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ORIGINAL PAPER

Baffles and Bastions: The Universal Features of Fortifications

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Abstract This article discusses several universal features of fortifications and distinguishes those features that are unequivocally military in function. The evidence adduced includes the features of known historic fortifications, relevant prescriptions by ancient military authors, and geometry. The archaeologically visible features that are universally used in military defenses are V-sectioned ditches, "defended" (especially baffled) gates, and bastions. It is also noted that ritual, ceremonial, or any other peaceful activities conducted within an enclosure having these architectural features does not preclude its obvious military function.

Keywords Ancient fortifications · Warfare · Prehistoric enclosures · Pre-gunpowder weapons · Symbolism · Warfare

Introduction

This article's primary purpose is practical: to inform prehistoric archaeologists about the unequivocally defensive features (i.e., those having only or primarily a military function) of the large-scale constructions or earthworks they may encounter. The defensive features discussed below have all been found in many times and places, and thus were not mere styles nor culturally arbitrary. The features of most interest are also those that have historically documented functions as military defenses. Our primary focus is on three characteristics of fortifications: V-sectioned ditches, defended gates, and bastions. We argue that V-shaped ditches (when backed by a barrier) surrounding all or at least the most vulnerable parts of a site had a defensive function. Certain gate forms, especially when "baffled" or screened, are invariably defensive. The only possible and documented function of bastions, especially when regularly spaced, was to direct fire against attackers. Because this article is addressed to archaeologists, our emphasis is on the plan or subsurface cross-sectional forms of these

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fortification features because these represent the manner in which they are most likely to survive in the archaeological record. Except perhaps for brief mention, many other very common features of fortifications, such as naturally defensive or "strategic" locations, crenellations, machicolations, and revetments, are not discussed here, either because they are not always military in function or, if unequivocally defensive, are seldom part of the archaeological record.

We catalogue certain features typical of historically and ethnographically known fortifications. These features have specific roles in the defense of forts or fortified settlements. They must be commonly found at sites that were clearly built as and functioned as fortifications. The military utility of all these features was noted and recommended by ancient Greek, Roman, and Asian authors. Thus, the cases of fortification mentioned in the main part of the article are generally from historic periods in the Old World (especially the Near East and Europe) or were mentioned in ethnographic sources. These fortifications were variously constructed, e.g., earthen banks and ditches, rammed earth, adobe, brick, or stone. Many of their detailed characteristics are irrelevant to the purpose of this article because they occur only within particular culture-historical contexts (e.g., *murus gallicus*, arched portals) or can be found in nonmilitary constructions. Instead, we focus on only those characteristics that can be observed universally. Finally, we discuss very similar or even identical features found at prehistoric sites in both the Old and New Worlds.

This article's more general purpose is to counter a long-standing tendency of prehistoric archaeologists to dismiss or ignore the defensive functions and military significance of the large-scale features they excavate and analyze. Since the inception of our discipline, prehistorians have steadily uncovered obvious fortifications, sometimes associated with the remains of war victims and wholesale destruction. Yet, since World War II and until very recently it was common to find earthworks and other large features with V-sectioned ditches, defended gates, and/or bastioned walls interpreted solely as religious enclosures or symbols of status or possession (e.g., Coudart, 1991; Whittle, 1996; for a dismissal of *any* defensive function for *any* Neolithic or Eneolithic enclosure in Europe see Andersen, 1997, pp. 302–304, 309; for recent examples, see Scarre, 2005, pp. 411, 413, 418–419; for an Andeanist critique see Arkush and Stanish, 2005, pp. 3–7). We mention a few such instances in our discussion of prehistoric fortifications. Admittedly, this pacific inclination of prehistoric archaeologists has abated over the past decade (e.g., works by Milner, Haas, LeBlanc, Vencl, Mercer, Courtin, and Guilaine). Nonetheless, this tendency of postwar prehistorians to "pacify the past," whether intentional or accidental, has many roots and reflects many intellectual and popular prejudices (Keeley, 1996, pp. 163–183; Keeley, 2001). One reason that this counterfactual "pacification" has flourished and persisted is that prehistorians are spared the inconvenience of historical or ethnographic testimony—in this case, to the military purpose and defensive functions of certain large-scale features. Our goal is to eliminate this convenience for prehistorians.

Many of this article's citations indicate that what we say regarding the military functions of V-sectioned ditches, defended gates, and bastions is neither novel nor surprising to historians or archaeologists dealing with historical sites. However, historians and historical archaeologists may find it interesting that the fortification features they know only from a restricted time, place, and civilization [e.g., VanCreveld's (1989, p. 103) remark about the mutually protective function of European bastions in the age of cannon] are in fact both very ancient and widespread.

We also urge caution. As we note below, not all enclosures were fortifications, nor do all the features typically found at known fortifications have purely military functions. For example, curtain walls of an enceinte might simply be a peaceable barrier or a dike with no military function. Our point, however, is that unless a curtain has an historically declared military purpose or incorporates such clearly defensive features as V-shaped or deep ditches, defended gates, or bastions (see below), scholars cannot assume enceintes were built with an intended defensive purpose . . . in other words, a wall might be just a wall. In addition, we do not deny that fortifications possess a symbolic nature; however, in the case of *defensive* constructions, this symbolism is secondary in purpose.

Only certain forms of enclosing ditches, gates, and palisades are unequivocally defensive, and it is on these features that we focus our attention.

Enceintes

The militarily functional ditch and gate features and bastions discussed below, in fact and by definition, are all distinguished by being part of *enceintes* (that is, surrounding barriers or enclosures). Enceintes are barriers that prevent access to and, almost always, obscure vision of a particular location. They can consist of raw or daubed wooden palisades, earthen banks (ramparts), and walls of rammed earth, adobe, baked bricks, and natural or shaped stone. Modern Western military historians and analysts refer to such defensive palisades, ramparts, and walls as "curtains" or "curtain walls." However, many, if not most, of these curtains also were fronted by ditches. Thus, many enceintes consisted of a ditch or ditches backed by a curtain. It is important to note, however, that while curtain walls always act as barriers, they may not have always had a military function. To be considered *defensive*, their primary function must be a military one.

Curtains

For example, curtains serve as extensions of the shield; i.e., they protect defenders against the weapons of their attackers while allowing the former to use their most effective weapons (ideally, those most lethal at the longest range and with the highest rates of fire) against the latter. They provide a screen of maneuver for the defenders by hiding their strength and movements from attackers. If the curtain provides a raised platform for defenders, it increases the force (via gravity) and accuracy (via a better view) of defenders' weapons while decreasing those of their attackers. Curtains also deter *escalade*, i.e., the passage of attackers over (or, by destruction, through) a defended perimeter. However, all curtains are vulnerable to *escalade* and destruction if attackers are allowed to reach their base. Once they reach the base of a curtain, these surficial barriers themselves shield the attackers, causing defenders either to expose themselves to discharge missiles or emerge from behind the enceinte in a "sally" counterattack.

Many curtains and enceintes known to history and ethnography had more than just a military function (e.g., see most papers in Tracy, 2000). The walls of ancient and medieval cities were primarily defensive but also served as "customs" barriers, channeling goods through gates where they could be monitored and taxed. Indeed, the hated Farmer Generals' (or Customs) Wall around Paris, destroyed by a Parisian mob during the French Revolution, was built in the 18th century solely for this purpose (Schama, 1989, pp. 385–386). Some walls were intended to keep insiders *in* rather than keep outsiders *out*, as at modern prisons and concentration camps, and as was the case with the Berlin Wall and other Iron Curtain frontier enceintes. The college walls of the oldest Oxford colleges, high and topped with fearsome spikes or broken glass, originally had a defensive function during the occasional but bitter 13th and 14th century "town and gown wars" (Wooley, 1975, pp. 4–5). Yet these college "defense walls" were maintained into the 20th century, long after attacks by townspeople or other medieval outsiders had faded into legend because they inhibited the post-curfew egress and ingress of resident college undergraduates (personal observations of the senior author).

Some curtains primarily protected a group's or household's privacy, especially of elites, from personal contact with and the gaze of others (especially the *hoi polloi*) and served as a defense against thieves and seducers. A familiar example was the large atrium house typical of the historical Near East and Mediterranean, having blank exterior walls broken only by one or two gates, with all other doors and windows opening only into the interior atrium (Ling, 1991, p. 364). Some enclosure walls had no defensive functions but prevented the multitude from seeing or entering sacred locations and temple precincts, such as the *temenos* of ancient Egypt and the Near East (e.g., Aldred, 1984, p. 108; Macqueen, 1986, pp. 116–117; Mazar, 1990, pp. 492–495; Toy, 1955, p. 2). The "henge" enclosures of prehistoric Late Neolithic and Bronze Age western Europe with their ramparts outside the ditch (an indefensible or even antidefensive arrangement), such as Giant's Ring and Avebury, seem to have had primarily a ritual function (e.g., Champion *et al*., 1984, pp. 173–174; Mallory and McNeill, 1991, pp. 74–77). Therefore, as we stated earlier, while curtain walls are always barriers, they may not have always had a military function.

Ditches

Defensive enceintes often included ditches parallel to and just outside of the curtains (Figs. 1 and 2). The spoil removed from any excavation must be put somewhere and, to save the labor of transporting it, preferably nearby (as all archaeologists who must first place, almost inevitably later move, and finally replace their backdirt are painfully aware). The least labor of transport involves putting the spoil from excavation right next to it. Logically, the spoil from defensive ditches would be used to create earthen ramparts, to daub wooden palisades, or to thicken the brick or stonewalls behind them. However deep, whether dry or "moats" filled with water, fortification ditches just in front of the curtain wall discourage undermining of the curtain. All offensive mine tunnels must either pass several meters beneath an enceinte's deepest defensive ditches or, if emerging into them, risk close-range exposure to defenders' weapons and sallies. Ditches, especially those that are V-sectioned and thus the deepest for their excavated volume, cut horizontal, self-supporting, consolidated sediments and rock strata below the surface and thereby weaken the roofs of any tunnels passing beneath them.

Because of their geometry, V-cross-section ditches more than a meter or so deep have long been recognized as especially defensive. Their surface width, depth, steep sides, and narrow bottoms make them difficult for attackers to negotiate. This was well recognized by the Romans, who called such ditches *fossae fastigata* (sloped or pointed ditches), and used them often to encircle their fortifications (Johnson, 1983, pp. 47–50). These were noted as being used by Roman legions and specially recommended by the Roman military writer Hyginus (Johnson, 1983, pp. 47–50; Miller and De Voto, 1994, pp. 88–89). In fact, for simple geometric and mechanical reasons, V-sectioned ditches are unsuitable or inefficient for other conceivable purposes (see Appendix A). Their greater depth relative to volume, sloping sides, and narrow bottoms make them an awkward and inefficient source of spoil and difficult to excavate. The large circumference of their sides relative to their volume means they are more prone to erosion than other ditch forms (i.e., semicircular and shallow trapezoidal) when filled with *moving* water. Both of these reasons are why irrigation ditches, aqueducts, and moats have long been trapezoidal, square, or semicircular in cross section. Indeed, an ancient Indian military manual, *Kautiliya Arthasastra* (c. 300 B.C.), recommends

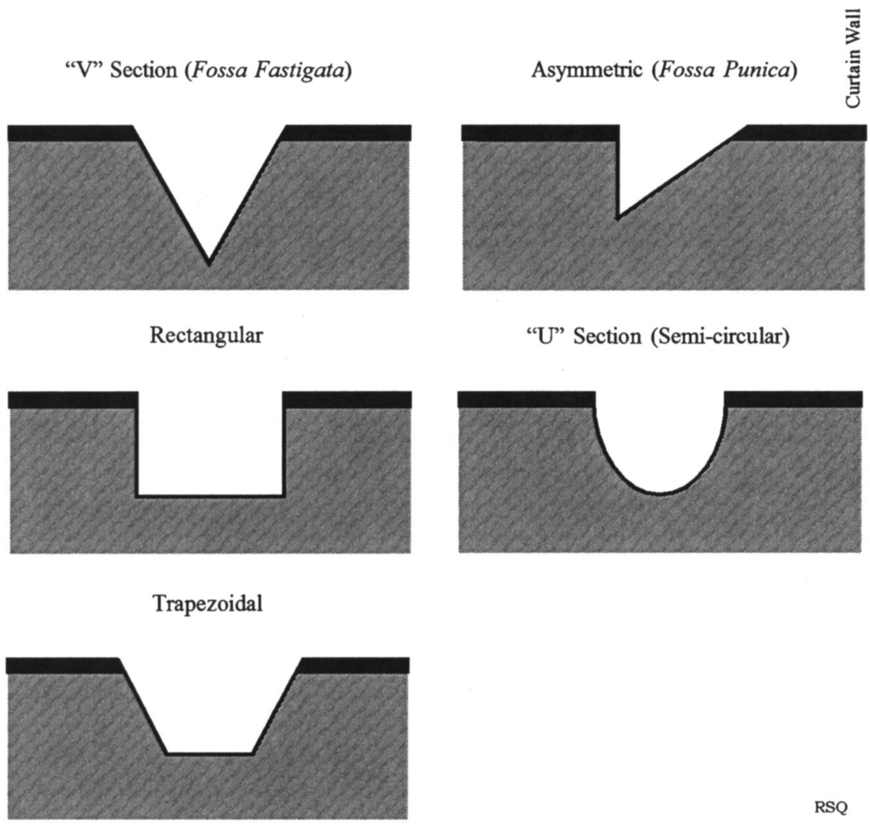

Fig. 1 Schematic ditch sections

that water-filled moat ditches be trapezoidal in cross-section (Kangle, 1972, p. 62). When Julius Caesar's army built siege fortifications (a contravallation) in A.D. 52 surrounding the Gallic hillfort of Alesia, the Romans dug two 2.4–2.7-m deep ditches in front of their curtain wall. The innermost (i.e., closest to Gallic Alesia), a water-filled moat, was trapezoidal in section, while the dry ditch just below the Roman palisade was V-sectioned (Keppie, 1989, pp. 181–183). The easiest ditches to dig are square or rectilinear, which are also good for irrigation and reasonably good for drainage.

A V section is also the most stable section for a ditch if the slope of the sides is at or below the angle of repose for the sediment through which it is dug (e.g., 35° for loose sand, much higher for more cohesive sediments such as silts, loams, and clays) and it is dry, meaning it does not carry water. This is because this form is least subject to mass wasting and sheet erosion (see Leopold *et al.*, 1964, pp. 333–388, 486–504; Longwell *et al.*, 1969, pp. 33, 163–166). A small sump slit and/or periodical cleaning could catch what little natural fill accumulated at the bottom. A Roman *fossa fastigata* had to be periodically dredged (by shovel) of accumulated sediment, one of the least popular duties of garrison soldiers. Indeed, one plausible theory for the deeper, narrow slits commonly found at the bottom of such fossae, unmentioned by classical authors, is that they were a consequence of repeated cleanings of the very bottom of the ditch with a shovel (Johnson, 1983, p. 47). We have found such slits at the bottoms of several Early Neolithic (c. 6200 B.P.) V-sectioned ditches in northeastern Belgium. Most of our Early Neolithic *fossae fastigata* show no signs

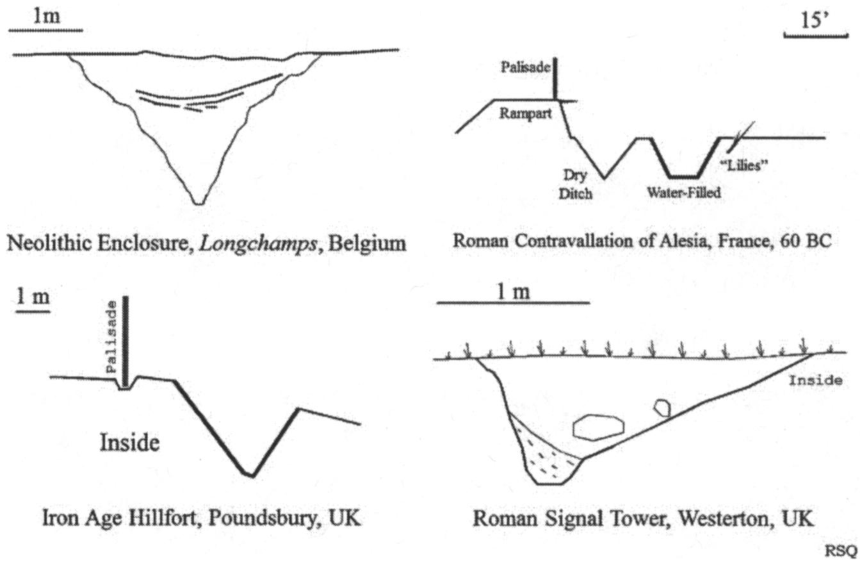

Fig. 2 Actual defensive ditch sections. Redrawn from L. Keeley field drawing and photos; Dyer (1992); www.romangask.org.uk/Pages/Papers/EastMid%20Lamb.html

of being cleaned or recut, although some newly uncovered ones nearby do (D. Bosquet and I. Jadin, personal communication, 2002). Regarding Roman V-section trenches, other popular explanations of these slits are that they act as (1) "ankle-breakers" to entrap the feet of anyone scrambling to climb up the steep walls from the narrow bottom of these trenches or (2) catchment drains or sumps to keep the trenches as dry as possible (Johnson, 1983, p. 47).

Roman fortifications also used an asymmetric, shallower type of V-sectioned ditch that had a gentler slope on the inner side (closer to the curtain) and a steeper slope on the outer side, called a *fossa punica* (Fig. 1). The adjective *punica* in Latin became an ethnic slur (against Carthaginians) meaning "tricky" or "treacherous" (Cassel's New Latin Dictionary, 1960, p. 454, *poeni*; it survives in English in the ironic oxymoron, "punic faith," see Webster's College Dictionary, 1997, p. 1057, punic). This form was used for ditches distant from the curtain, usually the outermost of a double or triple concentric ring of ditches (Johnson, 1983, p. 47). The shallower slope on the inward side exposed any attackers trying to shelter in the ditch to the unrestricted view and fire of defenders atop or along the curtain wall. The steep or vertical slope of the outer side made them difficult to clamber out of in retreat. This asymmetric form emphasizes one defensive advantage all V-sectioned ditches possess over other forms—exposure to fire from the curtain. Other more steeply sided forms can provide attackers reaching their inner walls a haven from defenders' fire (e.g., rectangular; Fig. 1). This protected "shadow" on the side nearest the enemy is why *trenches* (or fox holes) occupied by defenders are inevitably rectilinear or steeply trapezoidal in cross section, such as the famous ones of WWI (Strachan, 1998, pp. 43, 51).

Shallower and more U-sectioned ditches may or may not have a strictly military function. Often they seem too shallow or narrow (<1.5 m wide, ca. 1 m deep) to serve as much of a defensive barrier (although see below). On enceintes, they may have simply been a source of earth for ramparts or revetments or daub for palisades. At Early Neolithic Linearbandkeramik (LBK) sites in Belgium, the U-sectioned ditches along the palisades have more or less the same cross sections and depths as the daub pits alongside the houses. Many prehistorians would consider a defensive function for a ditch only if it were several meters wide and deep. For example, Mallory and McNeill (1991, pp. 35–36) are unimpressed by the 3-m-wide and 1–2-m-deep ditches of what they recognize as the defensive perimeter at an Early Neolithic enclosure in Ireland—"a schoolboy could have leapt across." They regard these ditches as mostly psychological and symbolic barriers. Tringham (1971, p. 174) claims that similarly wide (3–5 m) and deep (1.1–1.3 m) ditches at Eneolithic sites in eastern Europe were too "shallow" to be defensive and instead served as settlement "demarcations" and possibly as barriers to (only) nonhuman animals.

On the contrary, several classical military authors indicate that for centuries the Roman army was less finicky. At the end of every day's march, if no existing fort were available, Roman Republican and Imperial army units would fortify their encampments using a rigidly prescribed plan (a habit noted and admired by both Polybius and Josephus who had been defeated and captured by the Romans). According to Polybius (c. 180 B.C.), a ditch 3 ft (0.9 m) deep was sufficient to defend a camp, but when enemy cavalry was nearby, a ditch 12 ft (3.6 m) wide and 9 ft (2.7 m) deep was recommended. Josephus noted that the Roman camps he observed in Judea were often defended by ditches 6 ft (1.8 m) deep and wide, but, like Polybius, he does not specify a cross section (Josephus, 1970 [c. A.D. 75], p. 195). Claiming agreement with many earlier classical military authors, Hyginus (c. A.D. 170) recommended that V-sectioned fortification ditches (*fossae fastigata*) be at least 5 ft (1.5 m) wide and 3 ft (0.9 m) deep (Miller and De Voto, 1994, pp. 88–89). Later, when the Roman army had become much more defensive-minded, Vegetius (c. A.D. 390) also recommended temporary encampments be surrounded by a ditch 5 ft wide and 3 ft deep. When danger was less pressing, he considered that more permanent fortifications should have a ditch 9 ft (2.7 m) wide and 7 ft (2.1 m) deep, but have a ditch 12 ft (3.7 m) wide and 9 ft (2.7 m) deep when the situation was threatening (Bachrach, 2000, pp. 214–215; Grant, 1974, p. 300). While problematic in scale and perspective, several panels of Trajan's Column (c. A.D. 110) portray Roman soldiers digging or walking along the bottom of fortification ditches (Miller and De Voto, 1994, plates XI–XIII); none depict a ditch deeper than a soldier's breastbone—1.3–1.4 m. [In the 360s, the minimum height for a Roman legionnaire was lowered from 1.8 m to 1.72 m (Tomlin, 1989, p. 238); breastbones are at about 75% of full height or 1.3–1.35 m.]

Considering all this ancient testimony, it is clear that Roman military officers and engineers found ditches approximately 1.5 m wide and 1 m deep (probably most were V-shaped), when backed by a curtain, extremely useful defenses. These sources do recommend deeper ditches, but none more than 3 m deep. We would suggest that the most successful army of the ancient world, which for centuries fortified its camps as well as its more permanent settlements and successfully defended these countless times, was a more reliable judge of the minimal and optimal dimensions of defensive ditches than modern archaeologists.

Along many prehistoric enceintes, the ditches are interrupted or discontinuous, with ditch sections typically varying in length but little in depth. The reasons for the interruptions are unclear. One hypothesis is that as the lines of such ditches seldom follow a level contour, any rainwater collecting in the ditch would run to its lowest end (Daniel Cahen, personal communication, 1989). The greater the uninterrupted length and/or slope of the ditch, the greater the velocity of the flowing water and the more sediment the flow would pick up and carry. Thus, moving water would undercut and collapse the middle sections of a ditch and rapidly fill its lower end with sediment. The problem of sedimentary fill may be why Philo (c. 230 B.C.) recommended that unless waterlogged ground made it impossible, fortification ditches "should be absolutely dry" (Lawrence, 1979, p. 81).

Another popular explanation for these "interruptions" is that the ditch segments represent the corvée levies assigned to different teams, households, or small kin groups, the length of each section depending on the size of the work groups assigned to it (Audouze and Büchsenschultz, 1991, p. 85; Dyer, 1992, pp. 15–16; Mallory and McNeill, 1991, p. 78). What is needed to decide between these two plausible explanations is a study of the relationship between ditch segment length and slope. If the "hydraulic" hypothesis is correct, then outside of complex gate areas, the bottoms of longer ditch sections should have low slopes and short ditch sections should traverse steeper slopes. If the "social unit" hypothesis is correct, then away from complex gates, segment length should show no correlation with the slope of either ditch bottoms or natural topography. It appears that the continuous defensive ditches (which characterized European protohistoric and historic Iron Age fortifications) generally followed level contours interrupted only by gates (Audouze and Buchsenschultz, 1991, p. 87, Fig. 46; Dyer, 1992, pp. 9–11). In any case, even "interrupted" ditches produce spoil for earthen ramparts and daub to fireproof wooden palisades. When wider than a running stride (>2 m) and deeper than chest high (>1.3 m), they would inhibit the ingress of attackers, and their interruptions would channel attackers' approach to just a few sections of the curtain selected by the defenders.

Defended gates

Until the age of large cannon, gates were the most militarily vulnerable part of an enceinte. Gates are breaks in otherwise continuous defenses and, therefore, attract attacks. At least one gate through the enceinte must also serve the peaceful function of allowing access to the interior for prosaic, nonviolent but absolutely necessary purposes. While gates may serve their intended military function but once in a human lifetime, they must also be transited daily by humans, livestock, and vehicles carrying on the activities that sustain and enhance human life. The most heavily trafficked gates are usually located at the very points where natural barriers to access are minimal or nonexistent—on gentle slopes, across from fords in adjacent streams, on peninsulas bridging adjacent lakes and marshes—making them the best targets for infiltration. Because of this, gateways must always be defended.

The best general definition of "defended gates" is by Lawrence (1979, p. 304), speaking of ancient Greek examples: "The basic principle of their design was to subject the enemy to fire from as many directions as possible but especially against the unshielded right side and over as long a distance as possible." Like ditches, ramparts, palisades, and walls, defended gates provide defenders with protection, height, and a "screen of maneuver." We discuss three main types of defended gates: baffled, screened, and flanked.

Baffled gates

Baffled gates are one of the most ancient and long-used type of defended gate. They also are referred to as lateral, bent axis, offset, staggered, crab-claw, serpentine, and labyrinthine gates (Fig. 3). The simplest form of such gates merely overlaps curtain defenses (i.e., ditches, ramparts, palisades) to form an indirect and flanked entrance passage. A slightly more complicated form extended the curtain wall either outward or inward where the curtain turned parallel with the enceinte (e.g., bent axis). Such twice-bent extensions of the curtains were called *clavicula* by the Romans, who used them extensively in their fortifications, even at their most temporary camps (Johnson, 1983, p. 50; recommended by Hyginus, c. A.D. 170, Miller and De Voto, 1994, pp. 90–91).

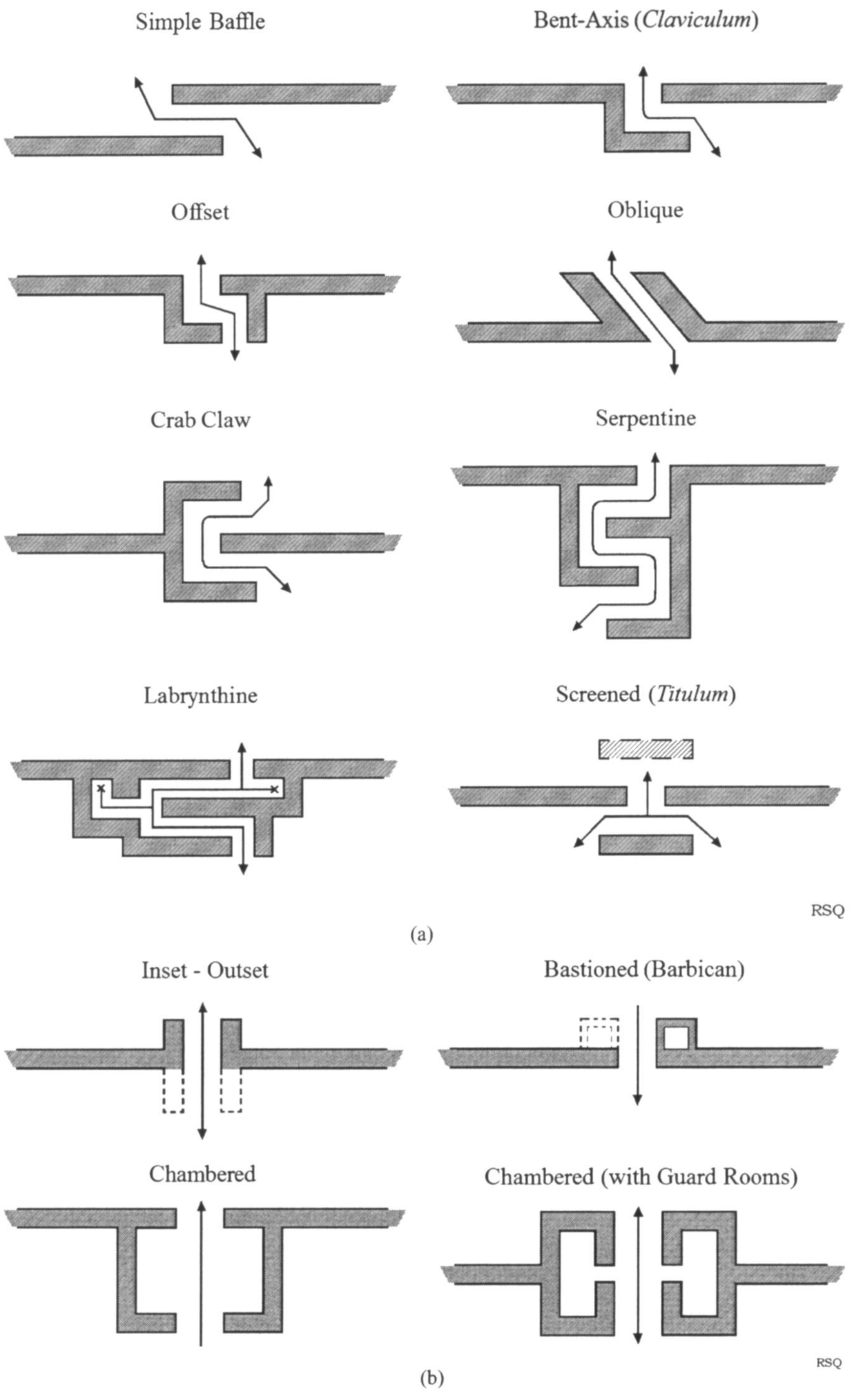

Fig. 3 **(a, b)** Schematic defensive gate plans

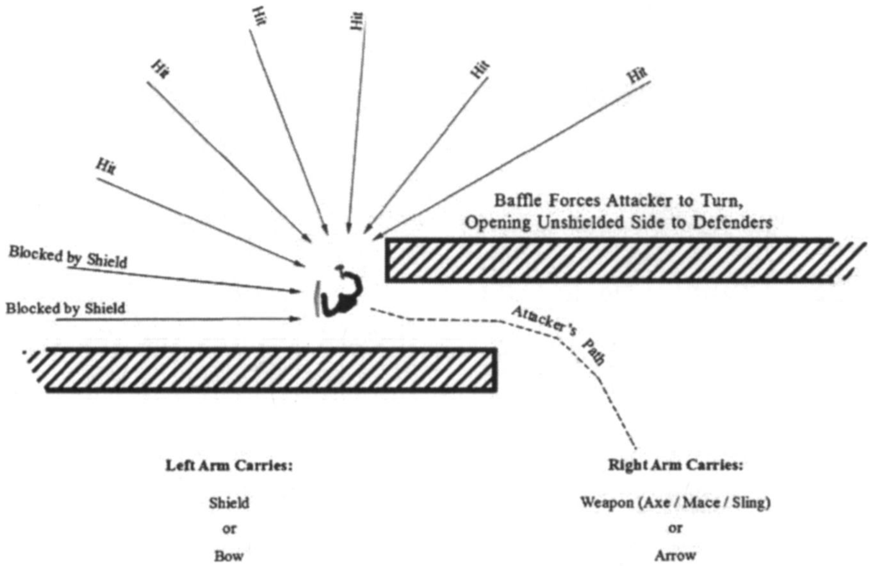

Fig. 4 Baffle gate use

Baffled gates force attackers who enter them to expose their flanks and rear to defenders' fire. Ideally, they require attackers to turn left exposing their unshielded right side (Audouze and Buchsenschultz, 1991, p. 97; Badawy, 1966, p. 56; Johnson, 1983, p. 50; Lawrence, 1979, pp. 80–81, 309, 332; Macqueen, 1986, p. 66; Toy, 1955, p. 31). Left-turning baffles also were useful against (typically) right-handed bowmen (see Fig. 4). Given the prevalence of such ancient left-turning baffles, Lawrence (1979) wonders why no ancient leader thought to form a gate assault force composed completely of left-handers. However, as Database 1 shows, despite the almost universal prescriptions of ancient military engineers and modern scholars, right-turning baffled gates seem almost as common as the more "rational" left-turning entrances. In some cases, a series of baffles was used to create a sinuous or serpentine gate. These more complex baffled gates often included false turnings into dead ends or traps, in which case such gates can be called "labyrinthine" (Figs. 3 and 5). Because baffled gates are so restrictive and difficult to negotiate for peaceful, everyday traffic, at historic fortifications such gates were primarily used for narrower "postern" (secondary) gates or "sally ports" (gates from which striking parties of defenders emerge to clear walls or destroy siege works). Both Philo (c. 250 B.C.) and Vitruvius (c. 30 B.C.) recommended that posterns and main gates should be "crooked," "at an angle" with left lateral turning approaches (Lawrence, 1979, pp. 80–81, 309, 340–341).

As Database 1 indicates, baffled gates were used at some of the earliest known fortifications. They were observed by (and sometimes bedeviled) the first Europeans, who faced native fortifications in Africa, Mexico, and eastern North America (e.g., Cortez, 1986, pp. 57, 153; McNeill, 1991, p. 56; HNAI 15, 1978, pp. 278, 377; Hudson, 1976, p. 212; Malone, 1991, pp. 14, 17). Even after fortifications were built or modified to withstand cannons, bent axis and baffled gates were still being used, such as at the Koskino and St. George's Gates at Rhodes (A.D. 1480–1510), at Bijapur (A.D. 1565), Fort St. George (Madras, 1760), and many other fortifications in India (Toy, 1955, pp. 238, 240, 1957, pp. 21–29, 41–44, 69, 109, 127).

Screened gates

Another ancient and common form of defended gate is the screened gate at which a barrier covers the gate in front or behind, or occasionally both (Figs. 3 and 5). A screened gate acts as a paired baffle gate with one access turning left, the other turning right. The Romans

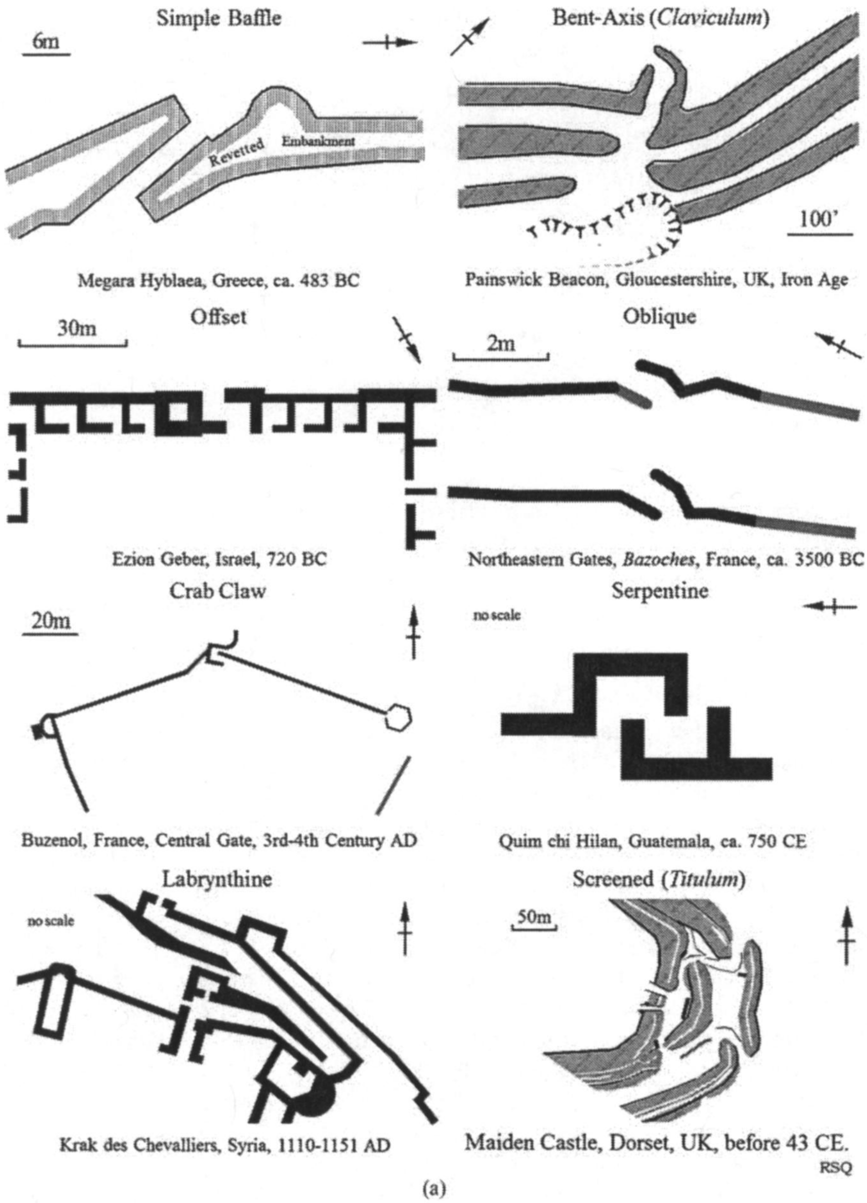

Fig. 5 Actual defensive gate plans. Redrawn from Andersen (1997), Barkay (1992), Barnes (1999), Cunliffe (1997), Demarest *et al.* (1997), Dyer (1992), Hogg (1981), Lawrence (1979), Mazar (1990), Wrightman (1985)

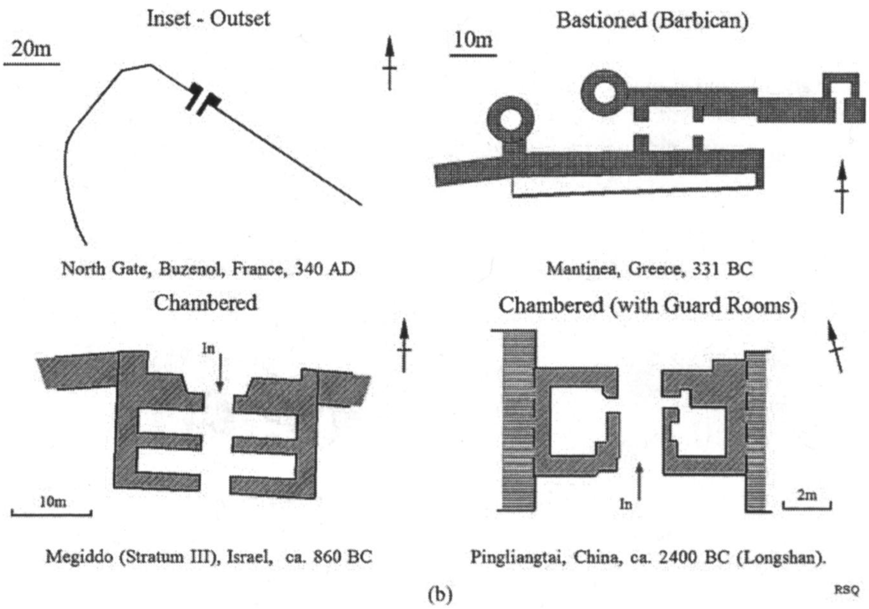

Fig. 5 Continued

called this gate type a *titulum* and used it extensively in their fortifications and fortified camps (Johnson, 1983, p. 50). Like baffles, screened gates appear at some of the earliest known fortifications (see Database 1).

Flanked gates

A third common form of defended gate was the flanked gate. As with baffled and screened gates, there are inset and outset forms (Figs. 3 and 5). These gates had a straight or direct entrance but were flanked on one or both sides by defenders' walls or towers, thereby creating a passageway that might be blocked or gated at both ends. In all times and places, this flanked form was commonly used for "main" gates probably because, compared with baffles and screens, it better accommodated the ever-necessary and incessant peaceable traffic. However, for this very reason flanked gates are more militarily vulnerable than baffled or screened gates. Therefore, the flanking features were seldom merely inward extensions of the palisade, rampart, or wall of the enceinte. Instead, towers or bastions (which allow a greater concentration of defenders and their fire) usually flanked such gates (see Figs. 3 and 5; Database 1). Closed gates at both ends of the passage created by such inset—outsets would confront any attacker breaching the outer gate with another sealed gate while they were under close attack from defenders on the flanks.

One form of the flanked gate, the *chambered* gate, was very popular for use as main gates from the Neolithic until very recently (Figs. 3 and 5). The simplest type has an inner and outer portal separated by a chamber, small courtyard, or, on either side, paired "guardrooms." At most historical fortifications, main gates had several constricted portals separated by chambers/courts or flanking guardrooms. If the court between the portals projected outward from the enceinte, it was called a *barbican* gate (Fig. 3), a form found at many medieval fortifications. Despite their universal and long popularity, we have yet to discover a clear statement regarding the military or strictly defensive function of gate chambers by any ancient author. Modern authors also offer little explanation (but see Lawrence, 1979, pp. 321–322; Toy, 1955, pp. 13–14) except citing one instance at a siege of Athens where the gate chamber was used as a trap for attackers. While the military benefit of several successive gates in a flanked passage is obvious, that of the intervening chambers is unclear. Given that chambers are typically used as main gates where the most civilian traffic would pass, along with their resemblance in plan to modern toll/ticket booths, we suspect that one of their principal functions was to police and toll those who pass through them. Nonetheless, it is difficult to imagine what regulatory purpose would be served by placing four to eight police/toll stations *in succession* on both sides of a gate passage.

Inner chambers or courtyards were a common feature of many unequivocally defensive baffled or screened gates (e.g., Boyd, 1988, p. 1694; Cooper, 2000, p. 188; Gravett, 2001, p. 166; Khanna, 1981, p. 141; Lawrence, 1979, pp. 312, 327; Mazar, 1990, pp. 384, 466; Toy, 1955, pp. 59, 92). Such gates also were common at historical forts that had an almost purely military function (e.g., Kennedy and Riley, 1990, pp. 181, 195; Lawrence, 1979, pp. 312, 384; other examples in Other References for Database 2, fortification categories E and F). These specialized uses and their long-term and universal presence at most historical fortifications are strong circumstantial evidence that gate chambers were useful for defense (almost every fortification listed in Database 2 had at least one chambered gate). We suggest that chambered gates represent a compromise between military defense, peaceful ready passage, and regulation of traffic through the most heavily traveled gates.

Simple *outset* flanked gates have been found at several prehistoric European enclosed sites that gave evidence only of ritual or nonprosaic activity, especially circular "ring ditch" enclosures from Neolithic and Bronze Age with spoil from the ditch piled on the exterior side (e.g., Stonehenge). Earlier Neolithic examples also may have had defensive function because their ramparts were on the interior of the ditch.

Regarding the hypothesis that prehistoric enclosures were simply livestock corrals, at best only simple flanked gates would be useful as corrals; baffled or screened gates would be pointless for this purpose. Even today, cattle- and sheepherders use inset and outset flanked gates (livestock chutes) to count the livestock leaving and entering their corrals. But domesticated cattle and sheep, rendered dumb after generations of human selection, can be considered already naturally "baffled" (e.g., domestic cattle will not cross a floor grate of horizontal bars or even solid ground painted with parallel stripes to mimic a grate). In addition, baffled or screened entrances would not deter nonhuman predators any better than would a simple closed gate too high to jump. A 1738 depiction of an 18th century African enclosure (Fig. 6) graphically illustrates these points (McNeill, 1991, p. 56). The outer barrier, protecting the cattle corral and cornfield, consisted of intertwined thorn bushes broken by two simple undefended gates. On the other hand, at the center of the outer enclosure, the actual village was surrounded by a palisade, broken by a single baffled gate. For these African villagers, then, a simple gate was sufficient to retain and protect their crops and livestock, whereas a baffled gate was necessary to defend their houses and persons. No enclosure with a baffled, screened, or chambered (main) gate can be just a livestock corral but must have, at least in part, a military defensive purpose.

Bastions

Bastions are external projections of a barrier large enough to hold several defenders and their fire weapons. Their purpose is to inflict flanking fire on any attackers closely approaching the enceinte and adjacent bastions. Bastions also are often towers. This extra elevation is

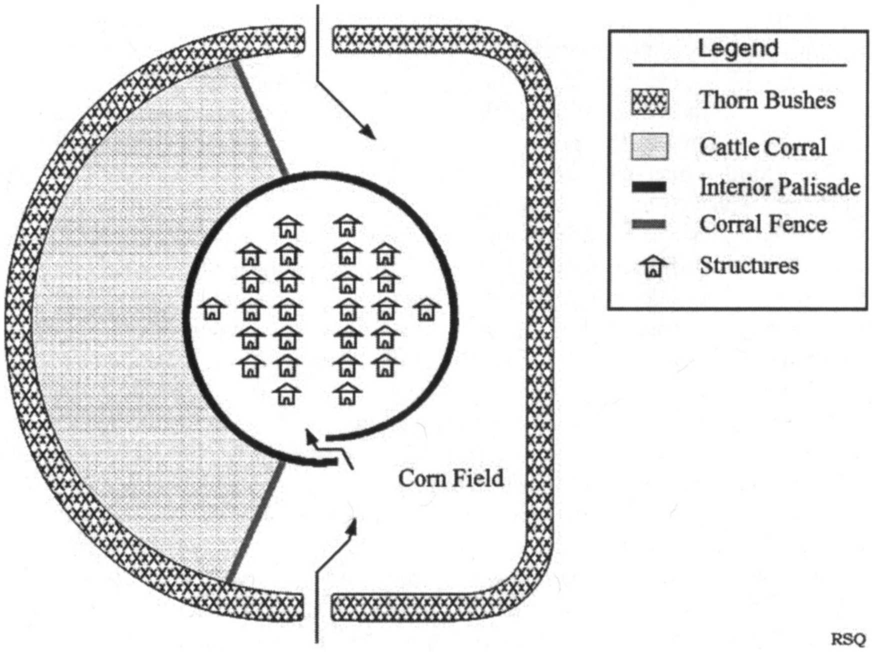

Fig. 6 Eighteenth century African village enclosure. Redrawn from McNeill (1991)

not necessary for their function but, relative to the top of the curtain, does increase the force of missiles projected from them and enhances their defenders' surveillance of their field of fire. The greater height of bastions can be archaeologically invisible because only their bases survive. But bastion bases that exhibit heavier construction than that found along curtains (e.g., larger and more closely spaced postmolds, larger or more solidly constructed foundations) implies they supported a heavier, probably higher, superstructure.

Bastions also may serve as buttresses for high, sheer walls. However, because they must accommodate one or more defenders along with their weapons, they need to be of a much larger dimension than mere buttresses. Compared with internal buttresses, external buttresses on fortifications are rare because they endanger the fortification walls (Lawrence, 1979, p. 207; Toy, 1955, pp. 14–15). Given buttresses' architectural function, an attacker need only undermine a bit of their bases to bring down the entire section of wall they support. The external buttresses typical of high temple and palace walls in ancient Egypt and Mesopotamia are much smaller (less than 2 m in width or extension) and usually more closely spaced (less than 5 m apart) than the bastions of contemporary historically known fortifications (see Badawy, 1966). Indeed, Philo of Byzantium (c. 240 B.C.) recommends (vainly it would seem, given what actually was done throughout later history) that bastion towers not be closely bonded to curtain walls because fissures develop that can endanger their stability (Lawrence, 1979, p. 85; Toy, 1955, pp. 30–31). Regarding Philo's recommendation, it is interesting to note that the projecting bastions of the first fortifications at Cahokia (in Illinois), c. A.D. 1100, were complete ovals that had only minimal contact with the curtain wall behind them.

Only a few plan forms (Fig. 7; Lawrence, 1988) of pre-gunpowder bastions prevailed for millennia and can be found worldwide. The most common bastions were square or rectangular in plan. Whatever the costs of constructing the enceinte, these bastions were the simplest to build. Rectangular forms also are roomy, providing the optimal space for

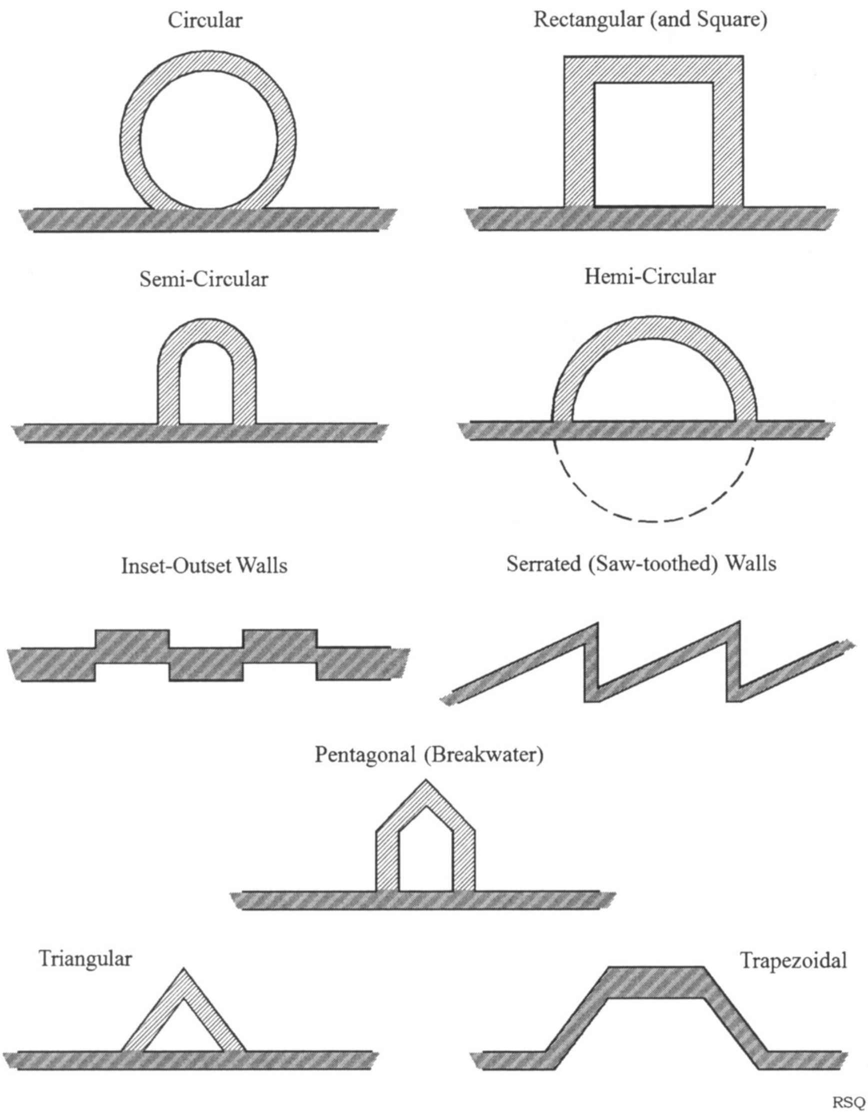

Fig. 7 Schematic bastion plans

defenders and artillery given their dimensions. However, there is an area of "dead ground" that protects attackers immediately in front of rectangular bastions (Fig. 7). Bastions of a triangular "breakwater" or pentagonal plan were rare until the age of cannons, even though they were highly recommended by Philo in 240 B.C. (Lawrence, 1979, p. 75). Geometrically, breakwater plan bastions were the form most easily defended by fire from adjacent walls and bastions because there is no "dead ground" beside or in front of them. Their rarity was probably the result of the extra curtain that was required and were thus more costly to build compared with a rectangular or oval bastion of similar projection. Plus, the former would crowd and limit the number of defenders who could use a bastion's most militarily effective point: its apex. Universally, semicircular or ovular plan bastions have been almost as common as the square and rectangular forms. Despite their difficulty of construction, Philo (c. 240 B.C.) also recommended round bastions and making special templates for their facing stones (Lawrence, 1979, pp. 75, 85). They shadow much less dead ground in their immediate fronts than the square or rectangular forms.

The spacing between bastions is highly variable but not random, and to some degree predictable. This spacing depends on topography, cost of materials, labor, and skill required for construction. To build 2 × 4-m bastions at 20-m intervals requires constructing 140 m of curtain for every 100 m of enceinte. Depending on the size of bastions, their internal structure, and their spacing, in many cases bastions would have increased the costs of construction between 30% and 100%. Some sections of enceintes overlooked naturally barred or impassable areas such as steep inclines or cliffs and deep waters that required, at the most, simple curtains with no expensive bastions. Construction costs would encourage builders to leave only the longest, militarily practicable intervals between them or eschew them altogether. Only the substantial military utility of bastions would induce builders to accept the extra costs of erecting them, and this military utility depends on the effective range of the defenders' weapons.

The optimal spacing between bastions would be between one half and one third the effective range of the principal defensive projectile weapons. This scheme allowed for the maximum intensity of covering fire, which would cover not only the adjacent recessed enceinte on either flank but the nearest two to three bastions and their approaches as well (Fig. 8). Bastions separated by more than the maximum effective range of defenders' primary weapons could not be mutually supporting. Bastion intervals greater than twice weapons' effective range would leave "dead or sheltered zones" in front of curtain walls where attackers could scale or undermine the curtain with relative impunity. The area immediately at the base of a wall is difficult to reach for defenders because they must expose themselves and lean over to fire at attackers just below. We found support for this bastion spacing scheme from Philo (c. 240 B.C.) who repeatedly recommended that bastion towers must be able to defend one another (Lawrence, 1979, pp. 79, 83). Vitruvius (c. 30 B.C.) advised that bastion towers not be spaced more than an "arrow's flight apart" so that the curtain between could be swept end-to-end by neighboring bastions (Toy, 1955, p. 31). In addition, Kern (1999, p. 11) notes of ancient Mesopotamian fortifications (3000 B.C. and later):

> "By placing towers no further apart than the range of such projectile weapons as bow, sling and spear—about thirty meters—the architects not only ensured that there would be no dead space between the towers but also made the full length of the wall subject to flanking fire from two directions."

Incidentally, the simple bow, sling, and javelin were all commonly used in defense of fortifications up till the age of cannon and where guns were few or nonexistent until the late19th century. As we argue below, this is the reason that fortifications with bastion intervals between 30 and 40 m were built for millennia, from the early Neolithic until just over a century ago.

The effective range of a fire weapon is the distance at which a weapon can inflict a fatal or debilitating wound and be aimed with accuracy to hit a vital part (called among today's handgun users "center mass") of the target. The striking force or kinetic energy that a missile delivers at impact depends on its mass and velocity (i.e., $1/2\ mv^2$). But before impact, air resistance and gravity slow and pull earthward all terrestrial missiles. Heavier and thus usually larger missiles require more force to discharge, are more subject to air resistance and gravity, and consequently have a shorter range. Lighter missiles are speedier, less subject to friction, and thus of longer range, but their smaller masses deliver less force except at close

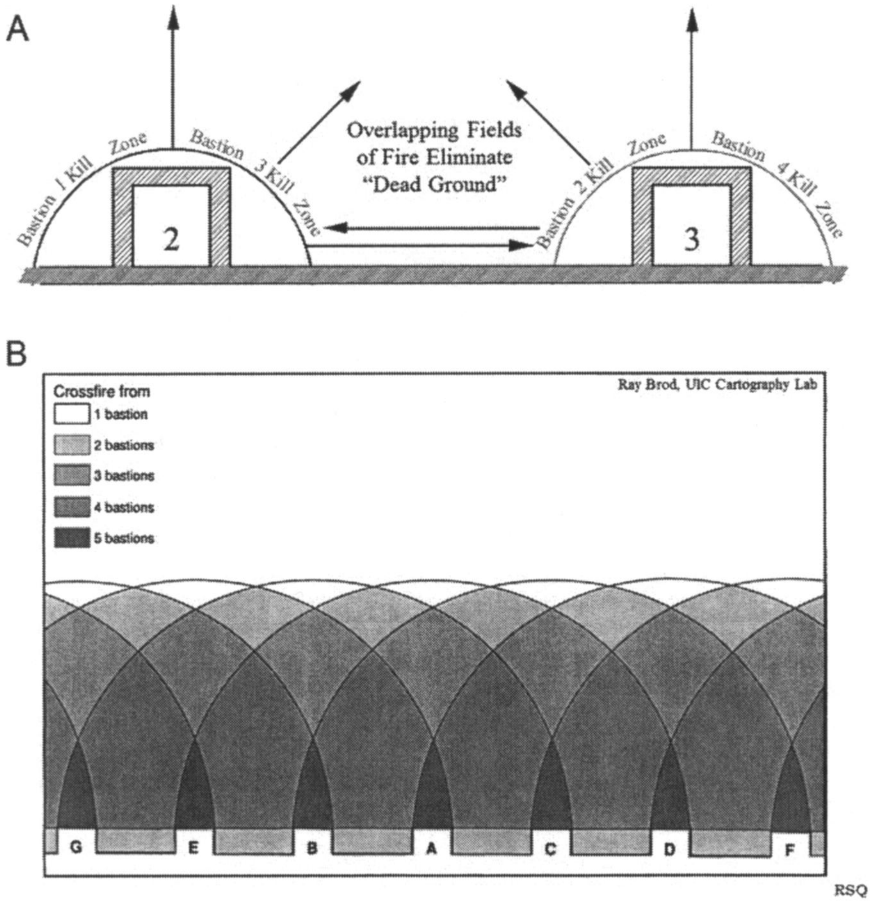

Fig. 8 Mutual fire cover among bastions

range. Accuracy also is essential in determining effective range. The military utility of any weapon is nil if it does not strike (or at least pass frighteningly close to) its human target. Most missile weapons can be used accurately at only a fraction of their maximum cast and of their much shorter maximum killing/wounding range. For example, modern high-velocity rifle bullets are deadly at ranges of two or three miles (3300–5000 m). However, today's most expert marksmen, even aided by electronic devices, can aim a bullet accurately enough to hit a stationary man-sized target at most only 1500 m away. [The "theoretical" range of the M16 assault rifle is only 500 m; in Gulf War I, using laser-computer sights, U.S. M1 tank gunners regularly hit Iraqi tanks at 3000 m and one British tank gunner at 5000 m (Clancy, 1994, pp. 55,156, Friedman, 1991, p. 283).]

The final component of the effective range of a weapon is a very human one, that is, the trained skill and physical abilities (strength, visual acuity, muscular coordination) of the wielder. For example, the sling is superficially an excellent weapon because it is simple to construct, uses widely available or simple-to-make ammunition, and releases a relatively heavy missile at a comparatively high velocity. The Roman army recruited only slingers who could hit a man-sized target at 185 m, but a slung missile, even a lead shot, could not inflict mortal or debilitating wounds at this distance (Ferrill, 1985, pp. 24–25; Gabriel and Metz, 1991, p. 75). Slingers this accurate were apparently rare even among those who had used the sling since early boyhood to drive livestock and assault predators, hence the Roman test. In contrast, recruits to Imperial Rome's sword- and javelin-wielding legions were not tested but trained in the use of their weapons. Josephus (A.D. 70; trans. Williamson, 1970, p. 195) observed that, even though the volunteer mercenaries of Imperial Rome's legions had not been "raised to battle," their constant training drills with sword, shield, and javelin were "bloodless battles," which meant their actual battles were merely "bloody drills." The deadly and celebrated archers of late medieval England, who decimated the armored knights and men-at-arms of France at Crecy and Agincourt, were recruited only from those who had constantly practiced using the longbow and its cloth-yard arrow since childhood (O'Connell, 1989, pp. 102–105). See Table 1 for more information regarding several historical, ethnographic, and modern experimental estimates of the effective and maximum ranges of various pre-gunpowder missiles cast or shot by skilled users.

Bastion intervals in the historical Old World samples, whether average or maxima (Table 2), can be best related to the maximum effective ranges of defenders' weapons. There was a general but stepwise increase of average and maximum bastion spacing over time (Fig. 9). A clear shift to longer spacing occurred after 750 B.C. when the compound bow became widespread among nonelites in the Near East and southeastern Europe. Bastion intervals of less than 20 m sometimes used in prehistory and early history were abandoned. Intervals of more than 60 m appeared after both handheld and stationary crossbows were introduced and became common (simultaneously) in China and Greece circa 375 B.C. After cannons came into widespread use (c. A.D. 1500), bastions were usually spaced more than 100 m apart, sometimes twice or triple that distance. Indeed, 16th century European fortification architects were recommending that the ideal interval between the tips of adjacent bastions was 250 m (Elbl, 2000, pp. 372–373, n. 82). When handheld guns or muskets became lighter, more reliable, and more widely available about A.D. 1600, some fortification designers recommended shortening the bastion interval to between 140 and 180 m (Hogg, 1981, pp. 115, 120). However, it is means and maxima, not minima, of bastion intervals that are most correlated with weaponry ranges.

Before the age of gunpowder, at all times and in all places there apparently was a marked preference for spacing bastions 25–40 m apart. This mode cannot be the result of constraints or compromises imposed by structural engineering or construction costs, because the same bastion interval is found in cases with quite different modes of enceinte construction, e.g., log or wattle-and-daubed palisades, earthen or rammed earth ramparts, adobe, fired brick or stone block walls. It is found along curtains and between bastions of varying height, thickness, and length.

The long and widely preferred modal range can be neither cultural nor stylistic (i.e., neither traditional nor arbitrary) because it characterizes too many different times in too many distant regions having independent cultural traditions. These various cultural traditions became separate and independent thousands of years before the first bastions appeared in their respective continents or subcontinents. For example, how could the builders of third and second millennium B.C. Near Eastern and southern European fortifications have culturally influenced their pre-Columbian (11th to 15th century A.D.) North American counterparts 3000 years later and half a world away? The simplest and most direct explanation for bastion spacing would be universally shared ranges of defenders' weapons. Javelins, slings, and bows were the weapons most commonly used by defenders of fortifications before cannons and muskets came into common use. Thus, worldwide and for millennia the average interval between pre-gunpowder bastions was often no greater than the maximum effective range

Table 1 Effective ranges of various weapons

Handthrown rocks	
30 m (i.e., equivalent to javelin)	D. Baatz, 1983, p. 136
Sling	
27 m	Editors of Time-Life Books, 1992, p. 27
46 m	Ferrill, 1985, p. 25
69–183 m	Gabriel and Metz, 1991, p. 75
100–400 m (maximum ranges)	Lawrence, 1979, p. 39
110 m (from high rampart, firing downhill)	Dyer, 1992, p. 23
Javelin	
11 m	Burton, 1966, p. 62
15–20 m	HSAI Vol. 3, 1948, p. 643
25–30 m	Johnson, 1983, p. 49
27–46 m	Meggitt, 1977, p. 57
30 m	Keeley, 1996, p. 51
30 m	Connally, 1989, p. 162
30–40 m	Lawrence, 1979, p. 40
46 m (maximum range)	Ferrill, 1985, p. 19
60–70 m	Ryan, 1981, p. 12
Spearthrower or atl–atl	
20–30 m	Crosby, 2002, p. 34
25–45 m	Cattelain, 1997, pp. 218–219
27 m	Darwin, 1909, p. 438
27 m	Cattelain, 1997, pp. 218–219
37–46 m	Crosby, 2002, p. 34
2002, p. 3440 m	Keeley, 1996, p. 51
Self-bow	
10–30 m (poison arrows)	Bartram, 1997, p. 329
15–20 m (poison arrows)	Burton, 1860, p. 477
20–40 m (poison arrows)	Bartram, 1997, p. 335
25 m (10 m optimum; poison arrows)	Lee, 1979, p. 217
27–37 m	Meggitt, 1977, p. 56
30–60 m	Kern, 1999, p. 51
46 m	Stewart, 1965, p. 375
46 m	Cattelain, 1997, p. 227
46 m	Malone, 1991, p. 22
50 m	O'Connell, 1989, p. 26
50–200 m (max. English longbow)	Keeley, 1996, p. 51
50–60 m	Drews, 1993, p. 105
90 m	Ferrill, 1985, p. 19
90–135 m	Gabriel and Metz, 1991, p. 67
100–165 m	Ferrill, 1985, p. 83
122 m	Stade, 1874, p. 22, n. 1
Sinew-backed or compound bow	
37–64 m	Grinnell, 1923 (1), p. 177
92 m	HSAI Vol. 1, 1946, p. 194
100–150 m	Gabriel and Metz, 1991, p. 67
Composite bow	
37–114 (max) m	Jenness, 1977, p. 31
100–180 m	Drews, 1993, p. 110
150+ m	Lawrence, 1979, p. 39
150–200 m	O'Connell, 1989, p. 103

Table 1 Continued

180–275 m	VanCreveld, 1989, p. 13
230 m	Gabriel and Metz, 1991, p. 70
230–275 m	Ferrill, 1985, p. 40
250–650 m	Wiseman, 1989, pp. 4—5
274 m	Keegan, 1993, p. 163
Crossbow (handheld)	
65–183 m	Hudson, 1997, p. xvii
73(eff.)–183 (max) m (repeater)	Temple, 1998, pp. 222—223
100–366 m	McNeill, 1982, p. 38
112–229 m	Temple, 1998, pp. 222—223
274 m	Ferrill, 1985, p. 171
300–915 (max.) m	Ebrey, 1996, p. 93
338–347 m	Toy, 1955, pp. 148—149
Catapult (dart-thrower) and ballista (stone-thrower); large fixed crossbows	
200–400 m (ballista)	Brice, 1990, p. 25
c. 275 m (max. ballista and catapults)	Gabriel and Metz, 1991, pp. 39—40
"several hundred meters"	O'Connell, 1989, p. 65
< 400–650 (max) m (catapult)	Lawrence, 1979, p. 46
580 m (1/2 max. range)	Temple, 1998, pp. 222—223
900m (max. China A.D. 618–907)	Shaughnessy, 2000, p. 177
Unrifled musket	
50 m	Weighley, 1991, p. 77
70 m	Chandler, 1966, p. 342
73 m	McPherson, 1988, p. 473
73–90 m	Keeley, 1996, p. 53
< 91 m	Gates, 1986, p. 20
100 m	Parker, 1988, p. 17
146 m	Hinds and Fitzgerald, 1996, p. 25
Smooth-bore cannon	
274 (canister)–732 (solid shot) m	Davis, 1983, p. 51
400 (canister)–900 (solid shot) m	Chandler, 1966, pp. 358–359

of the handthrown rock or spear (30 m) and no less than half the effective range of slings (50–80 m) and bows (60–120 m).

The length of enceinte is a rough measure of its cost, and because bastions dramatically increase costs, these costs should be positively correlated with bastion intervals—the longer the enceinte, the longer the intervals. At settlements, construction labor would be drawn primarily from those living within the area it enclosed. One could reasonably expect that fortifications enclosing larger settlement areas, thus housing more builders desiring protection, would show closer spaced bastions. Our data (Table 2) indicate that the lengths of fortifications and the areas of the fortified settlements were more or less irrelevant to bastion spacing. The built fortification lengths and defended areas of settlements are always less correlated with bastion intervals than either weapon ranges or chronology. Only at citadels, castles, and forts, where construction costs were derived (extorted?) from those outside the enceinte, are there high correlations between cost and bastion intervals. In our data, the variables that best and most significantly "predict" bastion intervals are weapon ranges and chronology.

A clear case of the relationship between bastion intervals and weapon ranges involves the late prehistoric (c. A.D. 1000–1500) fortifications of the Upper Missouri region (i.e., Middle

Table 2 Correlations with bastion intervals (using database variables as coded per Appendix B)

	Date (B)	Weapons (J)	Length (H)	Area (I)
A. All historical pre-gun fortifications ($N = 273$)				
Mean (C)	0.365	0.482	0.414	0.351
Maximum (E)	0.362	0.500	0.391	0.264
Minimum (F)	0.249	0.314	0.276	0.291
B. Historical settlement pre-gun fortifications (Categories A and B, $N = 129$)				
Mean (C)	0.540	0.509	0.310	0.317
Maximum (E)	0.588	0.565	0.239	0.189
Minimum (F)	0.308	0.288	0.213	0.285
C. Historical nonsettlement pre-gun fortifications (Categories C – F, $N = 144$)				
Mean (C)	0.410	0.393	0.256	0.233
Maximum (E)	0.384	0.368	0.388	0.365
Minimum (F)	0.341	0.295	0.010	0.017
D. All (including early gunpowder) historical fortifications ($N = 317$)				
Mean (C)	0.429	0.538	0.297	0.208
Maximum (E)	0.435	0.548	0.363	0.239
Minimum (F)	0.366	0.459	0.199	0.144
E. Historical (including early gunpowder) settlement fortifications (Categories A and B, $N = 147$)				
Mean (C)	0.551	0.537	0.211	0.166
Maximum (E)	0.604	0.588	0.243	0.176
Minimum (F)	0.438	0.424	0.143	0.120
F. Historical (including early gunpowder) nonsettlement fortifications (Categories C – F, $N = 170$)				
Mean (C)	0.442	0.580	0.467	0.428
Maximum (E)	0.443	0.545	0.563	0.526
Minimum (F)	0.394	0.539	0.329	0.299
G. Prehistoric and historical (including early gunpowder) fortifications ($N = 332$)				
Mean (C)	0.428	0.548	0.294	0.204
Maximum (E)	0.429	0.555	0.370	0.243
Minimum (F)	0.363	0.467	0.207	0.149
H. Pre- and historical (including early gunpowder) settlement fortifications (Categories A – B, $N = 159$)				
Mean (C)	0.530	0.560	0.277	0.171
Maximum (E)	0.573	0.608	0.273	0.193
Minimum (F)	0.419	0.442	0.167	0.132
I. Pre- and historical (including early gunpowder) nonsettlement fortifications (Categories C – F, $N = 173$)				
Mean (C)	0.432	0.578	0.466	0.428
Maximum (E)	0.429	0.542	0.564	0.528
Minimum (F)	0.390	0.541	0.325	0.298

Note. These are Pearson's r correlation coefficients calculated from Database 2 using Microsoft Excel. No probability (p) values are given because our database is too chronologically and geographically biased. These correlations do roughly indicate the strength of association between these variables in the Old World between prehistory and early Modern times.

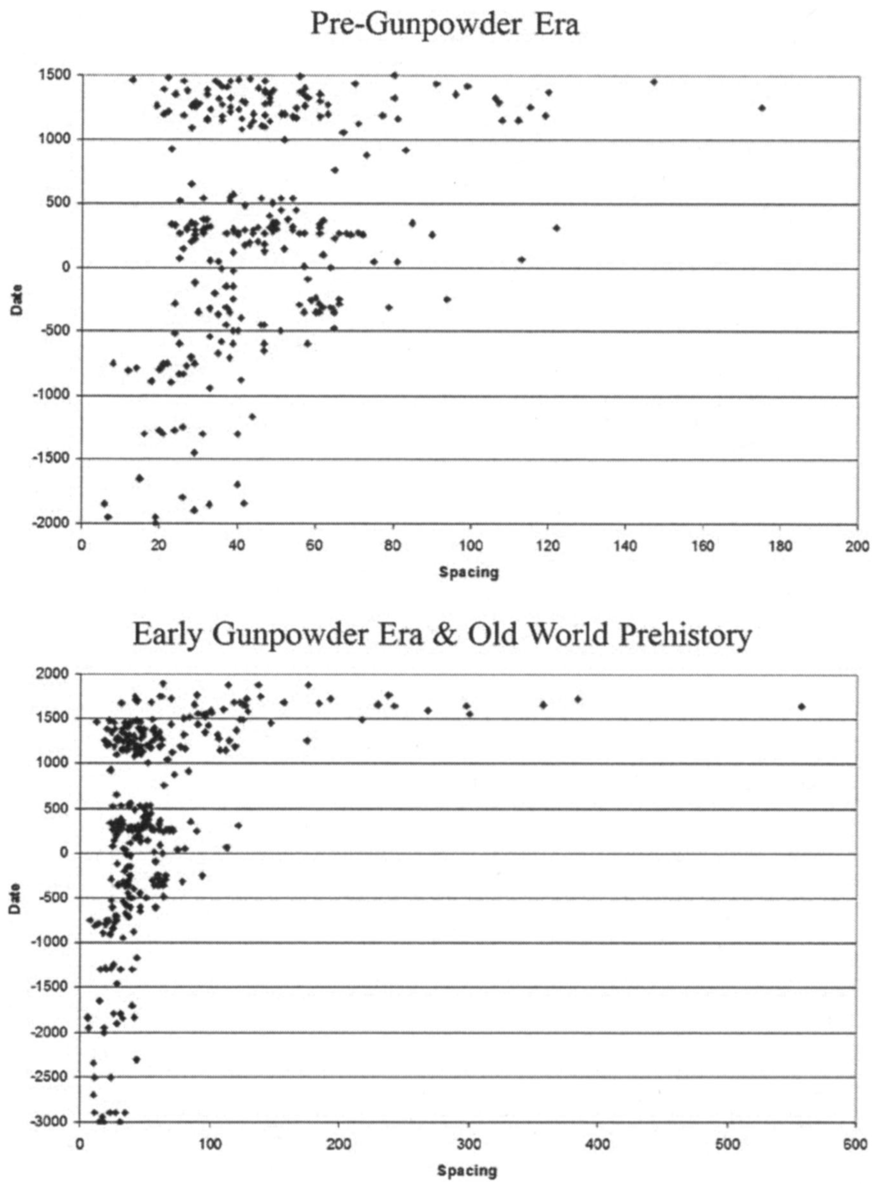

Fig. 9 Scatterplots of average bastion spacing vs. time

Missouri or Coalescent culture) compared with the contemporary ones of the eastern and southeastern woodlands (i.e., Mississippian culture) of North America (Database 2). The bastions of fortified villages on the Upper Missouri were spaced an average of 54 m apart [standard deviation (SD) = 13; range = 37–73], while those of contemporary Mississippians, hundreds of miles away, were spaced about 28 m apart (SD = 6; range = 20–38). Milner (2000, p. 58), with a larger sample of Mississippian fortifications, obtained a mean of 30 m (SD = 7; range = 21–44). Timber for palisades was generally more plentiful in the Mississippian region and scarcer in the Upper Missouri area of the Plains. However, the

Upper Missouri sites were located in or immediately adjacent to the riparian forests that, even today, line the rivers and major streams of that region. In any case they seemed to have experienced little difficulty obtaining, for hundreds of years, wood for their many houses and hearths. There was almost certainly a difference in weaponry between these two culture areas—Upper Missourians used sinew-backed compound and/or composite bows, while the Mississipians had only the shorter-ranged self-bow. At contact, a couple of centuries later, the Upper Missouri tribes (i.e., Mandan, Hidatsa, and Arikara, the direct cultural descendents of the late prehistoric Middle Missouri and Coalescent cultures) had composite bows made of both wood and horn strengthened with sinew backing. On the other hand, at contact, the tribes of the former Mississippian region (some, if not most, were cultural descendents of the prehistoric Mississippians) had only the self-bow and had not yet adopted either the compound or composite version (Driver and Massey, 1957, pp. 350–352, maps 137–138). Thus, prehistoric eastern North American bastions were spaced at one half the effective range of a self-bow at the same time that the intervals between bastions on the Upper Missouri were half the effective range of the composite bow.

On occasion and in very disparate circumstances, two curtain wall projections have served the same function as bastions; because of their plan forms, these are called inset—outset walls, sawteeth, or serrations (Fig. 10). In terms of simple geometry, both forms are much less costly and complicated to build than regular bastions. The inset—outset form appears only in a few Middle Bronze Age and Iron Age fortifications of Palestine (e.g., at Megiddo, Mirsim, Ezion, and Lachish, Barkay, 1992, p. 339; Hawkes, 1974, pp. 203–204; Kempinski, 1992, p. 175; Mazar, 1990, pp. 414, 428–429). The outsets in effect were shallow bastions projecting slightly from, but equal in width to, the inset sections of the curtain wall. However, in terms of plane geometry, the shallow extension of outsets lessened the range of defenders' weapons to the front of the enceinte and the angle of their fire at the flanks and (most effectively) the rear of attackers reaching the curtain or adjacent outsets.

Despite their lower cost, the relatively brief and very geographically limited use of inset—outset walls implies that these were a poor substitute for the long- and universally used bastions. While rare, the saw-toothed-plan form was used in Late Iron Age Palestine, centuries later in Iron Age Armenia and classical Greece, and, half a world away, much later independently invented in Inca Peru (Barkay, 1992, p. 342; Hawkes, 1974, pp. 145, 204; Hemming and Ranney, 1982, p. 69; Holladay, 1998, p. 378; Hyslop, 1990, p. 177; Lawrence, 1979, pp. 352, 354; Mazar, 1990, p. 439). Philo (c. 120 B.C.) recommended this "serrated system" for fortification walls on sloping ground (Lawrence, 1979, pp. 81–83). In terms of construction costs per length of enceinte wall, sawteeth are no more expensive than inset—outsets and less expensive than bastions. In terms of military utility, the curtain extensions or "cusps" of this form can be considered as half-bastions because defenders at their apex could provide only flanking fire covering the curtain and an adjacent bastion on one side. In the Near Eastern cases, the wall exposed to flanking fire was to the defenders' left (e.g., Arad, Lachish), while at Izbet Sartah and Karmir-Blur it was sometimes right and sometimes left. In the Peruvian (Sacsahuaman, Cuzco) and Greek (Gortys, Priene) instances, the flanked walls were to the defenders' right. Given the most efficient human stance for throwing or projecting rocks, javelins, sling stones, and arrows (i.e., left foot and side forward, right arm and side back), the Inca—Hellenistic form would require defenders to expose their backs to enemy missiles coming from further away to fire at attackers near the curtain. On the other hand, this form would expose the unshielded right side of attackers reaching the wall to flanking fire. The military advantages and drawbacks for defenders of the Near Eastern "exposed left" version would have been exactly reversed.

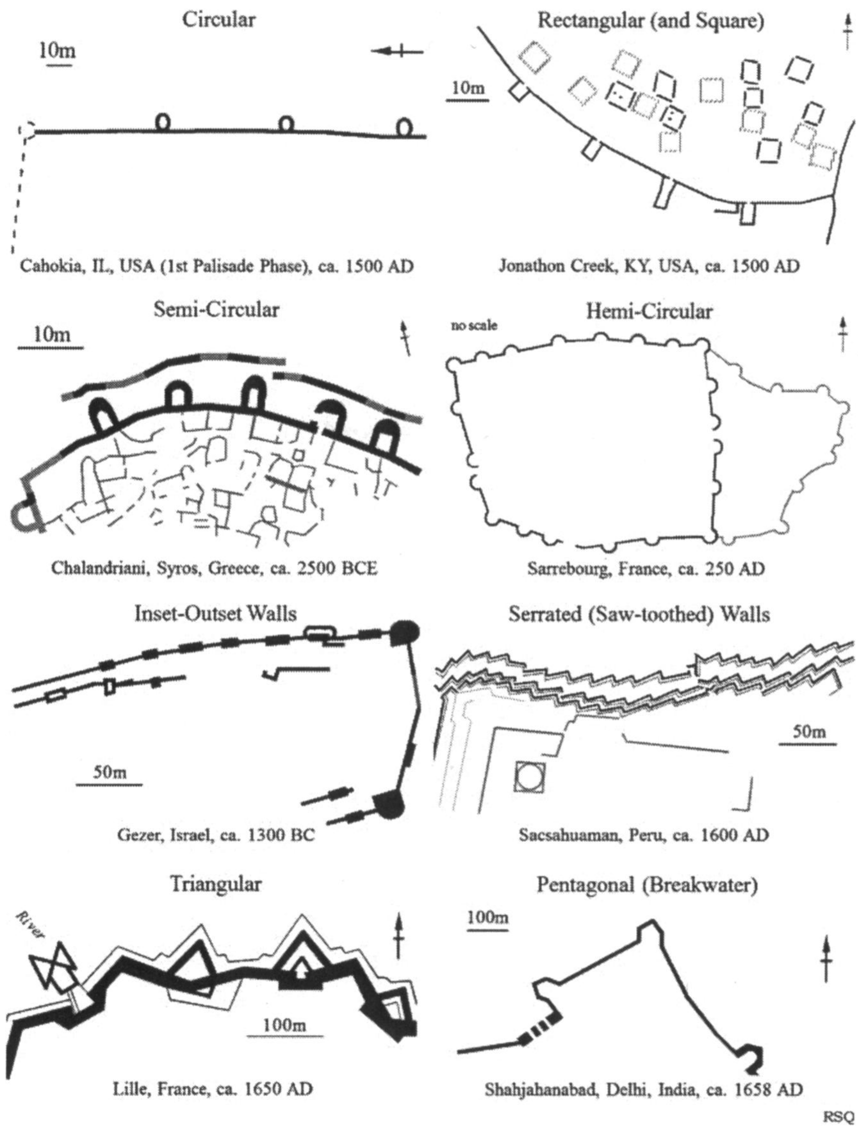

Fig. 10 Actual bastion plans. Redrawn from www.umw.edu/Dept/ArchLab/cahokia/; Hemming and Ranney (1982), Lawrence (1979), Mazar (1990), Pollak (1991), Toy (1955), Wrightman (1985)

At the Greek fortifications with both bastions and saw-toothed walls, the average spacing between the apices of the sawteeth was slightly less than half the average bastion spacing [Priene, sawteeth 31 m and bastions 65 m apart; Gortys, sawteeth 16 m and bastions 34 m apart (Lawrence, 1979, pp. 352, 354)]. At Lachish, the only measurable bastion interval on the inner wall was 18 m, while the average distance between sawteeth on the outer wall was 10 m (Hawkes, 1974, p. 204; $n = 12$). The sawteeth of the citadel at Karmir (Armenia, c. 750 B.C.) averaged 15 m apex-to-apex, while the bastion interval was 29 m. By the measurable reckoning of the architects of these ancient fortifications, sawteeth were only half as effective as bastions. Their high defensive utility/cost ratio vis-á-vis blank ramparts or inset—outset walls explains why they were occasionally invented and briefly used in Inca Peru and the ancient Near East. However, their mediocre military effectiveness compared with the more widely invented and universally used bastions explains why sawtooth curtains are so rare.

Discussion

After all that we have discussed, we do not deny that the curtains of an enceinte might simply be peaceable barriers or dikes with no military function. Not all enceintes were defensive. Our point is that unless a curtain has a historically declared military purpose or incorporates such clearly defensive features as V-shaped or deep ditches, defended gates, or bastions (see below), scholars cannot assume enceintes were built with an intended defensive purpose—a wall might be just a wall. Nevertheless, based on practical geometry and the testimony of history, no V-sectioned ditches a meter or more in depth, *if backed by a palisade, wall, or rampart,* and no wider than twice or thrice their depth had any known or reasonable function except defense against human attackers. Any prehistoric or undocumented historic site surrounded with ditches of this form, even if only along part of its enclosure, but especially its most militarily vulnerable approaches (level ground, gate vicinities), should be considered as having had some militarily defensive purpose. Throughout recorded history, V-sectioned ditches (>1.2 m deep) backed by curtains, baffled or screened gates, and bastions have always had defensive functions and were everywhere features of fortifications. Despite the high construction costs they imposed on their builders, these features have no other rational, practical, or, importantly, *documented* function.

However, it is important to note that ditched enclosures lacking any V-sectioned ditches, defended gates, or bastions may still have been built and/or used as fortifications. The Early Neolithic ditched enclosures, called "causewayed camps," of Britain represent a classic archaeological case (Mercer, 1999). They have usually been interpreted as ritual enclosures, yet the most complete modern excavations of several of them have given clear evidence that they also served as fortifications, having been attacked and defended by archers and in one case burned. The most poignant evidence of their military functions was found at the burned Early Neolithic enclosure of Hambledon Hill. It was the skeleton of a young man who had been killed by an arrow; he was carrying a child and both were buried beneath burnt rampart debris that had fallen into the fortification ditch. Because trapezoidal or U-shaped ditches and moats, unbastioned curtains, and simple gates occasionally can be found at known historical fortifications, an enclosure lacking any of the obviously defensive features focused on in this article cannot be automatically assumed to have had no military function. The evidence we have accumulated indicates that enclosures with just one clearly defensive feature must have had military defense as one of its intended functions. For other enclosures, a military function cannot simply be dismissed but must be entertained and investigated; for these cases, other evidence will be needed.

Symbolism

In countless historical cases, enceintes consist of a ditch (usually V-sectioned) backed by some form of curtain along one side of a triangle formed when the other sides were defended geographical barriers (i.e., very steep slopes and/or bodies of deep water; Fig. 11). The French term for such fortifications is *éperon barré*, that is, an artificial defensive barrier across the spur of a steep-sided ridge or headland. In English, these are called "promontory forts" or, along the seacoast, "cliff castles" (Dyer, 1992, pp. 10–12). Historians and historical

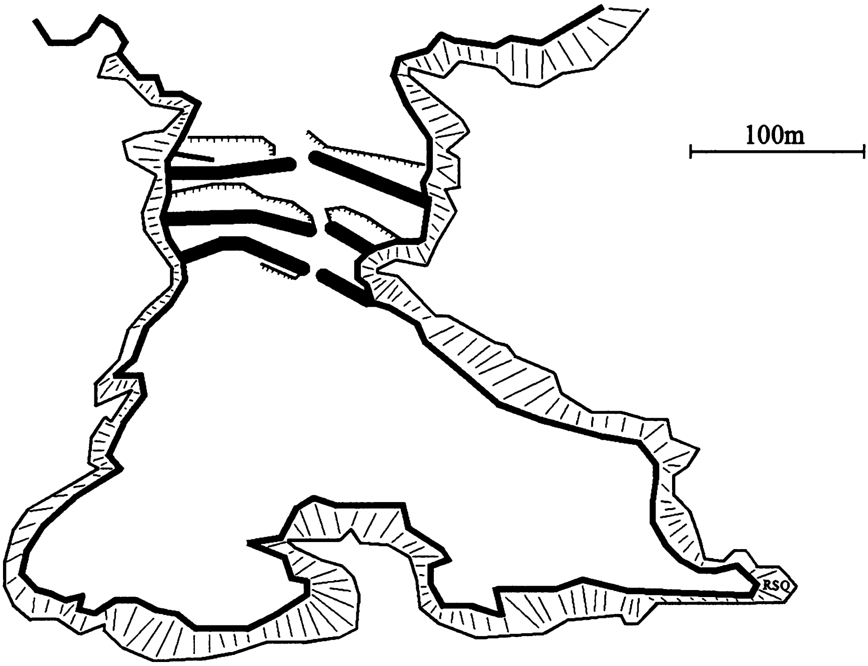

Fig. 11 *Éperon barré*. Redrawn from Dyer (1992)

archaeologists alike are well aware that such constructions were fortifications (e.g., Daniels, 1983, p. 8; Wrightman, 1985, pp. 246–248). However, for some prehistorians *éperon barré* seem to evoke only puzzlement or, that cliché for archaeologists' incomprehension, "ceremonial object or feature." For example, Cunliffe (1997, p. 157) notes that Julius Caesar saw Celtic cliff castles in "wide use" and acknowledges their "substantial defenses" in the form of ditches backed by ramparts. (He neglects to mention that the only "use" of them that Caesar observed was as extremely effective fortifications.) His astonishing *non sequitar* conclusion: "a ritual function is not unlikely."

In a more recent work, Cunliffe (2002, p. 88) claims the most up-to-date interpretation of these *éperon barré* is "the possibility ... that they might have been sacred sites" and "perhaps serving also as guiding landmarks for mariners." He does not explain why only a few headlands were segregated on the landward approaches by ditches and ramparts *invisible* from the sea, while adjacent ones, often more prominent or dangerous to mariners, were not so laboriously barred. These sites possibly could have been anything—chiefly residences? temples? athletic grounds? heliports? However, physical circumstantial evidence (deep V-sectioned ditches backed by ramparts) and eyewitness testimony (Caesar's) indicate that their most *probable* function and the only one they were *seen* to serve was as fortifications. The infamous Crow Creek prehistoric site (c. A.D. 1325) in South Dakota, like many of the prehistoric fortifications of the region, was an *éperon barré* consisting of a 1.8-m-deep trapezoidal ditch backed by a bastioned palisade on a steep bluff near the Missouri River (Willey, 1990, pp. xv, 3–7). Its palisades and more than 50 houses were burned, at least 60% of its inhabitants were slaughtered (approximately 500 men, women, and children), and their mutilated remains thrown into the outer ditch. This massacre occurred when a new, larger ditch-palisade was still being constructed and while the older inner ditch was filling with debris and the inner palisade's posts were being moved to the new defenses. The failure of Crow Creek's inhabitants to finish their particular "ritual enclosure" led to a completely unceremonious and nonsymbolic tragedy.

A still popular "pacified past" interpretation (whether intentional or accidental) of European prehistoric ditched enclosures is that they were corrals for livestock to prevent straying (especially at night) and protect them from nonhuman predators [e.g., Milasaukas, 2002, p. 179 citing (skeptically!) Lichardus *et al.*, 1985]. A purely livestock corral (i.e., an enclosure with no defensive function against humans) need be only a surface barrier that no cow, sheep, goat, hog, wolf, lion, or leopard could scale (i.e., at most 2–3 m or 6.6–9.8 ft high). For this reason, most known ethnographic and historic corrals have been entirely surficial and consisted of adobe walls, wooden fences, hedges, or *chevaux de frise* of thorn (Keeley and Cahen, 1989, p. 170) and never V-sectioned ditches. For example, the ditches used at zoos to contain animals, often the only barrier around such aggressive climber/leapers such as leopards, are invariably no more than 2–3 m deep, straight-sided, and rectangular in cross section, *never V-sectioned.* V-sectioned ditches represent extremely labor-expensive constructions that are completely superfluous, when not totally useless, barriers to straying livestock and nonhuman predators.

For obvious reasons, fortifications have long been extremely powerful symbols of possession, exclusion, independence, status, and political power. We do not deny that fortifications possessed symbolic power, we simply wish to stress that this symbolism was ultimately secondary to its primary defensive function. Thucydides (c. 410 B.C.) recognized that being fortified gave a city-state more diplomatic bargaining power (Lawrence, 1979, p. 113) or what might be called in today's military—diplomatic jargon: "deterrence leverage." Keegan (1993, p. 152) notes that fortifications were meant to defy central authority and overawe subjects as often as serve their military function.

The symbolism of fortifications is always predicated on their military function. When European fortification features lost their military function because of changes in weaponry or other changes in military practice, they disappeared or, at best, became schematic. When the widespread use of powerful cannon rendered the high walls, towering bastions, slit windows, crenellations, machicolations, and towering gates characteristic of medieval castles militarily useless or worse, they ceased being built and in many cases were abandoned or razed (Keeley, 1996, p. 57). They were replaced as elite status symbols by the far more livable palatial mansions, chateaux, and palaces of modern times.

The large-scale constructions that did serve military functions changed dramatically in appearance after widespread cannon use: low ramparts, short curtain sections (if any), extensive bastions, multiple trenches and moats, and a plethora of concentric angular outworks. They barely rose above ground level. From above they looked like a very schematic, geometric representation of an exploding star, all bastions and little or no curtain. Only in the outposts, where defenders and adversaries had little or no long-ranged artillery, did fortifications retain the features that had characterized them since prehistory, including baffled gates and up-standing curtain walls between bastions spaced less than 100 m apart (see especially Lawrence, 1964; Toy, 1957). Fortifications are most symbolically useful when they are militarily functional.

Fortifications protect what is most valuable to the defenders: their persons, homes, stored food and property, their livestock and other wealth, trade and administrative centers, and, very commonly, their ritual loci. Throughout recorded history, purposely built and often defended fortifications sometimes enclosed domestic habitations, sometimes not, sometimes ritual loci, sometimes not, and so on. Yet some archaeologists have argued that many prehistoric fortifications could have had *no* military function because ritual, trade, manufacturing, or administrative activity can be documented within them. Bastions must then be and actually have been interpreted as mysterious "fenced enclosures" (e.g., Andersen, 1997, p. 34), baffled or screened gates as ritual paths, and surrounding ditches backed by curtains as status symbols or mere boundary statements (see above). To be consistent, these archaeologists also would have to claim the many thousands of worldwide, purposefully built, and often attacked fortifications were *never intended to be or ever were* fortifications because they encompassed a temple or church, manufacturing district, trading post, administrative building, storehouse, or treasury. The Theodosian Wall (A.D. 447) around Constantinople (Byzantium) consisted of a ditch backed by two bastioned curtains interrupted only by complex defended gates and was purposely built as a fortification. Except for agricultural fields, this Byzantine enceinte surrounded every contemporary human activity and construction, including Hagia Sophia, the largest and most beautiful of early Christian churches. By some prehistorians' principles, it would be completely unexpected, indeed miraculous, that Byzantine Constantinople's "livestock corral," "ritual enclosure," or purely symbolic "settlement boundary" was somehow able to withstand scores of attacks and sieges by hundreds of thousands of enemies for over a thousand years. The military functions of fortifications are and were practically and logically independent of what they surrounded.

Because fortifications usually surround sites with many other functions and because they are so useful as symbols, their features often incorporate elements that either exceed or, to some degree, undercut military necessity. Aristotle's (384–322 B.C.) *Politics* recommended that fortifications should "contribute to the embellishment of a city" (Lawrence, 1979, p. 120). Walls may be built higher and gate towers larger than military necessity requires to intimidate and impress. Although Philo (c. 200 B.C.) recommended that walls be at least 9.2 m high (i.e., unreachable by ladder), most Hellenistic curtains had a 6–7-m-high wall walk (with parapet, 7.2–8.5 m high). A few were much higher, e.g., 14 m at Araxos and perhaps 18 m at Athens-Piraeus (Lawrence, 1979, p. 345).

From a purely military perspective, a curtain ideally would have no gates. If necessary, the most defensible gate would be no wider than that of a doorway admitting one person at a time (<1 m). However, main gates at fortified settlements had to allow the regular transit of people, livestock, and carts or loaded pack animals and, if busy, the simultaneous passage of streams in and out. Also, gates were sometimes the sites of many other activities. In the Old Testament, e.g., II Samuel 15, there are many mentions of gates being places of judgment, rostrums where leaders and prophets addressed assemblies, where rituals and, if large enough inside, trade was conducted (Gonen, 1992, p. 211; Mazar, 1990, pp. 469–470). As late as the 19th century, Moslem judges in North Africa held court at a walled town's main gate (Porch, 1983, p. 115). All of these nonmilitary uses could affect the design and dimensions of enceintes and gates, often to the detriment of their military utility.

Prehistorians of the past 50 years, almost invariably innocent of combat and usually unfamiliar of ancient military history, have exercised considerable imagination in finding completely symbolic or ritual explanations for enclosures with V-sectioned ditches, bastions, or baffled gates. Such exclusively pacific, uninformed interpretations ignore the obvious and practical and prefer the irrational, impractical, and arcane. Asserting that prehistoric enceintes with any one of these features, let alone two or all three, had *no* defensive function or intent is more than improbable. It is analogous to claiming that assault rifles (AK-47s, M-16s) are *only* symbols or that Chicago's freeways named for dead politicians are *only* mortuary monuments. The millions killed over the last few decades by these symbols and the millions of vehicles moving each day over these memorials are circumstantial evidence, at the very least, that rifles and freeways are much more practically useful, as well as that their symbolical value depends on their prosaic utility.

Site location

We have not addressed above, except obliquely regarding *éperon barré*, one issue that apparently has affected, even decided, archaeologists' interpretations of many enclosed sites—their topographic or geographical setting. These are complex and slippery issues that we address here only briefly and at their polar extremes. The most pacifist archaeological interpretations refuse to assign an enclosed site any defensive function if it was located in a tactically disadvantageous location, e.g., those on flat ground or overlooked by more defensible heights. The most bellicose explanations assign a military defensive function to any enclosed site with a strategic location, meaning situated at an obvious choke point or bottleneck to human transit by land or water. Both these simplistic interpretations are logically and historically wrong. As noted above, fortifications protect what people want to protect, particularly their immobile property, wherever these desiderata were located, which may not have been, indeed seldom were, the most tactically defensible hilltops. Except in extremely bellicose circumstances, fortified settlements, e.g., medieval walled towns, were located in difficult to defend but economically desirable places. Indeed, ditches, walls, bastions, and defended gates are exactly artificial substitutes for the military deficiencies of natural topography.

Naturally defended locations are rare in most lowland landscapes and often far from fields, pastures, fishing stations, hunting grounds, and drinking water. The Lava Beds of Northern California, comprising a rectangle 300 × 1000 m, is perhaps the most imposing natural fortress in the American West (Quinn, 1997; Utley and Washburn, 1977, pp. 250–255). In 1872–1873, 50–75 Modoc warriors in the Lava Beds held off 400–1000 American soldiers and artillery for six months, killing several dozens of the latter with almost no Modoc losses. However, this barren Stronghold, as it became known, was miles from the Modocs' fishing stations, water-lily beds, camus meadows, and hunting grounds and had few sources of water. Indeed, hunger and, after the soldiers seized one of the few waterholes, thirst was instrumental in the Modocs' dissentions and demoralization that led to their surrender.

Strategic locations are almost always "strategic" for nonmilitary, economic reasons: access to water, food, essential raw materials, trade/exchange, and transportation. Because long-range weapons (cannon) and ocean-going ships were first introduced to the West Coast of North America, the Golden Gate and Alcatraz Island strategically restrict entry to the San Francisco Bay, one of the best protected (from storms and tides) and economically desirable harbors in the world. This does not mean that every walled enclosure built next to the Golden Gate or on Alcatraz Island had a military function. Nor does the strategically important and tactically useful (e.g., for firing or dropping missiles on passing ships) Golden Gate Bridge have a military function. (It is fair to note, nonetheless, that 18th and 19th century fortifications were built at the south edge of the Golden Gate.) Artificial fortifications are not always necessary at naturally defended sites, and enclosures at strategic locales may have no military functions.

Earliest fortifications

The earliest possible fortifications were found at Jericho in the Pre-Pottery Neolithic (PPNA and PPNB, 8000–6000 B.C.) layers. These "defenses" consisted of a ditch backed by massive rock wall almost 6 m high and a (later) large circular tower at least 8 m high built just behind the wall (Mazar, 1990, pp. 41–42, footnotes). The excavator, Kenyon, interpreted both of these features as military defenses, whereas Bar-Yosef has argued that the wall was merely a barrier against floods and silt while the tower had some unspecified ritual function.

Because this controversy concerns an origin or a first, we make four observations:

(1) Bar-Yosef's interpretation for two similarly constructed, contemporaneous, and immediately adjacent structures requires two extremely different and independent motives—one practical, rational, very local but peculiar (a dike against flood waters from a spring in a desert oasis), the other irrational, impractical, and vague but universal (religious ceremony). Kenyon's explanation obeys Occam's Razor by requiring only one practical motive that is both local and universal—defense.
(2) The tower is poorly sited for defense (behind the wall), so that even from its greater height, fire from it would reach only along a short section of the wall (Mazar, 1990, pp. 41–42, Fig. 2.4). Presumably, this is why adherents of the defensive interpretation usually refer to it as a "watch-tower." On the other hand, it seems odd that such a painfully constructed, high holy temple with a peculiar internal staircase was not more centrally and safely located as was the case with later temples and ziggurats. Instead, it was built right next to a *supposedly* regularly flooded watercourse that might undercut its foundations. Whether there were any other such towers along Jericho's PPNA/B wall is unknown.
(3) The short stretch of Jericho's PPNA/B enclosure that Kenyon excavated (c. 16 m long) showed perhaps only one of the features that we argue above were unequivocally defensive: a dry (?) and in some places V-sectioned ditch (Watkins, 1989, p. 16). This outer ditch was impressively deep, cut over 2 m into hard bedrock, but was often rather broad (4–8 m) and not always V-shaped (Redman, 1978, p. 80). Given its ambiguous form, this ditch could plausibly have carried water and certainly was a source of rock spoil for building the adjacent wall and tower. No gates of any form were found from the PPNA/B period.
(4) If PPNA/B Jericho was the first fortification, the origin point of humanities' learning curve regarding earthwork defenses, its builders, could be expected to be unaware of the most militarily efficient features such as external bastions used only several hundreds of years later. On the other hand, if Jericho's wall and tower were actually a canal lining and holy "high place," they would represent an even more miraculous preciosity, being 4000 years older than the next appearance of elevated temples and lined canals in early Dynastic Mesopotamia (c. 3500 B.C.). Jericho's PPNA/B ditch, wall, and tower logically and probably had a defensive function but until more of its early Neolithic enceinte is uncovered, a completely nondefensive purpose for these structures remains plausible.

In Eurasia, the unequivocally defensive features discussed above came into use only after people became more or less completely sedentary, occupying one site yearround and over many years. Only then would the incredible investment of labor necessary to construct ditches and palisades, broken only by complex gates, around a single location become worthwhile.

Earliest V-sectioned ditches

After PPNA/B Jericho, the earliest known V-sectioned (actually a flat-bottomed, inverted, trapezoidal or truncated V) enclosure ditch, 3 m deep, backed by a curtain, was found at Tell es-Sawwan in Mesopotamia between 5600 and 5300 B.C. (Redman, 1978, p. 196; Roux, 1992, p. 54). Banpo (Pan-P'o) and Jiangzhai sites in central China, dating to 5000–4000 B.C., were enclosed by deep but trapeziodal-sectioned ditches, 5 m deep at Banpo (Barnes, 1999, pp. 104–106; Underhill, 1989, pp. 229–230). Dozens of LBK sites (c. 4500–4000 B.C.) in central and northwestern Europe were surrounded by 1.5–3-m deep V-sectioned ditches, backed by palisades (e.g., see Bosquet, 1992; various papers in vol. 73 [1990] of the journal *Jahresschrift fur Mittledeutsche Vorgeschichte*).

In Europe, many later Neolithic enclosures were of the same arrangement, such as Bronocice in Poland (c. 3700–3600 B.C.) where the V-sectioned ditch was 2–2.9 m deep (e.g., Milasaukas, 2002, pp. 234–235). The ditches that surrounded the prehistoric late Iron Age hillforts (750–400 B.C.) of Britain were usually V-sectioned (Dyer, 1992, p. 23). In fact, such ditches had been put to use at fortifications thousands of years before any classical Greek or Roman military engineer constructed them or any ancient military analyst/historian recommended them.

Ditches more that a meter deep (section either triangular or trapezoidal) were used prehistorically and were seen in use at fortifications by the first European explorers in Mesoamerica, North America, and sub-Saharan Africa (e.g., Coupland, 1989, pp. 208–211; Healy and Prikker, 1989, p. 46; Parkman, 1983, p. 353; Schmidt, 1990, p. 264; Weaver, 1993, pp. 137–138, 213, 342; Willey, 1990, p. 5).

Earliest defended gates

The oldest known and longest used defended gates had a baffled/bent-axis (claviculum) and screened or chambered plan forms. The enceintes at Tell es-Sawwan and Choga Mami (5600–5300 B.C.) were penetrated by baffled or bent-axis gates (Mazar, 1995, p. 523; Redman, 1978, p. 196). Hacilar IIA (5400 B.C., Turkey) had a screened gate with one turn leading to a dead end (labyrinthine), and later Hacilar I (c. 5250 B.C.) had two baffled and chambered gates (Mellaart, 1965, p. 113). The hooked overlapping ditch at Banpo (Pan-P'o, China c. 4000 B.C.) defined a classic claviculum gate (Hawkes, 1974, p. 218). The very 'type site' of the LBK (4500–4000 B.C.) had three screened gates, while many other LBK enceintes had baffled entries (e.g., Cahen *et al.*, 1990, pp. 130, 134–136; Höchman, 1990, pp. 71, 78). Other European Middle and Late Neolithic (4000–3000 B.C.) enclosures such as Bazoches (northern France), Sarup I (Denmark), Dimini (Greece), Sandomierz (Poland), and Homolka (Czech Republic) had baffled or screened gates (Andersen, 1997, pp. 42, 98; Champion *et al.*, 1984, p. 176; Hawkes, 1974, p. 116; Kowalewska-Marszalek, 1990, p. 239).

The earliest baffled gate found in South Asia was at Lothal (India, ca. 2500 B.C; Khanna, 1981, p. 138). The oldest (c. 3500–3000 B.C.) chambered gate known was found at the isolated desert site of Jawa (eastern Jordan); precociously, it has two successive chambers, a form that appeared only in the Near East centuries later (Mazur, 1995, p. 1524). The next oldest (single or double) chambered or symmetrically guard-roomed gates were uncovered at the fortified Sumerian colony of Habuba Kabira in Syria (3200–2800 B.C.; Nissen, 1988, pp. 120–122). Chambered gates restricted access to a later Egyptian funerary enclosure (c. 2700 B.C.), seemingly modeled on a fortress, and the Late Neolithic (c. 2400 B.C.) settlement of Pingliangtai, China (Barnes, 1999, p. 117; Mazar, 1995, p. 1525). As Database 1 indicates, baffled, screened, and chambered gates continued to be used throughout recorded history in Eurasia.

In the New World, baffled gates were in use centuries before the arrival of Europeans. Many Mississippian (A.D. 950–1400) fortifications had baffled gates (Milner, 2000, p. 59). The first Europeans to encounter the Native American farmers of eastern North America recorded such gates at fortified sites from Florida to Maine (HNAI 15, 1978, pp. 199, 278, 377; Hudson, 1976, p. 212; Malone, 1991, pp. 14, 17). At several Late Classic Maya sites (c. A.D. 730–830) in Mexico, a number of baffled and serpentine gates were found (Demarest *et al.*, 1997, pp. 231, 236, 243, 246). The Late Classic Maya fortification around Tulum

(c. A.D. 1300) has two simple gates, one outset and one inset flanked gate and one slightly baffled chambered gate (Coe, 1987, p. 149). During the conquest, Cortez encountered several baffled fortification gates that he found difficult; difficult enough to mention them in his letters to the Spanish king. One of these gates was a simple baffle in which one wall overlapped the other for about 30 m ("forty paces"); the others were serpentine baffles requiring three or four sharp turns to enter (Cortez, 1986, pp. 57, 153). The surviving three gates of the Inca fortress of Sacsahuaman above Cuzco, Peru, built almost a century before the Spanish conquest (c. A.D. 1440), were all baffled and serpentine (Hemming and Ranney, 1982, p. 69).

In Africa, ethnographically known inset gates were common, as Burton (1860, p. 252) describes in East Africa (see also Fadiman, 1982, p. 105), and were observed at the indigenous cities of Kano about the same time. These also were found archaeologically at Ife (A.D. 1700–1800), both in Nigeria (Connah, 2000, p. 27). Inner gates at Zimbabwe (A.D. 1350–1450) and some at Ife (Nigeria) and Margoula (Mali, c. 1880) were baffled (Connah, 2000, p. 33; Hawkes, 1974, p. 21). The Swahili city of Gedi (Kenya, A.D. 1000–1500) had one baffled, almost serpentine gate and another chambered gate on its inner wall (Connah, 2000, p. 37). At Kalenga (Tanzania, A.D. 1890), attacking Germans encountered a screened gate. At a simple village in central Africa, observed by a European explorer in the early 18th century, a baffled gate protected the village (Fig. 6). The degree to which baffled, screened, and/or chambered gates were independently developed in sub-Saharan Africa, after at least two millenia of contact with Eurasia across the Sahara and along the east coast, is unclear. There is no doubt Africans appreciated these more complex forms. The baffled gates of pre-Columbian America had to be an independent invention.

Earliest bastions

The earliest bastions occurred next to gates and often *only* next to gates, e.g., at Chogi Mami (c. 5500 B.C.), Hacilar II (c. 5000 B.C.), and Darion (c. 4200 B.C.) (Cahen *et al.*, 1990, pp. 136, 140; Höchmann, 1990, p. 58; Mazar, 1995, p. 1523; Redman, 1978, pp. 196–197). At Tell es-Sawwan (c. 5500 B.C.), there was one clear bastion away from the gates and two other external wall extensions that were wide enough to be bastions (i.e., not one of the much narrower internal buttresses) but did not project far from the wall (Redman, 1978, p. 197). One of these possible bastions is spaced exactly the same distance from the south gate, 19 m, as the obvious bastion is from the north gate. At Mersin (Turkey, c. 4000 B.C.), there were bastions on either side of the gate and one bastion along the wall, all with firing slits or embrasures (Badawy, 1966, pp. 140–141; Mazar, 1995, p. 1543). Dating before 3100 B.C., several Egyptian carvings showed towns with apparently bastioned walls being destroyed by symbols of King Scorpion and Pharaoh Narmer (Aldred, 1984, pp. 79–83; Mazar, 1995, p. 1524).

Since prehistory and for millennia regularly spaced bastions have been used to militarily defend sites everywhere. By about 3000 B.C. there were a number of fortifications in the Near East and Europe with multiple, regularly spaced bastions. The most well-designed, regular, and largest of these was the Late Uruk (c. 3200 B.C.) Sumerian colonial town at Habuba Kabira, Syria (Mazar, 1995, pp. 1523–1524; Nissen, 1988, pp. 120–121). It was extremely rectilinear in plan, with dozens of rectangular bastions spaced every 19 m, chambered gates, and even a small low outer wall to protect the footing of the main wall. [This low outwork wall was known to the classical Greeks as a *proteichisma*, and its purpose was to impede attackers from rolling siege towers or battering rams up to the main curtain (Lawrence, 1979, p. 85).] Habuba's fortifications were so sophisticated that there must be yet undiscovered predecessors in the Sumerian heartland, dated centuries earlier. In France and Portugal, somewhat later, a number of round bastioned fortifications have been uncovered (Andersen, 1997, pp. 143, 145; Champion *et al.*, 1984, p. 188; Hawkes, 1974, p. 90). By the early Bronze Age (2900–2300 B.C.), a number of city or town walls in the Near East and Pakistan – India had bastions (Database 2). The ancient Chinese character *cheng* has two interlocked meanings—"city" and "(defensive) wall"—which by A.D. 1000 had towering chambered gates (*wengcheng*) and bastions (*mamian* or *yangma*) (Steinhardt, 1990, p. 7, 2000, p. 421). As opposed to projecting gate towers, apparently bastions along curtain walls (*mamian*) were a late development in Chinese fortifications, perhaps not used until A.D. 300 (Steinhardt, 1990, pp. 7, 91).

To our knowledge the earliest bastions in the New World were those found along Palisade I at Cahokia, dating before A.D. 1150. Because these bastions were so regularly and efficiently (see above) spaced along approximately 2.8 km of curtain (Iseminger, 1993; personal communication, 2001), it seems unlikely that this is the first ever built in the Midwest, let alone in North America. An early postconquest "native" plan of the pre-Columbian city of Tlaxcala (Mexico) shows regular bastions (no scale) along its outer walls (Cortez, 1986, p. 14). Some pre-Columbian fortifications in Peru had regularly spaced bastions projecting from and protecting every angle in their curtain walls (Baudin, 1961, p. 133). The semicircular defensive palisades around the villages of the Tupinamba of coastal Brazil observed at Contact (c. A.D. 1530–1550) sometimes had regularly spaced bastions (HSAI 3, 1948, p. 118).

Conclusions

The very specific military functions of some features of fortifications allows archaeologists to infer, from their form and scale, some aspects of the arms and armor that were in use when and where these fortifications were built. For example, left-turning baffle entries imply that attackers carried shields. The spacing between bastions is strongly correlated with the types of weapons, especially their effective ranges, used by defenders. Revetments on curtains, not mentioned in this article, indicate that attackers used battering rams, and so on. Such inferences may sometimes be weak or ambiguous; they can strengthen interpretations when used with other lines of evidence. In any case, their potential implies that at least a passing knowledge of military architecture would be useful to many archaeologists.

Millennia before any literate observer noted their military utility and desirability, V-sectioned ditches backed by curtains, defended (especially baffled, screened, and chambered) gates, and bastions projecting from curtains have been used to defend many thousands of sites worldwide against attack from human enemies. Once historical literacy developed, first in Mesopotamia and Egypt and later diffusing or being independently invented elsewhere, the purpose of such defensive features became a matter of record. These features occurred at sites that records indicate were purposely fortified or whose fortifications resisted storming or sieges. Several military engineers of classical Greece, India, and Rome recommended V-shaped ditches, baffle gates, and bastions.

We challenge readers to find a single historic record of these features with *no* proposed or actually experienced defensive function, or a single architect, especially an ancient one, who recommended these features for an *entirely* nonmilitary function. V-sectioned ditches backed by a curtain, defended gates, and, especially, bastions are all completely superfluous to the goals of preventing livestock from straying, deterring the entrance of nonhuman predators or peaceful yet suspicious humans, or symbolizing a boundary to other humans. Many enceintes with these elements may have had symbolic significance, but this symbolism was not their only role and was obviously based on their military function. Archaeologists should stop struggling to imagine various arcane, impractical, or mystic functions for these features. When confronted with defensive features, archaeologists must abandon their penchant for pacifist interpretations and return to the burdensome, tedious task of understanding how, where, when, why, and against whom ancient people built such defenses.

The simple conclusion from all our data is that when archaeologists find a barrier fronted, even in part, by V-sectioned ditches, penetrated, even in part, by baffled or screened gates, or punctuated, even in part, with bastions, then one of its functions or purposes was certainly military defense. No matter what such an enclosure with these characteristics surrounds or delimits, it was a military defense. No matter what other likely or possible functions such an enceinte had or might have served, it was a military defense. In any case, prehistoric archaeologists need to pay careful attention to the planar and sectional dimensions and forms of the ditches, gates, and curtains of any enclosures they excavate or analyze. If they do, they will certainly discover that prehistory was commonly as fearful and bellicose as recorded history.

Appendix A. Defensive vs. other function ditches

The volume of any regular ditch is simply its cross-sectional area multiplied by its length. Thus, any ditches of the same cross-sectional area would, more or less, require the same amount of human labor to excavate and/or carry the same volume of water. In the table below, several ditch forms with the same cross-sectional area (A, arbitrarily set at 12) are compared, assuming the same substrate and length.

The ideal defensive ditch should be the hardest to jump or bridge (i.e., widest at the surface, largest B) and most difficult to climb out of (i.e., deepest, largest C) for a standard labor cost of construction (i.e., cross-sectional area A). Thus, defensive ditches should have the greatest depths and surface widths for a given cross-sectional area. In the table below, the most defensively useful ditch forms are those with the ***highest*** $B + C$ values.

Irrigation ditches must convey water. The greater their surface exposure (B), the greater their loss of water by evaporation. The greater the circumference (D) of an irrigation ditch's bottom and sides, the greater the area subject to erosion. Thus, the ideal irrigation ditch would expose the least surface and the least circumference for a given cross-sectional area. In the table below, the optimal irrigation ditch cross sections are those with the ***lowest*** $B + D$ values.

As evaporation is not a problem for drainage ditches, they need only to minimize their circumference subject to erosion (D) per a cross-sectional area. In the table below, the most efficient cross section for drainage ditches are those with the ***lowest*** D values.

Spoil ditches should minimize both their surface width (B) and depth (C) for a given cross-sectional area (A) to minimize hauling and lifting. In the table below, the most easily excavated spoil ditches are those with the *lowest* $B + C$ values (underlined).

The ideal cross sections for defensive ditches would be triangular, for irrigation ditches either U or square, for drainage ditches semicircular or shallow trapezoidal, and spoil trenches rectangular or square. The ideal forms of a water-carrying ditch for both irrigation and drainage (i.e., lowest $B + C + D$ values) would be semicircular and U-sectioned. The most naturally stable cross sections of stream channels are semicircular or shallow trapezoidal

Cross section	A[b]	B[a]	C	D	$B + C$	$B + D$
Triangle: isosceles[a]	12	6	4	10	***10.0***	16.0
Triangle: equilateral	12	5.26	4.56	10.52	***9.82***	15.78
Semicircular[a]	12	5.53	2.76	***8.67***	8.29	14.2
Trapezoid-shallow[a]	12	5	3	***9.32***	8.0	14.32
Trapezoid-deep[a]	12	4	4	10.24	8.0	14.24
U[a]	12	3.67	3.67	9.43	7.34	***13.1***
Rectangle: shallow[a]	12	4	3	10	7.0	14.0
Rectangle: deep	12	3	4	11	7.0	14.0
Square	12	3.47	3.47	10.38	6.94	***13.85***

Note. A = area; B = surface; C = depth; D = circumference.

[a]Maximum width on surface.

[b]Any unit of measure (feet, meters, cubits, etc.) squared; 12 used for ease of computation.

(B. Gladfelter, personal communication, 2000; Leopold *et al.*, 1964, pp. 200–202; Longwell *et al.*, 1969, pp. 190–191, 197). In short, V-sectioned ditches have the optimal geometry for defense but are poorly suited for any other function.

Appendix B. Codes for database 2

A. NAME OF SITE
B. DATE:

– (negative) B.C. (B.C.E.)
+ (positive) A.D. (C.E.)

C. BASTION INTERVAL (average, in meters). Measurements were from bastion center to bastion center on copier-enlarged plans. Excluded were the short intervals between bastions immediately flanking gates and other extremely irregularly spaced intervals. These latter were usually defended by other means, i.e., natural barriers (i.e., steep slopes, water, swamps) or other human-made but bastionless barriers (i.e., saw-toothed and inset-outset walls), or they were the artifacts of limited excavation and/or later destruction.
D. NUMBER OF BASTION INTERVALS MEASURED.
E. MAXIMUM BASTION INTERVAL (in meters).
F. MINIMUM BASTION INTERVAL (in meters).
G. FORTIFICATION CATEGORIES:

a. Settlement Defense 1: only or first (i.e., most exterior of several) defense works of a settlement, whether a village, town, or city.
b. Settlement Defense 2: second (more interior) defense works of a settlement, only if a third line of defense (category C) exists.
c. Citadel/Acropolis/Urban Castle: a settlement's innermost defense works (if others exist); these often defend the most important religious structures and/or the residences of the highest elites.
d. Castle/Fortified Palace: isolated (i.e., with little or no settlement outside their enceintes) elite residence.

e. Outpost: fortified frontier military and/or trading post at or beyond a society's borders.
f. Fort: a military installation within a society's borders and shorelines, usually at a strategic location.
g. Other: temporary field fortification, strategic barrier, e.g., ***limes***, "dikes"; their comparable features were not bastions but watchtowers. (Only one of these was included here, e.g., a short section of the Great Wall of China; because it was the sole example in this sample, it was placed in category E).

H. LENGTH OF CONSTRUCTED ENCEINTE (in meters). Includes all constructed defenses whether bastioned or not.
I. DEFENDED AREA (in hectares). Includes areas defended by natural features.
J. PRINCIPAL DEFENSE WEAPONS (ranked by effective range).

1. Handthrown rocks, javelins, and sling stones.
2. All the above plus the self-bow.
3. All the above plus the composite bow (includes medieval longbow).
4. All the above plus the handheld and small stationary crossbows.
5. All the above plus large immobile catapults and ballistae.
6. Smooth-bore cannon and muskets.

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References cited

Aldred, C. (1984). *The Egyptians*, Thames and Hudson, London.
Andersen, N. (1997). *The Sarup Enclosures*, Jysk Arkaeologisk Selskab, Moesgaard.
Arkush, E., and Stanish, C. (2005). Interpreting conflict in the ancient Andes. *Current Anthropology* **46:** 3–28.
Audouze, F., and Buchsenschultz, O. (1991). *Towns, Villages and the Countryside of Celtic Europe*, Batsford, London.
Baatz, D. (1983). Town walls and defensive weapons. In Maloney, J., and Hobley, B. (eds.), *Roman Urban Defenses in the West*, Council for British Archaeology, London, pp. 136–140.
Bachrach, B. (2000). Imperial walled cities in the West. In Tracy, J. (ed.), *City Walls*, Cambridge University Press, Cambridge, pp. 192–218.
Badawy, A. (1966). *Architecture in Ancient Egypt and the Near East*, MIT Press, Cambridge, MA.
Barkay, G. (1992). The Iron Age II–III. In Ben-Tor, A. (ed.), *The Archaeology of Ancient Israel*, Yale University Press, New Haven, CT, pp. 302–373.
Barnes, G. (1999). *The Rise of Civilization in East Asia*, Thames and Hudson, London.
Bartram, L. (1997). A comparison of Kua (Botswana) and Hadza (Tanzania) bow and arrow hunting. In Knecht, H. (ed.), *Projectile Technology*, Plenum, New York, pp. 321–343.
Baudin, L. (1961). *Daily Life in Peru*, Macmillan, New York.
Bosquet, D. (1992). Les dispositifs d'entrée des encientes du rubane de Belgique. Unpublished M.A. thesis (Mèmoire de Licence), Universitè Libre de Bruxelles, Brussels.
Boyd, T. (1988). Urban planning. In Grant, M., and Kitzinger, R. (eds.), *Civilizations of the Ancient Mediterranean: Greece and Rome*, Vol. III, Scribner's Sons, New York, pp. 1691–1700.
Brice, M. (1990). *Forts and Fortresses*, Facts on File, New York.
Burton, F. (1966 [1856]). *First Footsteps in East Africa*, Praeger, New York.
Burton, F. (1995 [1860]). *The Lake Regions of Central Africa*, Dover, Mineola, NY.

Cahen, D., Keeley, L., Jadin, I., and Van Berg, P. (1990). Trois villages fortifèe du urbane rècent en hesbaye liégois. In Cahen, D., and Otte, M. (eds.), *Rubanè et Cardial*, ERAUL 39, Liége, pp. 125–146.
Cassell's New Latin Dictionary (1960). Funk and Wagnalls, New York.
Cattelain, P. (1997). Hunting during the Upper Palaeolithic. In Knecht, H. (ed.), *Projectile Technology*, Plenum, New York, pp. 213–240.
Champion, T., Gamble, C., Shennan, S., and Whittle, A. (1984). *Prehistoric Europe*, Academic Press, London.
Chandler, D. (1966). *The Campaigns of Napoleon*, Macmillan, New York.
Clancy, T. (1994). *Armored Cavalry*, Berkeley Books, New York.
Coe, M. (1987). *The Maya*, Thames and Hudson, New York.
Connah, G. (2000). Contained communities in tropical Africa. In Tracy, J. (ed.), *City Walls*, Cambridge University Press, Cambridge, pp. 19–45.
Connally, P. (1989). The Roman army in the age of Polybius. In Hackett, J. (ed.), *Warfare in the Ancient World*, Facts on File, New York, pp. 149–168.
Cooper, F. (2000). The fortifications of Epaminondas and the rise of the monumental Greek city. In Tracy, J. (ed.), *City Walls*, Cambridge University Press, Cambridge, pp. 155–191.
Cortez, H. (1986 [1519–1526]) *Letters from Mexico*, A. Pagden, trans., Yale University Press, New Haven, CT.
Coudart, A. (1991). Social structure and relationships in prehistoric small-scale sedentary societies. In Gregg, S. (ed.), *Between Bands and States*, Southern Illinois University, Carbondale, pp. 395–430.
Coupland, G. (1989). Warfare and social complexity on the Northwest Coast. In Tkaczuk, D., and Vivian, B. (eds.), *Culture in Conflict*, University of Calgary Archaeological Association, Calgary, pp. 205–214.
Crosby, A. (2002). *Throwing Fire*, Cambridge University Press, Cambridge.
Cunliffe, B. (1997). *The Ancient Celts*, Oxford University Press, Oxford.
Cunliffe, B. (2002). *The Extraordinary Voyage of Pytheas the Greek*, Walker, New York.
Daniels, C. (1983). Town defenses in Roman Africa. In Maloney, J., and Hobley, B. (eds.), *Roman Urban Defenses in the West*, Council for British Archaeology, London, pp. 5–19.
Darwin, C. (1909). *Voyage of the Beagle*, Collier and Son, New York.
Davis, W. (1983). *First Blood, Civil War Series*, Vol. 2, Time–Life Books, Alexandria, VA.
Demarest, A., Mansky, M., Wooley, C., Van Tuerenhout, D., Inomata, T., Palka, J., and Escobedo, H. (1997). Classic Mayan defensive systems and warfare in the Petenbalum region. *Ancient Mesoamerica* **8:** 229–253.
Dobson, B. (1989). The empire. In Hackett, J. (ed.), *Warfare in the Ancient World*, Facts on File, New York, pp. 192–221.
Drews, R. (1993). *The End of the Bronze Age*, Princeton University Press, Princeton, NJ.
Driver, H., and Massey, W. (1957). Comparative studies of the North American Indians. *Transactions of the American Philosophical Society* **47**(2): 165–456.
Dyer, J. (1992). *Hillforts of England and Wales*, Shire Publications, Princes Risborough BUCKS.
Ebrey, P. (1996). *Cambridge Illustrated History of China*, Cambridge University Press, Cambridge.
Editors of Time-Life Books (1992). *Incas: Lords of Gold and Glory*, Time-Life Books, Alexandria, VA.
Elbl, M. (2000). Portuguese urban fortifications in Morocco. In Tracy, J. (ed.), *City Walls*, Cambridge University Press, Cambridge, pp. 349–385.
Fadiman, J. (1982). *An Oral History of Tribal Warfare*, Ohio University Press, Athens.
Ferrill, A. (1985). *The Origins of War*, Thames and Hudson, London.
Friedman, N. (1991). *Desert Victory*, Naval Institute Press, Annapolis, MD.
Gabriel, R., and Metz, K. (1991). *From Sumer to Rome*, Greenwood Press, Westport, CT.
Gates, D. (1986). *The Spanish Ulcer*, Da Capo Press, Cambridge, MA.
Gonen, R. (1992). The late Bronze Age. In Ben–Tor, A. (ed.), *The Archaeology of Ancient Israel*, Yale University Press, New Haven, CT, pp. 211–257.
Grant, M. (1974). *The Army of the Caesars*, Evans, New York.
Gravett, C. (2001). *History of Castles*, Lyons Press, Guilford, CT.
Grinnell, G. (1972 [1923]). *The Cheyenne Indians*, University of Nebraska Press, Lincoln.
Hawkes, J. (1974). *Atlas of Ancient Archaeology*, McGraw-Hill, New York.
Healy, P., and Prikker, N. (1989). Ancient Maya warfare. In Tkaczuk, D., and Vivian, B. (eds.), *Culture in Conflict*, University of Calgary Archaeological Association, Calgary, pp. 44–60.
Hemming, J., and Ranney, E. (1982). *Monuments of the Inca*, Little, Brown, Boston.
Hinds, J., and Fitzgerald, E. (1996). *Bulwark and Bastion*, Pioneer Press, Union City, TN.
HNAI 15 (1978). *Handbook of North American Indians*, Vol. 15, Northeast, Smithsonian Institution Press, Washington, DC.
Höchman, H. (1990). Frühneolithische einhegungen in Europa. *Jahresschrift für Mittledeutsche Vorgeschichte* **73:** 57–86.

Hogg, I. (1981). *The History of Fortification*, St. Martins, New York.
Holladay, J. (1998). The kingdoms of Israel and Judah. In Levy, T. (ed.), *The Archaeology of Society in the Holy Land*, Leicester University Press, London, pp. 368–398.
HSAI 1 (1946). *Handbook of South American Indians, Vol. 1: Marginal Tribes*, U.S. Government Printing Office, Washington, DC.
HSAI 3 (1948). *Handbook of South American Indians*, Vol. 3: *Tropical Forest Tribes*, U.S. Government Printing Office, Washington, DC.
Hudson, C. (1976). *The Southeastern Indians*, University of Tennessee Press, Knoxville.
Hudson, C. (1997). *Knights of Spain, Warriors of the Sun*, University of Georgia Press, Athens.
Hyslop, J. (1990). *Inka Settlement Planning*, University of Texas Press, Austin.
Iseminger, W. (1993) The Cahokia stockade: A study of fortification form and function. Paper presented at the 1993 Midwestern Archaeological Conference, Milwaukee, WI.
Jenness, D. (1977). *Indians of Canada*, University of Toronto Press, Toronto.
Johnson, A. (1983). *Roman Forts*, St. Martins, New York.
Josephus (1970 [c. A.D. 75]). *The Jewish War*, G. Williamson, trans., Penguin Putnam, New York.
Kangle, R. (trans.) (1972). *The Kautiliya Arthasastra*, Banarsidass Publishers, Delhi.
Kazdova, E., and Weber, Z. (1990). Archtektur der Lengyel–Rondelle in mittleren donauraum. *Jahresschrift fur Mittledeutsche Vorgeschichte* **73:** 159–169.
Keegan, J. (1993). *A History of Warfare*, Knopf, New York.
Keeley, L. (1996). *War Before Civilization*, Oxford University Press, New York.
Keeley, L. (2001). Conflict and war, archaeology of. In Smelser, N., and Bates, P. (eds.), *International Encyclopedia of the Social and Behavioral Sciences*, Pergamon, Oxford, pp. 2537–2542.
Keeley, L., and Cahen, D. (1989). Early Neolithic forts and villages in NE Belgium. *Journal of Field Archaeology* **16:** 157–176.
Kempinski, A. (1992). The middle Bronze Age. In Ben–Tor, A. (ed.), *The Archaeology of Ancient Israel*, Yale University Press, New Haven, CT, pp. 159–210.
Kennedy, D., and Riley, D. (1990). *Rome's Desert Frontier*, University of Texas Press, Austin.
Keppie, L. (1989). The Roman army of the later Republic. In Hackett, J. (ed.), *Warfare in the Ancient World*, Facts on File, New York, pp. 169–191.
Kern, P. (1999). *Ancient Siege Warfare*, Indiana University Press, Bloomington.
Khanna, O. (1981). *Archaeology of India*, Clarion Books, New Delhi.
Kowalewska-Marszalek, H. (1990). Sandomierz-Wzgorse Zawichojskie, Beispiel einer neolithischen befestigen Anlage in Sudoustpolen. *Jahresschrift fur Mittledeutsche Vorgeschichte* **73:** 237–247.
Lawrence, A. (1964). *Trade Castles and Forts of West Africa*, Stanford University Press, Stanford, CA.
Lawrence, A. (1979). *Greek Aims in Fortification*, Oxford University Press, Oxford.
Lawrence, T. (1988). *Crusader Castles*, Claredon Press, Oxford.
Lee, R. (1979). *The !Kung San*, Cambridge University Press, Cambridge.
Leopold, L., Wolman, M., and Miller, J. (1964). *Fluvial Processes in Geomorphology*, Freeman, San Francisco.
Lichardus, J., Lichardus-Itten, M., Bailloud, G., and Cauvin, J. (1985). *La protohistorique de l'Europe*, Nouvelle Clio, Paris.
Ling, R. (1991). The arts of living. In Boardman, J., Griffin, J., and Murray, O. (eds.), *The Oxford History of the Roman World*, Oxford University Press, Oxford, pp. 362–387.
Longwell, C., Flint, R., and Sanders, J. (1969). *Physical Geology*, Wiley and Sons, New York.
Macqueen, J. (1986). *The Hittities*, Thames and Hudson, London.
Mallory, J., and McNeill, T. (1991). *The Archaeology of Ulster*, Queen's University of Belfast, Belfast.
Malone, P. (1991). *The Skulking Way of War*, Johns Hopkins University Press, Baltimore, MD.
Mazar, A. (1990). *The Archaeology of the Land of the Bible*, Doubleday, New York.
Mazar, A. (1995). The fortification of cities in the ancient Near East. In Sasson, J. (ed.), *Civilizations of the Ancient Near East*, Scribner's, New York, pp. 1523–1537.
McNeill, W. (1982). *The Pursuit of Power*, University of Chicago Press, Chicago.
McNeill, W. (1991). American food crops in the Old World. In Viola, H., and Margolis, C. (eds.), *Seeds of Change*, Smithsonian Institution Press, Washington, DC, pp. 43–59.
McPherson, J. (1988). *The Battle Cry of Freedom*, Oxford University Press, Oxford.
Meggitt, M. (1977). *Blood is Their Argument*, Mayfield, Palo Alto, CA.
Mellaart, J. (1965). *Earliest Civilizations of the Near East*, McGraw-Hill, New York.
Mercer, R. (1999). The origins of warfare in the British Isles. In Carman, J., and Harding, A. (eds.), *Ancient Warfare*, Sutton, Stroud, UK, pp. 143–250.
Milasaukas, S. (2002). *European Prehistory*, Kluwer/Plenum, New York.

Miller, M., and De Voto, J. (trans./eds.) (1994). *Fortification of the Roman Camp (Polybius and Pseudo Hyginus)*, Ares Publishers, Chicago.
Milner, G. (2000). Palisaded settlements in prehistoric eastern North America. In Tracy, J. (ed.), *City Walls*, Cambridge University Press, Cambridge, pp. 46–70.
Nissen, H. (1988). *The Early History of the Ancient Near East 9000–2000 B.C.*, University of Chicago Press, Chicago.
O'Connell, R. (1989). *Of Arms and Men*, Oxford University Press, New York.
Parker, G. (1988). *The Military Revolution*, Cambridge University Press, Cambridge.
Parkman, F. (1983). *France and England in North America*, Vol. I, Literary Classics of the United States, New York.
Pollak, M. (1991). *Military Architecture, Cartography and the Representation of the Early Modern City*, Newberry Library, Chicago.
Porch, D. (1983). *The Conquest of Morrocco*, Knopf, New York.
Quinn, A. (1997). *Hell with the Fire Out*, Faber and Faber, Boston.
Redman, C. (1978). *The Rise of Civilization*, Freeman, San Francisco.
Roux, G. (1992). *Ancient Iraq*, 3rd ed., Penguin, New York.
Ryan, L. (1981). *The Aboriginal Tasmanians*, University of Queensland Press, St. Lucia.
Scarre, C. (2005). *The Human Past*, Thames and Hudson, London.
Schama, S. (1989). *Citizens*, Knopf, New York.
Schmidt, P. (1990). Oral tradition, archaeology and history. In Robertshaw, P. (ed.), *A History of African Archaeology*, Heinemann, Portsmouth, NH, pp. 252–270.
Shaughnessy, E. (ed.) (2000). *China: Empire and Civilization*, Oxford University Press, Oxford.
Stade, H. (1874 [1557]). *The Captivity of Hans Stade of Hesse*, Hakluyt Society, London.
Steinhardt, N. (1990). *Chinese Imperial City Planning*, University of Hawaii Press, Honolulu.
Stewart, K. (1965). Mohave warfare. In Heizer, R., and Whipple, M. (eds.), *The California Indians*, University of California Press, Berkeley, pp. 369–382.
Strachan, H. (1998). *The Oxford Illustrated History of the First World War*, Oxford University Press, Oxford.
Temple, R. (1998). *The Genius of China*, Prion, London.
Tolok, M., and Makkay, J. (1990). Spuren van grabenlagen aus bicske-galagonyas. *Jahresschrift fur Mitteldeutsche Vorgeschichte* **73:** 119–124.
Tomlin, R. (1989). The late Roman Empire. In Hackett, J. (ed.), *Warfare in the Ancient World*, Facts on File, New York, pp. 222–249.
Toy, S. (1955). *A History of Fortification from 3000 B.C. to A.D. 1700*, MacMillan, New York.
Toy, S. (1957). *The Strongholds of India*, Heinemann, Melbourne.
Tracy, J. (ed.) (2000). *City Walls*, Cambridge University Press, Cambridge.
Tringham, R. (1971). *Hunters, Fishers and Farmers of Eastern Europe 6000–3000 B.C.*, Hutchinson, London.
Underhill, A. (1989). Warfare during the Chinese Neolithic period. In Tkaczuk, D., and Vivian, B. (eds.), *Culture in Conflict*, University of Calgary Archaeological Association, Calgary, pp. 229–237.
Utley, R., and Washburn, W. (1977). *Indian Wars*, Houghton Mifflin, Boston.
VanCreveld, M. (1989). *Technology and War*, Free Press, New York.
Watkins, T. (1989). The beginnings of warfare. In Hackett, J. (ed.), *Warfare in the Ancient World*, Facts on File, New York, pp. 15–35.
Weaver, M. (1993). *The Aztecs, Maya and Their Predecessors*, Academic Press, San Diego, CA.
Webster's College Dictionary (1997).
Weighley, R. (1991). *The Age of Battles*, Indiana University Press, Bloomington.
Whittle, A. (1996). *Europe in the Neolithic*, Cambridge University Press, Cambridge.
Willey, P. (1990). *Prehistoric Warfare on the Great Plains*, Garland, New York.
Wiseman, D. (1989). The Assyrians. In Hackett, J. (ed.), *Warfare in the Ancient World*, Facts on File, New York, pp. 36–53.
Wooley, A. (1975). *The Clarendon Guide to Oxford*, 3rd ed., Oxford University Press, Oxford.
Wrightman, E. (1985). *Gallia Belgica*, Batsford, London.

Bibliography of recent literature (and additional database references)

Andrews, G. (1975). *Mayan Cities*, University of Oklahoma Press, Norman.
Badawy, A. (1968). *A History of Egyptian Architecture*, University of California Press, Berkeley.
Brentjes, B. (1995). The history of Elam and Achaemenid Persia. In Sasson, J. (ed.), *Civilizations of the Ancient Near East*, Scribner's, New York, pp. 1001–1021.

Buisseret, D. (1991). *Mapping the French Empire in North America*, Newberry Library, Chicago.
Burney, C. (1977). *The Ancient Near East*, Cornell University Press, Ithaca, NY.
Burton, R. (1964 [1893]). *A Personal Narrative of a Pilgramage to Al-Madinah and Mecca*, Dover, New York.
Burton, R. (1893). *A Mission to Gelele*, Tylston and Edwards, London.
Callwell, C. (1906). *Small Wars*, 3rd ed., HM Stationery Office, London.
Cambridge Ancient History, Vol. IV, 2: Persia, Greece and the Western Mediterranean 525–479 B.C. (1988). Cambridge University Press, Cambridge.
Cambridge Ancient History, Vol. XIV: Late Antiquity, Empire and Successors. (2000). Cambridge University Press, Cambridge.
Cantwell, A., and Wall, D. (2001). *Unearthing Gotham*, Yale University Press, New Haven, CT.
Carman, J., and Harding, A. (eds.) (1999). *Ancient Warfare*, Sutton, Stroud, UK.
De la Vega, G. 1951 (1605). *The Florida of the Incas*, J. G. Varner and J. J. Varner, trans., University of Texas Press, Austin.
Finley, M. (1977). *Atlas of Classical Archaeology*, McGraw-Hill, New York.
Fleming, P. (1989). *The Siege at Peking*, Oxford University Press, Oxford.
Freeman, C. (1993). *The World of the Romans*, Oxford University Press, New York.
Guilaine, J., and Zammit, J. (2005). *The Origins of War*, Blackwell, Oxford.
Goldsworthy, A. (1996). *The Roman Army at War 100 B.C.– A.D. 200*, Oxford University Press, Oxford.
Goldsworthy, A. (2003). *The Complete Roman Army*, Thames and Hudson, New York.
HNAI 13 (2001). *Handbook of North American Indians, Vol. 13 Plains*, Smithsonian Institution Press, Washington, DC.
Ilan, D. (1995). The dawn of internationalism: The middle Bronze Age. In Levy, T. (ed.), *The Archaeology of Society in the Holy Land*, Leicester University Press, London, pp. 297–319.
Kelly, R. (2000). *Warless Societies and the Origin of War*, University of Michigan, Ann Arbor.
Kenoyer, J. (1991). Urban process in the Indus tradition. In Meadows, R. (ed.), *Harappa Excavations 1986–1990*, Prehistory Press, Madison, WI, pp. 29–60.
Knecht, H. (ed.) (1997). *Projectile Technology*, Plenum, New York.
Laubin, R., and Laubin, G. (1980). *American Indian Archery*, University of Oklahoma Press, Norman.
LeBlanc, S. (2003). *Constant Battles*, St. Martins, New York.
Lewis, R. B., and Stout, C. (1998). *Mississippian Towns and Sacred Spaces*, University of Alabama Press, Tuscaloosa.
Maloney, J., and Hobley, B. (eds.) (1983). *Roman Urban Defenses in the West*, Council for British Archaeology, London.
Mazar, A. (1992). The Iron Age I. In Ben-Tor, A. (ed.), *The Archaeology of Ancient Israel*, Yale University Press, New Haven, CT, pp. 258–301.
Meyers, E. (1997). *Oxford Encyclopedia of Archaeology in the Near East, Vol. 2*, Oxford University Press, Oxford.
Murname, W. (1995). The history of ancient Egypt. In Sasson, J. (ed.), *Civilizations of the Ancient Near East*, Scribner's, New York, pp. 691–717.
Murowchick, R. (ed.) (1994). *China: Ancient Culture, Modern Land*, University of Oklahoma Press, Norman.
Muscarella, O. (1995). Art and archaeology of western Iran in prehistory. In Sasson, J. (ed.), *Civilizations of the Ancient Near East*, Scribner's, New York, pp. 981–999.
Mylonas, G. (1961). *Eleusis and the Eleusian Mysteries*, Princeton University Press, Princeton, NJ.
Otterbein, K. (2004). *How War Began*, Texas A & M Press, College Station.
Patrich, J. (1995). Church, state and the transformation of Palestine. In Levy, T. (ed.), *The Archaeology of Society in the Holy Land*, Leicester University Press, London, pp. 470–484
Rice, G., and LeBlanc, S. (2001). *Deadly Landscapes*, University of Utah Press, Salt Lake City.
Singh, S. (1989). *Ancient Indian Warfare*, Motil Banarsidass, Delhi.
Stern, E. (1995). Between Persia and Greece. In Levy, T. (ed.), *The Archaeology of Society in the Holy Land*, Leicester University Press, London, pp. 432–465.
TravelChinaGui.decom 2002 /attaction/shaanxi/xian/citywall.htm
Vallat, F. (1995). Susa and Susianain second millennium. In Sasson, J. (ed.), *Civilizations of the Ancient Near East*, Scribner's, New York, pp. 1023–1034.
Ward Perkins, J. (1978). *Pompeii A.D. 79*, Museum of Fine Arts, Boston.
Webster, D. (2000). The not so peaceful civilization. *Journal of World Prehistory* **14:** 65–119.
Whitcomb, D. (1995). Islam and the socio-cultural transition of Palestine-Early Islamic period (638–1099 C.E.). In Levy, T. (ed.), *The Archaeology of Society in the Holy Land*, Leicester University Press, London, pp. 486–498.

Wood, W. R. (1967). *An Interpretation of Mandan Culture History*, Bureau of American Ethnology Bulletin 198, U.S. Government Printing Office, Washington, DC.

Databases available online at http:/www.uic.edu/depts/anth/faculty/Keeley.html
Database 1: Data and Sources for Selected Defensive Gates.
Database 2: Codified Data on Bastion Spacing.