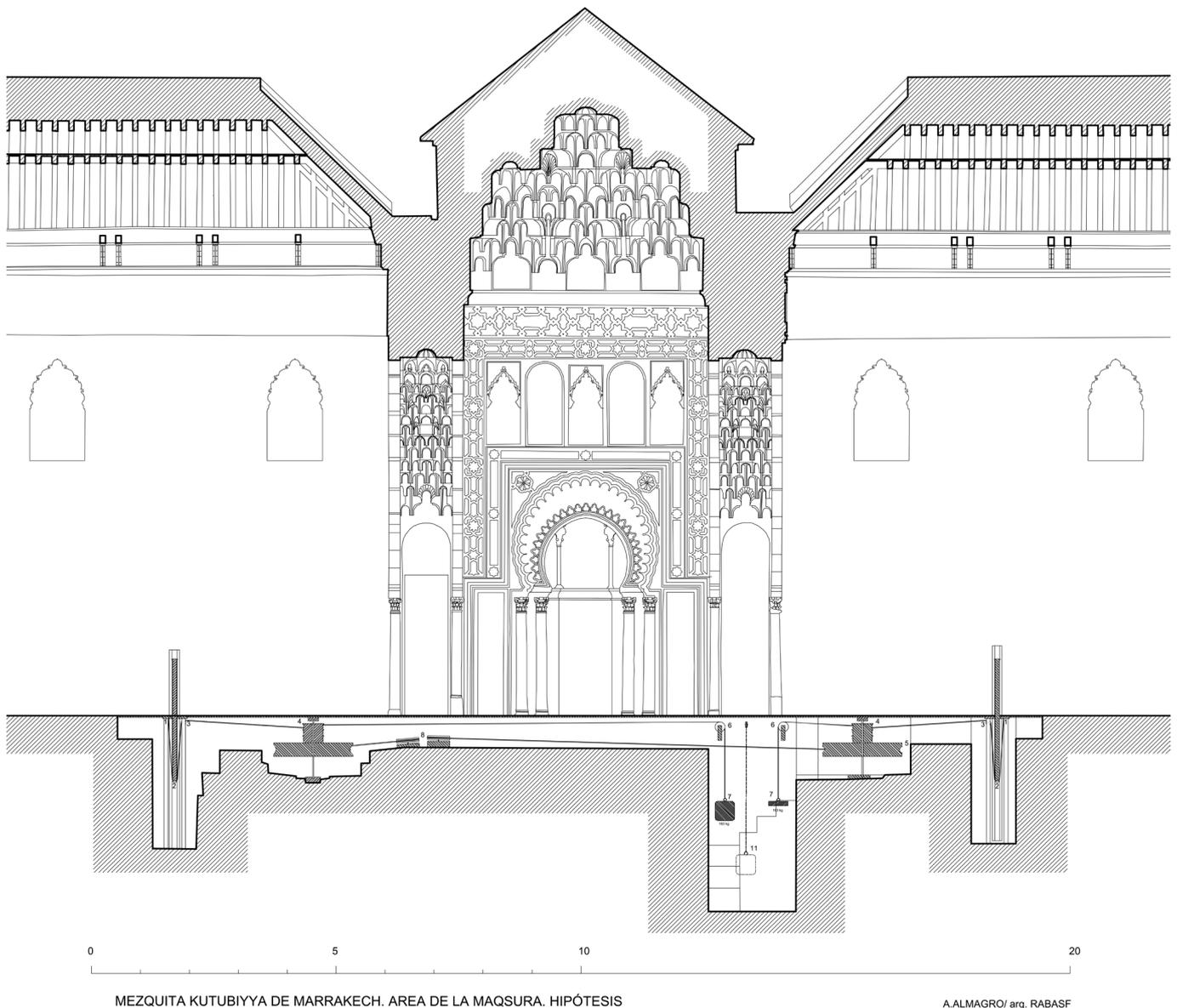


Figure 7. Hypothetical cross section of the *maqṣūra* showing the screen-raising and -lowering mechanism. Author: A. Almagro.

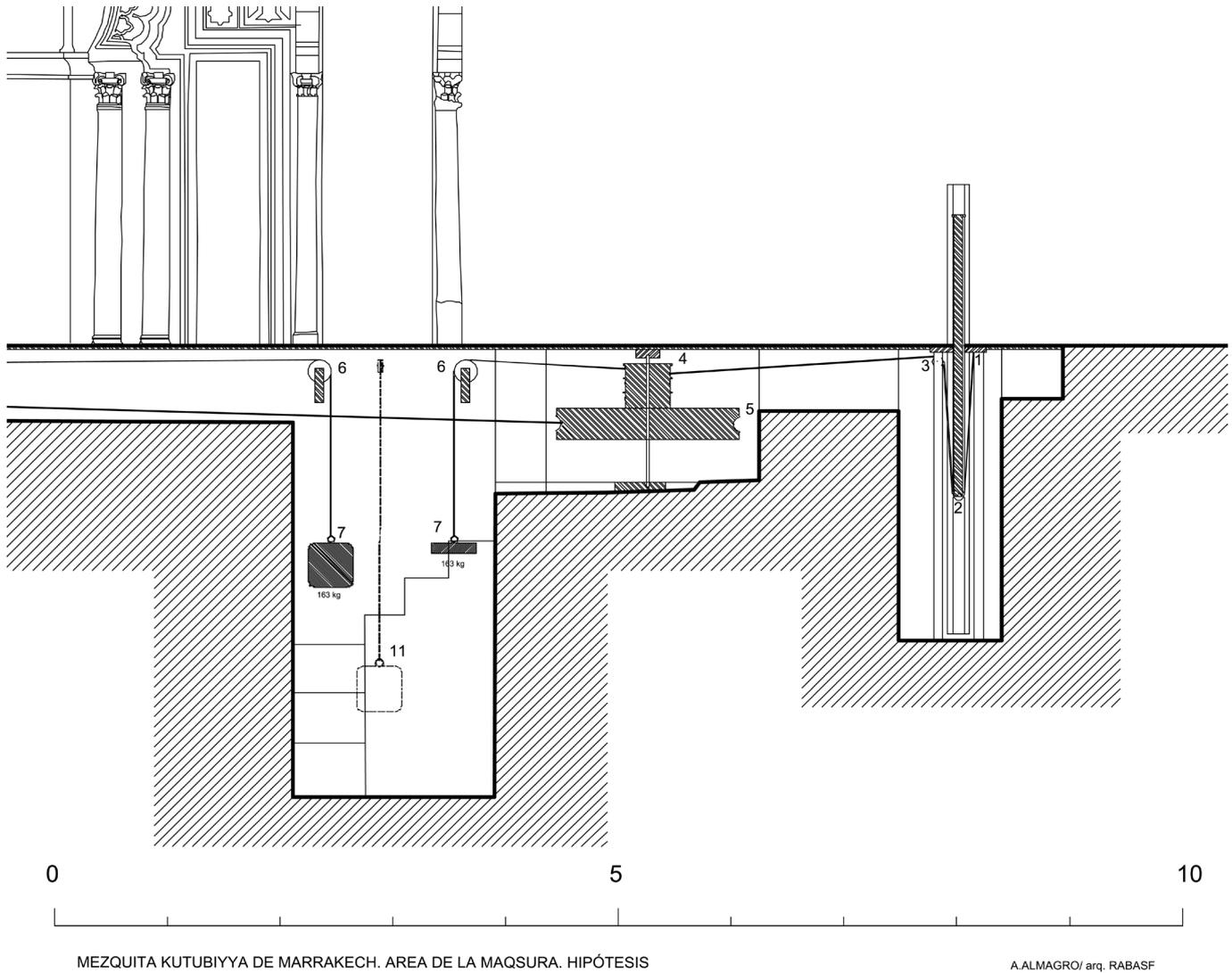


Figure 8. Detail of the *maqşūra*'s screen-raising and -lowering mechanism. Author: A. Almagro.

This account will obviously be based on the fixed infrastructure that has come down to us. And although we know no reports of any similar system⁶, we can nonetheless look at some devices of antiquity bearing a certain resemblance, especially the *aulaeum* of Roman theatres, a curtain or tapestry that could be raised or lowered into the stage through a slit to reveal or hide the *proscenium*. Pits were habitually dug behind the *pulpitum* to house these curtains, hidden during the performance and raised to a certain height between times (Beare 1941).

⁶ Although the ingenuity developed in the Muslim world for the construction of diverse mechanisms for clocks, automatons, etc. is well known, there are no reports of other retractable *maqşūras* (Zielinski and Weibel 2015).

They worked with a system of pulleys and ropes hidden beneath the *proscenium*, which was usually hollow for storing other stage effects.

Judging from what we know of other *maqşūras* with fixed screens, the screen in this case would not have been made of fabric but rather wood in order to guarantee adequate protection of those praying within. The remains show clearly that the *maqşūra* was closed off by means of vertical screens that could be concealed in the floor pits and slid up and down along rails housed in the grooves previously described in the pillars and *qibla* wall (Fig. 8). These grooves would have been fitted with wooden slats separated by the thickness of the screens plus a certain slack to allow them to slide, maybe even greased or waxed to reduce friction.

The workings seemed to have been underpinned by a symmetrical branching structure. Although there were five spans to be closed off, the chronicle *Al-Hulal al-Mawshīya* talks about six sides. This suggests that the system would have been broken down symmetrically, dividing the screen of the axial arch into two halves so that two symmetrical subsystems could work with three screens each. All must have been worked by a single mechanism housed in the room accessed from the door to the left of the mihrab, the same used by the Caliph to enter the *maqṣūra*. This single mechanism would have moved all the screens at once, in all likelihood by means of a winch moving two ropes, one for each of the subsystems. It is also possible that, instead of a horizontal-axle winch (windlass), a vertical-axle winch (capstan) was used, similar to those described below. A capstan comprises a vertical barrel around which a rope is wound and then it is turned by means of several radial bars, normally fitted in the upper part, which are pushed by one or more people walking around the axle. These ropes, suitably routed, would have worked another two vertical-axle winches or capstans that in turn drew another three ropes that would then move the three screens of each group.

The screens would have dropped under their own weight, but to raise them they would have had to be pulled up by ropes, which would have been visible. A more likely possibility was that they were raised from below. A rope might have been attached to the screen's lower edge and then run up one of the faces. This would then be pulled horizontally by means of a pulley on the upper edge of the pit. This procedure, however, apart from calling for a traction force equal to the weight of the screen, inevitably would also have generated horizontal drag, since there was no guarantee, after all, that the first section of the rope would remain absolutely vertical. This horizontal drag would have generated greater friction on the guides as the screen slid through. A more logical solution would have been to use a double block-and-tackle (Fig. 8) and fit a pulley on the bottom of the screen and another on the near edge of the pit. One end of the rope would have been fixed to the opposite edge of the pit (1), threaded around the lower pulley (2) and then the near edge of the pit (3). With this arrangement, even if the ropes were not perfectly vertical the strain on the bottom part of the screen would always be vertical. To make the screen move a given distance, the rope would have to be pulled twice that distance. Conversely, due to the law of conservation of energy within the machine as

a whole, the effort to pull the rope would have been half the weight of the screen.

To pull the rope, the logical solution would be to wind it round a capstan (4), moved by a barrel of a bigger radius (5). It was to house these capstans that the two circular holes would have been dug on either side of the *maqṣūra*. The trace wood found at the bottom of these holes would have served for fastening the vertical axles, perhaps also with other such joists higher up, of which there are no present remains. The shape and size of the holes suggest there would have been a larger barrel with a radius of about 0.80 m in the lower part of the hole. Equally, the smaller barrel, around which the rope that moved the screen was wound, is likely to have had a radius of about 0.2 m. The ropes reached the smaller capstan barrel from the centre of the screens, and the position of the barrel-housing hole suggests they did so tangentially to the smaller barrel and perpendicular to the screens. This would have cancelled out any sideways strain on the block-and-tackle and its supports. Only the middle screens of the central arch would call for other horizontal pulleys to keep the ropes perpendicular (Fig. 5).

To minimize the effort of pulling the rope on the smaller capstan, there is likely to have been another rope attached to a counterweight (7) wound around it in the opposite direction and then passing through another pulley (6); this counterweight would have been able to sink down the deep pit dug in front of the minbar door. With this setup, when the screen ropes were wound round the capstan to raise the screen, the counterweight rope would have unwound, thereby lowering the counterweight to offset part of the effort. The 4-m pit would have enabled 4 m of the counterweight rope to unwind while the corresponding 4 m of each screen rope was being wound round the capstan, thereby lifting the screens 2 m.

To activate these capstans, another rope would have been wound round each one of the larger barrels and then threaded through a horizontal block-and-tackle (8) set up in front of the door to the left of the *mihrāb*. According to contemporary chronicles this door gave onto the room housing the device that activated the system. In this room there must have been a horizontal-axle winch (windlass) (9), probably turned by two cranks (10); around this windlass would have been wound the two ropes coming from the capstans described above. Turned by one or two people this windlass would have allowed all the screens to be moved simultaneously. It is also possible that the system used a capstan turned by several people (12). The operator controlling the cap-

stan would have been able to “brake” the screens as they dropped moved by their own weight.

All these mechanisms were hidden below the level of the pavement (Fig. 7). Given the state of the remains, we cannot now ascertain whether the approximately 0.5 m distance between the present ground level and the mosque’s floor would have remained completely hollow, covered by a wooden decking or if all this space except for the pit and capstan holes was filled in with earth. In the latter case, the ropes would have to have been guided through tubes, perhaps the typical water-pipes made of tongue-and-grooved ceramics. In any case the entire area would have also been covered by carpets or mats to hide the screens and the mechanism. These mats would have been lifted before working the mechanism, as described in *Al-Ḥulal al-Mawshīya*.

The device used to slide out the minbar automatically, as described in the chronicles of the time, would have been much simpler. These mobile minbars, characteristic of the western Muslim world, were usually fitted with wheels that ran on wooden rails laid on the floor to guide the minbar as it came out from its closet. The dimensions of the door designed for this purpose, both in the first mosque and in the enlargement, are large enough to allow for passage of the minbar from the current mosque. All that would have been needed was an opening in the threshold of the door communicating with the counterweight pit and a pulley through which a rope would pass. It was tied at one end to the back of the minbar and at the other to a counterweight to move up and down inside the pit (Figs. 5 and 8 No. 11). When the doors were opened or some sort of brake or restraint was released, the counterweight would then pull the minbar out, leaving its rear just at the point of the opening through which the rope was pulled. The return manoeuvre could have been achieved by means of another rope pulled from behind, powered by a winch located in the same room from which the *maqşūra* screens were activated.

One question that had always remained unanswered until now was whether this retractable *maqşūra* system was also installed in the enlarged mosque when a new *qibla* wall was built with a new *miḥrāb*, 59 m to the south. Logically, in this new site there must have been another *maqşūra*. Until recently there were some fixed screens of modern appearance, as shown in the photographs from the 1920s published by Basset and Terrasse (1932, figs. 70 and 72). What seems to be clear is that the mechanism fitted in the first *maqşūra* became redundant and unused after the enlargement, especially after two arches were

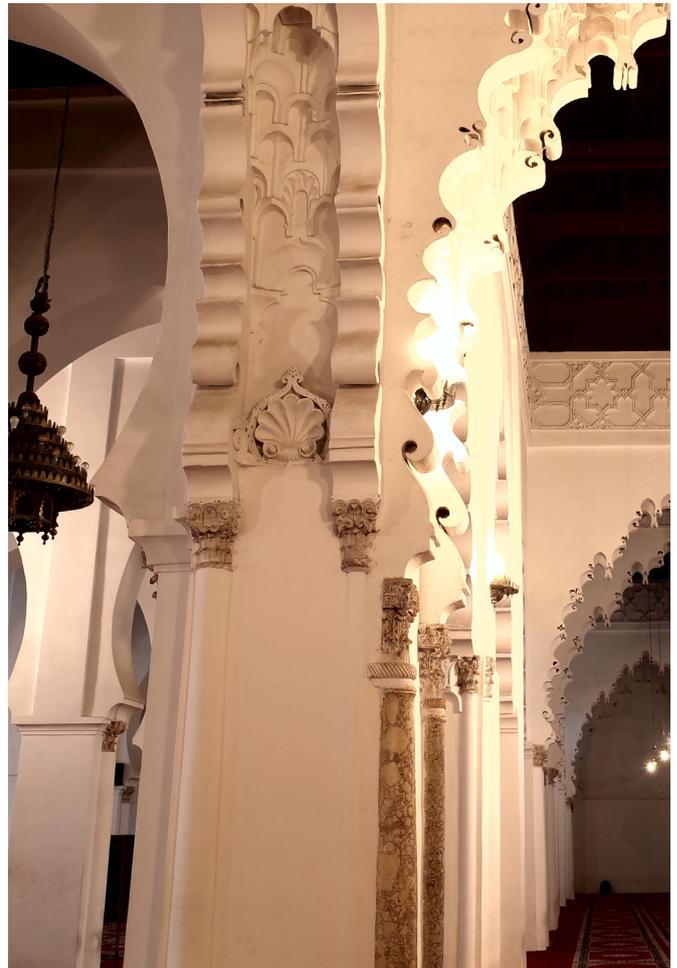


Figure 9. Columns and capitals attached to the jamb of the access arch to the *maqşūra* area in the central nave of the second phase of the Kutubiyya mosque. The one on the right is rather smaller, perhaps due to the existence of the groove for the screen of the enclosure that has been probably hidden. Author: A. Almagro.

opened up within its precincts to communicate the first mosque with the new building, breaking through the *qibla* wall (Fig. 1). It would therefore seem very likely that the first *maqşūra* was dismantled and taken in parts to the new building. Bearing in mind the brief lapse of time between the end of the first phase and the start of the enlargement, and also the fact that the later chronicles and accounts make no mention of the existence of two *maqşūras*, it would seem logical to conclude that they were speaking of the setup in the enlargement, where the initial device would now be up and running after being moved from the first site. In particular al-Maqqarī’s report at the start of the seventeenth century that he saw remains of the device that no longer worked bears out this hypothesis, because he says nothing that suggests they might still have existed in the first site. It is more than likely, therefore, that the

damage to the infrastructure we see today occurred during the dismantling and move and not necessarily during the ruin and sacking of the first mosque phase (Almagro and Jiménez, forthcoming).

Another factor that might corroborate this hypothesis is the report by Basset and Terrasse of wooden slabs on the floor of the current mosque that might well have been the screen-sliding grooves (Basset and Terrasse 1932: 191, note 1). But there are other items visible in situ that, in my judgment, support this hypothesis too. In the freestanding pillars of the enlarged part, corresponding to the limits of the *maqşūra*, in the jambs of the arches running parallel to the *qibla* wall, there are pairs of engaged semi-columns apparently serving as support to the arches. Those closest to the *qibla* are notably thinner than those further away (Fig. 9); this is an original idiosyncrasy since the capitals, undoubtedly original themselves, are narrower too, although they do tend to offset the difference, all of them bearing lambrequin arches of equal thickness. Particularly noteworthy and revealing here is the layout of the grooves guiding the screens in the early phase of the mosque, which are offset towards the *qibla* instead of running down the middle of the pillar. The same arrangement would no doubt have been adopted upon switching the screen-raising system to the new *maqşūra*; this in turn meant that the southernmost columns had to be slimmer than the others.

Until now no excavations or explorations have been conducted in the *maqşūra* of the current mosque; this would now be desirable if what we have just posited is true: i.e. that more remains to be discovered, and in a better state, of the whole device. We hope that this investigation can be carried out one day.

CALCULATION OF THE FORCES OF THE ACTIVATING MECHANISM OF THE MAQŞŪRA'S RETRACTABLE SCREENS

To bear out the feasibility of this working hypothesis, we will try to calculate the forces that would have to have been exerted to move the whole mechanism. This calculation takes in half the system, i.e., the three moving screens of each half (Fig. 8). Our working assumption is that the screens would have been on average 5 cm thick⁷.

The weight of the mobile screens, on the assumption of a wood density of 500 kg/m³, would be:

Screen A:	$5.17 \times 2.00 \times 0.05 = 0.517 \text{ m}^3$	258 kg
Screen B:	$3.71 \times 2.00 \times 0.05 = 0.371 \text{ m}^3$	185 kg
Screen C:	$2.50 \times 2.00 \times 0.05 = 0.250 \text{ m}^3$	125 kg
Total	$= 1.084 \text{ m}^3$	542 kg

In the system made up by pulleys 1-2-3 the lifting force needed would be cut by half. The total drag of the three ropes raising the three screens would then be 271 kg while the run would be double that of the screens: the ropes would have to be pulled 4 m to raise the screens 2 m.

These ropes would be wound around the smaller of the two capstan barrels, with the larger barrel, fixed rigidly to the former, moving in the opposite direction from the pull of the main rope.

It has been assumed that each three-screen group would be fitted with a counterweight inputting 60% of the necessary screen-raising force, i.e., 163 kg (7), which must have been activated by a rope wound round the same barrel as the screen-towing ropes but in the opposite direction, and with a 4 m run, this being the depth of the pit in front of the minbar door. If the counterweight was made of stone, with an assumed density of 2700 kg/m³, its size would have been $163/2700 = 0.06 \text{ m}^3$, giving us a cube approximately 40 cm to a side. If it was made of lead, with a density of 11300 kg/m³, it would have been smaller: $163/11300 = 0.014 \text{ m}^3$, coming out as a cube 24 cm to a side or a cylinder 40 cm in diameter and 10 cm high. Using a smaller leaden counterweight would have allowed a longer run and accordingly a larger movement of the screens.

The force needed to be exerted on the smaller capstan barrel (4) to raise the screen would therefore be $271 - 163 = 108 \text{ kg}$. In capstan barrels 4-5 the ratio of radiuses has been assumed to be $0.2/0.8 = 0.25$. Therefore, it turns out that the rope around the larger capstan barrel (5) would need to be pulled 16 m to raise the screens two metres. Winding the ropes around the larger barrels would call for 3.14 turns. Under the law of conservation of energy, the force to be applied on each main rope would be $108 \times 0.25 = 27 \text{ kg}$.

The forces are maintained on pulley wheels 8. Our working assumption here is that the ropes from each half of the system would be wound around windlass 9-10, wherein the force of each rope is the aforementioned 27 kg. The ratio of radiuses between the capstan barrel and the sweep of the cranks has been assumed to be

⁷ These calculations are based on the assumption of solid screens but they might have been made of latticework to lessen the weight.

$0.15/0.40 = 0.375$; the force to be exerted on each crank would therefore be 10.12 kg. Assuming the existence of two ropes and two cranks, this would be the force to be exerted on each one, with two people moving the whole system. It is assumed that a normal individual could easily cope with a force of 10 kg. Action by a single person is another possibility, but in this case the person concerned would have needed to be somewhat stronger. The friction of capstan and block-and-tackle axles, and especially the screen guides, has to be factored into the equation too. Another possibility would have been an increase in the counterweight, albeit with the constraint of making sure the screens could still drop under their own weight. Over 17 turns of the cranks would have been needed in order to wind 16 m of rope around the windlass barrel (9); on the assumption of three seconds for each turn, this would have taken under one minute. If a capstan was used (12), the time needed would have been somewhat more, although more people could take part at once, each one exerting a correspondingly lower force.

As we have already pointed out, the device to slide out the minbar automatically would have been simpler. All that would have been needed is a counterweight falling down the pit and exerting a downwards vertical force on the rope, which would then be transformed into a horizontal force by means of the block-and-tackle to overcome wheel friction and draw out the minbar. It could then be returned to its site by means of a capstan in the operations room pulling a rope attached to the back of the minbar. The force to be exerted would correspond to the counterweight in the pit plus the necessary force to slide the minbar along after overcoming wheel friction. The force needed would undoubtedly have been much less than that needed to raise the *maqşūra* screen.

It has to be borne in mind here that we are working here with relatively little trustworthy information about the numerous details of the mechanism, especially its mobile components, so the calculations could have come out otherwise if other data had been used. The weight of the screens, of the counterweights and diameters of the capstan barrels could all differ from our working assumptions here, though we do hold these up as plausible.

To corroborate all the above we constructed a scale model to show how the device we have imagined might work from a mechanical point of view (Fig. 9). This 1/25 scale model has borne out the feasibility of this hypothesis. Both the screen-raising and minbar-moving systems worked as expected and in accordance with the descriptions given in chronicles and texts. The verisimilitude of this hypothesis



Figure 10. View of the scale model made to test the hypotheses of how the *maqşūra* screen-raising and -lowering system and minbar-moving systems might have worked. Author: A. Almagro.

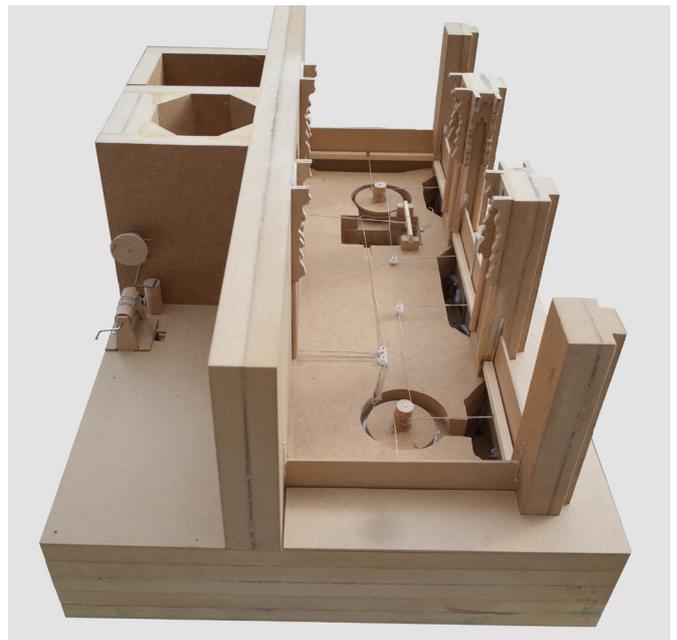


Figure 11. View of the scale model showing the *maqşūra*'s screen-raising and -lowering mechanism. Author: A. Almagro.

is therefore shown to be convincing (Fig. 10). The accompanying video corroborates all the above assertions.

In any case, the aim here has been to show that this system is feasible and viable. On the basis of relatively simple mechanisms within reach of those who might have dreamed up this ingenious device in the twelfth century, they managed to amaze all the witnesses who gave such spellbound accounts in chronicles and poetry of the time.

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ANNEX: VIDEO

A video about Maqṣūra model can be download from the website of this article.

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