

# Signalling and the design of the Gask Ridge system

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## ABSTRACT

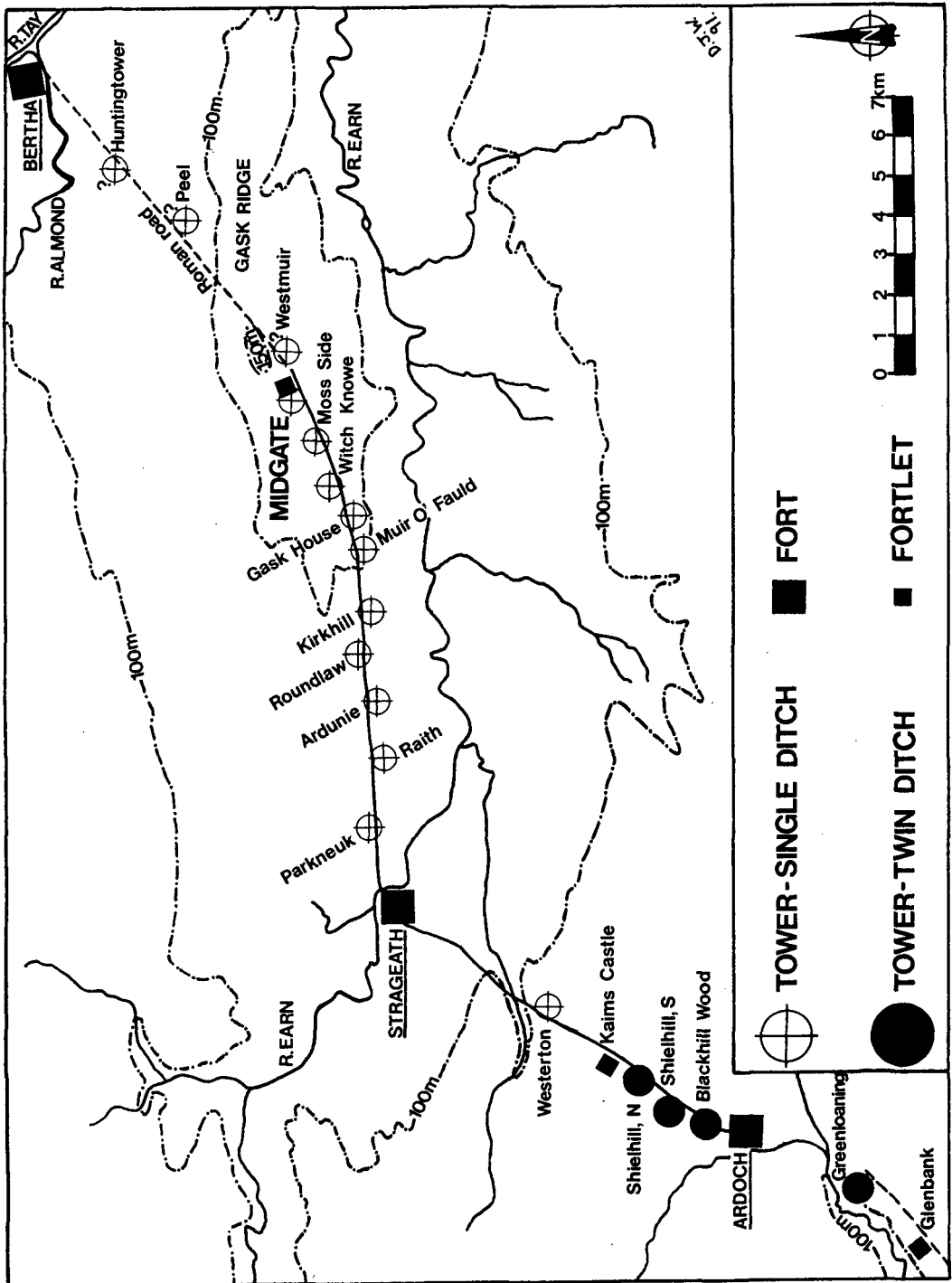
*This paper attempts to describe the signalling arrangements along the Gask Ridge, in Strath Earn, and the influence that these may have had on the general layout of the system of Roman installations, in an effort to understand the purpose and context of the Roman line. It also reports on the re-excavation of a possible Roman fortlet within metres of the Gask Ridge tower of Midgate (NO 02112047). This juxtaposition suggests that the Gask Ridge fortlets may not be exactly contemporary with the towers. Although, for the moment, there is insufficient evidence to prove that the fortlets belong to another Flavian phase, or to a different period altogether, the former may still appear more likely.*

## INTRODUCTION

Scientific study of the Gask Ridge began at the turn of the century with the excavation by D J Christison (1901) of the fortlet of Kaims Castle and some of the eight watch towers then known on the Ridge itself. Although a great deal was learned through this programme, none of the sites yielded dating evidence and, as we shall see, the excavation of the fortlet may have been flawed. Since then, another fortlet has come to light at Glenbank (Maxwell 1990), to the south of Ardoch, along with evidence for 10 new towers, bringing the number known or suspected<sup>1</sup> to 18 (illus 1). The towers can also now be seen to fall into two distinct groups, although the significance of the change is uncertain. For, whilst those to the north of Kaims Castle, including those on the Gask Ridge itself, have a single surrounding ring ditch, those further south have two. Furthermore, a single stratified Flavian sherd from Gask House (Robertson 1974, 20) and a possible second from Westerton (private communication), both in the northern group, have finally provided a probable date for, at least, the single ditched towers, whilst the discovery of the Flavian fort at Doune has suggested a possible destination for the southern end of the system (Maxwell 1984).

A picture has, thus, been built up of an integrated Flavian system, stretching (at least) from the Teith at Doune to Bertha on the Tay; the fortlets of Glenbank and Kaims Castle have usually been seen as part of this system, despite their current total lack of dating evidence.<sup>2</sup> With this much apparently settled, the debate has moved on to consider the exact context in which the system was built. For example, some scholars would argue for an early date, with the line forming part of the provisions made during Agricola's fourth season (Hobley 1989, 73–4) and later replaced by the glen-blocking forts. Others support a later date, with the

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ILLUS 1 The Gask Ridge system

system representing an attempt to hold a frontier line defending Fife in the aftermath of the abandonment of Inchtuthil and the rest of northern Scotland (Breeze 1982, 61–5).

Cases can also be made for regarding the Gask as a ‘back stop’ frontier, for which the glen-blocking forts served as outposts, or for seeing the glen-blockers as the true frontier with the Gask as merely a closely watched road supervising the strategic invasion route through Strathearn (Pitts & St Joseph 1985, 278). Yet, despite the fact that three of the four forts on the system – Ardoch (Breeze 1983), Strageath (Frere & Wilkes 1989) and Bertha (Adamson & Gallagher 1986) – have Antonine as well as Flavian occupations, the assumption that all the more minor installations belong to a single Flavian line has persisted throughout these discussions.

If this was the case, we would appear to have a fairly logically laid out system. The presence of Glenbank between Doune and Ardoch, and Kaims between Ardoch and Strageath, suggests an alternating series of forts and fortlets set out along the road and interspersed with a closely spaced series of watch towers. Attempts to find signs of a regular tower spacing interval, based on the Roman mile (Rivet, 1964, 196–8), have never proved wholly convincing (Table 1), but this need hardly surprise us in view of the irregular tower spacings on the contemporary Wetterau Limes, to the north of Frankfurt in Germany (Woolliscroft & Hoffmann 1991).

TABLE 1  
Gask Ridge site spacings

Glenbank – Greenloaning	c 2300 m
Greenloaning – Ardoch	c 2750 m
Ardoch – Blackhill Wood	900 m
Blackhill Wood – Shielhill South	875 m
Shielhill South – Shielhill North	950 m
Shielhill North – Kaims Castle	875 m
Kaims Castle – Westerton	2300 m
Westerton – Strageath	c 4200 m
Strageath – Parkneuk	1750 m
Parkneuk – Raith	1520 m
Raith – Ardunie	1510 m
Ardunie – Roundlaw	1110 m
Roundlaw – Kirkhill	960 m
Kirkhill – Muir o’ Fauld	1440 m
Muir o’ Fauld – Gask House	870 m
Gask House – Witch Knowe	800 m
Witch Knowe – Moss Side	1120 m
Moss Side – Midgate	1400 m
Midgate – Westmuir	c 915 m
Westmuir – Peel	c 3975 m
Peel – Huntingtower	c 1940 m
Huntingtower – Bertha	c 3175 m

It is, however, apparent that the system as we have it today cannot be complete. Glenbank is not intervisible with Doune and, although Huntingtower would, from its likely original tower height, have been visible from Bertha, both spacing and signalling considerations suggest that further towers await discovery at both ends of the line. Other obvious gaps exist between Westmuir and Peel, Westerton and Strageath, and Greenloaning and Ardoch, whilst a number of smaller gaps (Table 1) might also repay attention.

At one time it also seemed likely that the system continued south, beyond Doune, perhaps to the Flavian fort of Camelon. A well-preserved hill top ring-ditch at West Plean, to

the south of Stirling, was once interpreted as a tower of the Gask Ridge type (Crawford 1949, 18). This has been shown to be non-Roman (Steer 1956),<sup>3</sup> however, and all that can now be said is that, whilst extensions to the south of Doune or, indeed, to the north of Bertha cannot be ruled out, there is no firm evidence that they existed.

## THE SIGNALLING SYSTEM

Despite these gaps in our knowledge, it is possible to reconstruct at least a skeletal signalling system for the Gask Ridge, as currently understood, based on a study of each installation's field of view, from its likely full original height (Woolliscroft 1989b). As all long-range Roman signalling relied on visual techniques (Leiner 1982), direct communications could take place only between intervisible sites. The reader is cautioned from the outset, however, that such a study can show only what was possible or, at best, likely. Signalling is a process that leaves little physical trace and attracted scant detailed comment from ancient writers. It must always be remembered, therefore, that the fact that a signalling system was apparently both possible and desirable on a given Roman deployment does not necessarily mean that any such system actually existed. That said, there are design oddities on a number of Roman frontiers that seem to make sense only as moves to accommodate signalling (Woolliscroft 1989a; Woolliscroft & Hoffmann 1991) so that some signals provision does appear likely on many, if not all, of Rome's major military systems.

Almost all of the known Gask Ridge installations are intervisible with both of their immediate neighbours; in the few cases where they are not (Westmuir, for instance, cannot be seen from Peel), it already seems likely on spacing grounds that the sites are not true neighbours, as intermediate towers may still remain to be found. It should, therefore, have been possible to pass signals from tower to tower along, at least, most of the line. Indeed, mutual intervisibility between neighbours seems to have been regarded as important and, as on the Wetterau Limes in Germany, there are signs that the irregular inter-site spacings are, to some extent, caused by the need to ensure it. For example, there is a tendency, especially on the Gask Ridge itself, for the towers to be sited on or near pronounced changes in the angle of slope of the ground, so that a number of sites are set at the limit of the field of view of one or other of their neighbours and so appear on their skyline. Where this is the case on the Ridge itself, it is usually a site's eastern neighbour that marks the limit of its vision, which suggests that the system may have been laid out from the west. Indeed, so pronounced is this tendency, that it becomes easy for a first-time visitor to locate the sites on the ground with little help from a map. Nevertheless, as the inter-site spacings are generally quite short (if slightly longer than those in the Wetterau), ranging from c 800 m to just over 1500 m (Table 1), and many of the installations have fairly extensive views, most can see sites well beyond their immediate neighbours, at least in one direction. There are, thus, considerably more sites than would have been required for a simple line of relay stations. In such a system each installation might be expected to lie at or near the limit of view of both its neighbours so as to use the longest possible links and the smallest number of stations. This apparent over-provision may require explanation and this, in turn, may have implications for signalling. So before attempting to interpret the intervisibility data from the sites, it is worth taking a closer look at the likely role of the system.

Donaldson (1988, 352–3) has argued that the fact that the Gask Ridge sites are so closely spaced suggests that the signalling techniques employed on the system were limited in range to around a Roman mile. But experiments by the writer (Woolliscroft 1993, 26–61)

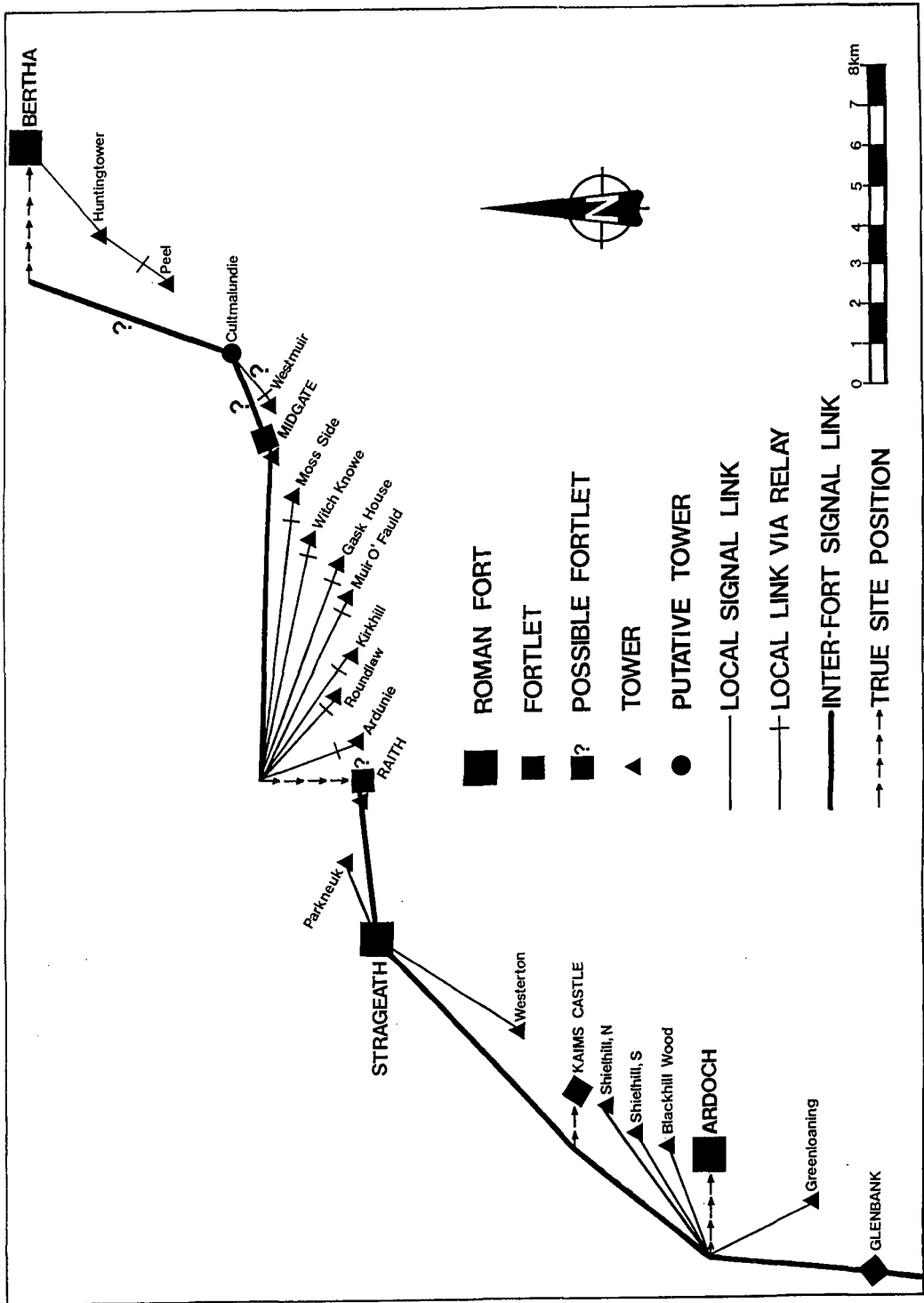
have shown that almost all the recorded Roman visual methods were capable of much greater ranges, even in less than perfect weather: especially the relatively primitive, beacon based, alarm signals that are likely to have been of most use on the frontiers (Woolliscroft 1989a, 9). This means that although the Gask may have had a signalling system, it cannot be thought of as being only a signalling system. Furthermore, whilst it would certainly have been possible for the line to have operated in a strictly linear manner, with signals being relayed from site to site through every link in the tower chain, this would have been both unnecessary and inefficient (Woolliscroft & Hoffmann 1991, 534). It would also have been slow, for a signalling system based on relays only a few hundred metres apart is likely to have been little faster than a mounted messenger, even if it was only intended to carry simple alert beacons. If it was expected to compete with the messenger in terms of information carrying capacity it would have been even slower, and Donaldson would appear to have ignored the numerous instances of Roman forts sited very much further from outlying watch towers, with which they are obviously associated (eg Topping 1987; Woolliscroft 1988, 25–7).

The Gask tower spacings are, on the other hand, perfectly reasonable for a line of observation posts; the overlapping fields of view would have allowed tight surveillance and, between them, they enable almost every inch of the line to be watched. Despite the misleading term ‘signal tower’, which is often applied to them, signalling would probably have formed only a minor part of their role. In this they would parallel certain modern deployments, for the writer is informed that observation posts on parts of the Green Line in Cyprus are set at very similar intervals and knows from experience that those on the former East German border were often even closer. Yet these are or were equipped with modern electronic communications for which no such range restrictions could be suggested.

In practice, like its present-day equivalent, any small Roman frontier post faced with trouble would simply have wanted to contact the nearest garrison base (in this context the nearest fort) in the quickest way possible. Its role would have been to supervise and provide early warning, rather than direct defence. In studying any possible signalling system, therefore, we should probably bear this in mind and look for simplicity and efficiency, rather than complexity. We should also look to see how the forts themselves might have communicated with each other so as to allow the system to act as a single co-ordinated whole under emergency conditions and to facilitate a general troop concentration should a threat emerge at any one point that was beyond the capacity of the local garrison unit to handle alone.

We can now turn to the intervisibility details to see what pattern emerges. Doune cannot be seen from any other known Roman installation, although it does have a view into the heart of Stirling if, as still seems possible, a fort is to be expected there.<sup>4</sup> This means that, for the moment, no signalling system can be traced beyond Glenbank (illus 1 & 2). This fortlet can be seen from Ardoch, however, and, although not visible from either Doune or Stirling, it stands in a reasonable position to link the fort to points further south. Likewise, all the known towers between Glenbank and Kaims also have direct views of Ardoch, as should the three additional towers that might be expected, on spacing grounds, between Glenbank and Ardoch: around Balhaldie (NN 823064),<sup>5</sup> Kingfisher Hotel (NN 834080) and Kierallan Farm (NN 837089). In other words, the area is set up to allow the sort of direct signalling system already found on Hadrian’s Wall (Woolliscroft 1989a) and the northern part of the Wetterau Limes (Woolliscroft & Hoffmann 1991, 535–6) in which each minor installation has a direct link to a fort rather than signalling laterally from tower to tower along the line.

The position of Kaims Castle is slightly unexpected, although it may still have a certain



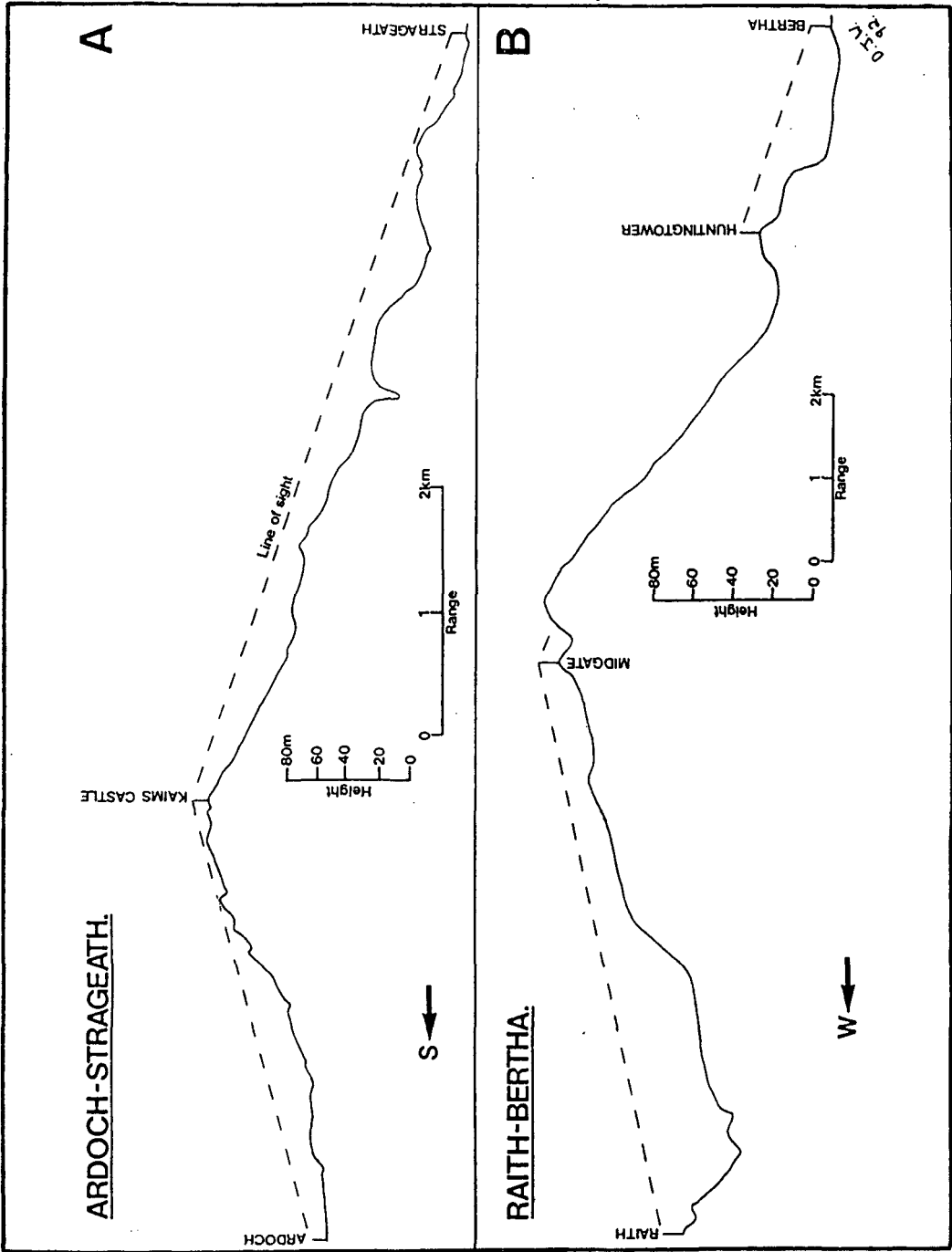
ILLUS 2 The signalling system of the Gask Ridge, schematic drawing

logic. The fortlet stands at the northern end of a flat hilltop which is the only point from which the forts of Ardoch and Strageath can both be seen simultaneously, so that a single installation here could have served as a relay point linking the two. But, standing where it does, Kaims is only just able to fulfil this role. The site has a clear view to Strageath (illus 3,A). But, even assuming that the fortlet was equipped with a gate tower about 10 m high (Woolliscroft 1993, 61–90), this would have been visible only from the very top of a similar tower at Ardoch, and even then only one at the southern end of the fort. The intervisibility is, thus, somewhat borderline and would have been easily blocked by trees or bushes at the southern end of the hilltop. Yet Strageath would have retained its easy view to Kaims even if the fortlet had been sited up to 350 m further south, so it is somewhat surprising that Kaims was not built at the southern end of the summit, c 320 m to the south, from where the view to Ardoch would have been very much more secure. Nevertheless, the link between the two forts could still be operated by the fortlet, as sited, and Kaims may have been pushed to the absolute limit of Ardoch's field of vision in order to improve its own more immediate view north and/or to compensate, to some extent, for the fact that the hill is much closer to Ardoch than to Strageath. The ranges, with Kaims Castle as sited, are: Kaims-Ardoch 3.7 km and Kaims-Strageath 6.6 km; the position chosen for Kaims, whilst at first sight illogical, shortened its distance from Strageath by c 5%.

Westerton also has a direct view to Strageath; the two intermediate sites, which spacing considerations might suggest lie between the two, also seem likely to have done so, as would any intermediate tower between Westerton and Kaims. Again, therefore, this part of the system shows signs of having been efficiently laid out, with all of the known sites certainly enjoying direct views to a fort, and with the two forts themselves connected via a simple, one-stage, relay. But we now come to look at the Gask Ridge itself.

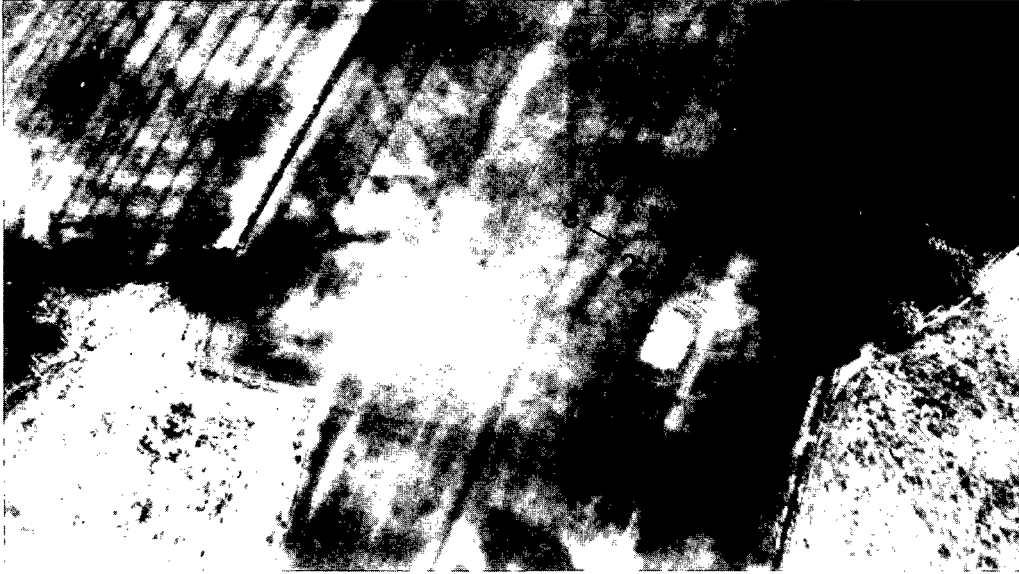
Both Parkneuk and Raith can be seen from Strageath, but Raith, which stands on the western summit of the Ridge, is close to the eastern limit of view of the fort, even from a 10 m tower. This means that if any signals from the rest of the Ridge-top towers were to reach Strageath, they would have to have been relayed via Raith. Interestingly, like Kaims, Raith could have been sited up to about 350 m farther from the fort and still have remained visible but, again, there are good reasons for the site being built where it is. The tower, as sited (NN 933185), has a quite spectacular field of vision, making it an excellent lookout point as well as an important potential signal relay. Its view extends far to its west and north, allowing it to watch long stretches of the Highland fringe. To its south and south-east it looks right across Strathearn to Kaims Castle, as well as controlling an excellent view of the floor of the strath itself. But, perhaps most importantly, its view to the east takes in all the remaining ridge-top towers as far as Midgate. Only to its north-east is its view somewhat limited. Yet, only 350 m farther to the east, the position would have been rather less advantageous: after passing over this western summit, the Roman road starts to run a little way to the south of the ridge top. As all of the towers are built close to this road, their views to the north become seriously degraded and a more easterly Raith would have been no exception.

In view of its excellence as a lookout and signalling position, it is interesting that at least one aerial photograph of Raith (CUCAP AKD 96) has shown what appears to be the ditch of a rather larger rectangular site (illus 4, arrow 2) surrounding the modern water tank, the construction of which destroyed the known tower (arrow 1). This ditch is quite distinct from the well-defined crop mark of a former plantation boundary (arrow 3), but has not yet been tested by excavation. It is, however, of just the right size and shape to be an additional



ILLUS 3 Profile of the terrain of the Gask Ridge system to show site intervisibilities





ILLUS 4 Raith. 1 Water-tank on the site of the tower; 2 cropmark of ditch of rectangular site, possibly a fortlet; 3 cropmark of a former plantation boundary

fortlet of the Kaims Castle/Glenbank type and, although such an identification remains, at best, hypothetical, its possible implications will be considered below.

The fact that most of the remaining ridge-top towers lie behind the apparent optimum lookout line, must, inevitably, reflect on the system's function. One might have expected a Roman frontier garrison here to have been primarily interested in what was happening to its north, and yet, of the 11 known towers on the ridge itself, only Raith and Midgate have completely unimpeded views in this direction, even from tower-top height.

The traditional explanation has been that the ridge would have been heavily forested in Roman times and that the towers were designed to monitor, report on and, to some extent, control any movements across a cleared strip of ground around the road itself (Breeze 1982, 62). In other words, they were designed to look east/west along the system, rather than to the north. It now appears that the level of forest cover in Roman Scotland may have been exaggerated in the past (Breeze 1992, 331–5). Whatever the local position may have been, it seems unlikely, in practice, that there would have been that much need for such a watch, because anyone crossing the road from the north would already have had to reach, and then climb, the Gask Ridge itself; although this is not especially difficult, the fact that almost no modern roads cross the ridge is a reflection of the fact that there are very much easier ways through the area. The main route which, to judge from the temporary camps, all Roman invasions seem to have followed (Hanson 1987, 121–7) passes through Strathearn, to the south of the Gask, along what is now the main A9 road from Stirling to Perth. The only other viable route through the area is that followed by the modern A822 which passes quite close to Strageath and then runs due north through Crieff to enter the Highland passes at Fendoch. It is interesting to note, therefore, that all of the towers on the Gask Ridge, no matter how poor their views north, have superb views over Strathearn and that, in many cases, these views

would have been seriously worsened had the sites been positioned so as to obtain better views to the north. It may also be significant that Raith is positioned so as to enjoy particularly good views along the route now followed by the A822; although Christison's claim (1901, 28) that the site can be seen from Fendoch is mistaken, it is visible from hills in the fort's vicinity. This raises a number of interesting possibilities and additional parallels with other frontiers.

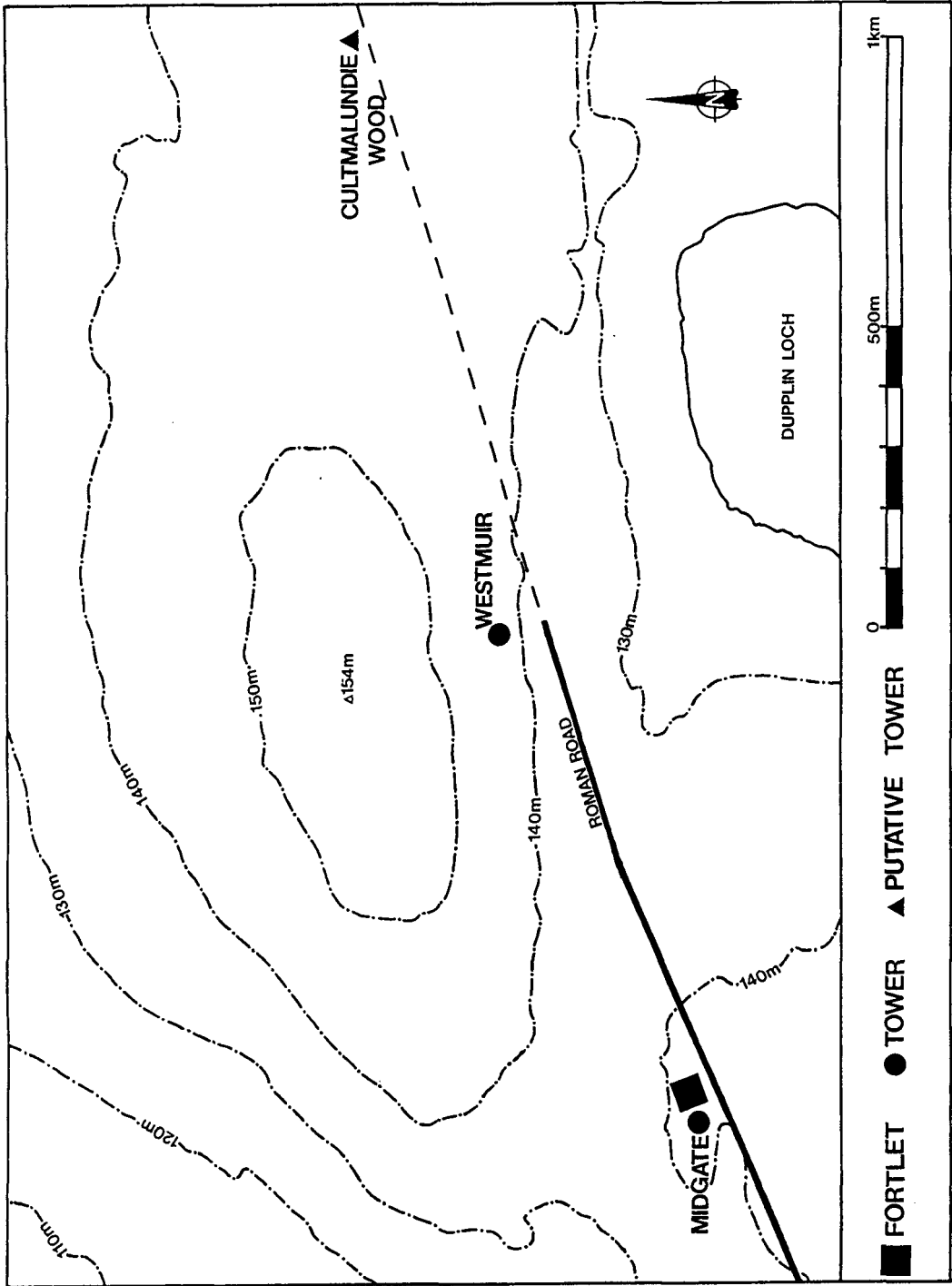
Many of the towers on the contemporary Wetterau Limes also have limited views out from the line and, again, these sites almost all have superb views over their hinterland. This means that any invader entering the area, along the Fulda Gap (the most likely invasion route from the north), could be monitored and conspired against from the relative safety of the surrounding hills, so that the Limes could act, to some extent, as a defence in depth. This, in turn, would have made the defences more flexible and more able to maintain co-ordinated action after being penetrated than a shallow defensive line (Woolliscroft, 1988, 23–5); the provision of special towers, apparently to facilitate cross-Wetterau signalling, may be a sign that these opportunities were exploited (*O.R.L.* Abt A, Band 2,1, 1936, Strecke 4 & 5, 67–72; Helmke, 1910; Kofler, 1898).

It is possible that the Gask Ridge may have been intended to work on a similar basis, with the tower crews watching routeways and likely trouble spots from a safe distance, as well as simply monitoring their own immediate environs. If so, the superb overlapping views to the north of Raith and Midgate, and the thorough observation cover of Strathearn provided by the rest of the ridge-top sites, would have put it in an excellent position to do so.

Such a possibility might also shed light on the system's relationship with the glen-blocking forts. For, if we are to see these installations in their traditional defensive light (Ogilvie & Richmond 1967, 76), rather than as 'springboards' (Breeze 1982, 55–6) for assaults into the Highlands that never materialized, their positions are such that most would have received almost no prior warning of attack.

Under normal conditions, one assumes that the Romans would have maintained intelligence cover ahead of their lines to give advance warning of any major attack (Woolliscroft 1988, 23–7). But, in the fluid conditions that are likely to have existed for much of the Flavian period in Scotland, intelligence breakdowns could easily have placed the glen-blockers in serious jeopardy. For example, even if one accepts the supposed Fendoch tower as Roman,<sup>6</sup> it could have given the fort no more than a few minutes warning of a surprise attack down the Sma' Glen, and the positions of other glen-blockers, where no such towers are even hinted at, would have been very much worse. Some, such as Bochastle, command views of only a few hundred metres into their glens and so, even at full cohort strength, their garrisons could easily have become hostages to fortune. Midgate and Raith, on the other hand, could, between them, have watched over many miles of the same Highland fringe, but from a range of about 10 km, as well as guarding against flanking movements through Strathearn.

There is obviously little point in an early warning system if the warnings it provides come too late for effective counter-measures to be taken. The Gask Ridge is far enough back from the Highlands to give up to an hour's warning of any attack (even by horsemen), but is still close enough to provide a view of what was happening, at least during daylight and in reasonable weather. In this context, although it is still possible to envisage a scenario in which the glen-blockers formed a distinct non-contemporary line replaced or preceded by the Gask, it is also possible that the two lines could have usefully existed together, with the Gask representing a 'back stop' frontier to which the glen-blockers were, to some extent, outposts.



ILLUS 5 The topography of the eastern end of the Gask Ridge

To return to the signalling details; all of the ridge-top towers, as far east as Midgate (illus 2 & 3,B), can be relayed to Strageath via Raith;<sup>7</sup> Midgate itself occupies a knoll towards the eastern end of the ridge with extensive views in all directions except, again, the north-east, the direction of Bertha. The site of Westmuir, the next tower to the east, on the other hand, is much more difficult to account for. The tower lies c 920 m from Midgate and is situated beside the Roman road, which again, here, lies a little to the south of the ridge-top. A section drawn from the 1:10000 Ordnance Survey map would suggest that this position would also have been just about visible from Raith, but the writer's own survey contradicts this, and the tower is also out of sight of Bertha, to which it is closer than to Strageath. (The half-way point is close to Moss Side.) Such a position follows the pattern set by most of the other towers on the ridge and, as ever, it has a good view to the south. But, from a signalling viewpoint, one might have expected this site to be different, for only c 300 m to its north is the highest point (154 m) on the whole Gask Ridge (NO 029210: illus 5).

Had Westmuir been built on this summit, it would have had considerable advantages. For example, without losing much of its view to the south, it would have been visible from both Raith and Bertha, almost from ground level (illus 3,B), allowing a fairly simple two-stage relay to link Bertha with both Strageath and Kaims Castle. It would also have had an even better view north than Midgate, which would have allowed it to see much further to the north-east along the Highland line, and east towards Perth and the end of Strathearn. Yet the opportunity was ignored, producing a tower with no view north and with limited views in every other direction except south.

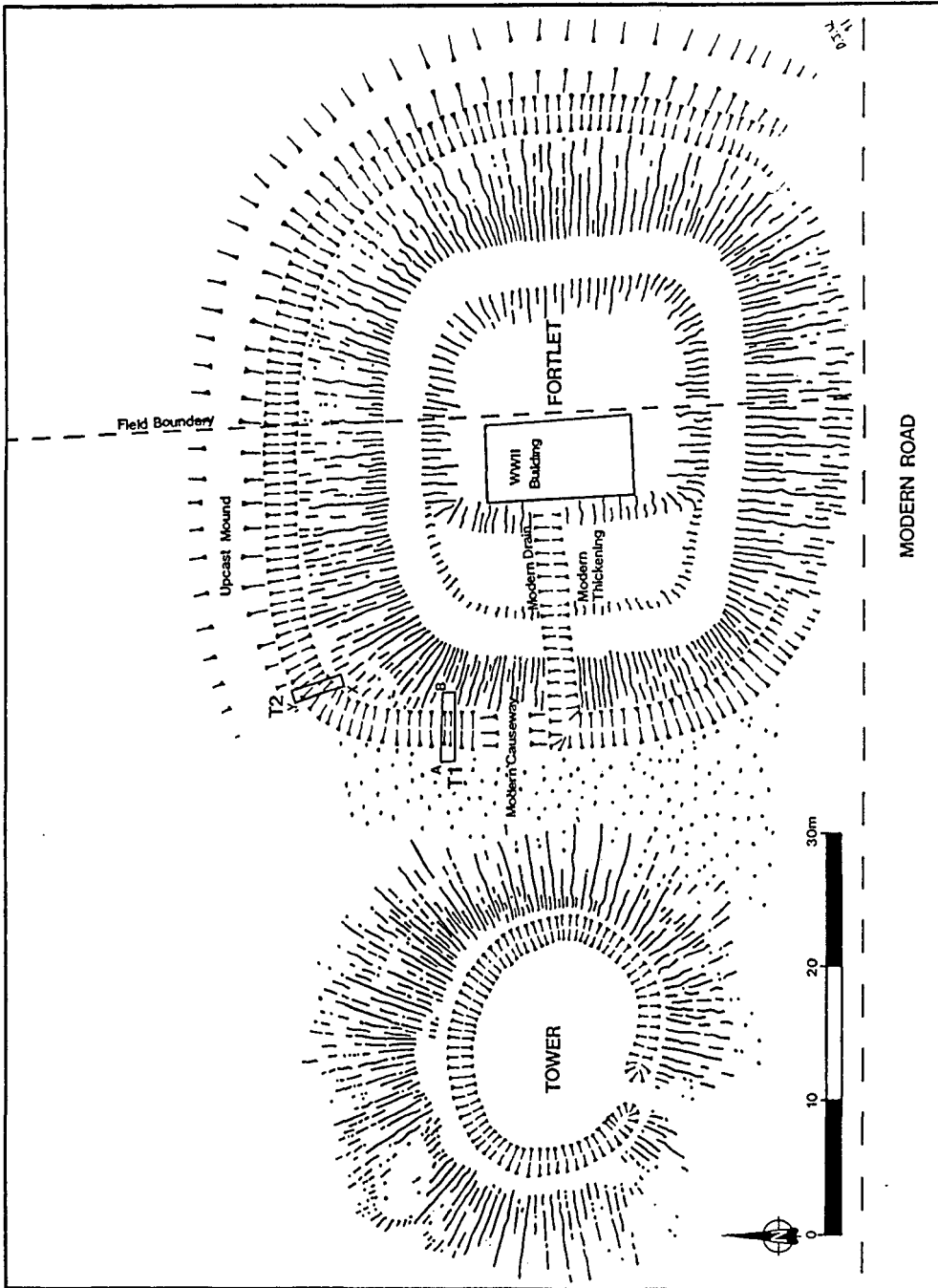
Fortunately, on spacing grounds, the next tower to the east should lie somewhere in Cultmalundie Wood (c NO 040213). It cannot be stressed too highly that, at the moment, the very existence of such a tower is no more than hypothesis. The writer can find no trace on the ground and the dense woodland will make aerial photography useless. But the gap between Westmuir and Peel does seem far too long not to have held intermediate sites and a considerable area of the wood can be seen from both Bertha and Midgate, as well as from Westmuir itself. Such a site would still not have been visible from Raith, however, and so any inter-fort communications between Bertha and Strageath would have needed to pass through a rather more inefficient three stage relay via Cultmalundie, Midgate and Raith.

To the east of Cultmalundie Wood the ground falls away rapidly towards the fort at Bertha and to the Tay but, although contour maps would suggest that Peel and the two or three towers that might be expected between it and Cultmalundie, may just have been visible from Bertha, this could not be confirmed on the ground; these links have not been included on the signalling plan (illus 2). These sites could, however, have been relayed to Bertha via Huntingtower, which does have a clear view of the fort and, as Huntingtower could also have relayed signals to Bertha from any sites between itself and Peel, the system, as a whole, is (depending on the existence of a tower in Cultmalundie Wood) potentially complete.

### MIDGATE (also called Thorny Hill)

Unfortunately, however plausible the above outline system may be, there is one problem which makes it impossible to accept without reservation.

If we return to the dawn of archaeology on the ridge, Christison's original programme included excavations at Midgate (NO 02112047), which was then the most easterly Gask site known (Christison 1901, 32-5). Here, in addition to one of the standard timber towers, he also revealed a rectangular structure, which he took to be a second fortlet of the Kaims Castle



ILLUS 6 Midgate, showing the tower and fortlet and the positions of the two excavation trenches



ILLUS 7 Midgate fortlet seen from the approximate full height of Midgate tower (west). The summit of the ridge can be seen in the distance on the extreme left

type, lying immediately north of the Roman road and only a few metres east of the tower (illus 6). Yet, although Christison's report has remained the foundation for all subsequent studies of the area, this site seems largely to have been forgotten and, when mentioned at all, it is usually dismissed as non-Roman, or even as a virtual figment of its excavator's imagination. Indeed, an observer of the calibre of O G S Crawford (1949, 54–5) was able to visit the site and deny that anything was visible. As the existence of a fortlet at this particular site could cast doubt on our model of the entire system, it was felt important that Christison's identification should be re-examined.

#### THE SITE

The importance of the site lies in its very close proximity to the Midgate tower, for its western ditch comes to within 13 m of the tower ditch (illus 6) and it seems most unlikely that two Roman installations so close together could be exactly contemporary.<sup>8</sup> Moreover, where a group of small Roman military sites, such as the Gask Ridge fortlets, form a distinct morphological class they might reasonably be expected to be contemporary, so that a date for any one installation is highly suggestive as a date for them all.<sup>9</sup> This means that if Midgate is a fortlet of the same type as Kaims Castle and Glenbank, its position would cast doubts (in the absence of evidence to the contrary) as to whether any of the fortlets are likely to have belonged to the tower system.

The site lies at the eastern end of a small but distinct knoll, with its western half in the

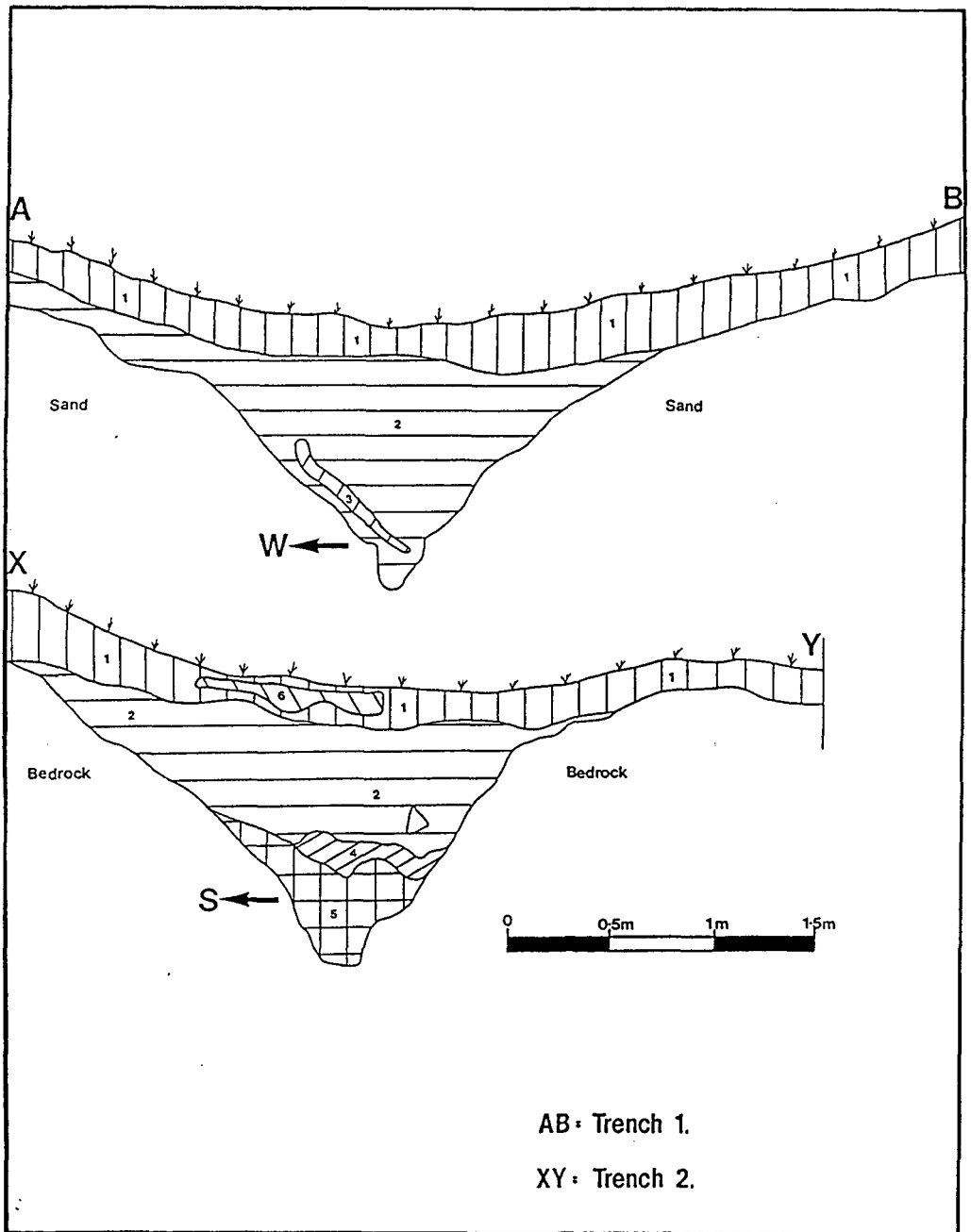
uncultivated south-east corner of a field and its eastern half in dense coniferous woodland. Despite Crawford's denial, it is still clearly visible as an earthwork (illus 7), although it has been heavily damaged since Christison's day by the imposition of a Second World War building (11.13 × 5.8 m) in its interior. It consists of a rectangular enclosure, almost identical to Kaims Castle, measuring 20 m N/S × 23 m E/W internally (Kaims measures 20 × 22 m), rather more square than is shown by Christison's original plan (Christison 1901, Fig 8). Like Kaims it is surrounded by the remains of an earth rampart which, as a surface feature, measures c 4–5 m thick, except in the west where it has been thickened to 11 m since Christison's plan was drawn, perhaps in connection with the Second World War activity. On lower ground, 7 m (on average) out from the ramparts (again as at Kaims), a single ditch can be traced as a shallow hollow, c 3.5 m wide, round all but the south side, where it has been destroyed by the modern road. The orbit of this ditch is rather less regular than is normal for a Roman installation, but this is inevitable, especially in the north, due to the shape and steep sides of the hill.

As Christison (1901, 34–5) pointed out, the ditch is surrounded on its northern and eastern sides by a low mound. He interpreted this as a branch of the Roman road, to give access to the site, and his plan shows it continuing south past the site's south-east corner to the modern road, which largely follows its Roman predecessor, but is here probably on a slightly more northern line. The feature, however, begins to turn, parallel with the ditch, at this corner before being cut off with it on the south side of the site (illus 6); as it consists mainly of rubble from the partly rock cut ditches, it is clearly an upcast mound. There is also a causeway across the western ditch, a little north of centre, and immediately north of a narrow channel through the rampart, which gives the impression of being an entrance. Neither feature appears on Christison's plan, however, despite being conspicuously visible, and so both seem likely to be modern. The channel, in particular, is probably meant for drainage of the interior and may again be connected with the Second World War activity, and the causeway is probably its upcast mound. No other signs of an entrance survive, but this need not surprise us since the entrance at Kaims Castle had been carefully blocked and was also invisible before excavation (Christison 1901, 20). If the site is Roman, one would expect its entrance to have been on the south side, like that of the tower, facing the Roman road.

#### THE EXCAVATIONS

Christison's excavations were confined largely to the interior and produced similar results to Kaims Castle, with no buildings being uncovered, only the remains of paving. Unfortunately, this area has now been so badly damaged by a combination of Christison, Second World War activity and exceptionally heavy infestation by rabbits, that it was thought unlikely that further excavation would produce useful results. Work, therefore, was confined to re-surveying the site and sectioning the ditch, an operation that Christison does not appear to have carried out. Two trenches were dug (illus 6) which, for reasons of accessibility, were grouped around the ditch's north-west corner. Trench 1 (5 × 1 m) sectioned the western ditch towards its northern end where it was just beginning to turn into the corner, whilst Trench 2 (4 × 1 m) cut the western end of the north ditch, again just as it was turning into the corner. The two trenches were thus set at an angle of c 70° and lay 7.6 m apart at their closest.

Both trenches (illus 8) sectioned a 'V'-shaped ditch with a bottom slot or 'ankle-breaker'. In both cases the ditch was 2.5 m wide and a little over 1.2 m deep (1.27 m in Trench 1 and 1.21 m in Trench 2). In Trench 1 the ditch had been dug into firm, but easily



ILLUS 8 Midgate fortlet, the excavated ditch sections. It should be noted that points B and X are both on the inner side of the ditch (see illus 6). 1 turf and topsoil, 2 grey gritty loam, 3 yellow sand, 4 grey silt, 5 plum/grey sand, 6 grey sandy loam



worked yellow sand, but in Trench 2 it was cut through a hard, if brittle, purple/grey sandstone, so that its bottom slot is unlikely to have been the accidental result of cleaning. In both trenches the ditch had been deliberately backfilled with a slightly brown, grey loamy material (L2), probably degraded turf. This was identical to material currently being produced (in disturbing quantity) from the remains of the ramparts by rabbit activity, and was probably the result of the partial slighting of those ramparts. In both sections this layer was essentially homogenous, but both showed a fair degree of gradation, with a preponderance of finer particles towards the bottom, consistent with a long period of water action since backfilling. In Trench 1 the backfill filled the entire ditch, with no detectable sign of primary silt, even in the bottom slot. This, coupled with the very sharply defined sides of the sand cut ditch, suggest that the ditch was backfilled almost immediately after being dug or re-cut. Trench 2 showed a deep silt deposit, some 0.5 m thick in two layers. The lower, and much the thicker, was a 0.4 m deep layer (L5) of silty purple/grey sand, similar to the weathering product of the natural bedrock, which in the area immediately outside the ditch had weathered to produce a thick (c 0.2–0.25 m) layer of soft, but clean, purple/grey sand. Above this, the northern two-thirds of the ditch were covered by a layer (L4) of clean grey silt c 0.1 m thick. The border between these layers was somewhat vague, but that between them and the backfill (L2) was very clear cut; taken together, the two trenches may suggest that the ditch was open and subject to natural silting for some time and was then backfilled whilst in the process of being cleaned out. No dating evidence was found, but this activity must have taken place long enough ago for the backfill to have been graded by water action.

#### INTERPRETATION

In the absence of datable material, one cannot honestly claim that the excavations prove a great deal. Perhaps the most that can be said is that nothing was found in either trench or in the general layout of the site that is other than consistent with a Roman fortlet. Unfortunately, however, a 'V'-shaped ditch, even one with an 'ankle-breaker', is not necessarily diagnostic as Roman in northern Britain; a number of sites of Iron Age date, or at least of Iron Age culture, have also produced such ditches, for example Cnoc a' Caisteil near Alness (Rideout 1987, 68) and Hartburn, Northumberland, which was itself once thought to be a Roman fortlet (Jobey 1973, 17.). Taken together with the surface survey and Christison's results, however, the very close similarity of Midgate to Glenbank and to Kaims Castle appears to make it virtually certain that these nearly identical sites form a distinct class which, although presumably contemporary, do not fit comfortably with the towers. Indeed the writer would wonder whether there would ever have been any doubt over this if Midgate had not been so close to its tower. Furthermore, the aerial evidence from Raith (illus 4) may, as stated, present a fourth member of this class, occupying the same site as a known tower and, therefore, actually over- (or under-) lying it. It is important to remember that none of these sites has yet produced dating evidence and, despite its traditional identification as such, Kaims Castle is no more certainly a Roman fortlet than Midgate. A firm absolute and relative dating (*vis-à-vis* the towers) must, thus, await further excavations, especially at Raith; in the meantime we can use only what evidence we have to weigh up the possibilities.

The site of Midgate itself is not as helpful as might have been hoped, because the tower and fortlet are just far enough apart to remain completely separate. Their ditches do not intersect and, so far as can be seen, neither of their ditch upcast mounds overlies the other. It is, therefore, impossible to establish a relative dating between the two sites and we are left

with a process of elimination between prehistoric, Roman and post-Roman dates for the 'fortlets'.

A non-Roman date has been advocated to the writer in a number of private conversations but, although the possibility must continue to be borne in mind, it does seem somewhat improbable. This is partly a subjective conclusion, because the general form of the 'fortlets', coupled to their (albeit inconclusive) ditch-profiles appears so Roman, but it is also based on their relationship with the Roman road. For, whilst these are the only such sites known in the area, all are within a few metres of the road. Two have their entrances oriented towards it (Christison 1901, fig 2; Maxwell 1990, 353–9), and, whilst the position at Raith is uncertain, even Midgate, whose entrance is unknown, lies parallel to it. It would thus appear most unlikely that these sites could have been constructed before the road was built, or at least planned, which tends to rule out a prehistoric date.

A post-Roman date might be more conceivable, although again the sites' morphologies argue against it. Although such a date cannot be ruled out, severe doubt is cast over it by the apparent presence of a unit of six Roman miles (8877 m) in the sites' spacings. Glenbank and Kaims Castle are almost exactly six Roman miles apart, and Midgate is 12 Roman miles from Kaims, six Roman miles from Raith and six from the fort at Bertha.<sup>10</sup> The use of this unit by non-Roman builders seems unlikely, whilst the very presence of such a systematic approach would make a Roman date more probable, especially since the degree of gradation in the Midgate ditch fill rules out relatively modern dates.

If, therefore, we assume that the 'fortlets' are Roman, the choice is between the Flavian and Antonine periods, the times at which the system's forts were occupied. For the moment, it must be stressed that the evidence for either (or indeed any) period is inconclusive; although the traditional Flavian date may still be considered more likely, it is worth reviewing the evidence, if only to remind ourselves that the case is unproven and to suggest areas in which further data could be sought.

A Flavian date would certainly be more convenient because, although it would complicate our present picture of the system, it would leave its fundamentals unchanged. We would simply have to envisage a process of development in which fortlets were added to a system of towers and forts, or in which towers were added to one of forts and fortlets. The former, in particular, would leave the signalling arrangements discussed above substantially unchanged and there is a certain amount of evidence that might support such a scenario. For example, we have already seen the recurrence of a unit of six Roman miles in the system, and it is noteworthy that Glenbank is six Roman miles from Doune, the only fort on the system that, so far, has shown no sign of re-occupation in the Antonine period (Maxwell 1984). More persuasive evidence might be seen in the fact that there is no sign, as yet, that either Kaims or Glenbank replaced towers, and that Glenbank, like the towers in its vicinity, has a double ditch. It is always dangerous to argue from an absence of evidence and the Glenbank ditch could, of course, be coincidence, but this does seem to link the southern fortlets more closely to the towers and may suggest that a change was made to the system's overall plan during the course of its construction. If so, it would appear that the Gask Ridge sector itself was built first, for whilst at Midgate and Raith the fortlets may have replaced towers (or possibly vice-versa) that had already been completed, Kaims and Glenbank seem to have been built together with their surrounding towers, which may all, therefore, be slightly later. Furthermore, G S Maxwell (1986, 354) has recently sought to establish a rational spacing system for the towers in the southern area, based on the north gate of Ardoch, and of which Glenbank and Kaims seem to form an integral part. All this should have helped to tie the

system together once and for all but, unfortunately, it is still unproven whether these double ditched southern towers are themselves Flavian. Only the single ditched towers have so far produced dating material and, as these show no such regularity in their spacing (Table 1), the two types need not necessarily go together.

An Antonine date for the 'fortlets' would force rather more of a change in our model. Current thinking envisages a Flavian system of forts, fortlets and towers, and an Antonine system of forts only, with no signalling links between them, because none of the forts is intervisible. Antonine fortlets would change this to an arguably more balanced picture: a Flavian system of forts and towers and an Antonine system of forts and fortlets. Such a use of small fortlets as road posts is hardly unknown in Antonine Scotland and three, admittedly tenuous, strands of evidence could be marshalled in favour of an Antonine date.

First, there is a general tendency for small fortlets of this type to be more of a second- than a first-century phenomenon. For example, Maxwell (1990) compares the standard picture of an integrated Flavian Gask Ridge system with fortlets, to the Flavian system on the Wetterau Limes in Germany. Yet it is noteworthy that, where they have been investigated, the Kleinkastelle of the German Limes have often proved to be later than the original Flavian design (Batz & Herrmann 1989, 374–423) and usually date to the second century. Similar tiny fortlets proliferated in the mid second century, as milecastles or Kleinkastelle on the frontiers, as road posts in their hinterlands, or as components of coastal defences (Bellhouse 1989; Newall 1976). First- and early second-century fortlets, on the other hand, are rarer and usually larger, as can be seen at Haltwhistle Burn (Gibson & Simpson 1909), Cargill (Richmond 1943, 47–8) and Castleshaw (Walker 1989). Milecastle-sized fortlets do occur in the first century, for example at Old Burrow and Martinhoe in Devon, (Fox 1977, 15–20) but they are much less common.

A second strand of evidence stems from possible parallels between the interiors of Kaimes Castle and Midgate, and some of the milecastles of the Antonine Wall. Christison (1901, 21, 33–4) expressed surprise that he could find no sign of internal buildings in these 'fortlets', and this continues to cause puzzlement. Christison had pioneered the excavation of timber features in Scotland (Christison & Cunningham, 1898, 443–6) and was thus quite capable of finding such buildings. Yet in both 'fortlets' he found only a paved interior. It does not, however, seem to have occurred to him to look under this paving for signs of an earlier period which may have involved buildings. This is a pity, because in recent years a number of Antonine Wall milecastles have been found which had had their interiors cleared of buildings and paved over at some time after their completion. The milecastles picked out for such treatment (Wilderness Plantation, Kinneil and possibly Seabegs Wood: Wilkes 1974, 57; Keppie & Walker 1981, 145–6) are all in important potential signalling positions (Woolliscroft 1993, 208–307) and the Gask Ridge 'fortlets' may have had a similar history. Kaimes Castle, in particular, could have been vital for signalling and it would be interesting to see what a re-excavation of the site might reveal.

The third piece of evidence is the most tenuous of all. It has long been fashionable to use spacing criteria and the relationships between known Roman installations to help in searching for new ones. The value of such numbers games may sometimes be debatable, but we have already seen the recurrence of a unit of six Roman miles in the spacing of the Gask Ridge 'fortlets' and in their relationship to the forts of Bertha and Doune. It was because of this pattern that the writer sought out the aerial photograph of Raith (illus 4) discussed above, and if the pattern is projected farther south it would also place installations on the long-suspected sites of Stirling, and Torwood (c NS 834846). The principal interest, however,

would lie in the fact that a further six-mile spacing to the south of Torwood would project, as the base of the system, not the Flavian fort of Camelon, as might be expected, but the Antonine Wall fort of Mumrills.

The evidence from signalling is ambiguous, even if we are right in thinking that there actually was such a system in place. Certainly, it might be thought odd if the Antonine forts were left without relay sites to provide inter-fort communications; if the Antonine system had used isolated relay stations, rather than a closely spaced line of watch posts, fortlets would have been a safer size of installation to use. But there is a problem because, although the 'fortlets' come tantalizingly close to being able to provide such links, they do not quite manage it and this must throw doubts on their relevance to an Antonine context.

The problem, once again, is the failure to occupy the eastern summit of the Gask Ridge, to the north of Westmuir. This appeared peculiar enough on a Flavian system, where it merely produced an unnecessary degree of inefficiency, but on an Antonine fort and fortlet system it would have been fatal. For, although Kaims can link Ardoch to Strageath, Raith (if it exists) can link Strageath to Midgate, and Glenbank can link Ardoch to points farther south, Midgate's view to Bertha is blocked by the ridge summit, so that one of the system's forts would have been left cut off. The puzzle is thus: if the 'fortlets' are Antonine, why was Midgate not built on the higher ground to its north-east so as to link Raith and Bertha and allow the whole system to work ?

There are two possible solutions, but neither appears very satisfactory. For example, it could be that there actually was some sort of minor installation outstationed on the summit that we have simply not yet found. This seems unlikely, if only because it would have been such a needlessly complex arrangement. The summit is only 7 m higher than the 'fortlet'. Midgate is already fully exposed to the prevailing westerly wind, so it would have gained little in the way of shelter by being positioned off the highest point and, as both Raith and Kaims are sited on hilltops, there seems to be little reason why Midgate should not also have been.

The second possibility rests on the weakness of the evidence for an Antonine occupation of Bertha (Adamson & Gallagher 1986). Excavations at the site, so far, have produced only a single phase of defences and all of the stratified pottery is Flavian. The only evidence for Antonine activity is a single sherd of probable Antonine pottery, picked up as a surface find, and a dedication to *Disciplinae Augusti* found in the river (Keppie 1983, 402) which, although undated, is of a type which does not occur before Hadrian and is generally Severan (RIB 990, 1128, 1723, 1978, 2092).

Obviously, if the fort did not have an Antonine phase, there would be no need for any signalling arrangements to include it. But even this is not quite enough because, if this were the case, Midgate would become the terminal installation of the system. This might be surprising in its own right (although not impossible) as the site is only a fortlet. One would certainly expect that if there was the opportunity to place the terminal site of such a line on a magnificent position with a superb view towards the exact direction from which any major trouble might be expected to come, then that opportunity would be taken up. If this site could also have provided observation cover, from a safe distance, of Bertha and of a greater area around it than the fort itself could command, one would have expected such a site to be doubly tempting. In other words, even if Bertha had not existed, one would expect that, if Midgate was part of a system consisting only of forts and fortlets, it would still have been built on the ridge summit.<sup>11</sup>

There is also another difficulty. Antonine fortlets at Midgate and Raith would leave our

model of the Flavian system unaffected, due to the presence of towers. But, if Kaims Castle was Antonine there could be no general signalling system on the Flavian line since this site, which is the only possible link between the forts of Ardoch and Strageath, has no corresponding tower. This, however, is to begin to enter a circular argument since, despite mapping a possible Flavian signalling system we still cannot be sure that one ever existed, or was even aspired to. Under these circumstances, all that can be said is that, whilst the Gask Ridge's minor installations do seem to make most sense in the traditionally envisaged, single-period, probably Flavian, context, there are peculiarities even here; the exact position will be known only when a good deal more excavation and aerial reconnaissance has been carried out.

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## NOTES

- 1 Greenloaning, Westmuir, Peel and Huntingtower are known only from aerial photography, although there seems little doubt as to their identity.
- 2 G S Maxwell (1990, 354) mentions amphora fragments from Glenbank but has yet to publish their date and context.
- 3 The results of the excavation were surprising because the site stands on an exposed hilltop with a superb view over Stirling to the Highland fringe, a marvellous signalling position but an unpleasant place to live.
- 4 It is still not certain that Doune is part of the Gask System. Its discoverer (Maxwell 1984) has suggested that it might have done away with the need for a fort at Stirling, but the two are six Roman miles apart, the same as Ardoch and Strageath. They would also have had complementary roles because Stirling, the traditional gateway to the Highlands, watches the primary route over the Forth, whilst Doune guards an ancient secondary pathway through the extensive Forth mosses.
- 5 The National Monuments Record 6-inch map records a ring-ditch at this reference discovered from the air in 1984 which may be the missing tower, but the writer has been unable to obtain further information.
- 6 The site is unexcavated, but its prominent central mound and faint outer ditch do not look like any other Flavian tower. It stands in a cairnfield and until the 1770s had five standing stones on it. In 1783 large amounts of stone were removed to build a bridge over the Almond (Crawford 1949, 48–9). Yet all other Flavian towers in Scotland are built solely of timber. As for its position, Fendoch is visible but not the newly discovered putative fortlet (information from G D B Jones) which stands only a few hundred metres away. Its famous view up the Sma' Glen is actually extremely limited, even from the height of a Roman tower, perhaps no more than c 400 m. The site is also some distance from the fort; a vastly superior site can be found on the opposite (northern) side of the glen mouth whence a tower would have had a dramatically improved view up the glen, and a view to the fortlet, whilst being much closer to the fort.
- 7 It has been the writer's usual policy not to cite any intervisibility that has not been personally checked in the field but, as much of the ridge-top is heavily wooded, the intervisibilities between Raith and the sites to the east of Kirkhill have been checked using the contours on 1:10000 maps. The maps would suggest, however, that the views would have been very clear with no borderline cases.
- 8 Christison (1901, 32) attempts to get around the issue by describing the tower as an outwork of the fortlet.

- 9 The entire tower system has, after all, been dated on precisely this basis.
- 10 The spacings are exact to within 1–3%. Within this margin the sites appear to have been sited in accordance with local tactical considerations. It is noteworthy that the forts of Camelon, Ardoch and Strageath do not fit into this sequence. Ardoch and Strageath are also six Roman miles apart, but Kaims lies much closer to Ardoch than to Strageath, and Glenbank is much closer to Ardoch than Doune. The measurements are scaled from maps and thus subject to inaccuracy due to the unevenness of the ground, but as the difference between six Roman and six statute miles is c 725 m, almost half a Roman mile, it is unlikely that the two units could be mistaken for one another.
- 11 It might also be interesting to speculate as to why the Second World War installation was not built on the ridge summit, since the writer is informed that it was an anti-aircraft position.

## REFERENCES

- Adamson, H C & Gallagher, D B 1986 'The Roman fort at Bertha, the 1973 excavation', *Proc Soc Antiq Scot*, 116, (1986), 195–204.
- Baatz, D & Herrmann, F R 1989 *Die Römer in Hessen* (2nd edn). Stuttgart.
- Bellhouse, R L 1989 *Roman Sites on the Cumberland Coast, a New Schedule of Coastal Sites*. Kendal.
- Breeze, D J 1982 *The Northern Frontiers of Roman Britain*. London.
- Breeze, D J 1983 'The Roman Forts at Ardoch', in O'Connor, A & Clarke, D V *From the Stone Age to the 'Forty-Five*, Edinburgh, 224–36.
- Breeze, D J 1992 'The Great Myth of Caledon', *Scott Forestry*, 46 (1992), 331–5.
- Christison, D 1901 'Excavations Undertaken by the Society of Antiquaries of Scotland of Earthworks Adjoining the "Roman Road" Between Ardoch and Dupplin Perthshire', *Proc Soc Antiq Scot*, 35 (1900–1), 16–43.
- Christison, D & Cunningham, J H 1898 'Account of the Excavation of the Roman Station at Ardoch, Perthshire Undertaken by the Society of Antiquaries of Scotland in 1896–97', *Proc Soc Antiq Scot*, 32 (1897–8), 399–476.
- Crawford, O G S 1949 *Topography of Roman Scotland North of the Antonine Wall*. Cambridge.
- Donaldson, G H 1988 'Signalling Communications and the Roman Imperial Army', *Britannia*, 19 (1988), 349–56.
- Fox, A 1967 'Martinhoe and Old Burrow', in *Studien zu den Militärgrenzen Roms* (Proc 6th Int Limes Congress), Köln, 15–20.
- Frere, S S & Wilkes, J J 1989 *Strageath, Excavations Within the Roman Fort 1973–86* (Britannia Monograph Series No.9). London.
- Gibson, J P & Simpson, F G 1909 'The Roman Fort on the Stanegate at Haltwhistle Burn', *Archaeol Aeliana*, 3 ser, 5 (1909), 213–85.
- Hanson, W S 1987 *Agricola and the Conquest of the North*. London.
- Hartley, B R 1970 'The Evidence of Samian Ware for the Flavian-Trajanic Frontiers', *Roman Northern Frontier Seminar*, 2 (1970), 1–5.
- Helmke, P 1910 *Römische specula über einer Germanischen Anlage auf dem Johannisberg bei Bad Nauheim*. Bad Nauheim.
- Hobley, A S 1989 'The Numismatic Evidence for the Post-Agricolan Abandonment of the Roman Frontier in Northern Scotland', *Britannia*, 20 (1989), 69–74.
- Jobey, G 1973 'A Native Settlement at Hartburn and the Devil's Causeway, Northumberland (1971)', *Archaeol Aeliana*, 5 ser, 1 (1973), 11–53.
- Keppie, L J F 1983 'Roman inscriptions from Scotland: some additions and corrections to RIB I', *Proc Soc Antiq Scot*, 113, (1983), 391–404.
- Keppie, L J F & Walker, J J 1981 'Fortlets on the Antonine Wall at Seabegs Wood, Kinneil and Cleddans', *Britannia*, 12 (1981), 143–62.
- Kofler, F 1898 'Straßenturm im Wolfersheimer Walde', *Westdeutsche Zeitschrift*, 17, Limesblatt, (1898), 767–71.

- Leiner, W 1982 *Die Signaltechnik der Antike*. Stuttgart.
- Maxwell, G S 1984 'New Frontiers: The Roman Fort at Doune and its possible significance', *Britannia*, 15 (1984), 217–23.
- Maxwell, G S 1990 'Flavian Frontiers in Caledonia' in Veters, H & Kandler, M (eds) *Akten des 14. Internationalen Limeskongresses 1986 in Carnuntum*, Vienna, 353–65.
- Newall, F 1976 'The Roman Signal Fortlet at Outerwards, Ayrshire', *Glasgow Archaeol J*, 4 (1976), 111–23.
- Ogilvie, R M & Richmond, I A 1967 *Cornelii Taciti de Vita Agricolae*. Oxford.
- ORL = Fabricius, E Hettner, F & von Sarwey, O *Der Obergermanisch-Raetische Limes Des Roemerreiches*.
- Pitts, L F & St Joseph, J K 1985 *Inchtuthil: the Roman Legionary Fortress* (Britannia Monograph Series, 6). London.
- RIB = Collingwood, R G & Wright, R P 1965 *The Roman Inscriptions of Britain*. Oxford.
- Richmond, I A 1943 'Recent Discoveries in Roman Britain From the Air and in the Field', *J Roman Stud*, 33 (1943), 45–54.
- Rideout, J S 1987 'Excavation of an Earthwork at Cnoc a' Caisteil, AIness, Easter Ross', *Glasgow Archaeol J*, 14 (1987), 63–9.
- Rivet, A L F 1964 'Kaims Castle' and 'The Gask Ridge Signal Stations', *Archaeol J*, 121 (1964), 196–8.
- Robertson, A S 1974 'Roman "Signal Stations" on the Gask Ridge', *Trans Perthshire Soc Natur Sci*, (Special Issue), (1974), 14–29.
- St Joseph, J K 1976 'Air Reconnaissance of Roman Scotland 1939–75', *Glasgow Archaeol J*, 4 (1976), 1–28.
- Steer, K A 1956 'An Early Iron Age Homestead at West Plean, Stirlingshire', *Proc Soc Antiq Scot*, 89 (1955–6), 227–51.
- Topping, P 1987 'A New Signal Station in Cumbria', *Britannia*, 18, (1987), 298–300.
- Walker, J (ed) 1989 *Castleshaw, the Archaeology of a Roman Fortlet*. Manchester.
- Wilkes, J J 1974 'The Antonine Wall Fortlet at Wilderness Plantation, Lanarkshire', *Glasgow Archaeol J*, 3 (1974), 51–65.
- Woolliscroft, D J 1988 'The Outpost System of Hadrian's Wall', *Trans Cumberland Westmorland Antiq Archaeol Soc*, 2 ser, 88 (1988), 23–8.
- Woolliscroft, D J 1989a 'Signalling and the design of Hadrian's Wall', *Archaeol Aeliana*, 5 ser, 17 (1989), 5–19.
- Woolliscroft, D J 1989b 'Elevated Archaeological Photography', *British Archaeol*, 13 (June 1989), 18–21.
- Woolliscroft, D J 1993 *Signalling and the Design of Roman Frontier Systems*. Unpublished PhD thesis, University of Manchester.
- Woolliscroft, D J & Hoffmann, B 1991 'Zum Signalsystem und Aufbau des Wetterau-Limes', *Fundberichte aus Baden-Württemberg*, 16 (1991), 531–43.