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Late Medieval Divergences: Comparative Perspectives on Early Gunpowder Warfare in Europe and China[1]

Tonio Andrade

When historians discuss the revolutionary changes associated with guns, they tend to focus on Europe's early modern period (1500–1800), but the late medieval period (1300–1500) was arguably more significant. It was then that guns became widely adopted, grew in power and size, and, finally, toward the 1480s, took on their classic form, which would remain largely the same for the next three centuries. The work of scholars such as Kelly DeVries, Robert Smith, Bert Hall, and Clifford Rogers has examined these developments in Europe, establishing that the late medieval period was a key watershed in the history of guns, as important as – perhaps more important than – the early modern period.[2] But what is intriguing is that this was not just true of Europe. Recent work by historians of China has demonstrated that during the thirteenth, fourteenth, and

[1] The author wishes to thank the Harry Frank Guggenheim Foundation, Emory University's College of Arts and Sciences, and the Emory University History Department for helping to make possible the research that underlies this piece. Emory Woodruff Library's outstanding staff helped to obtain materials, particularly Marie Hansen, Guo-hua Wang, and Alain Saint Pierre. Thanks also to the editors and anonymous reviewers of *Journal of Medieval Military History*, whose excellent and stimulating advice greatly improved this article.

[2] Robert D. Smith and Kelly DeVries, *The Artillery of the Dukes of Burgundy, 1363–1477* (Woodbridge, 2005); Kelly DeVries and Robert D. Smith, *Medieval Military Technology*, 2nd ed. (Toronto, 2012); Kelly DeVries, "The Technology of Gunpowder Weaponry in Western Europe during the Hundred Years' War," in *XXII. Kongress der internationalen Kommission für Militärgeschichte* (Vienna, 1997), pp. 285–99; Robert D. Smith, "Artillery and the Hundred Years War: Myth and Interpretation," in *Arms, Armies and Fortification in the Hundred Years War*, ed. Anne Curry and Michael Hughes (Woodbridge, 1994), pp. 151–60; Robert D. Smith, "All Manner of Peeces: Artillery in the Late Medieval Period," *Royal Armouries Yearbook* 7 (2002), 130–38; Robert D. Smith, *Rewriting the History of Gunpowder* (Sundby Lolland, Denmark, 2010); Clifford Rogers, "The Military Revolutions of the Hundred Years War," *The Journal of Military History* 57:2 (1993), 241–78, "'Military Revolutions' and 'Revolutions in Military Affairs': A Historian's Perspective," in *Toward a Revolution in Military Affairs? Defense and Security at the Dawn of the Twenty-First Century*, ed. T. Gongora and H. von Riekhoff (Westport, CT, 2000), pp. 21–35 and "The Artillery and Artillery Fortress Revolutions Revisited," in *Artillerie et fortification: 1200–1600*, ed. Nicolas Prouteau, Emmanuel de Crouy-Chanel, and Nicolas Facherre (Rennes, 2011), pp. 75–80; Bert S. Hall, *Weapons and Warfare in Renaissance Europe: Gunpowder, Technology, and Tactics* (Baltimore, 1997).

fifteenth centuries Chinese guns were also evolving rapidly, transforming East Asian warfare.[3]

Reading the evidence from China in conjunction with that from Europe reveals puzzles that I believe illuminate both historiographies, because although gunpowder warfare evolved rapidly in both Far Eastern and Far Western Eurasia, it also evolved differently: Western Europeans focused on gunpowder artillery; Chinese focused on smaller guns, particularly firearms (handheld guns). Thus, whereas it seems that firearms did not play a major role on Western European battlefields until the mid-1400s at the earliest (they were present, but in relatively small proportions), there were around 150,000 dedicated firearms units in the Chinese armed forces by the 1370s, a proportion of 10 percent of infantry forces, a ratio that would rise to 30 percent by the mid-1400s.[4] This latter figure would not be matched in Europe until the mid-1500s. In contrast, wall-smashing gunpowder artillery began to appear in Europe by the late 1300s and did not appear in Chinese warfare until introduced by Europeans, starting in the 1500s.

What accounts for these divergent developments? And, equally importantly, why in Europe did all forms of guns – handheld and artillery – improve so rapidly in the second half of the 1400s, whereas in China development slowed or ceased, so that by the early 1500s Chinese recognized that European guns were superior and began adopting them?

The answers I offer here are preliminary, and much more research is needed, but I believe that the explanations may be relatively straightforward. War makers in China were able to make effective use of handguns because they already had

[3] And not just China. The pioneering work of Gábor Ágoston has made a similar case for the dynamism of the Ottoman Empire's gunpowder weaponry. See especially Gábor Ágoston, *Guns for the Sultan: Military Power and the Weapons Industry in the Ottoman Empire* (Cambridge, 2005) and Gábor Ágoston, "Firearms and Military Adaptation: The Ottomans and the European Military Revolution, 1450–1800," *Journal of World History* 25:1 (2014), 85–124. For the historiography on China, see especially Wang Zhaochun 王兆春, *Zhong guo huo qi shi* 中国火器史 (Beijing, 1991); Wang Zhaochun 王兆春, *Zhong guo ke xue ji shu shi: jun shi ji shu juan* 中国科学技术史：军事技术卷 (Beijing, 1998); Li Huguang 李湖光, *Da Ming di guo zhan zheng shi: da Ming long quan xia de huo qi zhan zheng* 大明帝国战争史：大明龙权下的火器战争 (Beijing, 2010); Liu Xu 刘旭, *Zhong guo gu dai huo yao huo qi shi* 中国古代火药火器史 (Zhengzhou, 2004); Stephen G. Haw, "The Mongol Empire – The First 'Gunpowder Empire'?" *Journal of the Royal Asiatic Society* 23:3 (August 2013), 1–29; Peter Lorge, *The Asian Military Revolution: From Gunpowder to the Bomb* (Cambridge, UK, 2008) Peter Lorge, *War, Politics, and Society in Early Modern China, 900–1795* (London, 2005); Sun Laichen, "Chinese Military Technology and Dai Viet: c. 1390–1497," *Asia Research Institute Working Paper Series* No. 11 (September 2003); Sun Laichen, "Military Technology Transfers from Ming China and the Emergence of Northern Mainland Southeast Asia (c. 1390–1527), *Journal of Southeast Asian Studies* 34:3 (2003), 495–517; Yao Jiarong 姚家荣, "Xi pao de ying yong yu Ming dai de guo fang" 西砲的应用与明代的国防 (M.A. Thesis, Hong Kong Lingnan University, 2004); Harriet Zurndorfer "What is the Meaning of 'War' in an Age of Cultural Efflorescence? Another Look at the Role of War in Song Dynasty China (960–1279)," in *War in Words: Transformations of War from Antiquity to Clausewitz*, ed. Marco Formisano and Hartmut Böhme (Berlin, 2010), pp. 89–113.

[4] Wang Zhaochun, *Zhong guo huo qi shi*, pp. 103–6.

large standing infantry armies with a long and vibrant tradition of drill. By using drill to instill techniques such as the famous volley fire method – which makes its definitive appearance in Western European records only in the 1500s, and, most scholars argue, toward the very end of that century[5] – Chinese forces were able quite early (by the mid-1300s) to compensate for the great drawback of early firearms, their slow rate of fire. Western European polities, on the other hand, generally lacked standing infantry armies, and the tradition of infantry drill (including volley techniques) appears to have died out with the Western Roman empire. In most of Western Europe, it was not until the very end of the late medieval period, with the development of standing armies, that infantry drill began to be implemented on a significant scale, and at this point handguns could begin to be used in large numbers on the battlefield.

And why did the Europeans develop powerful siege artillery, whereas the Chinese did not? Here I believe the answer lies in differing cultures of fortification. Chinese walls were an order of magnitude thicker than those of medieval Europe, and whereas fortifications in medieval Europe tended to be made of stone and were thus relatively brittle, Chinese walls had thick cores of tamped earth. Thus, existing European walls were far more vulnerable to artillery than were Chinese walls. It made little sense for anyone in China to invest the huge resources necessary to build large siege guns, because even the largest cannons would have had relatively little effect on existing walls. In Europe, in contrast, walls were susceptible to cannons, leading to an increased investment in and development of anti-wall artillery. As artillery became more effective, Europeans also began developing new fortification techniques, and the methods of construction they eventually adopted in some ways approximated the traditional methods of China: thicker, filled with earth, and battered (i.e., slightly sloped), although the Europeans, in contrast to the Chinese, also implemented principles of geometric defense, which during the early 1500s were codified into the famous *trace italienne* design of the artillery fortress.

The final question of why European guns continued developing and became superior to those of China is most difficult, and my answer is most speculative. I believe it has to do with the frequency of warfare, a venerable but, I believe, compelling explanation. In the period between 1350 and 1450, China saw frequent warfare, with armies of hundreds of thousands raging through East Asia. In this environment, guns developed rapidly, with designs being passed back and forth, and not just within China itself. The polity of Dai Viet, for

[5] See in particular Geoffrey Parker, "The Limits to Revolutions in Military Affairs: Maurice of Nassau, the Battle of Nieuwpoort (1600), and the Legacy," *The Journal of Military History* 71:2 (2007), 331–72. Work on the Ottoman Empire suggests that the Ottomans, with their standing armies, may have deployed volley fire as early as 1526, and were certainly doing so by the early 1600s. See Gábor, "Firearms and Military Adaptation"; Günhan Börekçi, "A Contribution to the Military Revolution Debate: The Janissaries' Use of Volley Fire during the Long Ottoman–Habsburg War of 1593–1606 and the Problem of Origins," *Acta Orientalia Academiae Scientiarum Hungaricae* 59:4 (2006), 407–38.

example, located in what is today the northern part of Vietnam, also developed significant innovations, which influenced China.[6]

After 1450, however, warfare in East Asia decreased. The Ming Dynasty, whose tumultuous beginning years had been full of armed conflict, established a general peace, and military innovation slowed. Meanwhile, the dynamic polities of Western Europe continued fighting and innovating. So when Portuguese ships brought guns to China, the Chinese recognized their effectiveness and rapidly copied them. Soon Western-style guns were bristling from the Great Wall itself.[7] In the period of intense warfare that began in the 1550s and continued through the end of the seventeenth century, Chinese military innovation sped up again, as Chinese war makers adopted and adapted arquebuses, warships, advanced muzzle-loading cannons, and even principles of geometric defense.

Early Guns

It is all too easy, when looking at early guns, to fall into anachronism. To fully appreciate them and understand their use, we must take account of the fact that the gun evolved in China from a weapon known as the fire-lance, and that distinctions between the two weapons were probably less clear in the 1300s than they seem in retrospect. The fire-lance, as its name implies, was a staff at the end of which was affixed a tube filled with gunpowder. The gunpowder was lit and then, ideally, spewed forth. The fire-lance had perhaps emerged by the end of the 900s, but it probably did not become an effective and widespread weapon until the 1100s, when fierce warfare between the warring polities of Song China (960–1279) spurred rapid development in weaponry. Fire-lances were often used to eject things other than fire. One could add to the gunpowder mixture rocks, pellets, caltrops, etc. Historians have drawn a distinction between these object-spewing fire-lances and true guns based on the criterion of muzzle occlusion. Fire-lances' projectiles did not occlude the barrel but were merely ejected along with the gunpowder mixture, leading the famous historian of Chinese science Joseph Needham to label them "co-viatives."[8]

It is said that the first "true guns" appeared in the second half of the 1200s, but the distinction between these "true guns" and fire-lances should not be over-drawn.[9] Aside from the fact that early guns in both China and Europe often had a

6 See especially Sun Laichen, "Chinese Military Technology and Dai Viet."

7 The literature on the Ming Dynasty's adoption of Western cannons is extensive. For an overview of recent work, see Tonio Andrade, "Cannibals with Cannons: The Sino-Portuguese Clashes of 1521–1522 and the Early Chinese Adoption of Western Guns," *Journal of Early Modern History* (in press, expected 2015).

8 Joseph Needham, *Science and Civilisation in China, V. 5 Part 7 Military Technology: The Gunpowder Epic* (Cambridge, 1986), p. 9.

9 Among the first firmly-dated extant exemplars is a piece from 1298, which is called the Xanadu Gun because it was discovered on the ruins of Xanadu (上都), the Mongol Yuan Dynasty summer palace in Inner Mongolia. Zhong Shaoyi 钟少异 et al., "Nei Meng-gu xin fa xian Yuan-dai tong huo chong ji qi yi yi" 内蒙古新发现元代铜火铳及其意义,*Wen wu* 文物 11

similar form to the fire-lance – short barrels affixed to the ends of poles and held out in front – it seems that in both China and Europe early firearms were often used much in the way a fire-lance was used: to spew forth fire for conflagrative purposes, with other items added to the mix for added damage.

Consider, for example, data from a battle of 1356, when the French attacked the English-held castle Breteuil. They were hurling stones at it from catapults and had also built a belfry, that is to say a siege tower on wheels. It must have been huge, because the chronicler Froissart says that each of its three stories could hold two hundred men. To counter the belfry, the English prepared "cannons throwing fire and large quarrels" (*kanons jettans feu et grans gros quariaus*), with which they planned to "destroy everything."[10] At first the English held these weapons in abeyance, fighting hand to hand from the walls. But when the French got the upper hand the English "began to shoot their cannons and throw fire onto and into the belfry, and with this fire they shot thick quarrels, and large ones, which wounded and killed large numbers, and made them [the French] so anxious [*les ensonnyèrent*] that they did not know what to do. The fire, which was Greek, took hold on the roof of the belfry, persuading those within to come out of it fast, or otherwise they would have been lost, turned to

(2004), 65–67. It is quite likely that certain other pieces predate the Xanadu Gun. One, for example, has an inscription that reads, roughly translated, "Made by bronzesmith Li Liujing in the year Zhiyuan 8 (直元), ningzi number 2565." An expert suggests that Zhiyuan (直元) should actually be zhiyuan (至元), which would put the date in the Western calendar at 1271 AD, a credible if not conclusive argument. Like the Xanadu Gun, it has a serial number (2565), which suggests that thousands of similar pieces were manufactured. There is reason for caution about the dating, because the reign name used is not a standard form, but the timing is not improbable. See "Ningxia fa xian shi jie zui zao you ming que ji nian de jin shu guan xing huo chong" 宁夏发现世界最早有明确纪年的金属管形火铳, *Xinhua News Net,* 2004–06–09, http://www.nx.xinhuanet.com/newscenter/2004–06/09/content_2278435.htm [accessed 20 September 2012]. Other, circumstantially dated guns may be from the 1220s. For example, in 1980, a 200-pound bronze gun was discovered in a cellar in Gansu Province. There is no inscription data, but contextual evidence suggests that it may be from the late Xi Xia period (Gansu was part of Xi Xia territory), probably after 1214 but before the end of the Xi Xia in 1227. What is intriguing is that it was discovered with a pellet and a tenth of a kilogram of gunpowder in it. The pellet, about 9 cm in diameter, is a bit smaller than the muzzle diameter of the gun (12 cm), which suggests that it may have been a co-viative rather than a true bullet-type projectile, although it is also highly corroded, suggesting that it used to be larger (thanks to Ben Sinvany for this idea). For more on this gun, which is known as the Xi Xia Bronze Cannon (西夏铜火炮) or the Wuwei Bronze Cannon (武威铜火炮), see Dang Shoushan 党寿山, Wu wei wen wu kao shu 武威文物考述 (Wuwei: Guang ming yin shua wu zi you xian gong si, 2001), esp. pp. 103–13. See also Niu Dasheng 牛达生 and Niu Zhiwen 牛志文, "Xi Xia tong huo chong: wo guo zui zao de jin shu guan xing huo qi" 西夏铜火铳：我国最早的金属管形火器, *Dao gen* 寻根 6 (2004), 51–57, esp. 51–52; and Liu Xiaolei 刘小雷, "Wuwei tong huo pao: shi jie shang zui gu lao de jin shu guan xing huo qi" 武威铜火炮：世界上最古老的金属管形火器, *Gansu Daily* 每日甘肃, 2012–02–17, http://gansu.gansudaily.com.cn/system/2012/02/17/012373433.shtml [accessed 21 September 2012].

10 Jean Froissart, *Les chroniques de Jehan Froissart, publiées avec les variants des divers manuscrits part M. le baron Kervyn de Lettenhove*, 25 vols. (Brussels, 1868), 5:376.

ash."[11] Another source from the same year notes a similar mention of the use of cannons "to shoot quarrels and Greek fire," in this case to set fire to the roofs of towers on a castle.[12]

This "Greek fire" was not the classic Greek fire of Byzantium, which was probably a petroleum-based liquid projected from siphons.[13] The Europeans had a tendency to apply the label "Greek fire" to all kinds of incendiaries, and in this case what was used was almost certainly some kind of gunpowder mixture, perhaps similar to early Chinese gunpowder recipes, in which the active ingredients of saltpeter, sulfur, and charcoal were mixed with other incendiary materials such as resins, oil, or pitch.[14] For example, a European recipe for "Greek fire" from circa 1450 reads as follows: "One calls 'Greek fire' a certain confection and brew [*bouillement*] of willow charcoal [*charbon de saux*], saltpeter, eau-de-vie, sulfur, pitch, and incense with a soft wool thread from Ethiopia."[15] This compound may have acted somewhat like early Chinese conflagrative gunpowder mixtures. Whether the gunners of the mid-1300s were using this recipe or another is impossible to determine, but it seems likely that some kind of gunpowder-like mixture was used.[16] In any case, it seems quite possible that medieval European gunners sometimes used their guns as the Chinese used fire-lances, loading them with a gunpowder mixture and then, instead of ramming in a wooden plug to increase the projectile quality of the shot, leaving the plug out, stuffing the barrel full of gunpowder and conflagratives, and using the weapon to set fire to things.

In China, fire-lances were primarily used, however, not as incendiaries but as anti-personnel weapons, discharging their pellets or shrapnel or rocks as co-viatives. Early European guns appear to have been used in the same way. For instance, the famous Loshult gun, perhaps the earliest-preserved European gun

11 Froissart, *Les chroniques de Jehan Froissart*, 5:377.

12 Froissart, *Les chroniques de Jehan Froissart*, 5:389; Henry Brackenbury, *Ancient Cannon in Europe, Part II: From AD 1351 to AD 1400* (Woolwich, UK, 1866), p. 39.

13 John Haldon, "'Greek Fire' Revisited: Recent and Current Research," in *Byzantine Style, Religion, and Civilization: In Honour of Sir Steven Runciman* ed. Elizabeth Jeffreys (Cambridge, 2006), pp. 290–325, here p. 291.

14 Haldon, "'Greek Fire'", p. 290.

15 Extracted in M. Reinaud and M. Favé, *Histoire de l'artillerie, 1re partie: du feu grégeois des feux de guerre et des origins de la poudre a canon* (Paris, 1845), p. 224. This type of recipe has a long pedigree in Europe. The recipe for Greek fire given by Marcus Graecus, probably written up in the early 1300s, goes as follows: "Take live sulfur, tartar, sarcocolla and pitch, boiled salt, petroleum oil, and common oil. Boil all these well together and then immerse tow in it…. When the fire is kindled it cannot be extinguished except by urine, vinegar, or sand." J. R. Partington, *A History of Greek Fire and Gunpowder* (Baltimore, 1999 [first published 1960]), p. 50.

16 To be sure, we cannot be certain that the "cannons throwing fire" were intentionally being used as incendiary weapons, because all black powder weapons from the late medieval and early modern periods shot out considerable amounts of fire along with their projectiles. Moreover, even if the cannons were being used as incendiary weapons, it is possible that the quarrels themselves were incendiary – perhaps tipped with burning gunpowder and other conflagratives, much as Chinese fire arrows were.

(most experts date it to the first half of the fourteenth century), has a barrel with deep ruts and scratches.[17] This has led researchers to conclude that the weapon was used to fire grapeshot or shrapnel.[18] When those researchers built and tested a replica of the Loshult gun, they found that it could be used quite flexibly, shooting quarrels, grapeshot, and pieces of flint. They therefore concluded that the Loshult gun was likely used at close range, primarily as an anti-personnel weapon.[19] This is precisely how Chinese fire-lances and early guns were used.

But the most intriguing parallel between early European guns and Chinese guns from the same period is their size. One of the earliest firmly dated guns still extant is the Xanadu Gun from 1298, so named because it was discovered on the ruins of Xanadu (上都), the Mongol Yuan Dynasty summer palace in Inner Mongolia. It is 6.2 kg in weight and 35 cm long. Another early gun, the Heilongjiang Gun, which has been dated to 1288, is even smaller: 3.5 kg, and 34 cm long, with a 2.6 cm bore.[20] Indeed, evidence suggests that nearly all other early Chinese guns – both extant and those whose existence we infer from historical records – were also small. For example, of the extant guns that we know for certain were early Ming pieces – i.e., from the 1350s through the early 1400s – nearly all are less than 80 kg in weight, and most weigh a couple kilograms or less. Guns considered "large" weighed only 75 kg.[21] To be sure, there are three preserved guns from 1377 of relatively large size: a meter long, with

17 Although, as Kelly DeVries has argued, there are troublesome issues surrounding the dating of the gun. See Kelly DeVries, "Reassessment of the Gun Illustrated in the Walter de Milemete and Pseudo-Aristotle Manuscripts," *Journal of the Ordnance Society* 15 (2003), 5–17. For more information on the gun, see the information page of the Swedish Historical Museum of Stockholm: http://mis.historiska.se/mis/sok/fid.asp?fid=114743 [accessed 3 January 2013].

18 See Smith, *Rewriting*, esp. pp. 115–18. Note that there is considerable controversy about this, with some researchers suggesting that its primary purpose was to shoot quarrels. On the controversy, see Wilfried Tittmann, "Die Eltzer Büchsenpfeile von 1331/3," *Waffen- und Kostümkunde*, 36 (1994), 117–28; Wilfried Tittmann, "The Guns of Archbishop Baldwin of Trier and the Guns in the Milemete Manuscripts of 1326/7 Some Critical Comments," *Journal of the Ordnance Society*, 17 (2005), 5–23; Klaus Leibnitz, "Fitting Round Pegs into Square Holes? Did Balduin of Luxemburg, Archbishop of Trier Use Gunpowder Artillery in the Siege of Eltz Castle 1331/33?" undated manuscript, available at http://www.vikingsword.com/library/leibnitz_round_pegs.pdf [accessed 1 March 2013].

19 See Smith, *Rewriting*, pp. 115–18.

20 Needham says 35 cm long. Lu Xu says 34 cm. Needham, *Gunpowder Epic*, pp. 289, 290. Cf. Liu Xu, *Zhongguo gu dai huo yao huo qi shi*, pp. 50–51. See also Wang Chong 王崇, A'cheng ban la cheng tong huo chong de lai li 阿城半拉城铜火铳的来历, *Hei long jiang shi zhi* 黑龙江史志, 268 (2012, issue 3), 33–34.

21 See Wang Zhaochun, *Zhong guo huo qi shi*, pp. 73–97; and Liu Xu, *Zhongguo gu dai huo yao huo qi shi*, pp. 106–7. Some historians – including the great Joseph Needham, have suggested that a collection of old cannons known as the Zhou cannons, and which weighed between 100 and 500 pounds, were forged by Zhang Shicheng in the 1350s or 1360s. This viewpoint has been firmly and persuasively refuted by Chinese scholars, who note that although the pieces in question do bear inscriptions for the dynastic term Zhou (周), which Shicheng did use, the guns were in fact most likely created during another Zhou period: the short-lived Zhou Dynasty of the warlord Wu Sangui in the 1670s. Needham, *Gunpowder Epic*, pp. 290–92. Discussion of controversy in Wang Zhaochun, *Zhong guo huo qi shi*, pp. 58–63.

a muzzle diameter of 21 cm, and two handles on either side, shaped for easy grip for human transport.[22] As Chinese scholar Wang Zhaochun notes, the existence of these guns shows – if any proof were needed – that the Chinese were entirely capable of making larger guns; but what is notable is that these are the only relatively large guns preserved from the early Ming period (pre-1500), and no other examples are known from either archeological or textual evidence.[23] Chinese researchers have concluded that they were an anomaly, and that during the fourteenth and fifteenth centuries Chinese guns remained small and light.[24]

How large were the earliest European guns? The evidence is much less copious. Whereas we have dozens of extant Chinese pieces that are certainly from the 1300s, only one surviving European gun can be firmly dated to that century, and it has been dated to 1399.[25] It is small, just 33 centimeters long and 1.24 kg in weight, but this means little, because we know that by then there existed huge bombards.[26] Other candidates for early European guns, however, are also small. The Loshult Gun, which is the most famous early European gun, and which most experts date to the middle of the 1300s, weighs just 9 kg and is 30 cm long.[27] It is thus remarkably close in size and weight to the earliest Chinese guns, such as the Xanadu Gun of 1298 (35cm long and 6.2 kg).[28]

Because archaeological evidence for early European guns is scant, we must turn to other sources. The earliest visual sources – two manuscript illustrations from the 1320s – depict guns that are relatively large, sitting on platforms, but these appear to be outliers.[29] All other data indicate that early European guns were small. Some of this evidence is relatively direct. For example, sources suggest that the guns used by the English at Crécy in 1346 – one of the earliest

22 Cheng Dong 成东, "Ming dai qian qi you ming huo chong chu tan" 明代前期有铭火铳初探, Wen wu 文物 (1988, no. 5) 68–79, here 74. Cheng Dong argues compellingly that the outcroppings were handles and not trunnions.

23 Wang Zhaochun, "Hong wu shi nian da tie pao," in *Zhong hua guo cui ci dian* 中华国粹大辞典, ed. Men Kui 门岿 and Zhang Xijin 张燕瑾 (Beijing, 1997), p. 183.

24 Cheng Dong, "Ming dai qian qi," p. 74; Wang Zhaochun 王兆春, *Zhong guo gu dai bing qi* 中国古代兵器 (Beijing, 1994), pp. 170–71. See also Wang Fuzhun 王福谆, "Gu dai da tie pao" 古代大铁炮, *Zhu zao she bei yan jiu* 铸造设备研究 (2008, no. 3), 46–56, p. 48.

25 On the lack of European guns, see Robert D. Smith, "Artillery and the Hundred Years War," p. 154. For lists of extant fourteenth-century Chinese guns, see Liu Xu, *Zhong guo gu dai huo yao huo qi shi*, pp. 106–7 and 123–25. On possible candidates for fourteenth-century guns, including the 1399 Tannebergbüchse, see Gerd Strtickhausen, "Bemerkungen zu frühen Feuerwaffen im 14. Jahrhundert," in *Würfen hin in Steine / gröze und niht kleine: Belagerungen und Belagerungsanlagen im Mittelalter*, ed. Olaf Wagener and Heiko Laß (Frankfurt, 2006), p. 52.

26 Robert Coltman Clephan, *An Outline of the History and Development of Hand Firearms* (London, 1906), pp. 26–27.

27 On issues with the dating of the Loshult Gun, see DeVries, "Reassessment."

28 Zhong Shaoyi et al., "Nei Meng gu," pp. 65–68.

29 On these and other early depictions of guns, see Valérie Serdon-Provost, "Les débuts de l'artillerie a poudre d'après l'iconographie médiévale," in *Artillerie et fortification: 1200–1600*, ed. Nicolas Prouteau, Emmanuel de Crouy-Chanel, and Nicolas Facherre (Rennes, 2011), pp. 61–74.

records of the use of guns in European history – were operated by one gunner or even, it seems, two guns to one person, which suggests that they were light.[30]

Other textual evidence is even more compelling. The nineteenth-century scholar Henry Brackenbury, reasoning that the cost of a gun must be directly related to the amount of metal used to make it, collected early sources recording the costs of forging and casting guns – there were many such sources – and then deduced gun sizes from price data. For example, one French receipt from 1342 records that 25 livres were paid for the manufacture of five bronze cannons and five iron ones. Using comparative price and wage data, Brackenbury determined that this sum would have sufficed to purchase five wrought iron cannons of 25 pounds each and five of bronze weighing 22 pounds each.[31] After compiling large amounts of such pricing data, he concluded that until the middle of the 1300s guns averaged around 25 pounds in weight. None of the guns in his data would have exceeded 120 or so pounds. They increased slightly in size until the early 1370s, but not by much. This is quite similar to the sizes of guns of China.

Guns of this size, he noted were "but feeble weapons in comparison with the great warlike engines of the period [i.e. catapults], which still were employed for the more serious operations."[32] Other scholars have corroborated his work and extended it, and Brackenbury has modern admirers.[33] Robert Smith, one of today's foremost historians of early artillery, writes that Brackenbury "is one of the few authors who uses the documentary evidence in a systematic and thorough manner and one which later writers have singularly failed to follow."[34] This is perhaps unfair to later writers, who have conducted outstanding systematic work – including Smith himself – but the point is clear: Brackenbury's research still stands. Early European guns appear to have been small through 1370 or so.

Of what use were such small guns? As Brackenbury notes, they could have "had little or no effect against the walls of cities or castles; they were quite incapable of making, or even assisting to make, a breach."[35] Historians have suggested that in fact guns were of marginal utility in European warfare until large guns emerged in the last quarter of the 1300s. Indeed, some have even wondered whether early firearms were used on the battlefield at all.[36] To be sure, data from Crécy in 1346 show the use of guns, but historians have found

30 Henry Brackenbury, *Ancient Cannon in Europe, Part I: From their First Employment to AD 1350* (Woolwich, 1865), p. 17.

31 Brackenbury, *Ancient Cannon, Part I*, p. 8.

32 Brackenbury, *Ancient Cannon, Part I*, p. 21.

33 One prominent example of the price-to-weight method, applied to German sources, can be found in the detailed work of Bernhard Rathgen, whose findings corroborate those of Brackenbury. Bernhard Rathgen, *Das Geschütz im Mittelalter* (Düsseldorf, 1987 [originally published 1928]), pp. 6–7 and 151ff. For a modern and very positive take on Brackenbury, see DeVries, "Technology of Gunpowder Weaponry."

34 Smith, "Artillery and the Hundred Years War," p. 153.

35 Brackenbury, *Ancient Cannon, Part I*, p. 21.

36 Brackenbury, *Ancient Cannon, Part I*, p. 21. He believes they were but feels there is room for doubt.

no other reliable evidence of guns on European battlefields until the battle of Beverhoutsveld of 1382, and thereafter there are few examples of guns playing decisive roles until the mid-fifteenth century.[37] Why? One possibility is technology: "[T]he technology was not yet there to make the gun an effective battlefield weapon. It was not until the late fourteenth and fifteenth centuries that guns began to appear regularly in battle."[38]

Yet what is curious is that the Chinese were able to make their small guns work on the battlefield. From the 1350s through the early 1400s, a period when there are few sources showing guns being used effectively in European battles, Chinese records contain numerous descriptions of firearms used decisively: against Chinese rebels, Tai elephants, Vietnamese ships, and Mongol horsemen.[39] Indeed, guns were considered so effective that, as I have already noted,

37 DeVries and Smith, *Medieval Military Technology*, p. 144; Kelly DeVries, "The Forgotten Battle of Beverhoutsveld, 3 May 1382: Technological Innovation and Military Significance," in *Armies, Chivalry, and Warfare in Medieval Britain and France*, ed. M. Strickland (Stamford, 1998), pp. 289–303.

38 Andrew Ayton and Philip Preston, *The Battle of Crécy, 1346* (Woodbridge, 2007), pp. 154–55.

39 I will discuss many such battles in a separate publication, but a quick mention of some examples is in order here. In the Siege of Shaoxing (1358), for example, guns (火筒) were used by a sallying force of defenders to drive back enemy troops. Xu Mianzhi 徐勉之, *Bao yue lu* 保越录 (1359); for a western-language account, see Herbert Franke, 2Die Belagerung von Shao-hsing im Jahre 1359," in *Krieg und Krieger im Chinesischen Mittelalter (12. bis 14. Jahrhundert)*, ed. Herbert Franke (Stuttgart, 2003), pp. 122–214. As Franke notes, at this siege, guns could not cause significant damage to walls or gates, and they were primarily used as anti-personnel weapons. Franke, "Belagerung," p. 213. In the campaign of Poyang Lake in 1363, firearms were used in at least one battle on land and, more famously, in clashes on the water. See Wang Zhaochun, *Zhong guo huo qi shi*, pp. 57ff; in English, see Edward L. Dreyer, "The Poyang Campaign, 1363: Inland Naval Warfare in the Founding the Ming Dynasty," in *Chinese Ways in Warfare*, ed. Frank A. Kierman, Jr. and John K. Fairbank (Cambridge, MA, 1974), pp. 202–42. In 1388, guns shooting in volleys defeated a force of Tai war elephants. See below, and see also *Ming shi lu* 明实录*, Tai zu shi lu* 太祖实录*,* Hongwu 洪武 11, Month 3, Juan 189. In a war of imperial succession in 1401, the usurper, the Prince of Yan (who would become the famous Yongle Emperor) found his huge forces routed by clever use of guns and poison crossbows, and he was nearly captured, an event that may have given him post traumatic stress disorder and likely stimulated him to pay close attention to guns in his future campaigns as a usurper and, even more spectacularly, in his subsequent bellicose reign. See Gu Yingtai 谷应泰, "Yan wang qi bing" 燕王起兵, *Ming shi ji shi ben mo* 明史纪事本末, Juan 16; a brief account in English is in David B. Chan, *The Usurpation of the Prince of Yen, 1398–1402* (San Francisco, 1976), p. 72; for another battle in which guns were decisive in this succession war, see Chan, *Usurpation*, pp. 80–81. In the Yongle Emperor's many campaigns, guns played decisive roles on various occasions. In the Vietnam campaigns, guns were used on both sides, as in the siege of Dobang City (1407), when guns proved decisive against Vietnamese war elephants. *Ming shi lu* 明实录*, Tai zong shi lu* 太宗文皇帝实录*,* Juan 62, Yongle 4, Month 12, Day 11. Cf Wang Zhaochun, *Zhong guo huo qi shi*, p. 110. For a brilliant discussion of the Ming Vietnamese wars, see Sun Laichen, "Chinese Gunpowder Technology and Dai Viet." In 1410, far to the north, the Yongle Emperor's firearm troops decisively defeated the Mongol leader Arudai near the Great Ghingan mountains, *Ming shi* 明史*,* Juan 154, Lie zhuan 42 列传第四十二, Liu Sheng 柳升; and *Ming shi lu* 明实录*, Tai zong shi lu* 太宗文皇帝实录*,* Yongle 8, Month 6, dingwei day (13 July 1410), Juan 105. In another battle, in 1414, Yongle himself led a vanguard

by the 1370s the armies of the Ming Dynasty were fielding some 100,000 or so gunners, 10 percent of total infantry, a proportion that appears to have continued increasing until by the mid-fifteenth century they comprised some 33 percent of infantry units.

Why might guns have been more effective on Chinese than on European battlefields? Was Chinese small-gun technology better? It is possible. But it is more likely that Chinese forces were simply better at deploying firearms than European forces because the effective use of handguns required coordinated drill. Guns were so slow to load that unless gunners worked closely with each other to maintain a constant rate of fire, they would find themselves overrun by the enemy before getting a chance at a second shot. Such coordination required painstaking and constant practice, i.e., collective drill.

Although there is still much research to be done on military training in medieval Western Europe, it seems that there was not much training done collectively. As military historian Michael Prestwich writes in the *Oxford Encyclopedia of Medieval Warfare*, in Europe, "there is surprisingly little indication of this type of drill [i.e. 'collective training'] taking place until the late fifteenth century."[40] This perspective is supported also in the work of Clifford Rogers, who notes that military ordinances from the medieval period say next to nothing about collective drill until the late fifteenth century, when the Burgundians began drilling; with the possible exception of Sicilian crossbowmen, who may have drilled in the eleventh century.[41]

There may of course be many examples of medieval European drill just waiting to be found, but it seems unlikely. Stephen Morillo has argued that the reason is simple: there were no centralized states to make them do it. "Drill," he writes, "may only be instituted where there is a central authority strong enough to gather sufficient numbers of men together, and rich enough to maintain them while they are trained…. In effect, strong infantry depends on strong government."[42]

of elite troops against a Mongol force, followed closely by firearm units. His gunners killed several hundred Mongols and threw their lines into disarray, at which Yongle's elite cavalry – the iron horsemen – chased the remainder back up the hills, capturing many horses. In that same campaign, the Mongols later tried again to attack the emperor and his small elite force but were blasted by Ming guns firing from ambush positions, allowing his elite forces to rout the enemy: "the number of men and horses killed and hurt was uncountable, and they all screamed out in pain and left…. Henceforth that place was called 'Barbarian Slaughtering Hold.'" Jin Youzi 金幼孜, "Bei zhen hou lu" 北征后录, one juan, http://www.guoxue123.com/other/gcdg/gcdg/021.htm [accessed 29 October 2012]. Another source, the *Ming Veritable Records*, adds the intriguing detail that the guns "fired in continuous succession" [连发神机铳炮], which suggests volley fire. *Ming shi lu* 明实录, *Tai zong shi lu* 太宗文皇帝实录, juan 152.

40 Michael Prestwich, "Training," in *The Oxford Encyclopedia of Medieval Warfare and Military Technology*, vol. 1, ed. Clifford Rogers (Oxford, 2010), 370–72, p. 372.

41 Clifford Rogers, *Soldiers' Lives through History: The Middle Ages* (Westport, CT, 2007), pp. 68–69.

42 Stephen Morillo, "The Age of Cavalry Revisited," in *The Circle of War in the Middle Ages*, ed. Donald J. Kagay and L. J. Andrew Villalon (Woodbridge, 1999), p. 52. As a peer reviewer of

The Chinese, in contrast, had a long and unbroken tradition of centralized states with standing armies. Even during times of division and fragmentation, China's warring states maintained armies and trained them collectively. Drill was a core principle of Chinese warcraft. As the great military genius Zhuge Liang (AD 181–234) put it, "Disciplined troops under an incapable general cannot lose. Undisciplined troops under an able general cannot win."[43]

Consider, for example, the case of volley fire, one of the most venerable methods by which forces armed with slow-loading missile weapons – such as crossbows, slings, or early guns – could maintain a constant hail of fire, thus avoiding the deadly pauses during which they might be rushed by an enemy armed with short-range weapons. The idea is straightforward. Soldiers stand in rows, usually one in front of the other, launch their missiles, and then move back to the rear to reload, while their comrades shoot. With several lines of soldiers, the shooting can be continuous.

The principle may be simple, but it is very hard to train soldiers to do it properly. The men must be drilled, exercised, and trained exhaustively so that the sequence becomes second nature. Otherwise discipline evaporates once the men face an actual enemy in battle. In separate works, Geoffrey Parker and Olaf van Nimwegen have examined the difficulties that Dutch military leaders experienced as they sought to instill the musketry volley technique in their troops during the late 1500s and early 1600s.[44] The challenges were significant. As Parker wrote, "Changing a pike square perhaps fifty deep into a musketry line only ten deep inevitably exposed far more men to the challenge of face-to-face combat, calling for superior courage, proficiency and discipline in each individual soldier. Second, it placed great emphasis on the ability of entire tactical units to perform the motions necessary for volley-firing both swiftly and in unison. The answer to both problems was, of course, practice."[45]

The Europeans of course had classical precedents for the volley technique – the Greek military writer Aelian (second century AD) described countermarch

this article points out, however, Morillo does not take into account in his argument the urban militias, which were quite influential in the late Middle Ages. This is a topic that requires more research, although it may be that the decentralized structure of many urban militias – with artisan guilds responsible for supplying set numbers of militiamen, who sometimes fought under their own banners – was not as conducive to large-scale collective drill as the more centralized organization of a true standing army.

43 Zhuge Liang 诸葛亮, *Bing yao* 兵要 (*The Essence of War*), in Zhuge Liang 诸葛亮, *Zhuge Liang Ji* 诸葛亮集, compiled by Zhang Shu 张澍 (1781–1847), ed. Duan Xizhong 段熙仲 and Wen Xuchu 闻旭初 (Beijing, 1960), juan 2.

44 See especially Olaf van Nimwegen, *The Dutch Army and the Military Revolutions, 1588–1688,* trans. Andrew May (Woodbridge, 2010), pp. 100–12; and Parker, "Limits to Revolutions." But see also J. P. Puype, "Victory at Niewupoort, 2 July 1600," in *Exercise of Arms: Warfare in the Netherlands, 1568–1648*, ed. Marco van der Hoeven (Leiden, 1997), pp. 69–112.

45 Geoffrey Parker, *The Military Revolution: Military Innovation and the Rise of the West* (Cambridge, 1996), p. 20.

formations for javelin- and sling-units in his work *Tactics*.[46] The Dutchmen who implemented the volley-fire technique in the early 1600s were inspired by the rediscovery and dissemination of Aelian and other ancient military thinkers carried out by the Flemish classicist Justus Lipsius (1547–1606).[47] It seems, however, that the volley technique had died out with the Romans, at the very least in northwest Europe, and had to be revived and re-formulated nearly from scratch.

In China, the volley technique also had deep classical roots – it was used as early as the Warring States period (475–221 BC) – but in contrast to Western Europe, it never died out.[48] It remained vibrant because China's standing armies usually fielded large numbers of crossbow units, which had slow rates of fire. A

46 Geoffrey Parker, *The Cambridge Illustrated History of Warfare: The Triumph of the West* (Cambridge, 2008), p. 4.

47 Justus Lipsius, *De militia Romana* (Antwerp, 1614). For more on the influence of classical models on European warmaking in the early modern period, see Melissa Scott, "The Victory of the Ancients: Tactics, Technology, and the Use of Classical Precedent," Ph.D. dissertation, Brandeis University, 1992. (For Scott's examination of the musketry volley technique, see pp. 116–22.) Lipsius's 1595 book *De militia Romana* influenced not just Willem Lodewijk but also his cousin Maurice of Nassau, who read it on campaign and used it in his reorganization of the Dutch army. Jeanine de Landtsheer, "Justus Lipsius's *De militia Romana:* Polybius Revived, or How an Ancient Historian was Turned into a Manual of Early Modern Warfare," in *Recreating Ancient History: Episodes from the Greek and Roman Past in the Arts and Literature of the Early Modern Period*, ed. K. A. E. Enenkel et al. (Leiden, 2002), pp. 101–22; Peter Dear, "The Mechanical Philosophy and Its Appeal," in *The Scientific Revolution*, ed. Marcus Hellyer (Oxford, 2003), pp. 101–29; David Parrot, *The Business of War: Military Enterprise and Military Revolution in Early Modern Europe* (Cambridge, 2012), pp. 97–99; and, most important, Geoffrey Parker, "The Limits to Revolutions in Military Affairs."

48 A passage in Sun Bin's *Art of War*, which was discovered in a tomb in 1972, may refer to the practice, saying, "Long range units should be in front, short-range behind, and the crossbows should flow to help their rapidity." The passage appears in the section of the *Sun Bin bing fa* 孙膑兵法 called "Questions of the King of Wei" 威王问. It is a short and enigmatic passage, and it certainly admits of other interpretations. The translation in the best English translation of the book is quite different. See D. C. Lau and Roger T. Ames, trans., *Sun Bin: The Art of Warfare: A Translation of the Classic Chinese Work of Philosophy and Strategy* (Albany, 2003), p. 100. Here is my translation of the entire passage:

The Wei King said [to Sun Bin], "The enemy is numerous, and we are few; the enemy is strong and we are weak. What can be done?"

Sun Zi said, "The tactic is called 'Ceding to might.' You must protect your rear so that you can withdraw. Long-range units should be in front, short-range behind them, and let the crossbows flow to help their rapidity."

My interpretation is informed by that of an enigmatic young Taiwanese blogger who writes under the name Shuo Xuehan 朔雪寒, and whose website on Chinese military thought, *Ce lüe yan jiu zhong xin* (策略研究中心) was an incredible resource, filled with original sources and ruminations on China's military history. Alas, that website is now gone, and at present it seems not to have been rebuilt, which is a pity. I wish nonetheless to acknowledge that good parts of what I write about Chinese drill were inspired by it, particularly an article from the website on drill in history, in which Shuo Xuehan reflects on the film *Zulu* – the same film that Geoffrey Parker alludes to in his article, Parker, "Limits to Revolutions in Military Affairs." http://www.cos.url.tw/tacticspattern/id10001.htm [accessed 26 March 2013].

text from circa AD 801, the famous *Tong dian* (通典) of Tang Dynasty scholar Du You (杜佑, 735–812), notes the problem: "The crossbow is slow to load, and when battle is near it cannot shoot more than one or two times, and so battle is not a straightforward thing for the crossbow. At the same time, without the crossbow, it is not beneficial to do battle."[49] To compensate, Du You wrote, one should use the volley technique:

> [Crossbow units] should be divided into teams that can concentrate their arrow shooting.… Those in the center of the formations should load [their bows] while those on the outside of the formations should shoot. They take turns, revolving and returning, so that once they have loaded they exit [i.e., proceed to the outer ranks] and once they have shot they enter [i.e. go within the formations]. In this way, the sound of the crossbow will not cease and the enemy will not harm us.[50]

Similar passages can be found in other military manuals from the Tang Dynasty (618–907), the Song Dynasty (960–1279), and the Ming Dynasty (1368–1644), and there is also clear evidence of its use in battle, as when the official *Song History* describes how a famous general named Wu Jie (吴玠) and his younger brother Wu Lin (吴璘) deployed the volley technique to defend the Song against invasions by the Jin State during the 1130s:

> [Wu] Jie ordered his commanders to select their most vigorous bowmen and strongest crossbowmen and to divide them up for alternate shooting by turns [分番迭射]. They were called the "Standing-Firm Arrow Teams" [驻队矢], and they shot continuously without cessation, as thick as rain pouring down. The enemy fell back a bit, and then [Wu Jie] attacked with cavalry from the side to cut off the [enemy's] supply routes. [The enemy] crossed the encirclement and retreated, but [Wu Jie] set up ambushes at Shenben and waited. When the Jin troops arrived, [Wu's] ambushers shot, and the many [enemy] were in chaos. The troops were released to attack at night and greatly defeated them. [The Jin commander] Wushu was struck by a flowing arrow and barely escaped with his life.[51]

It is noteworthy that the *Song History* makes specific mention of this volley method, one of the few times that specific battlefield techniques are mentioned in the *Song History*, or indeed in any dynastic history, and it is likely that the Standing-Firm Arrow Teams fought many other engagements that are lost to history.

As historians have noted, to come up with the idea of volley fire and to implement it are two very different things. It is hard to persuade troops to "stand firm" when the enemy is advancing. As Tang and Song manuals noted, "the accumulated arrows should be shot in a stream, so in front of them there must be

49 Du You 杜佑 (735–812), *Tong dian* 通典, juan 149, "Warfare Part 2" (兵二), in Du You, *Tong Dian*, 5 vols., ed. Wang Wenjin 王文锦 (Beijing, 1988), 4:3818. The *Tong dian is* also available from wikisource, http://zh.wikisource.org/wiki/通典/卷149 [accessed 27 March 2013].

50 Du You, *Tong Dian*, juan 149, p. 3818.

51 Biography of Wu Jie, in *Song shi* 宋史, juan 366, "Lie zhuan 列传 125," "Liu Qi, Wu Jie, Wu Lin" 刘锜 吴玠 吴璘.

no standing troops, and across [from them] no horizontal formations."[52] Thus, crossbowmen had to face the enemy directly, with no troops protecting them in front. The only way to make certain that shooters stayed firm was to drill them regularly and intensively, and Chinese military manuals are full of techniques and regimens. The famous *Wu jing zong yao* (1044), for example, notes that "although large inspections of infantry and cavalry are not carried out frequently, one should nonetheless adopt a method of daily practice in each garrison [营] in order to teach sitting, rising, advancing, and retreating.… One should use drum sounds as signals."[53] The text describes specific large-scale exercises that combined different types of units – cavalry, spearmen, crossbowmen, archers, flagmen, drummers – whose movements were coordinated by drums, gongs, wooden clappers, and flag signals.

It seems that drilling techniques – and the volley technique itself – were rapidly adopted for guns. The first clear evidence is from the late fourteenth century. In 1388, Ming forces were fighting in Yunnan Province to put down an insurrection by a Tai leader named Si Lunfa (思伦发, d. 1399). The Tai force was huge, on the order of 100,000. But the numbers of Tai fighters worried the Ming much less than did the Tai war elephants, which "wore armor and bore on their backs war towers with ramparts."[54] The Ming commander, Mu Ying (沐英, 1344–92), gathered his officers together and admitted to them that the Ming attacks had so far failed against pachyderms, but, he said, "I do know what [the enemy] will be unable to withstand."[55] He explained his tactics carefully. His troops were to array themselves in three lines, setting up guns and some kind of gunpowder-fired arrow weapon (神机箭 – probably arrow-shooting guns but possibly rockets).[56] "When the elephants advance," he said, "the front line of guns and arrows will shoot all at once. If they do not retreat, the next line will continue this. If they still do not retreat, then the third line will continue this."[57] The following morning the troops were divided into three teams just as he had outlined. The enemy came out riding their armored elephants and advanced slowly and then, suddenly, rushed the Ming lines. "Our troops attacked them, shooting arrows and stones, the noise shaking the mountains and valleys. The

[52] This is from Li Quan 李筌, *Shen ji zhi di tai bai yin jing* 神机制敌太白阴经 (c. 759AD), juan 6 卷六, "Jiao nu tu bian" 教弩图篇, online at http://www.cos.url.tw/book/3/O-1–023-d6.htm.

[53] Zeng Gongliang 曾公亮, *Wu jing zong yao qian ji* 武经总要前集 (Beijing, 1959 [1506–21, based on original from 1231, which in turn was based on the 1044 edition], fols. 23ff.

[54] *Ming shi lu* 明实录, *Tai zu shi lu* 太祖实录, Hongwu 洪武 11, Month 3, juan 189.

[55] *Ming shi lu* 明实录, *Tai zu shi lu* 太祖实录, Hongwu 洪武 11, Month 3, juan 189, my translation. Cf. Geoff Wade, *Southeast Asia in the Ming Shi-lu*, http://epress.nus.edu.sg/msl/entry/2876 [accessed 26 October 2012].

[56] Sun Laichen suggests that they were rockets, and he is one of the world's experts on the topic. Sun Laichen, "Military Technology Transfers," p. 500.

[57] *Ming shi lu* 明实录, *Tai zu shi lu* 太祖实录, Hongwu 洪武 11, Month 3, juan 189. Cf. Wade, *Southeast Asia in the Ming Shi-lu*.

elephants shook with fear and ran."[58] The Ming pursued. According to the *Veritable Records*, half the elephants were killed, thirty-seven were captured, thirty thousand human heads were harvested, and ten thousand men were taken alive.

Scholars have hailed this passage as the first evidence of continuous volley fire with firearms in world history.[59] Of course, the evidence is not unambiguous – Mu Ying does not explicitly say that after the third row fires the first is to fire again and so on. On the other hand, there is no reason to doubt that a procedure that had been implemented for centuries with crossbows should not immediately have been adapted for guns. Chinese standing armies were able to draw on a deep and vibrant heritage of collective training. No "revolution in drill" was necessary.[60]

Other early Ming battles also show evidence of volley fire, such as the main battle of the bellicose Yongle Emperor's 1414 expedition against the Mongols. According to the *Veritable Records*, "the commander Zhu Chong led Lü Guang and others directly to the fore, where they assaulted the enemy by firing continuously and in succession firearms and guns. Countless enemies were killed."[61] The interpretation hinges on two characters: *lian fa* (连发), to fire in succession, one after another. Yet the meaning seems clear. *Lian* means connected and continuous, one after another. There is no description of taking turns, but the enemy was on horseback, and if the Ming forces were not using volley fire, then there would have been long gaps between shots, or chaos as everyone fired and loaded at their own pace. Moreover, the practice of volley fire was so deeply entrenched that there was no need to describe it in detail. Thus, Sinophone historians have convincingly interpreted this battle as evincing volley fire.[62]

Other evidence similarly suggests volley fire with firearms, and it even seems likely that the Chinese were the first to implement volley fire with arquebuses. Whereas most scholars believe it was either the Dutch around 1600 or the Japanese in 1575 who first employed arquebus volley techniques, a Chinese military manual of 1560 contains clear descriptions of the practice.[63]

58 *Ming shi lu* 明实录, *Tai zu shi lu* 太祖实录, Hongwu 洪武 11, Month 3, juan 189. Cf. Wade, *Southeast Asia in the Ming Shi-lu*.

59 Wang Zhaochun, *Zhong guo huo qi shi*, pp. 109–10; Sun Laichen, "Military Technology Transfers," p. 500.

60 The term "revolution in drill" is drawn, of course, from the famous article by Michael Roberts, "The Military Revolution, 1560–1660," in *The Military Revolution Debate: Readings on the Military Transformation of Early Modern Europe*, ed. Clifford Rogers (Boulder, CO, 1995), pp. 15–16.

61 *Ming shi lu* 明实录, *Tai zong shi lu* 太宗文皇帝实录, juan 152.

62 Wang Zhaochun, *Zhong guo huo qi shi*, p. 110.

63 There is also intriguing evidence that some kind of volley technique was used by the Ottomans in the battle of Mohács in 1526. See Gábor, "Firearms and Military Adaptation"; cf. Börekçi, "Contribution to the Military Revolution Debate." For Chinese examples, see Qi Jiguang 戚继光, *Ji xiao xin shu* 纪效新书 (18 juan version) (1560) (Beijing, 1999), p. 38 (in juan 2) and p. 94 (toward the end of juan 8). Other examples in Qi Jiguang 戚继光, *Ji xiao xin shu: shi si juan ben* 纪效新书:十四卷本 (Beijing, 2001), pp. 136, 152–3.

Thus, the volley technique was part of an uninterrupted Chinese tradition of drill. In Europe, on the other hand, systematic drilling emerged only in the early modern period. This contrast may explain why during the late medieval period handheld guns were more prevalent on the battlefield in China than in Europe.

Indeed, when we compare descriptions for early gun battles, we find that whereas Chinese sources rarely suggest that guns were fired all at once and are likely to say that they were "fired in succession," the few early European sources that describe guns used on the battlefield (and there are far fewer than describe artillery battles), seem to indicate that the guns were fired off all at once. In the battle of Crécy, for example, there is no indication that guns were fired in turns, and one chronicle even suggests the opposite: "with many guns they vigorously attacked the French camp, firing all the guns at once."[64] Another significant gun battle – this one considerably later – also suggests that guns were fired at once. This was in 1382, at the battle of Beverhoutsveld. On one side was an army of the Flemish town of Ghent, who were attacking the town of Bruges. The chronicler Froissart writes:

> The Ghentenaars positioned themselves on a hill and gathered themselves together. Then they fired off more than three hundred cannons all at once and turned themselves about so that the Brugeois had the sun in their eyes…. Then they launched themselves into the [Brugeois's] lines, crying "Ghent!" As soon as the Brugeois heard their voices and the cannons going off … they … threw down their weapons, turned tail, and ran.[65]

Kelly DeVries has rightly hailed the battle of Beverhoutsveld as "unique and special," one of the only times in late medieval Europe that guns were decisive on the battlefield and "the first such decisive use in the history of western Europe."[66] The firing of guns all at once rather than in turns happened again at another famous early field battle with guns, the battle of Bulgnéville of 1431, when the victors "shot with fire from their cannons and couleuvres [smaller guns] all at the same time."[67]

We certainly need more research into the comparative history of firearms, and particularly for the late medieval period, which was so seminal for their development, but it seems safe to suggest that one reason the Chinese were able to incorporate handheld guns into their infantry in such high proportions was that they were used to drilling units systematically, thanks to the fact that they had a long tradition of standing infantry armies. Intriguingly, it seems that in the Ottoman Empire, which also had standing armies, gunners were similarly

64 Anonymous, *Storie pistoresi,* in *Raccolta degli storici Italiani dal ciquecento al millecinquecento*, ed. L. A. Muratori (Città di Castello, 1897), p. 223. Cf. Brackenbury, *Ancient Cannon Part I*, p. 13. Note that Brackenbury mistranscribed the word scoccare for "soccare."

65 Froissart, *Les chroniques de Jehan Froissart* 10:31. With thanks to Kelly DeVries and Robert Smith, whose translation of this passage informed my own. DeVries and Smith, *Artillery of the Dukes of Burgundy*, p. 62; and DeVries, "Forgotten Battle," p. 300.

66 DeVries, "Forgotten Battle," p. 303.

67 Enguerrand de Monstrelet, *Chronique*, cited in DeVries and Smith, *Artillery of the Dukes of Burgundy*, p. 105.

integrated into army units quite early on – by the 1390s at the latest – although the numbers and proportions seem to have been considerably lower than those obtaining in early Ming China.[68] Much research remains to be done, but it is likely that scholars will find further Ottoman parallels with Ming China: standing armies, which were able to drill collectively, were likely better at deploying handheld guns than less permanent forces throughout Eurasia.

But what is perhaps even more intriguing is that by the end of the 1300s, Western Europeans – and the Ottomans, too – were beginning to develop guns that were quite different from those of China. Previously, in both Europe and China, guns had been used primarily as anti-personnel devices and perhaps secondarily to attack and set fire to wooden structures. But in the last quarter of the 1300s, European guns became very large and were increasingly used to blast down fortifications, whereas guns stayed small in China. Why? The answer may have to do with the fact that the Europeans and Chinese built very different types of walls.

Big Guns

Although there are some disagreements about timing, most medieval military historians believe that the decisive period for the emergence of big guns was the 1370s, and the development of huge guns proceeded rapidly over the following decades.[69] By the mid-1400s, guns ceased becoming larger in Western Europe, as gunsmiths focused more on mobility than size, but they continued to be aimed at walls, and successfully. In China, in contrast, no such developments took place. Guns remained small. Whereas Westerners were making guns that weighed many tons, "large" guns in China from the 1300s and 1400s weighed only 75 kg or so in weight, and the vast majority of Chinese guns weighed just a kilogram or two.[70] Moreover, Chinese records make clear that although guns were ubiquitous at sieges, they were not used to blast down walls. Rather, they were aimed at people and, sometimes, wooden gates and towers.

Why? Historians have suggested that Chinese gun makers did not need to destroy walls because China was a unified empire: "Since China was under a single sovereignty, gunpowder weapons were only needed on ships and for defence of fortified places against barbarian harassment. For both these purposes,

68 Ágoston, "Firearms and Military Adaptation," 93–4; Ágoston, *Guns for the Sultan*, pp. 16–24.

69 DeVries, "Technology of Gunpowder Weaponry"; Devries and Smith, *Medieval Military Technology*, pp. 140ff; Kelly Devries, "The Use of Gunpowder Weaponry by and against Joan of Arc During the Hundred Years War," *War and Society* 15:1 (1996), 4–5; Philippe Contamine, *War in the Middle Ages* (New York, 1984), pp. 140ff; Smith, "Artillery and the Hundred Years War"; Rogers, "Military Revolutions of the Hundred Years War."

70 Wang Zhaochun, *Zhong guo huo qi shi*, pp. 58–63, 74. As I have noted above, there are extant guns that are larger, but they appear to be an anomaly, a road not travelled. Nor is there any evidence that they were used against walls.

smaller and more mobile guns alone made sense."[71] But of course, walls stood in the way of many Chinese armies, and China was often not unified.

I believe that a better explanation has to do with the culture of fortification. The Chinese built different types of walls than did the Europeans, walls that were much less vulnerable to bombardment. Toward the middle of the twentieth century, a European expert in fortification mused on how astoundingly large China's walls were: "in China … the principal towns are surrounded to the present day by walls so substantial, lofty and formidable that the medieval fortifications of Europe are puny in comparison."[72] It is a significant observation, with profound implications.

Even in prehistoric times, the ancestors of the Chinese surrounded their cities with massive fortifications. The capital of a Neolithic settlement from the Longshan period (3000 to 2000 BC), known as Chengziya (c. 2500 BC), was surrounded by a long wall eight to ten meters wide.[73] In the Shang period (1600–1046 BC), Chinese city walls were even more massive. The walls of the Shang city of Zhengzhou, for example, which have been the object of considerable archeological research, stood ten meters high and had a width of more than twenty meters at the base and five meters at the top.[74] For the next millennia, Chinese kept building huge walls, so that by the late imperial period, nearly all prefectural and provincial capitals were fortified.

European walls were much thinner. The Romans were the great wall builders of European antiquity, and it seems that in the early Roman period (up to the end of the second century AD) Roman walls were often ten meters or so high, but they were not wide by Chinese standards, varying from 1.5 to 2.5 meters.[75] They were "built on a standard of .25 meters of width for each 1 meter of height. Thus an 8 meter high wall would be 2 meters thick."[76] Among the most impressive Roman walls were those of Rome itself. The city's Servian walls were up to 3.6 meters thick at their base, and during the period of the Emperor Aurelian they were rebuilt and eventually attained a thickness of around four meters and a height of six meters.[77] Walls in the far reaches of the empire could also reach four meters thick, such as the Diocletian-era walls known as the Saxon Shore

71 William H. McNeill, "Men, Machines, and War," in *Men, Machines, and War*, ed. Ronald Haycock and Keith Neilson (Waterloo, Canada, 1988), p. 14.

72 Sidney Toy, *A History of Fortification: From 3000 BC to AD 1700* (London, 1955), p. 181.

73 Victor F. S. Sit, *Chinese City and Urbanism: Evolution and Development* (Singapore, 2010), p. 39.

74 Ralph D. Sawyer and Mei-chün Sawyer, *Ancient Chinese Warfare* (New York, 2011), p. 125.

75 DeVries and Smith, *Medieval Military Technology*, p. 189.

76 J. E. Kaufmann, H. W. Kauffman, and Robert M. Jurga, *The Medieval Fortress: Castles, Forts, and Walled Cities of the Middle Ages* (Cambridge MA, 2004), p. 35.

77 Kaufmann et al., *Medieval Fortress*, p. 35; DeVries and Smith, *Medieval Military Technology*, p. 191.

Forts, which were 4.3 meters.[78] This is still far thinner than Chinese walls of the same period, which were often twenty meters wide at the base.[79]

The most impressive walls of the Western world were those of Constantinople, which had a double fortification system: an outer wall two meters thick and an inner wall four meters thick, separated by a no-man's land of about fifteen meters across.[80] These defenses have been justly lauded. One author has written that Constantinople had "the most famous and complicated system of defence in the civilized world."[81] Another has called Constantinople's "the most formidable development of fortification systems in the ancient world."[82] The intricacy of Constantinople's defenses was certainly impressive, but if we stretch our definition of "civilized world" and "ancient world" to East Asia, we may perhaps find occasion to moderate such statements. Constantinople's outer wall was a tenth the width of the wall of any reasonably sized Chinese city, and even the much stouter inner wall was merely a quarter or a third as thick.

In fact, for much of the Middle Ages, most towns in Europe had no walls at all. Some scholars have argued that in the German lands around 1200, there were only twelve towns with proper walls, and nine were left over from Roman times.[83] French and English towns were also usually wall-less, unless, again, they happened to have Roman walls. That is not to say that they were defenseless. Many European towns surrounded themselves with ditches, stockades, or low earthen ramparts. This was the case with the vast majority of German towns in the 1100s and 1200s.[84] These earthen ramparts could sometimes be quite thick, but they tended to be low and rudimentary. An earthen fortification in twelfth-century Hereford, England, for example, was probably about fifteen meters wide at the base, but it was just three meters high and seems to have been protected from erosion only by a layer of gravel. No wonder that it was replaced by a stone wall in the 1200s.[85]

78 DeVries and Smith, *Medieval Military Technology*, p. 191.

79 To be sure, some ancient northern European ringforts were much thicker than Roman-style walls, such as the ringwall of Otzenhausen, a Celtic fort in Saarland, Germany, parts of which were forty meters wide at the base. This was exceptional, however, and in any case Celtic fort-building practices died out during the early medieval period.

80 See Efpraxia Paschalidou, "The Walls of Constantinople: An Obstacle to the New Power of Artillery," in *XXII. Kongress der internationalen Kommission für Militärgeschichte* (Vienna, 1997), pp. 172–78.

81 Paschalidou, "Walls of Constantinople," p. 172.

82 Richard Tomlinson, *From Mycenae to Constantinople: The Evolution of the Ancient City* (London, 1992), pp. 213–22, cited in James D. Tracy, "Introduction," in *City Walls: The Urban Enceinte in Global Perspective*, ed. James D. Tracy (Cambridge, 2000), p. 10.

83 DeVries and Smith, *Medieval Military Technology*, p. 269. This is perhaps an understatement, though, since it is not always easy to tell whether towns had walls or not. See Hans Planitz, *Die deutsche Stadt im Mittelalter: von der Römerzeit bis zu den Zunftkämpfen* (Graz-Köln, 1965), pp. 231–35.

84 Planitz, *Die deutsche Stadt*, p. 260.

85 John R. Kenyon, *Medieval Fortifications* (New York, 1990), p. 186.

Hereford was not alone. In the 1200s and 1300s, new walls rose throughout Europe.[86] They sometimes matched but rarely exceeded the thickness, height, and length of Roman walls. Late medieval French walls were usually two meters or less in thickness. England's tended to be even thinner, with those of Southampton only 0.76 meters thick and those of Shrewsbury 1.37 meters thick.[87] Other English towns boasted walls of French thickness: those of Bristol ranging between 1.5 and 2.5 meters, those of Bath 1.9 meters thick, those of Newcastle 2.1 meters thick.[88]

In fact, Western-based historians and archaeologists often use the phrase "very thick" to refer to walls that would be considered very thin in the Chinese context, as for example, when Kelly DeVries and Robert Smith write about the Southern French keep at Najac, begun in 1253: "Its walls were also *very thick*, measuring 2.2 meters in width."[89] Or when they write that most French walls in the late medieval period were "*very wide*, most measuring nearly two meters in thickness."[90] To be sure, DeVries and Smith are making comparisons within the European context, but it still bears noting that these "very wide" walls were less than a tenth the thickness of average Chinese city walls.[91] Indeed, the *marketplace* of the Chinese city of Chang'an boasted walls thicker than the walls of European capitals, and that marketplace stood within the walls of Chang'an itself, which were far, far thicker.[92]

It is of course much easier to blast your way through a two-meter wall than a fifteen-meter wall, but it was not just the thinness of European walls that made them vulnerable to artillery. It was also the way they were built. European walls were made of stone, often with a filling of gravel or rubble, with limestone mortar often used as a bonding agent, a practice that went back to Roman times. Chinese walls, however, were much more resistant to artillery because they had an earthen core. Earthwork absorbs the energy of an artillery shot. An earthen-core wall might become riddled with holes during an attack, but those holes tended not to penetrate deeply, and the walls were resistant to shattering.

One must not imagine that Chinese walls were filled with loose earth. The Chinese were able to create sturdy, hard walls by using an ancient earth-tamping method. One constructed a framework of wooden planks of the height and width one wanted. Then one poured in a layer of earth. This earth layer was tamped

86 For France, see Christopher Allmand, *The Hundred Years War: England and France at War, c. 1300–c. 1450* (Cambridge,1988), p. 77. For England, see Kenyon, *Medieval Fortifications*, pp. 183–84. For the German lands, see Planitz, *Die deutsche Stadt*, pp. 229–42.

87 Kenyon, *Medieval Fortifications*, p. 187.

88 Kenyon, *Medieval Fortifications*, p. 187.

89 DeVries and Smith, *Medieval Military Technology*, pp. 248–49.

90 DeVries and Smith, *Medieval Military Technology*, p. 270. My italics.

91 Kaufmann et al., *Medieval Fortress*, p. 36.

92 Heng Chye Kiang, *Cities of Aristocrats and Bureaucrats: The Development of Medieval Chinese Cityscapes* (Honololu, 1999), p. 19.

down until highly compact. Then another layer was added, and another.[93] When the wall had reached its desired height, one removed the planks and used them to make the next section of the wall. The tamped-earth method produced walls that were surprisingly durable, and some ancient walls have survived four thousand years of rain and wind. Often these earthworks were encased in brick or stone to protect them from erosion, a practice that became more prevalent as time went on. The walls of Ming cities were built this way, and so was the Great Wall, rebuilt in the Ming period: a tamped earthen core (the earth sometimes interspersed with stone and rubble) encased in stone and brick.

But the tamped-earth method was not the only thing that made Chinese walls resistant to artillery: Chinese walls were also sloped. Whereas a vertical wall that is struck by a projectile perpendicularly receives the full force of impact, a sloped wall deflects the projectile and absorbs less energy.

What is intriguing is that as the Europeans began to adapt their fortifications to resist artillery, they ended up making them more like Chinese walls. In the course of the 1400s, the Europeans began building walls of sloped earthwork. As Kelly DeVries has shown, the practice seems to have begun in France and the southern Netherlands, where artillery warfare was particularly intense in the 1400s. Defenders added earthen outworks to their stone walls to protect them. These outworks were called *boulevards* in French and *bolwercqen* in Flemish, whence the English word "bulwark." They were made with wooden planks on the outside and earth on the inside, and they were sloped to lessen the force of horizontal fire. As boulevards' utility became recognized, they were made permanent and faced in stone.[94]

The boulevard was designed to protect vulnerable stone walls, but Europeans soon began building wholly new types of fortifications. These new walls were quite similar to traditional Chinese walls: filled with earth, encased in stone, and much thicker than the old stone walls. They were designed from the ground up to resist guns, and they worked. Artillery, which once breached walls rather regularly, was effectively countered, and sieges once again became long, drawn-out affairs, with tight cordons that lasted months. Gone were the days in which garrisons surrendered after a cannonball or two pierced the wall.

Traditional Chinese walls never needed to be rebuilt to resist artillery because they were never threatened by artillery. Consider, for example, the famous siege of Suzhou of 1366. This was one of the most important sieges of the violent early Ming Wars, when the forces of the Ming founder, Zhu Yuanzhang, were attacking the capital of one of his main rival states. Some experts have suggested that the siege of Suzhou proceeded as our standard image of a gun-era siege might lead us to expect. Ming specialist Edward Dreyer writes that "flaming

93 Yinong Xu, *The Chinese City in Space and Time: The Development of Urban Form in Suzhou* (Honololu, 2000), p. 113.

94 Kelly DeVries, "Facing the New Military Technology: Non-Trace Italienne Anti-Gunpowder Weaponry Defenses, 1350–1550," in *Heirs of Archimedes: Science and the Art of War through the Age of Enlightenment*, ed. Brett Steele and Tamara Dorland (Cambridge, MA, 2005), p. 48.

arrows and rockets were used for incendiary purposes, while cannon of a more standard cast battered the walls."[95] Peter Lorge, whose excellent work has laid the groundwork for much current research on China's military history, writes, "Zhu's army completely enclosed the city [of Suzhou] in a circumvallation, and pounded it with artillery. Ten months of firing resulted in that rare occurrence in Chinese city fortifications, a wall breach."[96] But if we look carefully at the historical sources, we see that guns played a minor role in getting through Suzhou's walls. That is not to say that gunpowder weapons were not important in the siege. Guns were certainly present, but they were aimed not at walls, against which they were useless, but at humans, against which they were lethal. The gates and towers of Suzhou were targeted not by guns but by weapons of a more traditional sort: trebuchets hurling huge stones and gunpowder bombs. The breach at Suzhou in 1366 was not even a proper wall breach. The breakthrough occurred not in the walls but at a gate. There is no record of cannons or catapults being used to effect this breach. It was probably done by traditional manual mining or battering, since the focus of the extant accounts describing it is on troops and men, not on machines of any kind.[97]

This should not surprise us. Not only were Ming guns relatively small, but Suzhou's walls were also enormously thick, which is to say they were normal Chinese city walls. The city's walls had been rebuilt in 1352 and records indicate that its seventeen kilometers of walls were 7.3 meters high, 11 meters thick at the base, and 5.1 meters thick at the top.[98] Moreover, the walls were made of tamped earth and were battered, sloping markedly from bottom to top, thus providing further resistance to artillery.[99]

How might European cannons of the late medieval period have fared against such walls? According to a Florentine diplomat, writing in the early 1490s, "the French say that their artillery is capable of creating a breach in a wall of eight

[95] Edward L. Dreyer, "Military Origins of Ming China," in *The Cambridge History of China, Volume 7, The Ming Dynasty, 1368–1644, Part I*, ed. Frederick Mote and Denis Twitchett (Cambridge, UK, 1998), p. 93.

[96] Peter Lorge, *The Asian Military Revolution: From Gunpowder to the Bomb* (Cambridge, 2008), p. 74 and *War, Politics, and Society in Early Modern China, 900–1795* (London, 2005), p. 105.

[97] Gu Yingtai 谷应泰, *Ming shi ji shi ben mo* 明史纪事本末, juan 4, "Tai zu ping wu" 太祖平吴. The description in the *Ming Veritable Records* is almost identical. *Ming shi lu, Hongwu shi lu,* juan 25, Year of Wu 1, Month 9, Xinsi day.

[98] The Chinese measurements for 1352 are as follows: 23 chi high, 35 chi thick at base, and 16 chi wide at the top. I converted to the metric measures using a chi length of 31.6 cm, a reasonable estimate for the length of a chi during this period. In the late 1360s, records suggest a slightly greater thickness for the top – 18 chi, or about 5.6 meters (3 zhang 5 chi thick at base and 1 zhang 8 chi thick at the top). The figures are from Yinong Xu, *Chinese City*, p. 114. Frederick Mote says they were 25 feet thick at the base and 25 feet high, but his estimates are not quite as evidence-based as Xu's. F. W. Mote, "A Millennium of Chinese Urban History: Form, Time, and Space Concepts in Soochow," *Rice University Studies* 59:4 (1973), 53.

[99] Xu, *Chinese City*, p. 113.

feet in thickness."[100] The diplomat suspected that his readers might not believe this, conceding that "the French are braggarts by nature,"[101] but let us take the French at their word and suppose that European siege artillery circa 1490 were capable of creating breaches in walls of up to eight feet thick – very thick in the European context. Would that siege artillery have proven useful against the walls of Suzhou, which, at eleven meters (or thirty-six feet) were more than four times thicker than the Frenchmen's hypothetical eight-feet walls? It is doubtful. To be sure, these French guns of the 1490s were not the massive bombards of the 1440s, but they were just as effective, making up in power and numbers what they lacked in size.

More importantly, would the Europeans have bothered to develop wall-smashing artillery – either the huge bombards of the early 1400s or the lighter but more powerful guns of the late 1400s – if they had faced walls like those of China? Large guns were enormously expensive to make, to transport, and even to fire – the largest required a hundred pounds of powder or more for a single shot.[102] Smaller siege artillery required less powder, but the expense was still significant. Scholars have estimated that a single shot from a sixteenth-century cannon cost the equivalent of a month's wages for an infantry soldier.[103] The kings and dukes of Europe were willing to pay these huge sums because the payoff was great. When your artillery train rolled up to a medieval town you could be fairly sure that you had a good chance of breaching its walls or, even better, intimidating its garrison into a quick surrender. In China, artillery would not have repaid the heavy investment. To be sure, the Chinese used catapults and guns to destroy wooden structures on walls, but the massive tamped-earth walls of China acted as a deterrent to the development of gunpowder artillery. Yet walls cannot explain everything about the military divergence. European guns did not just get bigger than Chinese guns. They also got more effective

The Classic Gun in Europe

In Western Europe, guns evolved rapidly in the second half of the 1400s. They came to have a long, tapered form, with a large length-to-bore ratio. This development had occurred by around 1490, and the new form was so successful that it would hold for the next three centuries. Historian Bert S. Hall has labeled

100 Cited in Philippe Contamine, "L'artillerie royale francaise a la veille des guerres d'Italie," *Annales de Bretagne,* 71:2 (1964), 223.

101 Cited in Contamine, "L'artillerie royale," p. 223.

102 Marios Philippides and Walter K. Hanak estimate that firing the huge bombards used by the Turks around the time of the siege of Constantinople in 1453 would have required up to 300 pounds of powder per shot. See Marios Philippides and Walter K. Hanak, *The Siege and the Fall of Constantinople in 1453: Historiography, Topography, and Military Studies* (Burlington, 2011), p. 423.

103 Jack Kelly, *Gunpowder: Alchemy, Bombards, and Pyrotechnics: The History of the Explosive That Changed the World* (New York, 2004), p. 78.

the development of the classic gun the "modern ordnance synthesis."[104] Robert Smith prefers to call the new gun design the "classic" gun.[105] They disagree about the reasons for the development (Hall believes it had to do with powder corning; Smith suspects new casting techniques) but they agree on the importance and the timing of the developments. But why did the classic gun emerge in Europe and not in China? This is one of the key questions of global military history.

No answer can be definitive – especially at this point, when we still know so little about global military history – but it seems that the forms of Chinese and European guns were developing along similar lines until around 1450. Until the mid-1400s, Chinese guns seem to have had length-to-bore ratios very similar to those of European guns, an average of 15 to 1 (Table 1).[106]

Table 1. Ratio of length to bore, Chinese guns, 1288–1423

Year	*Length (cm)*	*Bore (cm)*	*Ratio of length to bore*
1288	34	2.6	13.1
1332	35.3	10.5	3.4
1334	26.5	2.3	11.5
1338	47.5	10.5	4.5
1338	32	2.2	14.5
1340	21.5	2.6	8.3
1340	31.5	2.6	12.1
1351	43.5	3	14.5
1372	36.5	11	3.3
1372	45.7	2.54	18.0
1372	43	2	21.5
1372	36.5	11	3.3
1372	44.6	3.9	11.4
1375	63	26	2.4
1377	100	21	4.8
1377	42	2.2	19.1
1377	44.3	1.9	23.3
1377	44	2.1	21.0
1377	42	2.1	20.0

104 Hall, *Weapons and Warfare*, p. 87.

105 See especially Smith, "All Manner of Peeces," p. 136; cf. DeVries and Smith, *The Artillery of the Dukes of Burgundy*, p. 42.

106 The length-to-bore ratios of Chinese guns differed greatly according to the weight class, with smaller guns having much higher ratios, something that was just as true for Europe.

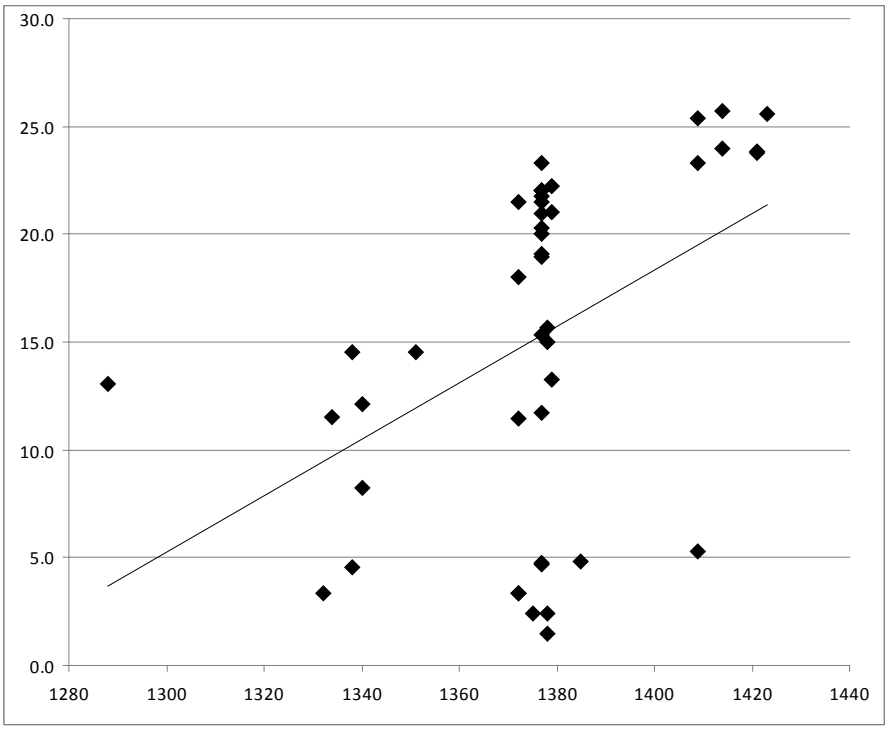
1377	36	1.9	18.9
1377	27	2.3	11.7
1377	38.5	1.9	20.3
1377	32.2	2.1	15.3
1377	43	2	21.5
1377	44	2	22.0
1377	44	2	22.0
1377	101.6	21.6	4.7
1377	44	2	22.0
1377	43.5	2	21.8
1378	36.4	14.9	2.4
1378	21.7	14.8	1.5
1378	36	2.3	15.7
1378	30	2	15.0
1379	26.5	2	13.3
1379	44.5	2	22.3
1379	44.2	2.1	21.0
1385	52	10.8	4.8
1409	55	10.4	5.3
1409	35	1.5	23.3
1409	35.5	1.4	25.4
1414	36	1.4	25.7
1414	36	1.5	24.0
1421	35.8	1.5	23.9
1421	35.7	1.5	23.8
1423	35.8	1.4	25.6
Average			15.2
Average with outliers excluded			18.9

Chinese guns through 1423 or so had a similar length-to-muzzle-bore ratio as those of Europe around the same period, or an average of 15.2, although the standard deviation, 7.9, is quite high because of the presence of a number of outliers (which is to say, guns whose length-to-muzzle-bore ratio is 6 or less). If we omit the outliers the average comes out as 18.9, with a standard deviation of 4.9.[107]

[107] These data are gathered from various sources: Wang Rong 王荣, "Yuan dai huo chong de zhuang zhi fu yuan" 元代火铳的装置复原, *Wen wu* 文物 1962 vol., no. 3, 41–45; Yuan Xiao-

Moreover, like European guns, Chinese guns were developing larger length-to-bore ratios, as seems clear from Figure 1.

Figure 1. Trends in the Development of Chinese Guns, 1288–1423



The vertical axis is the ratio of length-to-muzzle-bore, and the trend is quite clear. Through 1420 or so, Chinese guns were growing longer relative to muzzle bore, or toward the ratio that characterized the so-called "modern ordnance synthesis" and that was achieved in Europe in the late 1400s.

chun 袁晓春, "Shan dong Peng lai chu tu de Ming wan kou pao" 山东蓬莱出土的明碗口炮, *Wen wu* 文物, 1991 vol., no. 1, 91–92; Shi Baozhen 史宝珍, "Zhen jiang chu tu de Ming dai huo qi" 镇江出土的明代火器, *Wen wu* 文物, 1986 vol., no. 7, 91–94; Liu Hongcai 罗宏才, "Ding bian xian fa xian de yi jian Ming dai tie chong"定边县发现的一件明代铁铳, *Wen bo* 文博, 1988 vol., no. 4, 92–93; Liu Xu, *Zhong guo gu dai huo yao huo qi shi*, pp. 107, 117; Liu Shanyi 刘善沂, "Shan dong guan xian fa xian Ming chu tong chong" 山东冠县发现明初铜铳, *Kao gu* 考古, 1985 vol., no. 10, 914; Yin Qichang 殷其昌, "He zhang chu tu de Ming dai tong chong" 赫章出土的明代铜铳, *Gui zhou she hui ke xue* 贵州社会科学, 1982 vol., no. 5, 71–90; Chen Lie 陈烈, "He bei sheng Kuang cheng xian chu tu de Ming tong chong" 河北省宽城县出土的明铜铳, *Kao gu* 考古, 1985 vol., no. 8, 759; Shi Wanlin 师万林, "Gan su Zhang ye fa xian Ming dai tong chong" 甘肃张掖发现明代铜铳, *Kao gu yu wen wu* 考古与文物, 1986 vol., no. 4; Hu Zhenqi 胡振琪, "Ming dai tie pao" 明代铁炮, *Shan xi wen wu* 山西文物, 1982 vol, no. 1.

To be sure, there is considerable variation in these data, caused by the fact that guns used for different purposes had quite different length-to-bore ratios, but in general the trend seems clear enough for provisional speculation. European guns continued farther along the path of a high length-to-bore ratio, and when the Portuguese brought their cannons to China in the 1510s, cannons that were of the "classical gun" type, the Chinese were highly impressed, recognizing the many advantages that the longer barrel length and thinner walls conferred.

So what accounts for the fact that European guns kept evolving toward the "classic gun" form and the Chinese guns did not? It probably did not have to do with powder corning, because recent evidence strongly suggests that corned powder was used in China as early as 1370.[108] Moreover, as Robert Smith and Kelly DeVries have shown, the evidence in Europe for the impact of powder corning is considerably less straightforward than the corning hypothesis would suggest: "corned powder," they write, "was not the revolutionary development that some have asserted it to be."[109]

Other explanations suggest that Europeans managed to develop guns with greater freedom because they had the advantage of being late adopters. As historian Peter Lorge has written, "Gunpowder weapons had become a fairly mature technology [in China]…. In Europe, by contrast, the technology was new and quickly demonstrated a narrow set of effective uses. Free from preconceived notions … [Europeans] set off with renewed creativity. Progress in China continued slowly."[110] This is an intriguing idea, but it does not account for the speed of European developments or the fact that Chinese guns had been trending toward the classic gun shape through the 1300s and early 1400s but that this development seemed to slow in China in the mid- and late 1400s, even as it continued in Europe.

Another explanation suggests that the Chinese did not experiment as heartily with guns because they found them relatively useless against their most fearsome enemies, the horse-borne nomads of central Asia. To fight against nomads, logistics were the challenge, because the enemy could run away and draw out supply chains. They could sally and retreat, lure and engage at their will. Guns, no matter how good, simply were not so effective in such a context. The Europeans, in contrast, fought large infantry field armies and sieges, types of warfare that suited guns. As a result, historian Kenneth Chase argues, guns evolved more rapidly in Europe than in China.[111]

108 Shi Jungui 石俊贵 and Li Hong 李鸿, "Nei Meng gu chu tu de Ming chao chu nian tie ke di lei ji shi" 内蒙古出土的明朝初年铁壳地雷纪实, *Qing bing qi* 轻兵器 (Beijing), 2002 vol., no. 4, 36.

109 DeVries and Smith, *Artillery of the Dukes of Burgundy*, p. 46.

110 Lorge, *Asian Military Revolution*, p. 17.

111 This argument is also put forth by the Mongol specialist Thomas Allsen, "The Circulation of Military Technology in the Mongolian Empire," in *Warfare in Inner Asian History (500–1800)*, ed. Nicola De Cosmo (Leiden, 2002), p. 286: "[I]t may be offered as a working hypothesis that those states and cultures with a lengthy history of interaction with the nomads, who for so long lived under the threat and the spell of an earlier 'cavalry revolution,' were the more

The Chase hypothesis is a compelling one, but there are reasons to doubt it. For one, the Chinese themselves considered guns to be highly effective against nomads. The Ming used them to smash Mongol power in the late 1300s and early 1400s, as well as to defend against a huge Mongol invasion in 1449. Thereafter, guns were in great demand in China, especially on China's northern frontiers, precisely where the inner Asian incursions arrived, and the fortifications of the North were studded with gun emplacements. And when Portuguese guns arrived in the 1500s, they were sought after not just to war against infantry armies but to use against nomads, their long barrels jutting out from the Great Wall. More importantly, the Chase hypothesis downplays the tremendous variety of warfare within China itself. Nomads may have been the primary enemies in the North, but southern China was often beset by warfare that was similar to that of Europe: huge infantry armies clashing with each other and attacking cities. The Chase hypothesis should certainly not be discarded, but it probably represents only part of the explanation.

I believe that the most straightforward answer is most compelling: the Ming stopped improving their guns because they did not need to. Guns evolved quickly in the pre- and early Ming period, a time of constant and existential warfare. In the 1350s and 1360s, the founder of the Ming, Zhu Yuanzhang, fought incessantly with his rivals, and innovations in firearms provided an edge to those who made them. Even after he declared the establishment of the Ming Dynasty in 1368, he continued his conquests, west into Sichuan, north into Mongolia, southwest into Yunnan. These were massive wars against states whose militaries possessed, especially in the case of Sichuan, state-of-the-art weaponry. When Zhu Yuanzhang died, the Ming were rocked by an intense civil war, in which tremendous armies shot guns at each other in China's heartland. The usurper won and immediately began carrying out other massive expeditions, most notably a massive war in what is today northern Vietnam and five great campaigns into Mongolia. His expeditions involved hundreds of thousands of men armed with tens of thousands of guns. They stimulated innovations in firearms manufacture, tactics, and administration, particularly, it seems, the Vietnam Wars, because the Dai Viet state was a sophisticated gunpowder empire in its own right.

But after the usurper – the Yongle Emperor – died in 1424, the frequency and intensity of Chinese warfare decreased dramatically. From his death until the mid-1500s, there was only one dynasty-shaking military event: the Tumu Episode of 1449, when firearms played an important role in preserving the capital from a Mongol onslaught. Thereafter, as the Mongol threat lessened, warfare became less frequent, less intense, and, most importantly, less existential. Wars between 1449 and the 1540s tended to be police actions against minor

reluctant to accept the new technology diffused by the Mongols, the more hesitant to join the 'gunpowder revolution,' while those peoples on the extreme periphery of Eurasia, Europe and Japan, whose contact with the nomads was restricted and intermittent, were the more eager to interrogate and exploit its possibilities."

enemies. The Ming were overwhelmingly dominant. There was little challenge, little stimulus to further innovation.

Europe, in contrast, saw no let-up in the nearly constant warfare that had marked the 1300s and early 1400s. That, more than anything else, probably explains why European guns kept improving. Europe was at the beginning of a long Warring States period, one that would last, with a few breaks, until 1945. China's Ming Peace lasted a century, but in the 1550s, warfare began again, and it was intense and protracted, lasting through the late 1600s. During this period, China adopted, adapted, and innovated furiously, mastering muskets and advanced muzzle-loading cannons. By 1560, muskets were deployed with tactics superior to those of Europe; in the 1600s, the Chinese and their enemies were making wall-smashing cannons that in some ways were more sophisticated than those of Europe. This period of military innovation lasted until the next dynasty, the Qing (1644–1911), had concluded its own wars of conquest and consolidation in the mid-eighteenth century.

We still have enormous amounts to learn about global military history, particularly for the key late medieval period, a watershed for the development of guns in both China and Europe. The speculations in this article are highly provisional, but I hope they may prove stimulating and help to provoke further discussion. Even more importantly, I hope that they help to bring together two very exciting fields – medieval European military history and Chinese military history – helping to point the way toward a truly global military history.