15
Flavian fort sites in South Wales: a spreadsheet analysis

J. W. M. Peterson
School of Information Systems, University of East Anglia, Norwich NR4 7TJ, UK

15.1 Introduction

A Roman centuriation, with parameters determined by the relative position and orientation of Roman roads, has been postulated in the territory of the Dobunni (approximately the English west and south-west midlands). This paper shows how the existence of the same grid can be tested further using data independent of the original hypothesis by statistical analysis of Roman fort sites in South Wales.

An appraisal of the data with a spreadsheet shows a variable association of Roman forts with the centuriation, which can be related to the likely course of events during the Roman conquest of the area. We may therefore suspect that the survey, as it extended to South Wales, had a military function, and that the location of several Flavian forts was determined by the military commander, who was also a well-known land surveyor.

15.2 The definition of the centuriation.

We may calculate the *x-y* coordinates, in some modern survey, of the intersection points of a hypothetical centuriation by making a Euclidean transformation of the modern survey grid itself. For this we need to specify the centuriation's angle and module, and the location of one of its intersection points. In using this approach we assume, as Legendre (1957) did in the case of Tunisian systems, that some of the *agrimensores* (Roman land surveyors) were almost as competent as modern surveyors. The validity of this assumption has been supported most recently by evidence from the Saône plain in eastern France, where widely separated patches of centuriated boundaries fit a single calculated model with an accuracy of linear measurement better than one part in 2,500 (Peterson 1993, 48–60).

In the territory of the Dobunni, which covered approximately the English west and south-west midlands, a hypothetical centuriation grid has been defined (see Figure 15.1). The existence of the grid would explain why some road segments have simple angular relationships, and why others, corresponding to *quintarii*, are parallel and at multiples of 5 centuries apart.

Although a description of this system is currently unpublished, its documented parameters have been unchanged since January 1993. They are:

Angle east of north	34.1375°
Coordinates of one intersection	(40919, 25697), i.e. SP 0919 5697
Module	709.76m.

The module is the distance between *limites*, i.e. 2,400 Roman feet.

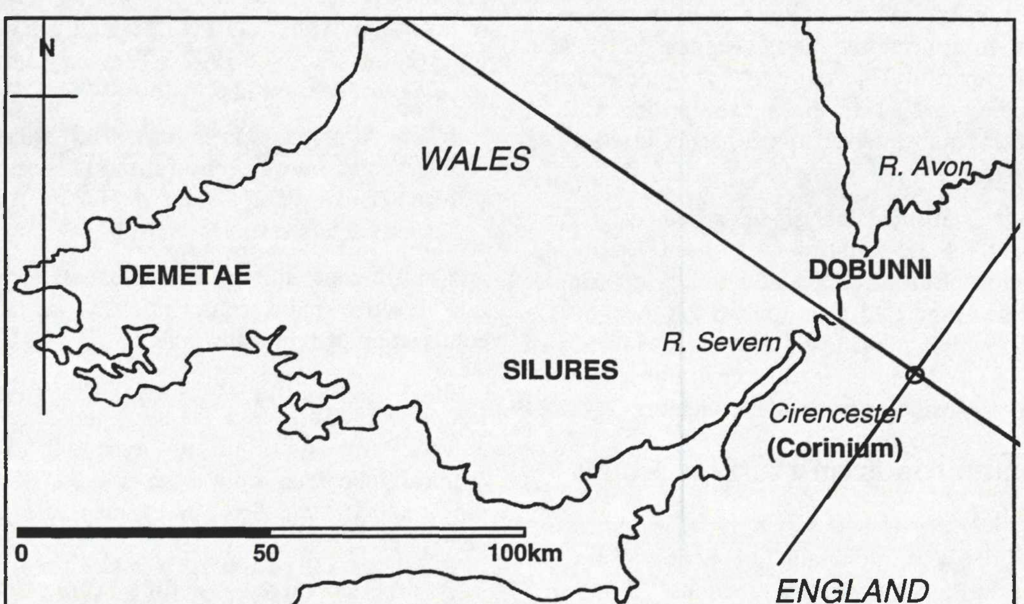


Figure 15.1: Position of the Dobunnian centuriation in relation to South Wales.

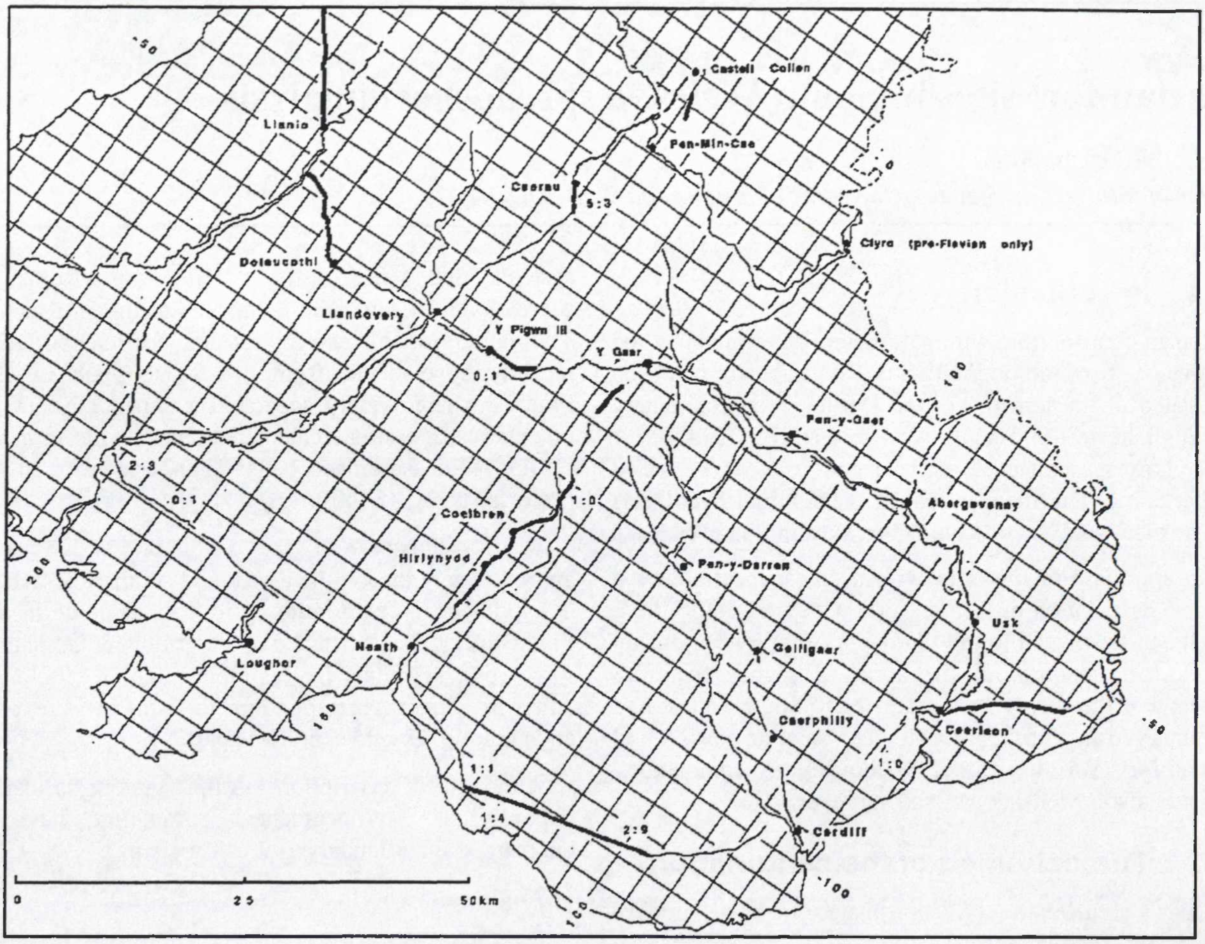


Figure 15.2: South Wales: Flavian forts, roads and hypothetical *quintarii*.

In theory, the principal axes of this grid have also been identified. The supposed *decumanus maximus*, in the west-north-west direction, lies on the line of Ermin Street (a Roman road) as it approaches Cirencester from the east-south-east. The other major axis is supposed to intersect this line near the early Roman fort which underlies the town. The *quintarii* are consequently defined by lines parallel to these axes at intervals of 3548.8m. One of their intersections is, again in theory, at (40978, 25657).

As used in the statistical analysis described below, these are independent values. After they had been determined, the configuration of an early fort and a river crossing at Hay on Wye (see Figure 15.5) prompted the thought that the centuriation might extend to the distant uplands of South Wales. The findings in this new area allow the hypothesis to be cônsidered in a wider context.

15.3 Roman roads and forts in South Wales.

Despite the hills and mountains of South Wales, its Roman roads have some straight sections. Following precedents set in other centuriations, and particularly in the previously identified Dobunnian example, they might be expected to show the effects of a hypothetical centuriated survey.

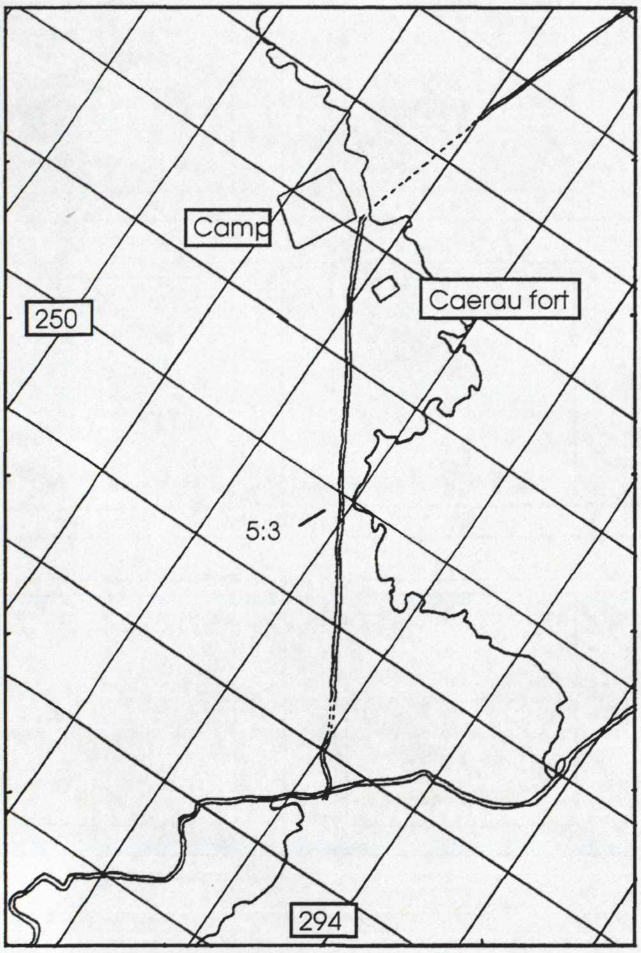
They may conform to the *limites*, sometimes on them or parallel to them, sometimes having rational tangent relationships with them because they coincide with their intersections (Peterson 1992). They may also be related to the *quintarii* because in principle

> 'every fifth main *limes* was made wider than the intervening ones, to ensure that it became a usable road' (Dilke 1971, 93, after Hyginus Gromaticus, second century AD),

and also because this principle appears to have been put into practice more conscientiously in the Dobunnian centuriation than in many others.

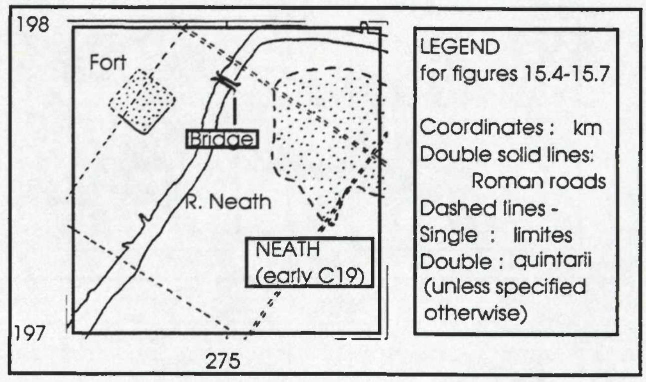
Figure 15.2 shows how the Roman roads described by Margary (1973) relate to the hypothetical grid of *quintarii* extended from its origin at Cirencester. Some of these roads are uncertain; only those marked 'Roman Road' on the 1:50,000 Ordnance Survey maps are shown with a heavy line.

As expected, there is a definite segment of Roman road parallel to the grid. This leads to a fort site, Y Pigwn. It is on hypothetical *quintarius* SD LX (60 to the left, or south-south-west, of the *decumanus maximus*). Apart



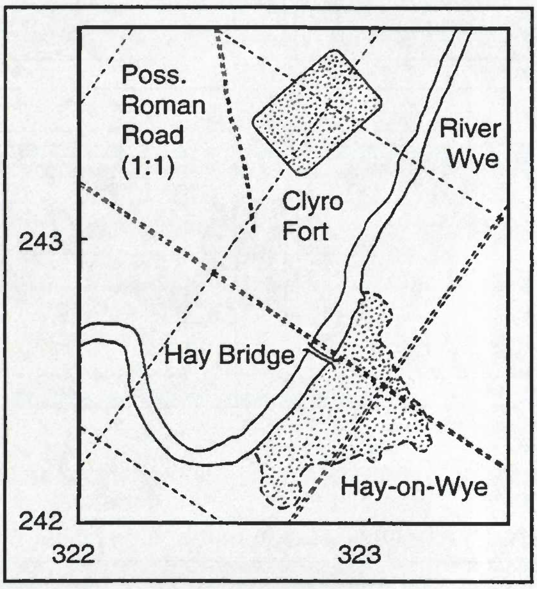
Based on Ordnance Survey 1:25,000 mapping with the permission of the Controller of Her Majesty's Stationary Office, © Crown Copright.

Figure 15.3: Roman road at 5:3.



Based on Ordnance Survey 1:10,000 mapping with the permission of the Controller of Her Majesty's Stationary Office, © Crown Copright

Figure 15.4: Neath.



Based on Ordnance Survey 1:10,000 mapping with the permission of the Controller of Her Majesty's Stationary Office, © Crown Copright

Figure 15.5: Clyro and Hay-on-Wye.

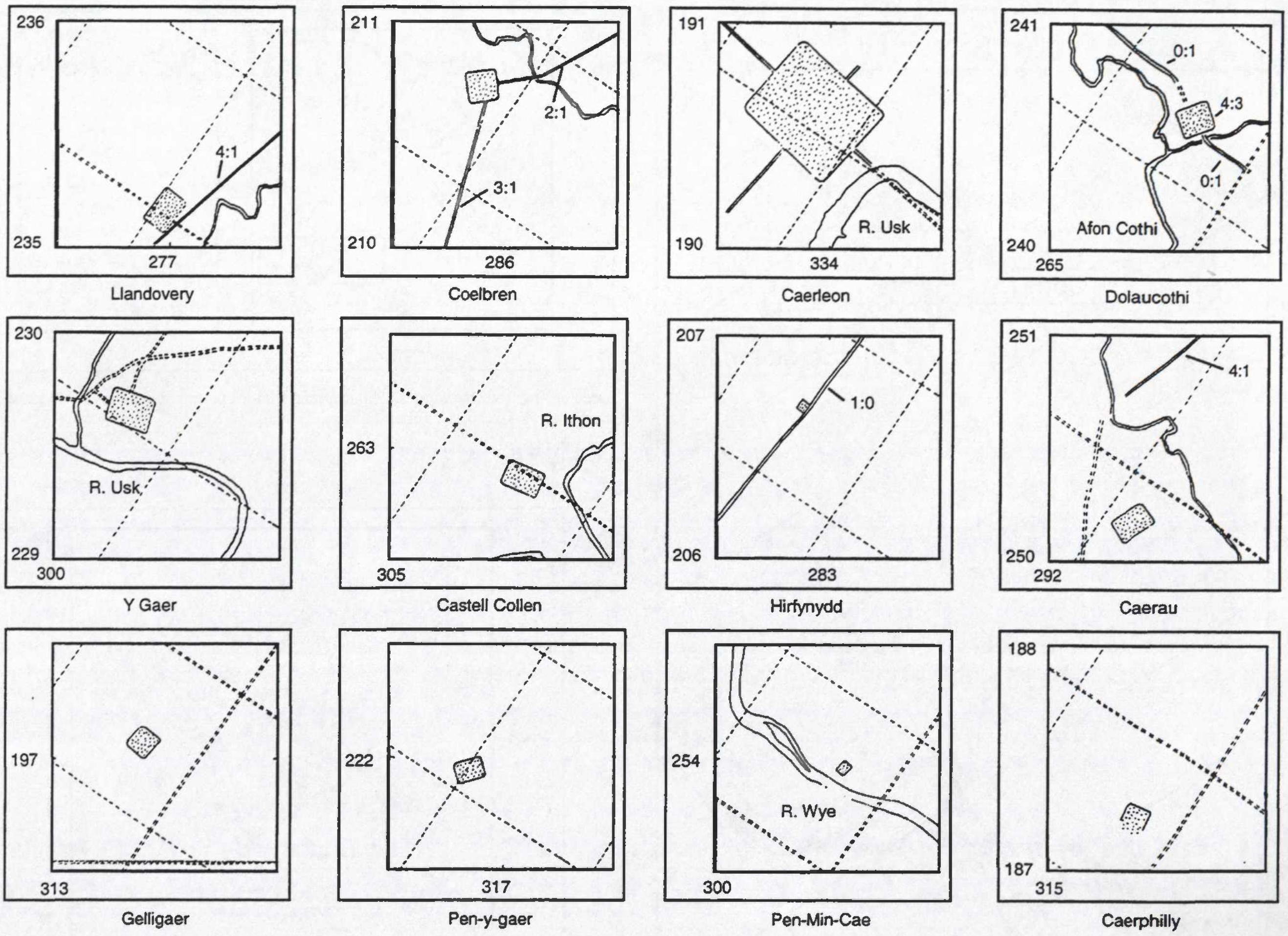
from this case of parallelism, oblique relationships can be seen between road segments and the survey grid. One is shown in greater detail (see Figure 15.3).

There are also two long-existing river crossings related to *quintarii*, at Neath and Hay-on-Wye. Margary (1973, fig. 13, 342) suggests that these are both at or near Roman river crossings. Both of them have attendant Roman military works intersected by *limites* (see Figures 15.4 and 15.5).

These relationships could indicate that the hypothetical Dobunnian survey extended to at least part of South Wales. However, there must be doubt. Constrained as they are by natural topography, the Roman roads may not be able to reflect the structure of a centuriated survey to any great extent. Their layout may thus not be particularly revealing.

Sites, which (geometrically speaking) are of lower dimension, may tell us more because they may be less constrained. In particular, the orientation of forts may be more freely chosen. They may also be placed at one of many alternative positions on quasi-linear (one dimensional) natural features such as rivers or hilltop ridges. Thus their locations, even if fixed in one dimension, may still be free in the other. For these reasons they may show the survey's effects more clearly.

Forts may be related to a centuriation in two principle ways. First, the orientation of a fort (or a fortified town) can be that of a centuriation; the second fortress at Gloucester (later a colonia) is related in this way to this hypothetical centuriation and there are other examples from France and Algeria (Chouquer & Favory 1991, 183; Soyer 1976, 141, 152). Second, the location, if it is to be regarded as significant, will be abnormally close to centuriation's *limites* or *quintarii*. These two expectations can be tested by a survey of the locations of all the forts, as they relate to the centuriation.



Based on Ordnance Survey 1:10,000 mapping with the permission of the Controller of Her Majesty's Stationary Office, © Crown Copright.

Figure 15.6: Configuration of forts.

15.4 Forts – definition of the survey

The survey area is the present-day country of Wales with a northern limit $y = 26800$. This limit was set in the earlier study of the Dobunnian area because it was the northern boundary of the 1:50,000 map initially used to study that system, and because this was the point at which apparent traces on the ground appeared to be tailing off. It is arbitrary, but it does correspond approximately to the modern conventional division between North and South Wales, and it restricts the fort sites to those in Nash-Williams' (1954, 9) 'southern command', with headquarters at Caerleon (Isca).

The chosen sites are those forts (of all sizes) which now seem to have been in use during the maximum military expansion in the area. According to a current atlas of Roman Britain (Jones & Mattingly 1993), this was in the Flavian period. In our area there are twenty sites used at some time between c. AD 74–100 (Jones & Mattingly 1993, Maps 4:34, 4:35), excluding those which are postulated or whose occupation or interpretation is not certain (see Figure 15.2).

The locational analysis relied on information provided by CADW, in the form of photocopies of fragments of the sites and monuments records base map. However, it was unrealistic to expect that suitable *x-y* coordinates, to 10m, would be available for all these sites, because not all scheduled areas are centred on the corresponding fort, so Nash-Williams' general survey was used in support. The CADW maps alone provided unambiguous data in 12 cases, and in five other cases they were unambiguous when both sources were used. Nash Williams alone provided less reliable locations for the other three sites: Pen-y-Daren, Usk and Abergavenny. Other more recent sources of data on these twenty sites were not used in order to avoid unconscious selection of particularly supportive information. The CADW data, supported by Nash Williams, have the merit, from the point of view of a numerical study which is trying to be objective, that they are drawn from a set of data which was independently created, even if it does not use all the most recently published results to provide locational information.

15.5 Analysis of orientation and location.

The orientation of one of the twenty sites, Neath, has already been shown; it is close to that of the centuriation. Similarly we may note the near coincidence of orientation of forts at Llandovery, Gelligaer, Hirfynydd, and Pen Min Cae (see Figure 15.6). However, this could be attributed mainly to the influence of natural topography. In any

Welsh forts KS calculations

	1	2	3	4	5	6	7	8	9	10
1		**Origin**		**Module**	3548.8		**Sites**	20		
2		40978								
3		25657		**Angle**	34.1375		**Max. D**	0.307		
4										
5						**Cumulative**			Intermediate	
6	**Site**	**Name**	**X**	**Y**	**Dist.**	**Observations**		**D**	Calculations	
7	**#**					Actual	Expected		(wnw)	(nne)
8										
9	16	Y Pigwn III	28280	23122	0.0158	0.05	0.031	0.019	2155	28
10	5	Castell Collen	30559	26286	0.0176	0.10	0.035	0.065	1047	3518
11	1	Llandovery	27698	23517	0.0177	0.15	0.035	0.115	2091	31
12	13	Llanio	26440	25644	0.0393	0.20	0.077	0.123	3147	3479
13	19	Caerphilly	31538	18722	0.1012	0.25	0.192	0.058	180	3186
14	17	Caerau	29239	25017	0.1117	0.30	0.211	0.089	1303	3351
15	18	Pen-Min-Cae	30056	25396	0.1217	0.35	0.229	0.121	216	426
16	7	Gelligaer	31341	19707	0.1353	0.40	0.252	0.148	240	3135
17	11	Usk	33778	20053	0.1381	0.45	0.257	0.193	3304	1931
18	2	Neath	27474	19773	0.1552	0.50	0.286	0.214	678	3273
19	12	Loughor	25643	19798	0.1706	0.55	0.312	0.238	1778	303
20	14	Dolaucothi	26564	24060	0.1853	0.60	0.336	0.264	329	1711
21	20	Abergavenny	32990	21404	0.1896	0.65	0.343	0.307	3212	1593
22	9	Cardiff	31808	17660	0.3046	0.70	0.516	0.184	2631	3008
23	6	Pen-y-Darren	30500	20679	0.3588	0.75	0.589	0.161	2009	2912
24	8	Pen-y-Gaer	31685	22194	0.3962	0.80	0.635	0.165	703	809
25	10	Caerleon	33391	19060	0.5266	0.85	0.776	0.074	934	2187
26	4	Y Gaer	30033	22966	0.5438	0.90	0.792	0.108	965	1477
27	3	Coelbren	28588	21071	0.5773	0.95	0.821	0.129	2291	2524
28	15	Hirfynydd	28288	20668	0.5842	1.00	0.827	0.173	2512	1054

NUM

Figure 15.7: Spreadsheet for Kolmogorov-Smirnov test.

case, only an incomplete set of plans could readily be assembled, so no statistical analysis of orientation was attempted.

The location of the forts is, on the other hand, more suitable for numerical analysis. We have a more complete set of data. When a fort's outline is known, the point centre of symmetry can be used to represent its location. Otherwise we can use a representative point in the centre of the scheduled area, or as indicated by Nash Williams.

These points show some near coincidences with the grid of *quintarii*. The significance of this can be assessed with a Kolmogorov-Smirnov test.

The site coordinates were entered into a Microsoft Excel spreadsheet. The screen (see Figure 15.7) shows the coordinates to 10m under the headings X and Y (columns 3 and 4). Intermediate values for distance are then calculated in columns 9 and 10. The distance of the site from a *quintarius* in the west north west direction is

$$((y-y_0)\sin\alpha-(x-x_0)\cos\alpha)\mathrm{Mod}\mu$$

In the north north east direction it is

$$((y-y_0)\cos\alpha-(x-x_0)\sin\alpha)\mathrm{Mod}\mu$$

where x_0, y_0 are the origin coordinates (to 10m), α is the angle of the centuriation east of north in degrees and μ is the module in metres.

The closest distance, $\underline{d}$, in column 5, is then the minimum of these two values and their differences from the module, expressed as a fraction of half the module (since no point can be further away from the sides of a square than its centre).

The Kolmogorov-Smirnov D values are computed by sorting columns 1–5 of the data rows 9–28 in ascending order of distance. The actual cumulative observations increase by one twentieth (in this instance) for each line. The expected cumulative observations for these distances are

$$1-(1-d)^2$$

Each D value is the difference between the corresponding values in the two preceding columns. The largest value, Maximum D, is identified in Row 3 Column 8.

From this table of figures we can see that the four sites with lowest distance values all have this distance measured in the north-north-east direction (remembering that 3518 signifies a distance of 31m in the opposite direction). In other words, they lie near *quintarii* running in the west-north-west direction, as earlier figures have shown.

A graph was produced as an Excel chart of the data rows, columns 5–7 (with appropriate format changes), treating the first column as *x* values for an *x-y* chart. This was transferred to a Word 5 document and captioned (see Figure 15.8).

The maximum D value is 0.307. For 20 observations a critical value of D of 0.29408 would be exceeded with a probability less than 0.025, on the hypothesis of uniform

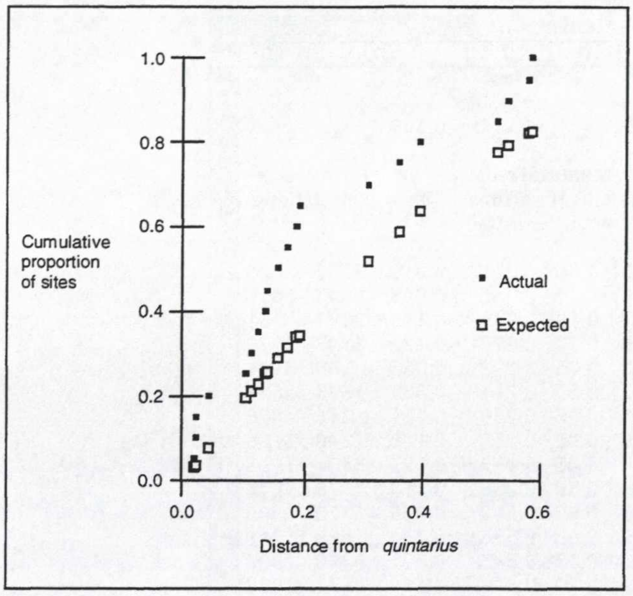


Figure 15.8: Graph of Kolmogorov-Smirnov test.

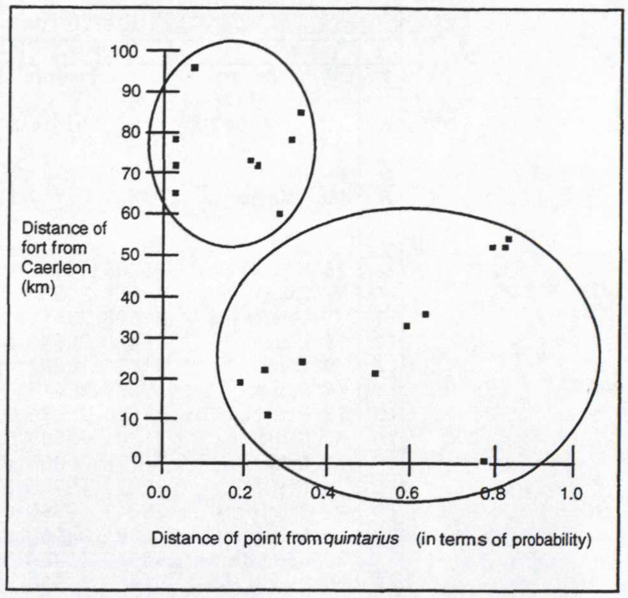


Figure 15.9: Distances of fort sites from *quintarii* and from Caerleon.

random distribution. There is thus less than a 2.5% chance that this distribution would be seen at random.

This apparent association between the 20 sites and the grid of *quintarii* supports the idea that the survey was extended to a larger area. However, it does not advance the original hypothesis much. For this, we need to view the data in another way.

15.6 The historical dimension

The Kolmogorov-Smirnov test treats all the fort sites as members of a single population. It takes no account of the order in which they are likely to have been established. This was a result of the process by which the Romans gained control over South Wales. The general picture is of two attempts to pacify the Silures. The first campaign was probably carried out from a base at Usk, but it had to be abandoned in AD 60. The second, in about AD 74 under Sextus Julius Frontinus, had its headquarters at nearby Caerleon (Jones & Mattingly 1993, Table 4.1, Maps 4:33, 4:34). In both cases the direction of advance was towards the north-west.

Clearly those forts which lie furthest in a north-westerly direction from this base area also lie closest to the *quintarii*. This can be shown graphically by plotting the distance of the site from Caerleon (as the crow flies) against the 'distance' of the site from a quintarius (Figure 15.9). This latter 'distance' is a ratio; it is the probability of seeing a random point as close or closer to the *quintarius*. The use of this measure simplifies our view of the data. If the forts were distributed by chance with respect to the quintarial grid, the distances from it, measured in this way, would have a uniform random distribution. We know from the Kolmogorov-Smirnov test that they probably do not. The figure confirms this and gives additional information. The forts appear to fall into two groups (ringed). The distances of forts up to about 55km vary widely, and apparently randomly, whereas at greater distances they are all relatively small. This further, and probably later, group of fort sites are thus anomalous. They are, in general, the ones which cause the statistically significant deviation from randomness measured by the Kolmogorov-Smirnov test.

15.7 Discussion and conclusions

Previous similar applications of a Kolmogorov-Smirnov test (Peterson 1988) were conducted using a BASIC program on a mainframe computer. Spreadsheets have some technical advantages for this, although care is needed in sorting the data (in order not to detach a fort's name from its coordinates). It is easy to change the module for square grid from the usual circa 710m to the larger scale of *quintarii*, or to the smaller scale of 355m (when dealing with intensively developed centuriations). Results are rapidly obtained, allowing quick comparisons.

The spreadsheet could also be used to process the data in a new way with very little effort. Here again parameter values could be quickly modified. For example, the base coordinates were hypothetically placed at Gloucester rather than Caerleon and it could be seen in a few seconds that the fort distances from the *quintarii* did not then fall into two distinct groups.

An historical implication can also be suggested. We have seen that the further (and generally later) forts may be associated with *quintarii*. If so, their sites were planned after the positions of these main survey lines had been determined. The nearer fort sites, by contrast, were not planned in this way. This distinction between forts established in an earlier and later phase of conquest suggests that a new commander, Frontinus, created a new pattern, linked to the extension of a centuriated survey.

The Romans created and used maps (*formae*) for military ends (Sherk 1974, 559). They had previously surveyed using *quintarii* in territory even more mountainous than that of South Wales. We know that in AD 29 or 30 a survey was completed in southern Tunisia that was

> 'not a centuriation worked out in all its detail, of the type that might serve as the basis of land allocation in (for example) *coloniae*, but ... a reconnaissance framework with *termini quintarii* placed at significant point recorded without doubt on a *forma* archived in Rome or Carthage' (Trousset 1978, 158).

According to Trousset, the third Augustan legion surveyed southern Tunisia immediately after their final victory, but in our case a similar survey could have been conducted during the campaign. This would allow a working draft of the *forma* to be used for planning those permanent military works, roads and forts, necessary to consolidate Rome's hold over the area.

Frontinus portrays himself through his writing as a man with a firm grasp of affairs at all levels. He sees widely: 'Since I alone of those interested in military science have undertaken to reduce its rules to system, ... ' (Frontinus 1925, 3). He also involves himself personally:

> '... I deem it of the first and greatest importance to familiarise myself with the business that I have undertaken, a policy which I have always made a principle in other affairs, ... for ... there is nothing so disgraceful for a decent man as to conduct an office delegated to him, according to the instructions of assistants.' (Frontinus 1925, 331).

He refuses to let even the most trivial detail escape him; he tells us that a certain aqueduct, the aqua Marcia, is 61,7101/2 paces long (Frontinus 1925, 347), doubtless after having walked it himself. He employs the most up to date methods:

> 'I also had plans made of the aqueducts ... By this provision, one reaps the advantage of being able to have the work before one's eyes, so to speak, at a moment's notice, and to consider them as if standing by their side' (Frontinus 1925, 359).

This suggests that Frontinus could have been personally involved in the latter stages of a Roman military survey in South Wales, that he used topographical information related to a grid of *quintarii* surveyed (or possibly resurveyed) during his campaign, that he knew from agrimensorial theory that these lines on his map were destined to become roads, and that he give orders for the forts to be constructed at points which would (eventually) be on them. This grand scheme was never fully executed, but perhaps a fragment remains near Y Pigwn.

Another aspect of Frontinus' writing is also relevant. He is the earliest securely attested writer in the works of the Roman land surveyors, and he is the one who includes a section devoted to surveying in hilly terrain, by a levelling technique called *cultellatio* (Moscatelli 1979). In the passage cited above he claimed not to direct affairs without personal knowledge and in the Aqueducts he mentions other works which he had 'written after practical experience'. South Wales could be the area where he gained his own practical experience of this sophisticated method of surveying.

Finally, a predictive generalisation seems plausible. If the positioning of the further fort sites was systematic, then other Flavian fort sites in South Wales may be found on *quintarii* - the supected fort at Carmarthen is an obvious candidate. The same relationships may also come to light in other periods and elsewhere. This latter possibility could be worth examining in the southern Tunisian system, because five out of seven forts shown by Trousset (1978, fig 1) in the Chott el Fejaj area appear to be 'near' the *quintarii*, in the sense that they fall in the half of the quintarial square nearest to them. Clearly, an accurate parameterisation of this system, plus sets of coordinates for a larger number of forts, would be needed in order to test this idea further.

Acknowledgements

I am extremely grateful to Jo Elsworth, Records Officer, CADW, for providing a very comprehensive set of data for this study. I must also thank Eleanor Vollans and Mark Hassall for their most useful comments on an draft of this paper.

References

CHOUQUER, G. & FAVORY, F. 1991. *Les paysages de l'antiquité*, Errance, Paris.

DILKE, O. A. W. 1971. *The Roman Land Surveyors*, David & Charles, Newton Abbot.

FRONTINUS, S. J. 1925. *The Stratagems and The Aqueducts of Rome*, Loeb Classical Library, Heinemann, London.

JONES, B. & MATTINGLY, D. 1993. *An atlas of Roman Britain*, Blackwell, Oxford.

LEGENDRE, M. 1957. 'Note sur la cadastration romaine en Tunisie', *Cahiers de Tunisie*, 19–20, 135–166.

MARGARY, I. D. 1973. *Roman Roads in Britain (Revised Edition)*, John Baker, London.

MOSCATELLI, U. 1979. 'Intorno ai passi di Frontino sulla cultellatio', *Rivista Storica dell'Antichità*, 9, 75–87.

NASH-WILLIAMS, V. E. 1954. *The Roman Frontier in Wales*, University of Wales Press, Cardiff.

PETERSON, J. W. M. 1988. 'Information systems and the interpretation of Roman cadastres', in S. P. Q. Rahtz (ed.), *Computer and Quantitative Methods in Archaeology: CAA 88*, International Series 446, British Archaeological Reports, Oxford.

PETERSON, J. W. M. 1992. 'Trigonometry in Roman cadastres', in J.-Y. Guillaumin (ed.), *Mathématiques dans l'Antiquité*, Centre Jean-Paleme Mémoires 11, Université de St-Étienne, St-Étienne.

PETERSON, J. W. M. 1993. *Computer-aided investigation of ancient cadastres*, Unpublished PhD Thesis. University of East Anglia.

SHERK, R. K. 1974. 'Roman Geographical Exploration and Military Maps', in H. Temporini (ed.), *Aufstieg und Niedergang der Römischen Welt*, 2 (1), de Gruyter, Berlin.

SOYER, J. 1976. 'Les centuriations romaines en Algérie orientale', *Antiquités Africaines*,10, 107–180.

TROUSSET, P. 1978. 'Les bornes de Bled Segui: nouveaux aperçus sur la centuriation romaine du Sud Tunisien', *Antiquités Africaines*, 12, 125–177.