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Early Greek Catapults and 'First-Generation Artillery Towers'

ABSTRACT: This article is intended to offer a discussion on the origins of the catapult in the Greek world. The discussion focusses on one problematic point, non-torsion artillery and its distribution. There are good reasons to think that such early catapults remained a kind of experimental weapon; it is only after the invention of torsion artillery, i. e. after the middle of the fourth century BC, that the catapult became a common weapon, widespread throughout the Greek world. As a result, the study calls into question the typology of artillery towers defined by Ober and its chronological implications.

Keywords: Ancient artillery – Athenian epigraphy – Catapults – Biton – Greek fortifications – Towers

Since the seminal works of E. Marsden, the different stages of development of the Greek catapult have been the subject of many studies and are now well known.¹ However, as is usual with this kind of highly technical research field, some hypotheses that are widely accepted could be further questioned. It is my ambition in this article to challenge some of these hypotheses, as has been done by Kingsley (1995b), Iriarte (2003), Schellenberg (2006) or Campbell (2013). Here I will focus on three main points: the technical treatise of Biton, the first stages of the development of catapults in the Greek world in the fourth century BC, and the so-called “first-generation artillery towers” that were defined by Ober (1987). I will show that early bow catapults, although attested epigraphically until the last quarter of the fourth century BC, were never widely used – a conclusion already reached, for instance, by Schellenberg (2006). In Athens for example, we have only a few mentions of catapults before the middle of the fourth century, while the bulk of our attestations dates from the Early Hellenistic period and concerns torsion artillery. This shows that artillery spread in the Greek civic arsenals only in the late fourth century BC. This simple observation, backed by epigraphical evidence, calls into question the date assigned by Ober to what he termed “first-generation artillery towers”, in the second

¹ Some of the ideas developed in this article have been first presented by the author during a talk at the ASCA in January 2020, as part of the *Meli* conference series, organised by Amélie Perrier and Sylvian Fachard. I owe the warmest thanks to Prof. Anthony Snodgrass, who gave invaluable feedback on a first version of the article, to Rémi Saou, whose conversation greatly helped me to improve this text, and to Hilary Tresidder, who corrected my English. I am also very grateful to the editorial board of *Historia* and to the anonymous reviewers, who helped me to avoid some mistakes by their helpful suggestions. All errors remain mine.

quarter of the fourth century BC. I will show that, contrary to what Ober asserted, the towers of this group could very well have been fitted with torsion catapults precisely of the calibres attested in Athens in the last years of the fourth century BC. The second half of the fourth century is therefore a much more likely context for the apparition of these towers explicitly designed to house artillery.

1. Theory: the Technical Treatises and Early Greek Catapults

The first explicit mention of Greek catapults occurs in Diodorus Siculus, referring to the situation in Sicily in 399 BC. Diodorus states that the catapult was invented at this moment.² These first catapults were used with success in 397 BC to shoot at the Carthaginian fleet from the coast, the main benefit here likely being an increased range³, and during the assaults against Motya.⁴ Marsden and, after him, Campbell (2013) took this fact for granted, but Kingsley (1995a: 149–155; 1995b) and Schellenberg (2006) have convincingly shown that the first forms of catapults appeared earlier than that, during the second half of the fifth century BC. At any rate, the supposed origin of the catapult in Southern Italy or Sicily is confirmed by the fact that the first catapult bolts seen in the Peloponnese came from Sicily.⁵

It is difficult to know what types of catapults were involved at such an early stage.⁶ Diodorus is not a reliable author from a technical point of view, so his precise phrasing does not really matter here.⁷ We have therefore to rely on other sources. The technical treatise of Heron gives very precious information on what he considers as the first catapult, the *gastraphetes* or belly-bow.⁸ What he describes is no more than a large and powerful bow, too hard to be drawn by hand, for which a very simple mechanism was created: the bow was fitted on a stock and drawn by pushing a slider against a wall or against the floor with the body weight of the operator. A locking mechanism allowed the discharge of the weapon. In short, this weapon is very similar to a crossbow. This kind of machine presented several advantages compared to a hand-bow: it allowed the use of a stronger bow, thus increasing the range and the power of the weapon (Marsden 1969: 12). A second advantage lied in the draw-length: with a hand bow the draw-length was necessarily limited by the length of the archer's arm, and the arrow-size had to be proportional to the draw-length. With a mechanical bow like the *gastraphetes*, on the other hand, the draw-length could be increased beyond the limits imposed by the size of the human body, and the length of the projectile could also be disconnected from the

² Diodorus Siculus, 14.42.1.

³ Diodorus Siculus, 14.50.3–4.

⁴ Diodorus Siculus, 14.51.1.

⁵ Plutarchus, *Mor.* 191E; *Mor.* 219A.

⁶ Cf. Campbell 2013: 678–680. See also Garlan 1974: 167–168 and Drachmann 1977: 119, who argue that the Sicilian catapults of 399 BC were already torsion weapons.

⁷ See Kingsley 1995b for an analysis on that point.

⁸ Heron, *Belopoeica*, W75.10–81.2.

draw-length; it became possible to shoot a longer arrow, or on the contrary a shorter, but heavier bolt, or even a stone. Lastly, the locking mechanism allowed the user to take aim without effort and to discharge at the right time. On the downside, for a hand-held weapon it was very cumbersome, and the odd drawing system (based on the weight of the operator) could not produce much more power than a hand bow; in a way, such a catapult was not very efficient from an energetic point of view. The next logical step to improve this weapon was to mount it on a stand, and to use a windlass to draw the bow (Marsden 1969: 13–14). There is no doubt that small bow catapults with these features were in use in the years following the invention of the *gastraphetes*, as we will see.

The literary evidence for bow catapults in the fourth century BC, though, is not straightforward. We know of four different designs of bow catapults, both arrow-shooting and stone-throwing models, from the treatise of Biton, probably written in the second century BC (M. J. T. Lewis 1999; Rihll 2007: 164–12). These catapults are:

- the two arrow-shooting machines designed by Zopyros of Tarentum in Cumae and Miletus (Biton, W61–67);
- the stone-thrower designed by Charon of Magnesia in Rhodes (Biton, W45–48);
- the much larger stone-thrower designed by Isidoros of Abydos in Thessalonike (Biton, W48–51).

The two arrow-shooting machines are referred to as *gastraphetai*, though they were not strictly belly-bows and were pulled back with windlasses. These catapults play a crucial role in Marsden's appraisal of Greek artillery, filling the gap between the original *gastraphetes* and torsion artillery with what he terms "advanced non-torsion artillery".

However, there is a significant problem with the four catapults mentioned, one that needs to be addressed here. If we follow Marsden (1969: 11–12), the powerful bows needed for those large catapults were composite bows: a core of wood, with a layer of horn on the belly and a layer of sinews glued on the back. These were very large bows: the first arrow-shooting machine described, discharging two arrows of six feet (1.85 m) at the same time, needed a nine-feet-long bow (2.8 m) with a perimeter of 15 dactyls (that is to say a diameter of ca 9 cm).⁹ The second arrow-shooting machine is described as a mountain *gastraphetes*, probably owing to its smaller dimensions allowing it to be carried more easily on rugged ground (just as in the 20th century the shorter guns used by the mountain artillery regiments were termed 'mountain' or 'pack' guns). This *gastraphetes* had a bow seven feet long (2.15 m) with a perimeter of 9 dactyls (i. e. a diameter of 5.5 cm). For the two stone-throwing machines Biton does not give the size of the bow nor the weight of the shot, but following Marsden's estimations, the bow of the catapult designed by Charon of Magnesia would have been of the same dimensions as the first arrow-shooting machine described, 2.8 m long and 9 cm in diameter (Marsden 1971:

9 Biton, W62. I use for this theoretical discussion the "Greek foot" of 30.8 centimetres described by Marsden, though it must be stressed that in reality such a standard foot never existed: the length of the foot varied between regions and periods and was often closer to 32.5 centimetres than to 31. When studying a fortification, one should always first identify the foot used in the construction, before trying to calculate the size of the catapults used for its defence.

80, n. 12). For the much larger stone-thrower designed by Isidoros of Abydos, Marsden postulates a bow with a length of no less than 15 feet (4.6 m) and a diameter of 30 cm.¹⁰ His conclusions have not been contested by the more recent studies of Campbell (2003) and Rihll (2007).

However, I would like to stress here that such bows are very unlikely, except maybe the smaller one, the bow of Zopyros' mountain *gastraphetes*.¹¹ There are several limiting factors to the building of a composite bow.¹² The first one is the wooden core: it is not possible to increase the size of the bow indefinitely, as a thicker piece of wood will be much less flexible and prone to break.¹³ The mere fact of stringing a composite bow puts the wood under heavy stress, to say nothing of drawing it. The bow of Isidoros' catapult would need a beam-sized wooden core at least 20 centimetres thick,¹⁴ and even the six-centimetre-thick wooden core of the other two bows seems altogether impossible. As for the other materials, a horn-strip generally has a thickness of less than five millimetres.¹⁵ If one wishes to increase the diameter of the bow while keeping the same ratio between the wooden-core, the horn, and the sinew, it is necessary to glue several layers of horn on top of each other – up to ten layers or even more for the bow of Isidoros' catapult. It is quite doubtful that a composite bow can be built on this basis, but this limitation also excludes the use of self-bows. As acknowledged by Marsden himself (1969: 14), the maximum size of historically-attested composite bows is 1.5 m in length and 5 cm in thickness. It is unlikely that the Greeks, who were not particularly keen on archery, could have overcome these technical limitations so readily.

10 Marsden 1971: 83–84, n. 22. The corresponding shot has an estimated weight of 40 mina (more than 17 kg). Because of the size of the projectile, he argues that this catapult was one of the standard types in Pergamon, even in the Hellenistic period.

11 This size, 2.15 m, is recorded for English longbows of the 16th Century, for instance. This type of *gastraphetes* could thus use a large self-bow rather than a composite bow – though a composite bow of this size cannot be definitively ruled out.

12 Heron briefly mentions the limitations imposed by the bow after the description of the *gastraphetes* (Heron, *Belopoeica*, W81.2–6); it seems clear that it was not possible for him (nor for Ctesibios, whose text he follows) to increase the dimensions of the bow indefinitely.

13 See Vitruvius, *De Architectura*, 10.16.5, where the author takes the example of a hole bored with an auger to show that a device working at a given scale may not work at all at a larger scale: "with an auger one can bore a hole with a diameter of half an inch, one inch, or one inch and a half; but if we want to bore a hole one palm wide with the same method, it cannot work, and for a diameter of half a foot or larger, it is generally agreed that it is not even possible to think about it" (*Terebratur terebra foramen semidigitale, digitale, sesquidigitale. Si eadem ratione voluerimus palmare facere, non habet explicationem, semipedale autem aut maius ne cogitandum quidem videtur omnino*). I believe that the same applies to the bow: it is perfectly possible to shoot an arrow of 200 grams or even, say, 500 grams with a large bow, but it seems altogether impossible to cast a 40-pound stone by simply increasing the proportions of the bow. For this new solutions had to be found. There are parallels of siege-weapons powered by bow in Ancient China; interestingly, they did not use larger bows, but rather multiple bows (up to three bows working together) to achieve greater power.

14 Here I assume that the wooden core covers two thirds of the thickness of the bow, one sixth being horn (5 cm, or 10 layers of 5 mm horn-strips), and the last sixth being the sinew plating on the back of the bow.

15 Five millimetres is clearly on the high side. Most of the Egyptian bows studied by McLeod (1958; 1962) have horn strips 2 or 3 millimetres thick.

If it were possible to build such giant bows, a second limitation immediately arises to their large-scale use: a composite bow is a sophisticated weapon, that needs several months to be assembled and dried.¹⁶ This can only increase the final cost of the weapon: the very large bows alluded to by Biton would have needed very specific craftsmanship, and for this reason they cannot have been used on a large scale. A composite bow is also relatively fragile and needs to be protected in a case (Balfour 1921: 303–304), notably to avoid humidity. Its materials are vulnerable to insects, especially the horn.¹⁷ This is even more critical for those large bows, intended to be used outside or in poorly insulated towers, and stored the rest of the time in an arsenal in similar conditions. In case of breakage, which can occur after repeated use, such a bow would have been difficult to replace on the spot. In short, the huge bows postulated by Marsden for the catapults described by Biton are most unlikely.

Both Marsden and Rihll, to explain Biton's interest for non-torsion artillery well into the Hellenistic period, postulate that catapults of this kind had some advantages over torsion catapults and were notably less affected by bad weather conditions.¹⁸ This can hardly have been the case. Of course, the springs of a torsion catapult must be preserved from humidity; Philon says so explicitly.¹⁹ But the same can be said of a composite bow. As a matter of fact, compared to a bow catapult, a torsion catapult is really straightforward in its principle: it does not need complex material but a spring, that can be very easily removed and changed when damaged. It is not very expensive to build and is quite simple to handle. It is therefore not surprising that torsion artillery became standard in the Greek and even in the Roman world, and that before its invention we have only a few attestations of catapults. The new design made possible by the adoption of a torsion-based propulsion system did not only make it possible to increase the power of the catapults, it also made their construction and their physical principle much simpler.

In this case, what of the four large bow catapults mentioned by Biton? Quite obviously, he never saw these machines and necessarily drew his descriptions more from literary knowledge.²⁰ Even though he is not very consistent in his use of tenses, some of

¹⁶ Rihll (2007: 166) even says that a large bow for a catapult would need one year or so to be prepared.

¹⁷ Ulysses' first action when he manages to get hold of his bow is to check that the horn has not been damaged by worms (Homer, *Odyssey*, 21.394–395).

¹⁸ Marsden 1969: 63; Marsden 1971: 83–84, n. 22; Rihll 2007: 167. See Ober 1987: 574 and n. 1. Cf. *infra*, n. 29.

¹⁹ Philon, *Belopoieica*, 72.

²⁰ *Contra*: Rihll 2007: 164–172. This is not the place to address all the unfounded ideas presented in Rihll's book (see, for instance, Campbell 2008 for some criticism), but her discussion of Biton's treatise is not at all satisfactory. She tries to show that the catapults described by the author were actual models used during the Hellenistic period, and that the introduction of torsion artillery did not replace bow catapults, even in the second century BC. She then tries to find historical figures that may correspond to Damis of Colophon and Isidoros of Abydos to support her theory – a somewhat hopeless quest, as they have very common names (on this point see also Meißner 1999: 162 n. 149). This goes against all the evidence. The only certain chronological elements from the text are: 1. the mention of the siege tower designed for Alexander the Great by Poseidonios; 2. the term *gastraphetes* used for the arrow-shooting catapults of Zopyros, implying that they were designed at an early stage of the development of the catapult; and 3. the mention of Thessalonike, implying that the catapult of Isidoros was designed after 315 BC (but there is absolutely no reason to propose a date as low as the second century BC, as it is clear that Biton had no objections against old machines). M. J. T. Lewis' argument, that the term *sambuca* that appears in the text could point to a date in

his descriptions are written in the imperfect, as an awkward way of acknowledging that the machines he describes belong to the past. The few chronological elements that can be drawn from the text also show that he relied on older sources, some of them dating from the fifth or the fourth century BC. For instance, Zopyros of Tarentum has been tentatively associated with a Pythagorean philosopher who flourished in the last quarter of the fifth century BC²¹ – at any rate, the two catapults attributed to him are termed as *gastraphetes*, which means that they were designed during the first stages of the development of artillery. Biton also mentions the siege tower designed by Poseidonios for Alexander the Great.²² On the other hand, Isidoros designed his catapult in Thessalonike, which gives a *terminus post quem* after the foundation of the city in 315 BC (Rihll 2007: 64, n. 44), making this bow catapult, conceived at a time when torsion artillery was already well developed, a rather conservative engine.

Biton, copying the texts of earlier writers, never calls into question the very possibility of the machines he mentions, but it seems clear that these catapults at least never went beyond the stage of prototype, or even never existed at all. One of them, the double-bolt *gastraphetes*, is obviously an experimental machine, as we have no other attestations of such catapults able to shoot two bolts at the same time.²³ For each of them he gives the name of the architect who designed it (with the verb ἀρχιτεκτονεύω, to design, for Zopyros of Tarentum and Charon of Magnesia and the verb κατασκευάζω, to prepare, for Isidoros of Abydos) and the place of conception: Miletus for the double-bolt *gastraphetes* of Zopyros, Cumae for his mountain *gastraphetes*, Rhodes for the stone-throwing catapult of Charon and Thessalonike for the stone-throwing catapult of Isidoros. This can be the city which commissioned the construction, but also, more simply, the place where the prototype was displayed. The case of Zopyros shows that these designers were famous enough to move from Italy to Asia Minor. However, it does not mean that their machines were built on a large scale, nor that they were effective. We have other examples of engineers designing machines that were most unrealistic, for instance the machine designed and presented during a lecture by Callias of Arados at Rhodes, which was supposed to lift enemy siege engines in the air and drop them inside the walls of the city. Of course, when asked to build this machine and to apply it against Demetrios' *hele-*

the second century BC, is convincing. The most probable and reasonable option is that Biton collected *exempla* of siege machines in books, whose sources ranged from the fourth to the second century BC. In my opinion, Rihll is much closer to the mark when she states that "Biton may rather have scoured Pergamon's Library – which was second only to Alexandria's – for descriptions of old war machines not because he desperately sought an alternative for torsion weapons but because it is said that the greatest war machines were made in the time of Demetrios Poliorketes" (Rihll 2007: 166). For a similar opinion, see also M.J.T. Lewis 1999: 161.

21 Garlan (1974: 167–168) expresses doubts about this identification. According to Marsden, Zopyros' *floruit* was in the middle of the fourth century BC (Marsden 1969: 13; Marsden 1971: 98, n. 52), but since then Kingsley (1995a: 149–155) has shown that he more probably belonged to the last third of the fifth century BC, and that the catapult designed in Cumae was probably designed before 421 BC, when Cumae was taken by the Sabellians.

22 Biton, W52.

23 This feature is quite reminiscent of the more complex repeating catapult mentioned by Philon (see *infra*, n. 27).

polis, Callias had to admit that he was unable to do so, and the *helepolis* was countered by a much simpler and even trivial trick, by pouring mud and water on the ground so as to bog it.²⁴

In fact, there are other instances where a catapult designed by an individual in a given place refers only to a prototype and never saw large-scale use. On three occasions, Philon mentions the name of the designer of a specific catapult and the place where it was built, just as Biton does; in all cases, it clearly refers to an experimental prototype. The first one is the bronze-spring catapult designed in Alexandria by Ctesibios. When commenting it, Philon even gives his own version of this machine.²⁵ But despite its alleged efficiency and ease of use, this type of catapult never supplanted the traditional torsion catapult, and we must conclude that such bronze-spring catapults were never used in actual warfare, though the prototypes apparently existed and worked. The same Ctesibios is mentioned again for the invention of a catapult powered by air-springs, for which we do not have other attestations.²⁶ Philon also discusses a repeating catapult invented by Dionysos of Alexandria in Rhodes, but he then states that “this was an ingenious and well-found arrangement, but it is of little use in practice.”²⁷ Rather similarly, we call “Da Vinci catapult” a catapult design that was invented and drawn by Leonardo Da Vinci, but this machine, of course, never saw action.

The catapults of Zopyros, Charon and Isidoros were probably of the same kind: designs, maybe prototypes or reduced-scale models, but they were far from widespread machines actually used in warfare, as we have seen that there are strong objections against the very possibility of such machines. All this, including Biton’s treatise, has more to do with speculations about mechanics than with engineering. We should not take at face value the descriptions put forward by Biton. As stated above, Isidoros’ catapult, having been designed in the early Hellenistic period or even later, well after the invention of torsion artillery, is a very conservative machine. Biton’s treatise is no less conservative, recording only bow catapults well into the second century.²⁸ Biton con-

24 The whole story is told by Vitruvius, *De Architectura*, 10.16.3–7. The terms are very clear: Callias produced during an *acroasis*, a public lecture, an *exemplar* of his machine, that is to say a reduced-scale model – the verb used for it, *constituere*, is very reminiscent of the Greek κατασκευάζω used by Biton to refer to Isidoros’ catapult. The fact that he was warmly welcomed in Rhodes shows that the Rhodians were fond of this kind of exercise, which could help to explain the catapult of Charon of Magnesia and the repeating catapult of Dionysios of Alexandria, designed in Rhodes as well.

25 Philon, *Belopoeica*, 67.28–73.20.

26 Philon, *Belopoeica*, 77.7–78. About this machine, only briefly mentioned by Philon, Marsden (1971: 184, n. 126) rightly notes: “Since Philon only included the air-spring engine for the sake of completeness, it does not appear that he had much confidence in it”.

27 Philon, *Belopoeica*, 76.21–22: φιλότεχνον μὲν καὶ οὐκ εὐερέτον ἔχουσα τάξιν, οὐ μέντοι γε εἰς ἀξιόλογον χρεῖαν πίπτουσα. Philon does not see the point to shoot several bolts at the same target; a catapult, in his opinion, should hit far and hard, which should make it useless to shoot a second bolt at the same target (cf. Philon, *Belopoeica*, 51.6–10; cf. Heron, *Belopoeica*, W74). It should be noted that Zopyros’ double-bolt catapult is, in the same manner, a somewhat useless refinement on a standard catapult.

28 M. J. T. Lewis (1999) proved decisively that the treatise was dedicated to Attalos II rather than to Attalos I. See *supra*, n. 20 for the chronological elements from the text itself. Rihll (2007: 168–169) went further by suggesting that it could be Attalos III, but without clear arguments. Drachmann (1977: 128) even made the supposition that the treatise was only a rhetorical exercise fictitiously dedicated to Attalos, but in fact much later.

sistently fails to acknowledge all the recent evolutions in catapult engineering²⁹ and the third-century experiments mentioned by Philon. His treatise also lacks crucial technical details; for instance, there is absolutely no mention of the dimensions of the bow and of the weight of the shots of the two stone-throwing catapults, and none of his catapults has a trigger. Drachmann (1977) even stresses that it is almost impossible to get any sense at all from the chapters of Biton dealing with catapults: the text may have been corrupted, of course, but in Drachmann's opinion Biton simply followed earlier descriptions and drawings without fully understanding them, and he is therefore not an author to be trusted on the subject. To put it simply, it is not possible, with the instructions given by Biton, to build a catapult.³⁰

We therefore have good reasons to seriously doubt Biton's competence as an engineer, and Drachmann (1977: 128) was perhaps not very far off the mark when he suggested that his book was an exercise from a school of rhetoric rather than a true technical treatise.³¹ On the other hand, the standard catapults described by Philon, Heron or Vitruvius do not need an inventor's name,³² simply because they were the mere description of actual catapults, widely used and known by their readers. Vitruvius, for instance, states that he draws his knowledge on the topic from his practice, but also from the teaching he received from his instructors, a clear sign that actual catapult engineering was an empirical competence acquired on the spot or by a pragmatic teaching, and not only through reading.³³ Philon, while speaking from a very general point of view, gives a lot of technical details on the actual operation of a catapult, including, for instance, a discussion on the best way to string the catapult and to adjust the springs after use, and some simple improvements in the standard catapult's design by replacing the metallic

29 See on this point M. J. T. Lewis 1999: 161. The author argues that Biton was interested in bow catapults only because he wrote in a context of crisis, when the city of Pergamon was desperately in need of weapons and had no supplies in sinews to build them; hence, it had to rely on another method of construction. It must be stressed, though, that it is not possible to create *all'improvviso* such large bow catapults in great numbers, which requires large quantities of specific raw material (wood of a specific kind, horn, sinew), and also skilled craftsmen (see Rihll 2007: 166). It was probably simpler to replace the sinews by another kind of fiber. Another objection is that this does not explain the description, in Biton's text, of other siege machines like a siege tower and a *sambuca*.

30 According to Meißner 1999: 161–162; 164, this would be owing to the fact that Biton, writing to Attalos, king of Pergamon, acted only as a technical advisor, giving general instructions that were to be adapted by the king's engineers. However, in such a context, one would expect the author to emphasize aspects such as performance, ease of use, cost, etc. These aspects are conspicuously absent from the text. Not even the weight of the shots is specified. On the other hand, very precise measures are given for some of the wooden parts of the catapults. The question is: why would Attalos care about such trivial details, when his technical advisor does not even provide him with a general explanation of the specific purpose of each machine?

31 This hypothesis can solve the problem of Biton's text itself. However, it seems to me that Drachmann has underestimated the importance of Biton's sources: Biton obviously did not invent the names of Zopyros, Charon and Isidoros, and he is clearly following one or several other texts.

32 Rihll (2007: 35–37) wonders why the name of the first inventor of the catapult is not recorded, and unconvincingly argues that he may have been a slave. In fact, for such a real device, we do not need a name: there may have been several men implied in the invention, and their name have not been recorded simply because these first catapults spread in the Greek world by copying actual machines rather than by the way of written accounts signed by an engineer.

33 Vitruvius, *De Architectura*, 10.11.2.

washers and levers with a wooden beam – something which never became widespread, as we know that catapults in the Roman times still had metallic washers and levers.³⁴ Compared to Biton, this sounds much more like actual engineering, and the standard catapults described by Philon, Vitruvius or Heron were obviously not of the same nature as the experimental machines recorded by Biton.

2. Practice: Early Attestations of Catapults in the Epigraphical Record of Athens

Therefore, if the machines described by Biton must be ruled out as impractical, what did the non-torsion artillery of the fourth century BC actually consist of? As stated above, the most natural evolution of the *gastraphetes* is to mount it on a stand and to fit it with a windlass to replace the belly-bow system, without necessarily increasing its size. This produces a small catapult, stronger than a hand-bow, capable of shooting heavy, armour-piercing arrows or small stones of the calibre of a sling bullet. There is no doubt that such catapults were used during most of the fourth century BC. For this discussion, a few Athenian inscriptions are crucial; they are already well-known, but I hope that my commentary on these inscriptions may bring some new insights on the subject. The first attestation of catapults in the Athenian epigraphical record is the presence of two boxes of catapult bolts on the Acropolis in the second quarter of the fourth century BC.³⁵ It is not certain that these bolts were intended to be used, and they may rather be dedications. Interestingly, it should be noticed that on the second oldest inscription of the group (IG II² 120, 37), the word “catapult” is misspelled (καταπλατών instead of καταπαλτών), maybe because this term was unfamiliar to the stone-cutter. Still, these attestations are very important to assess the diffusion of the catapult in the Greek world: this weapon was not unknown in Athens in the second quarter of the fourth century BC, but it was probably a rare weapon at this moment. Two passages of Plutarchus further confirm that catapult bolts were first seen in the Peloponnese during the lifetime of Archidamos III only,³⁶ presumably in the 360’s, and were still at that time a novelty coming from Sicily – two generations after the catapults of Zopyros. Aeneas, writing in about the same period, did know about catapults, but he mentions them only once, as a weapon potentially used by the attackers along with slings from “large machines”;³⁷ on the other hand, he does not record their use as a defensive weapon: in his mind the catapult was clearly not an important device to protect a place; the defenders had to rely on much simpler weapons, most of all stones simply cast with the hand.³⁸

³⁴ Philon, *Belopoeica*, 60–61.

³⁵ IG II² 1422, l. 8–9 (for the date, cf. Cole 1981 (371/0 or 363/2 BC, the more recent date being more probable, because closer to the other attestations); IG II² 120, l. 36–37 (362/1 BC); IG II² 1440, l. 48 (350 BC)).

³⁶ Plutarchus, *Mor.* 191E; *Mor.* 219A. Rihll (2007: 48) gives for this anecdote a date of “about 380 at the earliest”, but it can be safely connected with the Sicilian troops sent to help the Spartans after 370. Cf. Campbell 2008.

³⁷ Aeneas Tacticus, *Poliorcetica*, 32.7. Cf. Garlan 1974: 172–173.

³⁸ This rather primitive weapon is frequently mentioned in the text of Aeneas and appears as the main de-

The scarcity of the mentions of catapults in the first half of the fourth century, in fact, is very consistent with bow catapults: such machines, because of the limitations imposed by the bow, represented only small advantages over a hand-bow or a sling,³⁹ and it was maybe not a wrong financial calculation to favour the rate of fire and the mobility of the firepower by hiring or training traditional archers rather than investing too much money on such alternative weapons. Most of the cities, therefore, simply did not take them into consideration. In the text of Diodorus, the next mention of catapults, after their alleged invention in Syracuse in the early fourth century BC, concerns the year 340 BC: during the siege of Perinthos, Philip II used *oxybeleis*, arrow-shooting catapults. At the beginning of the siege, the defenders apparently did not have any artillery with which to retaliate until the Byzantines sent them reinforcements, and most of all catapults. It must also be noted that less than a decade before, during the siege of Olynthos, even the Macedonians apparently did not have any artillery, as noticed by Schellenberg (2006: 19). The siege of Perinthos, in fact, records a crucial step in the development of artillery: by 340 BC, artillery was just beginning to spread in the Greek world, but even some relatively important cities like Perinthos had not adopted the new weapon yet.⁴⁰ Only the king of Macedon or much more powerful cities like Byzantium – and Athens, as we will see – could afford this kind of weapon.

To return to the case of Athens, the following attestation, in 343/2 BC, records catapult bolts and also a spare trigger for a catapult, this time in an operational context, at the garrison fort of Panakton;⁴¹ but because of the very small number of catapult bolts (103 in total, compared to the 2,500 arrows mentioned in the same inventory and also, maybe, the large number of lead sling bullets⁴²), it is likely that the catapults were not present in great numbers in the fort and were quite a novelty in this context. Here again, it is perhaps not a coincidence that the stone-cutter misspelled the word *σχαστηρία* (trigger), a possible sign that this was an unusual term to him.⁴³ Still, this inscription shows a new step for the development of artillery, as it is the first clear attestation of the regular use of catapults in a defensive position. Given the date, the catapults involved here were probably bow catapults, as the inscription is only a *terminus ante quem*, recording quite a lot of items in poor condition.⁴⁴ However, torsion catapults cannot be excluded as they are attested soon after.⁴⁵

fensive weapon. It must be stressed that this simple weapon requires some space – in the case of a tower, a crenellated platform rather than a roofed tower with small windows or loopholes. This appears in strong contrast with Philon's *Poliorketika*, where the catapult is clearly considered as the main defensive weapon.

39 This is even clearer for the *gastraphetes*: the bow, being pulled back by the thrust of the user, cannot have been very powerful, no more than 90 or 100 lbs, which is not unusual for very strong hand bows.

40 Diodorus Siculus, 16.74. As Rihll (2007: 73) rightly notes, about one century later, a small Sicilian town (*πολισμάτιον*) which name is not even recorded had catapults available (cf. Polybius, 1.53.11).

41 SEG 46.185; see now the full edition of this text in Munn 2021, n°1.

42 Munn 2021: 286–287 for this hypothesis.

43 The stone bears ΣΧΑΣΕΗΟΙΑ, understood as *σχασ(τ)η(ρ)ία*. For this hypothesis, see now Munn 2021: 288.

44 According to Munn 2021: 292, the fortress may have been armed with catapults around 378–375. However, a date around 350 is enough to explain the bad condition of the objects.

45 This date is very close to the first attestation of torsion catapults given in the following inscription.

Another important inscription for this study is an inventory of military equipment stored in Piraeus, mostly naval gear, but which also includes several catapult parts.⁴⁶ It lists eleven *πλαίσια* of catapults “from Eretria” (l. 328–9), which is interpreted by Marsden as the frames of torsion catapults. This is our first clear mention of torsion artillery, which means that there were torsion catapults in Athens before 330 BC, and maybe already in 340 BC.⁴⁷ Rihll (2007: 65) has tried to argue that these were in fact parts of bow catapults, namely the sliders, but this interpretation of the Greek term is unconvincing and must be rejected.⁴⁸ She also stresses that the springs are not mentioned in the inventory; but as the catapults are disassembled and not complete, the frames were certainly unsprung and the springs could have been stored elsewhere or discarded because of their bad state of preservation.

However, alongside these parts that indubitably come from torsion catapults, the inventory also mentions “two bows in leather cases” (l. 332–3: *τόξα ἐσκυτωμένα* :II:). These bows, being in the middle of a list of catapult parts, were not hand-bows, but bows from catapults;⁴⁹ and because they are encased in leather, they were probably composite bows.⁵⁰ The inscription, then, should not be read in too exclusive a way by postulating that all the catapults involved were necessarily of the same type. Here it must be stressed that the catapult parts of the inventory do not come from a definite number of catapults but are rather spare parts or even mismatched odds and ends from old catapults: there are eleven frames, but fourteen stocks for catapults and seven bases, for instance. The frames are from Eretria, and so come from catapults that had already seen action a decade before, while the bows clearly suggest that there are parts from at least two distinct generations of catapults in the list – these bows, perhaps, being the remnants of catapults built in the first half of the century. The fact that the same items are recorded in several lists without modifications (as far as the catapults parts are concerned),⁵¹ down

46 *IG II²* 1627, B, 328–341 (330/29 BC). The same items are to be found again in subsequent inventories (*IG II²* 1628, D, 510–521 (326/5 BC); *IG II²* 1629, E, 985–998 (325/4 BC); *IG II²* 1631, B, 220–229 (323/2 BC)).

47 Marsden 1969: 57–58. The fact that these catapult parts come from Eretria even leads him to conclude that these catapults were used in Eretria in 340 BC before being transferred to Athens, and that they might be spoils of war taken from the Macedonians.

48 Cf. Campbell 2008 for a criticism of the theories of Rihll on this inscription. A *πλαίσιον* is clearly a kind of frame; to translate it as a slider is incorrect. Therefore, I use here the translations proposed by Marsden rather than Rihll’s interpretation.

49 They may be associated with the “six stocks for scorpions” mentioned in the inventory, that are clearly separated from the “fourteen stocks for catapults”. The term scorpion is used later to designate a small arrow-shooting catapult. This would clearly go with bow catapults. The small number of bows also shows that these were probably the most fragile parts of the whole, and that the others had to be discarded earlier because of their bad state of preservation – implying in return that the bow catapults mentioned in these inscriptions were already old machines in 330 BC.

50 The need of a case for a composite bow is notably underlined by Balfour (1921: 303). See also Ober 1987: 574 n. 1.

51 The last inventory, *IG II²* 1631, B, 220–229, mentions one more pulley-wheel and nine more bolts. According to Rihll (2007: 70), this would be an indication that “Athens was re-arming, that is, stockpiling military material in preparation of a war planned or foreseen”. This is pushing the evidence too far; nine more bolts is but a slim preparation for war. I prefer her other propositions, that these differences simply come from an accounting or an inscribing mistake.

to 323/2 at least, also suggests that these catapult parts were not used for years but only stored here, removed from service. This means that bow catapults were not thought of as totally out of use in the last quarter of the fourth century BC and were still kept in case of need. To sum up, in the third quarter of the fourth century BC, catapults of different generations, bow catapults and torsion catapults, were in use in the arsenals of Athens. In that way, the inscription is clearly from a period of transition.

This gives a likely context for the catapult of Isidoros of Abydos, which could be interpreted as an early Hellenistic desperate “defence and illustration” of the bow catapult against torsion artillery that was then becoming widespread – an attempt that was clearly a fire in the pan, and only saved from oblivion by Biton. For the third century, we simply have no attestations of bow catapults as weapons actually used in warfare. Heron, who certainly followed very closely in his treatise the artillery manual of Ctesibios (Marsden 1971: 1–2), written around 270 BC, only mentions bow catapults as a kind of incunabula, technically outdated and no longer in use, while Philon, by the end of the same century, never mentions them at all in his texts, despite the fact that he is very comprehensive in his description of catapult designs (Schellenberg 2006: 20).

At about the same time, torsion artillery was developing quickly: for the last twenty years of the fourth century BC, an increase in the mentions of torsion catapults in the Athenian inventories can be noticed. In an inscription dated from 318/7 BC, IG II² 1475, B, l. 35, several two-cubit catapults are listed, and one of them at least is characterised as *τρίχोटόνος*, “powered by hair-springs”. This term appears in another important inscription frequently discussed, IG II² 1467 l. 48–56, which is an inventory of the Chalcotheca traditionally dated from the Lysurgen period (338–326 BC), but in fact probably somewhat later (approximately 305/4 BC),⁵² where several two- and three-cubit catapults are listed and, here again, characterised as *τρίχोटόνος*. These “catapults powered by hair-springs” can be contrasted with the smaller “three-span catapult powered by sinew-springs” (*νευρότονος*) mentioned in another inscription of the late fourth century BC (probably 307/6 for the catapults), also including three-cubit catapults and a larger catapult capable of shooting both stones⁵³ – our first clear attestation of a stone-throwing catapult – and four-cubit long arrows.⁵⁴ That sinews were used for catapult springs in Athens by the end of the fourth century BC is further confirmed by a decree honouring

52 See D. M. Lewis 1988: 299–300; cf. SEG 38.143. Lewis argues that IG II² 1467, because of its specific *stoicheion* pattern, is only a fragment of a larger inscription, with IG II² 1485 and IG II² 1477, 1473 and 1490. The date is given by IG II² 1477. If this conclusion needs further demonstration, at any rate, IG II² 1467 could well be dated to the very end of the fourth century BC, and the date range in the Lysurgen period, based only on the lettering, must be considered with extreme caution. This correction has not been noticed by Rihll, who simply repeats the former dating.

53 According to the size of the bolts, this should be a 10-mina catapult (spring diameter of 11 dactyls, very close to the spring diameter of 10 and 2/3 dactyls of a four-cubit, arrow-shooting catapult).

54 IG II² 1487, l. 85–90. For the date, another year begins just after the catapults, dated from the archon Coroibos (306/5). The catapults were probably inscribed the year before. Cf. Marsden 1969: 69–70. The term is also restored in IG II² 1475, l. 31 and 34, but as there is certainly a *τρίχोटόνος* catapult in this inscription (and this term has the same number of letters as *νευρότονος*), it seems more reasonable to suppose that the other catapults recorded in the inscription were also powered by hair-springs (cf. Marsden 1969: 69).

Euxenides son of Eupolis, of Phaselis, who, among other things, provided the city with sinews for the catapults.⁵⁵

For the same period, Aristotle states that the ephebes, during their training, learned how to shoot with a catapult – a training later attested in other cities as well.⁵⁶ We can add a funerary inscription of the second half of the fourth century BC bearing the inscription “Herakleidas, Mysian, artilleryman” (Ἡρα[κ]λείδ[α]ς Μυσὸς κατ[α]παλταφέτας) (IG II² 9979). From all these elements emerges a very consistent picture: by the end of the fourth century BC, artillery had become a crucial point in the military policy of Athens, and the city was investing quite a lot of energy (and probably money) in having good catapults and soldiers trained to operate them. This change came only with the diffusion of torsion artillery; on the other hand, the introduction of the bow catapult, a few decades earlier, did not represent such an important change in warfare.

3. “First-Generation Artillery Towers” and their Use as a Chronological Element

A last question involving early artillery remains to be treated here; it is the typology of artillery towers presented by Ober (1987; 1992), as a new interpretation of a method initiated by Marsden (1969: 116–163). The first article is devoted to what Ober called “first-generation artillery towers”. This first generation is characterised by three main features:

1. The walls are composed of a single course of blocks, with a maximal thickness of 70 cm. This is a sign, according to the author, that they were not intended to resist heavy artillery fire and that it was not possible to put into battery heavy machines in the upper chamber of the tower. Because of this, the author believes that they were designed at a time when heavy stone-throwing machines had not been invented yet, which means before the reign of Alexander the Great (Ober 1987: 597).
2. The windows of the upper chamber are small, around one square metre, and close to the floor, meaning that they were intended for small catapults (Ober 1992: 159–161).

⁵⁵ IG II² 554, l. 14–16 (306/5 BC) (cf. Marsden 1969: 70). The only *νευρότονος* attested by epigraphical evidence is a three-palm catapult, that is to say one of the smallest calibres attested for arrow-shooting catapults. On the material used for catapult springs, see now Meißner 2017; Meißner 2018. Experimentation led him to conclude that wool, treated with linseed oil, wax and gum resin, was probably one of the best solutions available for hair-springs, sinew being mostly used for the smallest euthyntone catapults. On this question, one does find *en passant* in Heron and Vitruvius that women’s hair could be used with good results (Heron, *Belopoeica*, W112; Vitruvius, *De Architectura*, 10.11.2; cf. Vegetius, *De re militari*, 4.9). Among these, Heron may be considered as the earliest reference, as he closely follows Ctesibios’ artillery manual, dating from the early third century BC. In the passage of Vitruvius, the remark more clearly derives from a literary *topos*: to underline very critical circumstances during a siege, some historical sources, mostly during the Roman period, mention that the women cut their hair to make catapult springs (Appianus, *Libyca*, 93 (Carthage), Caesar, *BC*, 3.9.3 (Salonae), Polyaeus, *Stratagemata*, 8.67 (Thasos; does not explicitly refer to catapult springs)); see also Marsden 1969: 83 n. 3 for the sources about the aetiological myth of the cult of Venus Calva (the Roman women giving their hair during the siege of the Capitol by the Gauls in 390 BC). This story, obviously forged after 390 BC, could explain the diffusion of this *topos* in the sources of the Roman period, which eventually contaminated the technical writings on the subject.

⁵⁶ Aristotle, *Constitution of Athens*, 42.2. See Winter 1994: 36 for other examples.

3. These towers are rather small, between 35 and 60 m² (and 80 m² for Aigosthena, the largest tower of the group), and because of the position of the windows, they could not house catapults with a stock longer than 2.1 m in the smaller towers, and 2.5 m in the larger ones. According to Ober's calculation, a stone-throwing torsion catapult of this size would be of a very small calibre (0.16 to 0.26 kg), and an arrow-shooting torsion catapult would throw bolts under 0.5 m in length.⁵⁷ This is, in fact, his most important argument: these towers, being in his opinion too small for torsion artillery, were intended for bow catapults only. It means that they were built before the invention of torsion artillery. Following his calculation, a bow catapult with a stock length of 2.1 metres would be able to shoot a 1.1-metre-long arrow, or even a stone weighing 1.5 kg.⁵⁸ This is smaller than the smallest of Zopyros' arrow-shooting catapults. On the assumption that a bigger catapult is necessarily later, this led him to date this group of towers to before the middle of the fourth century BC (the date of Zopyros' career according to Marsden), and more precisely, to the second quarter of this century. It is only for the larger tower of Aigosthena that Ober put forward a date in the third quarter of the fourth century.⁵⁹

Since Ober's initial publication, this typology has been widely used to confirm the date of such towers and of the fortifications to which they belong;⁶⁰ it is indeed very serviceable, as we lack universal criteria to date fortifications. His typology allowed a very narrow date range of 25 years for the fortifications of this group and gave a criterion to make up for the shortcomings of dating the walls by their type of masonry alone, a notoriously unreliable method. On the other hand, it is difficult to apply such a typology to other fortifications than the few examples taken by Ober. Notably, when the windows are not preserved, there is a risk to dating the towers only by their size, which is an over-simplification and a weak criterion on which to base so precise a date.

More recently, however, Rihll (2006) has noted that the calibration formula used by Ober in his first article to estimate the size of torsion catapults was false: according to Ober, the stock-length of a torsion catapult (L), be it arrow-shooting or stone-throwing, is thirty times the diameter of the spring-holes (D).⁶¹ This formula, $L=30D$, is never recorded in ancient sources. According to Vitruvius, the stock-length of a torsion catapult is $19D$,⁶² while Philon has $19D$ only for the stone-throwing catapult, and an even smaller $16D$ for the arrow-shooting catapult.⁶³ Ober found the formula $L=30D$ in Marsden, where it does not refer to the stock-length, but rather to the total space needed to ma-

⁵⁷ Ober 1987: 600 and Table 3. See also note 63 and 65 for his calculations.

⁵⁸ Ober 1987: 599 and Table 2.

⁵⁹ Ober 1987: 586. The tower is precisely dated to 343 BC. This date clearly needs to be reasserted.

⁶⁰ It is, for instance, alluded to as a dating criterion in Fachard 2013: 91 and n. 49 and Fachard *et al.* 2020: 502 and 513 for Eleutherai or in Müth 2014: 116 and n. 40 for Messene. In this last case, the assumption that the important variations between the towers should be attributed only to different teams of workers must be seriously doubted. See also Maher 2017: 57–58, whose analysis of Arcadian fortifications is largely influenced by the typology of Ober.

⁶¹ The spring diameter is the base unit to measure a catapult. All the parts can be expressed according to this unit. The arrow, for instance, has a length of $9D$.

⁶² Vitruvius, *De Architectura*, 10.10.1 and 10.11.7.

⁶³ Philon, *Belopoeica*, 54.8 and 55.10.

nipulate a catapult in a horizontal position, including free space for the users (Marsden 1969: 34) – and Rihll (2006: 381–382) rightly notes that this extra space of 11 or even 14D is clearly exaggerated.⁶⁴ Ober mistook this formula for the stock-length, so when he compares the size of bow catapults and torsion catapults, he is comparing apples and pears, as he puts on the same level the actual stock-length of the bow catapult and an exaggerated, estimated total length, including free space, for the torsion catapult.

However, while the observation made by Rihll on this point is valuable, she did not push it to its logical conclusion and did not see that it called into question the very existence of Ober's typology, which is largely based on the assumption that his first-generation artillery towers simply could not house torsion catapults – and this assumption, with the correct calibration formula, proves clearly wrong, as we will see. Instead of this, Rihll used this typology to assess the diffusion of bow catapults in the Greek world in the fourth century BC (Rihll 2007: 50–52), not seeing that this is a circular argument: as these towers have been dated on account of their artillery, it should not be possible to use in return the date of the towers as a crucial argument to date the spread of artillery in the Greek world.⁶⁵

Now, it is necessary to take back the argument where Rihll left it. If the drawings of Ober are correct, the towers of his first-generation group were intended for catapults with a stock-length of 2.1 m, and this leaves enough space for the operation of the catapult. Applying the correct calibration formula, the towers can thus house arrow-shooting torsion catapults of a reasonable calibre: one-metre-long arrows (two cubits) with the stock length of 19D mentioned by Vitruvius, or even 1.2 metre long (approximately five spans, a calibre attested)⁶⁶ if we keep the proportion of 16D recorded by Philon. A stock-length of 2.5 m, as in Aigosthena, is from a five-span catapult (19D), or even from a three-cubit catapult (16D) – thus falling into the category of heavy arrow-shooting artillery, capable of seriously harming the besiegers' shelters or siege machines. Of course, in both cases, smaller calibres cannot be ruled out, notably the ubiquitous three-span catapult frequently mentioned by Philon and also attested in the Athenian epigraphical record.⁶⁷

All these elements must lead to the conclusion that the artillery towers of Ober's first generation group could in fact clearly have been designed with torsion artillery in mind: the calibres involved here are medium-sized catapults. The two- and three-cubit calibres

64 For arrow-shooting machines of small or medium calibre, for instance, the arms of the windlass can be manipulated from the side of the machine and not necessarily from the back. For a larger catapult, Philon gives four cubits for the space needed to operate a one-talent catapult; it is less than 5D (Philon, *Poliorcetica*, 1.71).

65 For a criticism of such circular argument, see Garlan 1974: 16: "Décrire l'évolution de l'art des sièges en arguant de dispositifs architecturaux précédemment datés en fonction de cette évolution ne serait guère très convaincant".

66 Philon, *Poliorcetica*, 4.17, where it is advised to use it to counter-fire the stone-throwing catapults of the enemy.

67 IG II² 1487, l. 89–90. According to Philon, this catapult, as well as the two-mina stone-throwing catapult, was small enough to be used in mine galleries (Philon, *Poliorcetica*, 4.31). With a stock-length of 1.5 m (19D) or even 1.25 m (16D), it was certainly possible to put it into battery in very small towers and even on the curtain walls.

are explicitly mentioned in the Athenian epigraphical record of the late fourth century BC, as mentioned above, meaning that they were already standard calibres at that time. As we have seen, the second half of the fourth century showed a rapid development in matters of artillery, and the catapults are more widely attested for this period than for the first half of the century, in connection with the development of torsion artillery. This is a much more likely context for the construction of the first towers explicitly designed to house catapults, and the space available in these towers is sufficient for the standard catapults of that time.

Only one of Ober's arguments remains at this stage: the towers of his first-generation group are clearly too small to have housed stone-throwing catapults, even applying the correct formula,⁶⁸ and it is true that their walls consist in single-coursed masonry and may not have been strong enough to resist heavy artillery fire from heavy stone-throwing catapults.⁶⁹ This type of heavy catapult only appeared during the reign of Alexander the Great,⁷⁰ so if we are to retain this argument, the towers considered by Ober could well be dated to the third quarter of the fourth century BC, instead of the second quarter, as he has it. But here, we must take into consideration that these heavy stone-throwing machines were rare and expensive, even in the Hellenistic period; Philip V, for instance, used them on a large scale, but the big sieges of his reign, while proving his ability in siege warfare, were generally solved by rather traditional means, most of all mines, whereas the catapults were mainly used to shoot at the defenders or to protect the siege works.⁷¹ We must also not forget that small-scale fortifications, such as the walls of Siphai in Boeotia, an important member of Ober's first group, were primarily designed to afford protection to a small town against an occasional raiding-party, but certainly not to withstand a grand-style siege with heavy catapults, against which its best means of defence would have been a rapid surrender. In other terms, the potential threat that the builders of the fortifications of Siphai had in mind was clearly not the siege array of Alexander the Great. In that particular case or in the case of isolated towers, the single-coursed walls of the towers may well be a mere sign of that simple fact, rather than a chronological argument that should absolutely preclude a date in the Hellenistic period.

The argument that the towers were too small to house large stone-throwing catapults in their top chamber is also hardly convincing as a chronological feature: Philon of Byzantium, while recommending the use of ten-mina and thirty-mina stone-throwing

68 A stone-throwing catapult with a stock-length of 2.1 m would have a calibre of one mina or so (around 0.5 kg). A stock-length of 2.5 m is from a two-mina catapult, the smallest calibre attested in the text of Philon. Larger catapults must be excluded not only because of their stock-length, but also because of the height needed for such machines (Winter 1994: 34–35).

69 Cf. Ober 1987: 598: "Such weapons do not seem to have been conceived of by the designers of any of the towers considered above".

70 First attestation in Diodorus Siculus, 17.42.7 and 45.2 during the siege of Tyre.

71 Polybius, 5.99–100 (siege of Thebes in Phthiotida, where Philip V used 150 arrow-shooting and 25 stone-throwing catapults, which mainly allowed him to keep the defenders away from the walls to dig a mine); 9.41–42 (siege of Echinaios, where catapults of one talent and thirty mina are used, but only to afford protection to the main siege engines, two towers with rams, and to the trenches dug toward the wall); 16.11 (siege of Prinassos, where mines are used despite the rocky ground).

catapults to defend a place, never says that they should be located in the top chamber of the towers, but rather in the ground-floor chamber,⁷² or even, more simply, on batteries (*belostaseis*) located outside the wall itself.⁷³ Despite the fact that his book is a very idealistic description of the defenses of a town, written by the end of the third century BC, he does not conceive of towers large enough to carry thirty-mina catapults in their top chamber.⁷⁴ In fact, in any sophisticated Greek fortification, there is a ready-made place for such batteries, namely the space between the city-wall and the *proteichisma*. In this position, the crew of the catapult could be protected from direct shots by the battlements of the *proteichisma*, and the ditch could keep the attackers at bay, while lighter catapults located on the towers of the wall itself could afford covering fire. In the fortifications of Athens, for instance, the space between the wall and the *proteichisma* was generally nine metres wide;⁷⁵ this is more than enough to set a battery for 30-mina, stone-throwing catapults, or even for heavier machines.⁷⁶ This space was also a ring-road, so that in case of need the batteries could be rapidly dismantled and moved. This would make it possible to place the batteries in the most convenient place, where the threat was higher, regardless of the presence of specific towers in the area. This is, in fact, the system that is explicitly described by Philon who, except on *Poliorcetica*, 1.21, seems to consider the heavy artillery batteries of the defenders as mobile batteries that can be moved as circumstances dictate.⁷⁷ So here again, the fact that the towers of Ober's first-generation group were too small to house large catapults is not a sufficient argument to date them before the apparition of the heavy stone-throwing catapults. Moreover, it is important to stress that there are in fact many examples of fortifications designed at the very end of the fourth century BC or even later that have only towers which, according to their size and structure, should belong to Ober's first-generation group.⁷⁸ It is only for later

72 Philon, *Poliorcetica*, 1.21.

73 Philon, *Poliorcetica*, 1.32, where it is recommended for the heaviest machines; cf. 3.67–71.

74 Only in rare cases, such as the famed fortifications of Rhodes of the late Hellenistic period (i. e. after 227 BC), does one find batteries at the top of the towers (Winter 1994: 37) or even on the wall itself (see for a plan Filimonos 1994; but see Garlan 1974: 348 who stresses that it was not certain that the wall of Rhodes had such batteries directly on the curtain wall; on the other hand, they are attested in Miletus in the second century BC, for instance). See also Garlan 1974: 350–351, where the batteries located on the first floor of the towers are described as an exceptional feature of Hellenistic fortifications.

75 Theodoraki 2020: 246–247.

76 30-mina catapult = stock length of 5.8 m. When put into battery at a 45° angle, it could be fitted in an even smaller space. Even a one-talent catapult (stock length = 7.3 m) could be fitted between the wall and the *proteichisma* of Athens.

77 See, for instance, Philon, *Poliorcetica*, 3.6: “It is useful to oppose each of their machines with two ten-mina stone-throwing catapults that must be transferred wherever the enemy moves one of his stone-throwing catapults, in order to hit and destroy the machine, if possible, by a counter-battery fire” (ἀντιστάναι δὲ χρησίμων πρὸς ἕκαστον αὐτῶν δύο δεκαμναίους λιθοβόλους, οὓς δεῖ μεταφέρειν οὗ ἂν καὶ οἱ πολέμοι κινῶσι τινα τῶν πετροβόλων, ἵνα ἂν δύνῃ ἀνταφείας συντρίψῃς πατάξας τὸ ὄργανον). In 3.68, Philon also advises having the batteries “properly set in the right places” (τῶν βελοστάσεων ἐπὶ τῶν ἐπικαίρων τόπων κατὰ τρόπον ἐπισκευασμένων).

78 See, for instance, the *diateichisma* of Plataea, dated to the very end of the fourth century BC at the earliest, which has only towers of a relatively small size (Konecny *et al.* 2013: 107), or the fortifications of New Halos, founded in 302 BC, where the author of the study notes: “Ober's typology puts the relatively small towers of Hellenistic Halos in the period when its Classical predecessor had not even been besieged, taken

periods, especially after the second half of the third century BC, that towers (or rather permanent batteries) intended for heavy stone-throwing catapults are attested – and then only in the most sophisticated defensive systems.⁷⁹ As has been already underlined by Winter (1997: 283–284), the size of a tower cannot in itself constitute a chronological criterion.

Thus, we have here all the elements for proposing a rebuttal to Ober's typology. None of the criteria he put forward to date his "first-generation artillery towers" in the second quarter of the fourth century BC can withstand criticism, and it is necessary to go further than Rihll did: not only must the proportions of the catapults proposed by Ober be rejected, but his typology, in its present state, must be abandoned.⁸⁰ New research on the shape, size and features of artillery towers must imperatively be conducted to see if there are elements that could lead to a new typology, starting with towers that have been securely dated independently of the alleged size of their catapults. In the actual state of our knowledge, Ober's first-generation towers should be assigned more generally to the second half of the fourth century BC, but it is altogether impossible to preclude a date in the third century without other elements. This statement has an impact on our understanding of Greek fortifications: the phases traditionally used in scholarship must be used with caution, and we need a new narrative on that point.

Conclusion

From what we have seen, it appears quite clearly in our sources that the introduction of catapult in the Greek world was only a slow process, and our evidence is patchy before the middle of the fourth century BC, showing that the bow catapult remained a rare weapon rather than a game-changer in the Classical warfare. In the case of Athens, our first clear attestations for the operational use of catapults, in 343/2 at Panakton and in 330 BC (recording an earlier operational use of catapults in Eretria, maybe in 340 BC), may already involve torsion catapults (and this is even certainly the case for Eretria). It

and destroyed by Parmenion's Macedonian army unit in 346 BC. In my opinion, small towers of ca 6x6 m were the norm in Thessalia and perhaps also elsewhere in mainland Greece until the end of the 4th century BC" (Reinders *et al.* 2014: 119). Another recently published example is the city-wall of Vergina, intensively excavated and securely dated to the reign of Cassander (i. e. after 305 BC), where all the towers had a size comprised between 26 and 47 m² (Stamatopoulou 2021: 67).

79 See Winter 1994 for a few examples – notably Perge, where the fortifications, clearly belonging to the late Hellenistic period (see now Martini 2016: 224), could only house arrow-shooting catapults. The same Winter (1997: 282–283), from a large sample of towers, concluded that only a small minority of the towers could house heavy artillery.

80 There are other shortcomings to Ober's typology: his first and second generation groups are drawn from clearly separated geographical areas (Central Greece for the first generation, Asia Minor for the second generation); there is a possibility that the variations observed between these two groups are related to different regional building traditions and not to their belonging to two distinct chronological phases. The heuristic use of the typology is also highly problematic: most of the towers of the first group are in fact dated because of their belonging to the group, instead of being included in the group because of a date secured by external elements.

is only after the introduction of the torsion-based propulsion system that we have more evidence for the use of catapults in operational contexts. Nevertheless, the last third of the fourth century saw a rapid evolution in catapult engineering, and some outdated models remained in use alongside more recent machines for quite a long time; therefore, bow catapults may have been used as late as the end of the fourth century BC, before being clearly supplanted by torsion artillery. This reading of the available sources should lead to a reassessment of the concept of “first-generation artillery tower” put forward by Ober more than thirty years ago: it seems difficult, in the light of what we have seen on early catapults, to maintain the date he proposed in the second quarter of the fourth century BC for the first artillery towers in the Greek world. The fact that these towers could well house torsion catapults suggests that they should rather be dated to after the middle of the fourth century BC.

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