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A new kind of segmented mill from Africa Proconsularis

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Abstract: This paper attempts an overview of new kind of segmented mill, examples of which have been found at Thysdrus (El Jem) and Zama in Africa Proconsularis. These grain mills are quite different morphologically and technically from other mills in the ancient Mediterranean world. These rare archaeological finds are not discussed in the ancient literature or in modern scholarship, leaving them difficult to understand. This article explores the history of segmented mills and the operation and dating of this African mill type.

Keywords: segmented mill, Delian mill, Africa Proconsularis, Thysdrus, Zama

While carrying out a survey of ancient mills in Africa Proconsularis, I found in the Museum of El Jem (ancient Thysdrus) and at the archaeological site of Zama the remains of two segmented mills. Segmented mills, as their name suggests, are made of several elements, in contrast to other types that are made of monolithic blocks. These objects have not been a focus of interest for researchers either because of their rarity as archaeological finds, or because of their still ambiguous technical complexity. They have been found in Greece and especially on Delos, which explains the name of one of the types, the "Delian mill." Segmented mills have also been found at sites in Egypt and Sicily that were part of the Hellenistic world.

The mill of El Jem is better preserved than that of Zama, and we can identify its lower part (*meta*) as well as several pieces of the upper part (*catillus*). On the other hand, the Zama machine is represented by only seven surviving pieces. Even if the elements of this machine (lower part, upper stones, central ring) are identifiable with the help of the example at El Jem, the mode of operation poses a problem, which I will try to resolve by advancing some hypotheses.

Faithful to the concept of the "Africanness of techniques,"[1] the segmented mills from Thysdrus and Zama differ from other segmented mills known from the Mediterranean world in their shape, size, working-surface slope, way of functioning, material, and assembly. It is striking that these two machines are located in an area well known for the wide distribution and abundance of rotary mills of the Pompeian type; Africa Proconsularis has exceeded other regions (Gaul, Spain, Mauretania) in terms of the number of these finds.[2] These new discoveries thus reinforce the idea that Africa was open to the Mediterranean world, since it housed all attested grinding techniques.

In this article, I first review the segmented mills found so far at ancient sites across the Mediterranean and then present and discuss the two devices recently identified in Africa Proconsularis.

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1 Souissi 2020, vol. 1, 323.

2 Jaccottey and Longepierre 2011, 95; Anderson et al. 2011, 151–67; Souissi 2020, vol. 1, 70; Souissi 2022, 1–3.

History of research on ancient segmented mills

This type of mill was first mentioned in a report about the ruins of the Hellenistic city on Delos. During his archaeological excavations in 1931 and 1932, W. Deonna identified two types of large rotary mill made of separate pieces, unknown elsewhere.[3] These millstones are found in large numbers in Delian houses, the best preserved being those found northwest of the House of Dionysus, in the theater district. During the same period, the excavations carried out between 1930 and 1932 in Egypt at the site of Clysma revealed a set of materials for flour and oil mills. Among the finds was:

> a *catillus* of a special model, of black basalt, formed by joining, with the help of metal links, a certain number of pieces of varying section offering a sharp edge, sometimes on the right, sometimes on the left, of which the role seems to have been to crush hard substances such as olive pits.[4]

Excavations in Egypt (1928–35) brought to light another device, in the Greco-Roman city of Karanis, which still retains some elements of its mechanism.[5] Archaeological work has yielded additional devices in the same geographical sphere (Fig. 1), that is to say, in Greece (at the Nekromanteion of Acheron near Ephyra) and in Egypt (at El Badia).[6] In Sicily, the archaeological work carried out by l'École française de Rome on the site of Megara Hyblaea from 1949 until the 1980s revealed a set of pieces (18 artifacts) that also belong to this segmented type.[7]

With these archaeological finds, the problem has always been to identify how the device was assembled and how it worked. Several authors have tried to reconstruct this "appareil énigmatique,"[8] but their reconstructions remain uncertain and hypothetical because of the complexity of this machine. Storck and Teague reversed the two key elements by confusing the fixed part with the mobile part (Fig. 2).[9] Moritz, in his landmark work, devoted only a few lines to this type, comparing them to Pompeian mills by designating the central part the *meta*, around which the outer ring rotates to grind grain.[10] Runnels, who named this device the "Delian mill," repeated an idea proposed by Moritz when identifying it as the oldest type of rotary mill in Greece.[11]

It was only with the 1987 excavations on Delos and G. Siebert's discovery of a complete mill in situ in the Maison des Sceaux,[12] as well as the publication of an article by M. Brunet in 1997, that things became clearer. Brunet took advantage of the discovery of an in situ

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3 Deonna 1938, 134–35.

4 "[U]n *catillus* de modèle spécial en basalte noir formé par la réunion à l'aide de liens de métal d'un certain nombre de pièces de sections variées offrant une arête tranchante, tantôt à droite, tantôt à gauche, dont le rôle semble avoir été d'écraser des substances dures comme des noyaux d'olives" (Bruyère 1966, 60–61).

5 Peacock 2013, 155, fig. 3.

6 Peacock 2013, 157.

7 Chaigneau 2017, 439–47.

8 Brunet 1997, 29.

9 Storck and Teague 1952, 164.

10 Moritz 1958, 92.

11 Runnels 1990, 147. As far as we know, rotary querns were not introduced to Greece before the 1st c. BCE.

12 Siebert 1988, 755–61.

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Fig. 1. *Updated distribution map of segmented mills. (After Chaigneau 2017, 440, fig. 1.)*

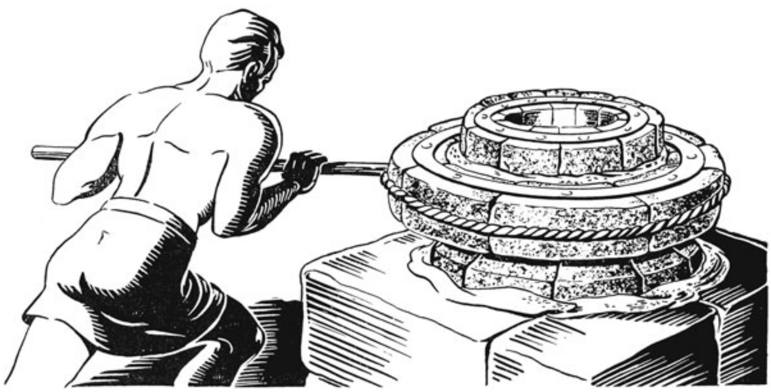

Fig. 2. *Reconstruction of a Delian segmented mill by Storck and Teague. (Storck and Teague 1952, 164, fig. 40.)*

mill to reconstruct the device.[13] According to him, the central part, made up of eight elements or pieces, must have been the running grindstone (in the shape of a top) that turned against the fixed outer ring, made up of six pieces (Fig. 3). Despite its uncertainty, Brunet's analysis remains the most plausible.[14]

It is essential at this point to note the distinction between Delian mills and segmented mills. All the mills mentioned in this article are segmented mills, but the ones mentioned so far (from Delos, Acheron, Clysma, and Megara Hyblaea) are Delian mills, meaning that in addition to being made up of segments, they have another specificity: unlike every other rotary mill, their running stones (*catillus*) turned inside the lower stones (*meta*).[15] In a

[13] Brunet 1997, 30–31.

[14] Peacock 2013, 159.

[15] Chaigneau 2019, 207.

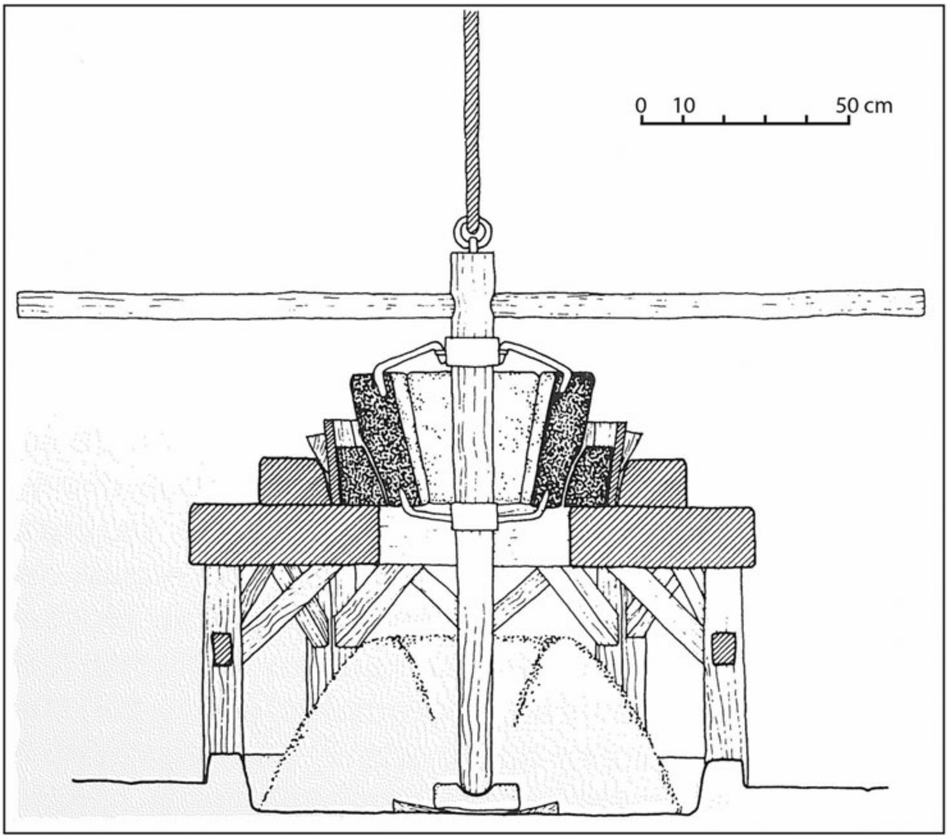

Fig. 3. *Reconstruction of a Delian segmented mill by Brunet. (Brunet 1997, 30.)*

2013 article, D. Peacock proposed a typology of Delian mills.[16] But, as we will see, the North African segmented mills are not of the Delian type. The only similarity between the mills of Africa Proconsularis and these previously identified segmented mills is the fact that the millstones are composed of separate parts.[17]

But why resort to a segmented mill at all? Deonna suggested that this type had the advantage of transportability.[18] The same idea has been repeated by other historians. According to Moritz, "a segmentary mill had no advantages except that segments are more easily transported than complete stones."[19] It also required smaller blocks to build, and these are much easier to find. In addition, this type had other advantages. From a technical point of view, it offers the possibility of improving production by increasing the active surface,[20] and this is why the two mills of Zama and El Jem, as we will show, have a large diameter, which exceeds even that of the Pompeian mills. This surface area offered an improved grinding capacity in both quantity and quality, since the grains would infiltrate

16 Peacock 2013.

17 I thank the anonymous reviewer for commenting on this point.

18 Deonna 1938, 135.

19 Moritz 1958, 92.

20 Chaigneau 2017, 446.

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the active surface of the artifact and remain there long enough to be well ground.[21] Additionally, this type was guaranteed a long life, as maintenance could be performed in the case of wear on the individual parts. These could be replaced, whereas any damage to the Pompeian mills rendered the entire *catillus* or *meta* unusable and required the abandonment of the whole mill.

Two newly identified segmented mills in Africa Proconsularis

El Jem

A segmented mill is located in the garden of the Archaeological Museum of El Jem (ancient Thysdrus).[22] The context of this artifact's discovery is unknown, and therefore it is not possible to say if its current assembly is original or a modern restoration, though the mortar does not look modern. We should ask how this machine was moved from its original place of discovery (which should not be far from the city of Thysdrus) to the museum and whether the device has kept its original configuration.

The device (Fig. 4) measures 82 cm in diameter and 24 cm in height.[23] The lower part is formed by 12 trapezoidal pieces that have variable dimensions, especially in their widths. The smallest piece is 31 cm long and 17 cm wide; it is 11 cm thick at the outside edge and 7 cm thick at the inside, next to the central ring (Fig. 5). The largest piece is 32 cm long and 28 cm wide.[24] These petal-shaped pieces surround a central ring 27 cm in diameter, with a central perforation 10 cm in diameter and 8 cm high (Fig. 6). The central ring occupies a slightly lower position compared to the assembly of the 12 pieces (Fig. 5). The slope of the grinding surface is 22°, which is similar to that of Roman rotary mills.[25]

The upper part was made up of pieces smaller than those in the lower part. Only seven of these pieces survive; they measure between 23 and 26 cm in length and 8 and 14 cm in width. Their height varies between 15 and 17 cm. Judging by these dimensions, between 20 and 21 stones comprised the upper circle. On the outside of each of the surviving upper stones are traces of a metal band or brace, 2.5 cm high (Fig. 7). There must have been another ring in the center of the upper layer of stones, similar to the ring at the center of the lower stones, that had the same thickness as the upper stones.

Zama

I identified a second segmented mill at Zama, of which only seven segments of the upper ring or *catillus* survive (Fig. 8).[26] Much better cut than the El Jem mill, this machine is made

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21 Jodry 2011, 30, fig. 29. Researchers of the "Groupe Meule" have given the active surface of the mill the technical term "couronne."

22 Souissi 2020, vol. 2, 353–54, no. 584.

23 This diameter puts it among the largest mills of its type. The diameters of segmented mills described by Peacock vary between 55 and 70 cm, while those presented by Chaigneau vary between 65 and 90 cm (Peacock 2013, 154–57; Chaigneau 2019, 207).

24 I do not have all of the thickness measurements, since the stones are set in mortar. I was able to measure four of the pieces after removing them from their setting; these were found to have almost the same thicknesses.

25 The slope of Roman millstones is between 23° and 30° (Longepierre 2012, 78).

26 This machine is in storage at the archaeological site. There is no inventory number on it. Souissi 2020, vol. 2, 355–56, no. 585.

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Fig. 4. *Segmented mill from El Jem. Long edge of ruler: 30 cm. (Skander Souissi.)*

up of sedimentary upper stones about 30 cm long,[27] 15–16 cm wide, and 12–14 cm thick. The slope of the working surface is about 25°. Around the exterior, traces of two iron bands are clearly visible, each 3 cm high, with the best-preserved piece being 0.3 cm thick (Fig. 9). The diameter of the upper stones would have been about 104 cm, taking into account the 18 pieces required to restore the circle. Three of these stones, whose upper surfaces were not smoothed but rather left rough, had well-smoothed inner ends. This detail shows that there was a central stone ring inside the *catillus*.

It should be noted that the El Jem and Zama devices do not come from the same workshop. Despite their morphological and technical similarity, the two artifacts present some differences. The El Jem mill is carved from sandstone that may have come from Jebel Bou Gobrine[28] or the sandstone quarries of Rejiche-Mahdia,[29] the nearest and most likely source. The Zama mill is carved from a yellow limestone found everywhere in Tunisia, of which the Siliana syncline[30] represents a nearby source (only a few kilometers from the site). In addition, although both mills have metal strapping, El Jem's machine has

27 One of the five complete stones is about 29 cm long.

28 Blondel et al. 1985, 156–59.

29 Slim et al. 2004, 256–57.

30 Souissi 2020, vol. 1, 175.

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Fig. 5. *The segmented mill from El Jem after removal of the seven surviving upper stones and three of the lower stones. Long edge of ruler: 30 cm. (Skander Souissi.).*

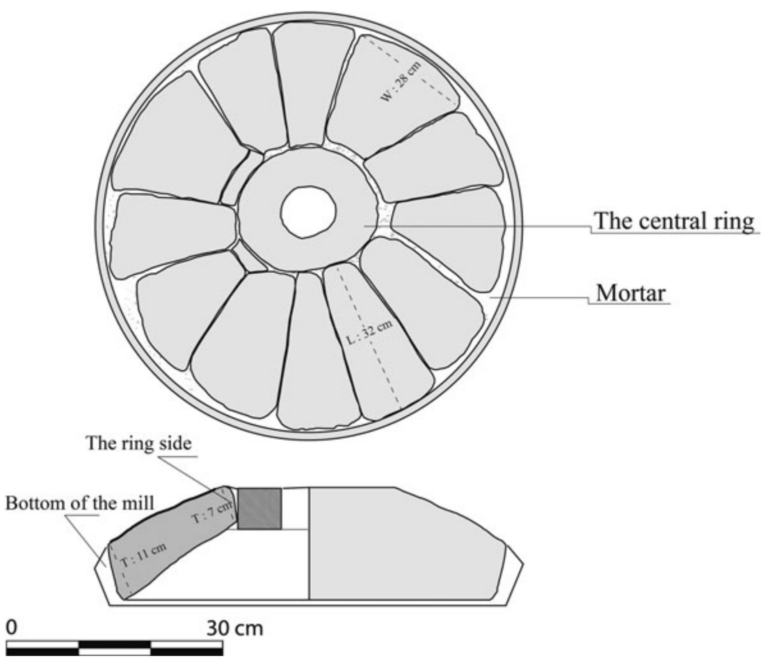

Fig. 6. *Drawing of the lower section* (meta) *of the segmented mill from El Jem. (Drawing by Skander Souissi.)*

only one brace while the Zama device has two. For these reasons, I believe that the two mills were not manufactured in the same workshop but in two different ones, since each workshop specialized in its own type.

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Fig. 7. *Traces of the metal band around the upper stones of the mill from El Jem. (Skander Souissi.)*

Fig. 8. *The surviving segments of the segmented mill from Zama. Scale: 20 cm. (Skander Souissi.)*

How did these mills work?

A central rotary spindle (axis) passed through the two central rings to rotate the *catillus* (upper stones). This rotation could have been accomplished either by wedging, which is a centering system in which a wedge is jammed into the central opening to force the *catillus* to turn together with the spindle (Fig. 10a shows how this worked in hydraulic millstones), or by a centering device, a system in which a metal ring is fixed around the central axis and metal arms extend from either side of this ring to the metal band around the outside of the running wheel, again forcing the *catillus* to turn with the spindle (Fig. 10b).

As for how the grain was introduced, the upper stones are shorter in length than the lower stones, creating a space between the inside of the upper ring and the central rotary

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Fig. 9. *Traces of the iron bands around the segmented mill from Zama. Scale: 20 cm. (Skander Souissi.)*

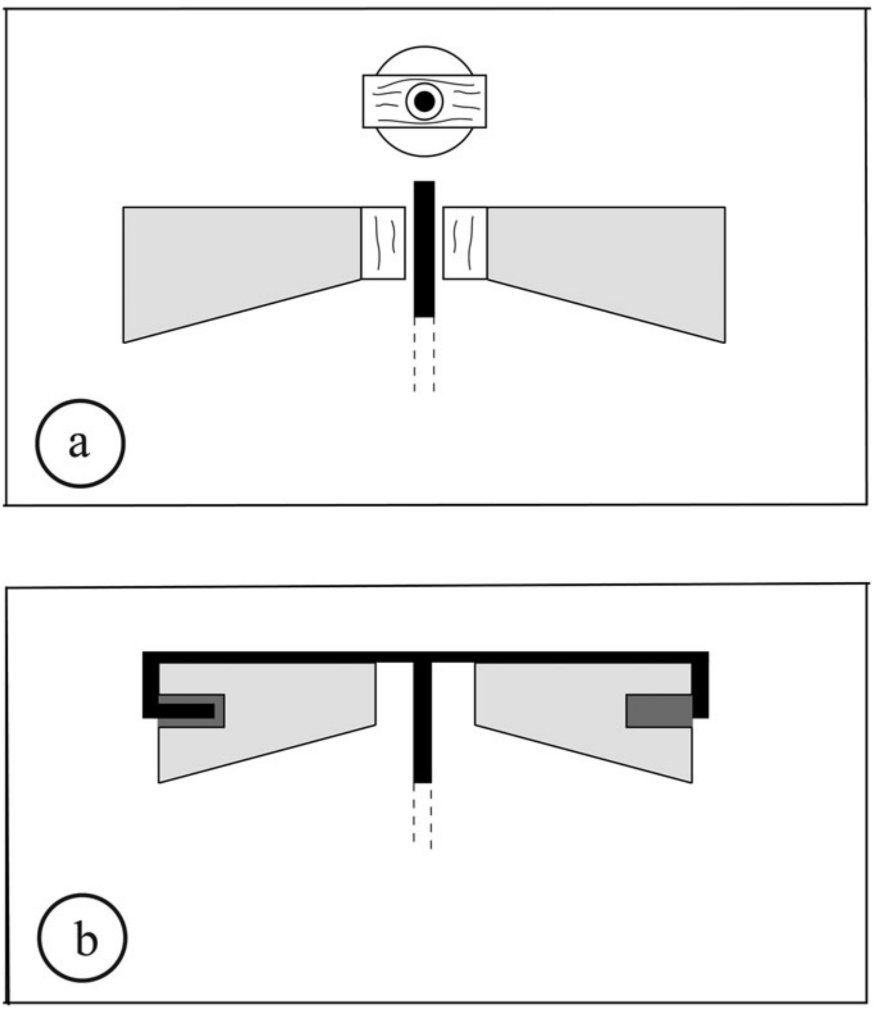

Fig. 10. *Models of two rotation mechanisms: (a) a wedging system, and (b) a centering device. (Models by Longepierre 2012, 503–4.)*

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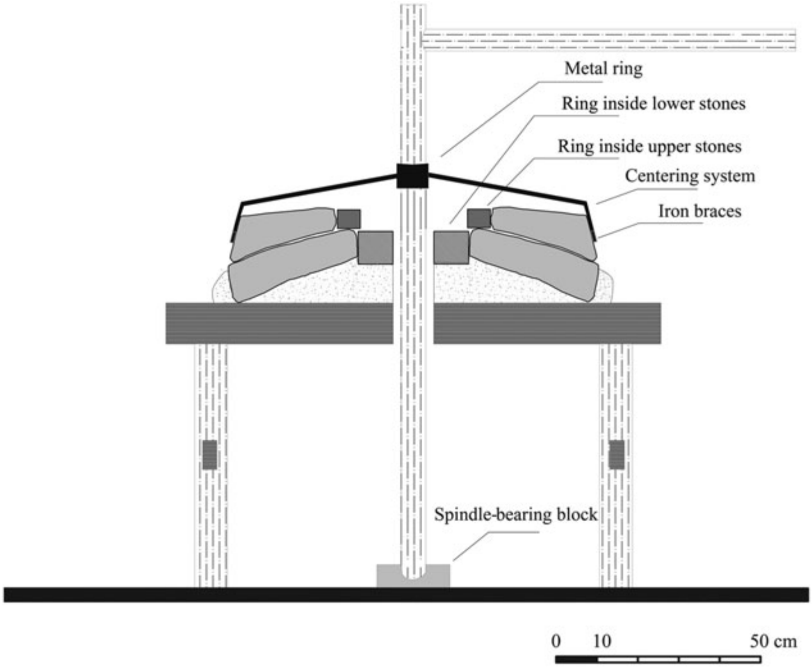

Fig. 11. *A first reconstruction of the segmented mill from El Jem. (Reconstruction by Skander Souissi.)*

spindle. Therefore, it is possible that the upper ring was narrower than the lower, in both thickness and width, to allow the grain to be directed into this space (Fig. 11). The lower ring of stones (the *meta*) must have been placed in a position slightly higher than the surrounding pieces in order to ensure that the grains would slide into the space between the upper and lower stones, that is, the grinding surface between *catillus* and *meta*. The mill was fed from above, and it is probable that there was a funnel attached to the top. Finally, this structure probably relied on a spindle-bearing block (Fig. 11). But that in itself could not adjust the height of the upper stones and thus the gap between the millstones. The machine would also have needed a mechanism to adjust the height and spacing of the grindstones, thereby minimizing the risk of friction and disintegration that could contaminate the flour.[31]

This hypothesis, with the transmission of movement accomplished either by a wedging system or by a centering device, could be accepted in the absence of additional evidence. But a different hypothesis dispenses with the second central ring in the *catillus*, and it is both less complicated and more likely. A metal ring was attached around the central axis, and at least four double dowels or metal blades extended from this ring to the interior tips of the catillus stones. Double fixing-holes are still visible on one of the surviving upper stones (Fig. 12). These dowels transmitted the movement of the wooden axis to the *catillus* (Fig. 13).

Dating the African segmented mills

Are the El Jem and Zama mills ancient, medieval, or modern? Dating these mills poses a problem. First of all, as is the case with most crushing materials in Africa Proconsularis, the

31 For the use of such a technique, see Wilson 1995, 500–1, fig. 1.

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Fig. 12. *Double fixing-holes on the innermost face of one of the upper stones of the segmented mill from El Jem. (Skander Souissi.)*

objects do not come from a stratified context or from a systematic excavation, and we know very little about them. According to Peacock, this type of mill was well known and widely diffused during the post-medieval period in places like Derbyshire in England, Kaim Hill in Scotland, and Melos in the Aegean. In particular, La Ferté-sous-Jouarre east of Paris has produced large numbers of this type.[32] However, there are no indications that the El Jem and Zama mills are modern. There is no resemblance between these two devices and those of La Ferté-sous-Jouarre, especially in terms of the type of stone used. In addition, there is no evidence that French millstones were transported to Africa, even during the colonial period.

Could these two mills be medieval? We know that Africa experienced an economic decline starting with the Vandal invasion

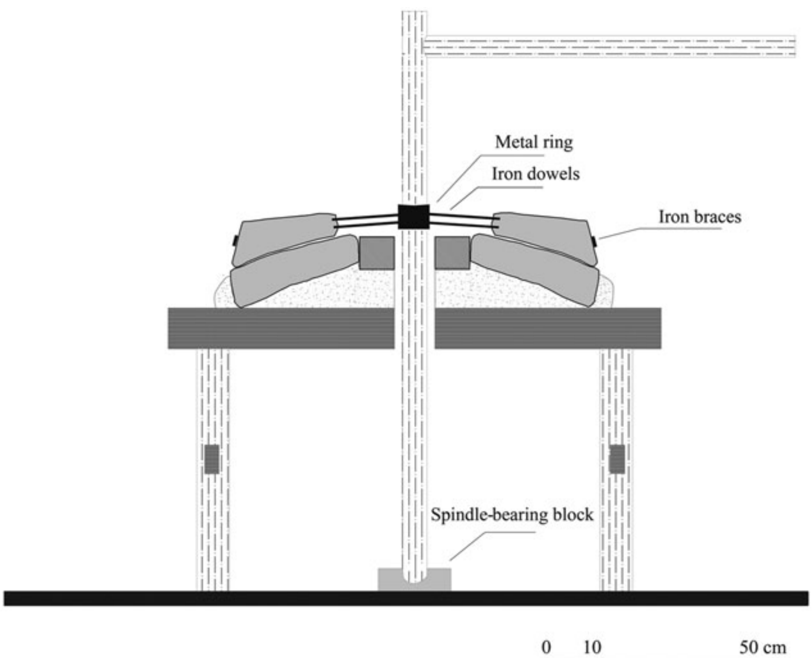

Fig. 13. *A second reconstruction of the segmented mill from El Jem. (Reconstruction by Skander Souissi.)*

32 Peacock 2013, 153.

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and accentuated by the social and economic changes that Africa experienced with the Arab occupation and especially the Hilalian invasions. From then on, Africa became again the domain of the Bedouin and the plunderer as in the time of the Numidians, representing a change in the way of life and a return to the rural economy. People still milled grain, but instead of using large mills, which would indicate a mass artisanal production, we see a return to manual rotary mills for smaller, family consumption. We can see this change in the many heavy Roman millstones (Pompeian type) that were left behind at abandoned sites, indicating that artisanal production had stopped.[33]

Are the mills ancient? Several clues lead us to this hypothesis. Africa Proconsularis experienced a great economic boom under the Roman Empire, which made it the "breadbasket of Rome" and one of the most important provinces in terms of the annona. Rome's need for oil and especially wheat was met by imports from Africa Proconsularis, and any interruption to the supply could have caused famine.[34] So, even during the crisis of the 3rd c. CE, Africa Proconsularis was protected, as evidenced by its commercial activities and the agricultural remains of oil mills and millstones, signs of mass production.[35] The economic and social situation changed and deteriorated with the Vandal invasions and later the Arab occupation, with a return to a family economy and production restricted to family needs, and hence to the use of small millstones (querns).

In addition to the political instability of the medieval period and the change in the way of life for Africans, ancient rotary querns can be distinguished from medieval mills by their shape. The slope of the ancient grinding surface, which is generally conical, ranges between 17° (in Africa Proconsularis[36]) and 20° (in Gaul[37] and Britain[38]) for querns, and between 23° and 30° for large millstones.[39] However, from Late Antiquity and especially in the medieval period, there was a technical change, with a flat, less conical shape or even a horizontal grinding surface.[40] In Britain, the slope of late rotary querns was reduced to 10°.[41] In addition, excavations in the medieval levels at Zama have uncovered a collection of small querns (manual rotary mills), with slopes ranging from 0° to 6°, and rarely

33 Souissi 2020, vol. 1, 335–36. The last attestation of the Pompeian type of millstone in Africa dates from the 5th c. at the site of Musti in Tunisia (Williams-Thorpe 1988, 261), coinciding with the Vandal invasion of Africa Proconsularis.

34 Jaïdi 1990, 126–29.

35 Concerning the role of these millstones, I am currently working on a paper on grain mills as an index of African economic growth during the crisis of empire, "Des nouveaux témoignages du boom agricole africain: étude des matériaux de broyage," delivered at Colloque Villes et Campagnes, Tunis, 17–19 Novembre 2022.

36 Souissi 2020, vol. 1, 48.

37 Longepierre 2012, 78.

38 Cecil Curwen 1937, 140.

39 Longepierre 2012, 78.

40 Longepierre 2012, 85. "La forte inclinaison de la face active des moulins de type Avenches…, a été interprétée comme le signe d'un travail lent. Une inclinaison prononcée contribue en effet à faire descendre plus vite le grain entre les meules. Dans les moulins médiévaux et modernes, la face active des meules est horizontale ou d'une inclinaison très faible qui ne dépasse jamais 5°. Si elle avait été nettement conique, le grain ne serait pas resté assez longtemps entre les meules pour être moulu, leur rotation étant trop rapide."

41 Cecil Curwen 1937, 144.

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Fig. 14. *Medieval rotary quern from Zama. (Skander Souissi.)*

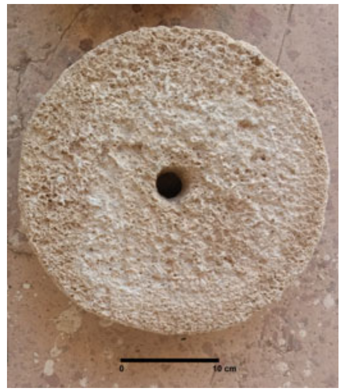

Fig. 15. *Modern rotary quern from El Jem. (Skander Souissi.)*

reaching 10°,[42] a type that has survived into the present day (Figs. 14 and 15).[43] In short, given the currently available evidence, it is not possible to attribute the two segmented mills from Thysdrus and Zama to any period other than antiquity.

On the "Africanness of techniques"

Both literary and archaeological documentation show that Africa Proconsularis exhibits quite diversified and sometimes original techniques. Without going into any specificities here about their origins, the existence of modified instruments, often unique, suggests a form of African adaptation of imported mills, resulting in a sort of "Africanness" of these tools.[44] The adaptations include hopper mills driven by a linear (to-and-fro) motion rather than an oscillating movement (on the arc of a circle) as seen at Olynthus; *trapeta* (olive-crushing machines employing two crushing stones or *orbes*) with stone basins (*mortaria*) whose internal and external shape differs from those discovered in Italy, notably at Pompeii; and the small size characterizing the Pompeian type of mills found in this area.

The African segmented mills do not escape this particularity. These machines are made up of stone pieces, a concept recalling the Delian mill, but have a different mounting and functioning mechanism. If the Delian mill, the most frequent type within this category of machines, consists of runner stones turning inside the fixed part, the African model presents as a large rotary mill with its two parts superimposed (*meta* and *catillus*).

Conclusion

Two large mills intended to grind grain come as no surprise in a cereal-producing region that provided much of the annona to Rome. Nevertheless, what is new with these two discoveries is that they support the idea of the limit of Hellenistic influence in the western Mediterranean basin. It should be remembered that recent studies have

42 Souissi 2020, vol. 2, 48–189.

43 On the millstones shown in figs. 14 and 15, see, respectively, Souissi 2020, vol. 2, 178, and Souissi 2020, vol. 1, 286.

44 Souissi 2020, vol. 2, 15 (Type 182), 192 (Type 312) and 458 (Types 800, 801, 810).

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confirmed that grinding techniques of Hellenistic origin never went beyond the eastern Hérault Valley in Gaul to the north and the coastal region of Africa Proconsularis.[45]

Because of its geographical position, and thanks to its maritime connections, Africa Proconsularis possessed several types of grinding techniques. Sometimes these came with a kind of African adaptation, which gave rise to original local types. That is what we see in these two devices from El Jem and Zama, a local version of a segmented mill. Finally, we should be aware that there are probably other examples of segmented mills in this territory, especially given the technical advantages that this machine offers, but for lack of excavation, or due to destruction or reuse, we cannot find and detect them in Africa Proconsularis.

Acknowledgments: This article is dedicated to my late father who taught me history. I would like to thank the anonymous reviewer for valuable remarks that have improved this work. I also thank Victoria Leitch, Samira Sehili, Jean-Pierre Brun, and Andrew Wilson for their expert advice.

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