LERNIE XIV: comparology and stereovideo.

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E 1: images and parallels

Information comes and goes in bits. In archaeology, as most elsewhere, visual bits are favourite; not everything, as in painting - though just about everything can be visually demonstrated - but just about the best. Do we make the best use of them?

Image analysis is as old as vertebrate life . It began with the first image of mud in the lamprey's eye - or strictly the second, which could be compared with the first. It was unimportant, a newly evolving extra sensor of danger - danger signalled by visible changes in the environment. But soon it took over in most developing organisms. In humans it has become the most highly sensitive and refined experiential mechanism.

This is hardly ever appreciated or utilised properly. Even in colour matching and pattern recognition it still attracts an aura of intuitive mystique. The comparative aspect is so integral it remains hidden. So does the way we over-adapt - read eg Wallach (1985) : if you can still trust your own eyes after that, start again; if you can't, that's good - read on.

Much research is sheer visual comparison. Nearly all of this is sequential in space or even (worse luck) in time. We have to look at one image, and then at the next - or even compare it with another we remember we saw, some time ago... There is a lot of compensation and we get used to accepting much compromise - and are glad to forget about it.

The only really valid check is truly coincident comparison. This, again, is so much part of the routine in certain fields - such as forensic examination (bullet marks), range finding, and analysis (graticules and microdensitometers) - it escapes attention. In other contexts like archaeology it is so rare - how often does even Grant the Enlarger get used that way? - that it still has a great sobering effect when it is not downright disastrous: it shows up our memory and destroys confidence. But cheer up - help is at hand.

Anything eye can do - and quite a lot eye can't - film can do better.

Sending pictures instantly by phone is cheap and easy (eg Simpson 1982). And now you can make, reduce or enlarge instant and adequate transparent xerox copies of photographs, even in colour. (Existing drawings will of course do, too - but they had to be measured, and that's no longer to be encouraged!). Overlay them, and you have equally instant and fully reliable direct comparison, there for the making.

Comparology studies the actual process of comparison. It explores the limits and errors, object and subject relativity, physiological and psychological constraints, etc. Its professional code requires the validation of every comparison in these terms. There are optimum designs and unexpected spin-offs: Some overlays instantly convey (Fig 1); others can confuse (Fig 2); two similar images next to each other may be 'overlaid' by squinting- minor differences in form(and colour) then become enhanced (Fig 3). Curiously, two identical strongly coloured images - eg when projected on adjacent, identical fiche readers - if thus superimposed, produce a spurious illusion of 3-Depth!

Such DIY overlay is the easy and direct way and so far much cheaper and quicker for short runs (Figs 4-8). But when you have to compare a thousand ships, pots (cf Lindsey et al., Orton, this vol.) or key outlines, or component histograms, or concentration curves or wear patterns, or X-radiographs or hut plans - each with each - life suddenly seems much too short. Luckily, again (as you well know), the key(board) to your release is before you. Adequate digitising systems are now in common use for transforming both still and moving, 2-D and 3-D, pictorial input straight into machine-processable data(see Wilcock & Coombes, Laflin, Lindsey et al., Graham etc. this vol.;also eg Fig 20 below, and Hawker et al.1981). You are free -

ever let the fancy roam
the computer will mind home...

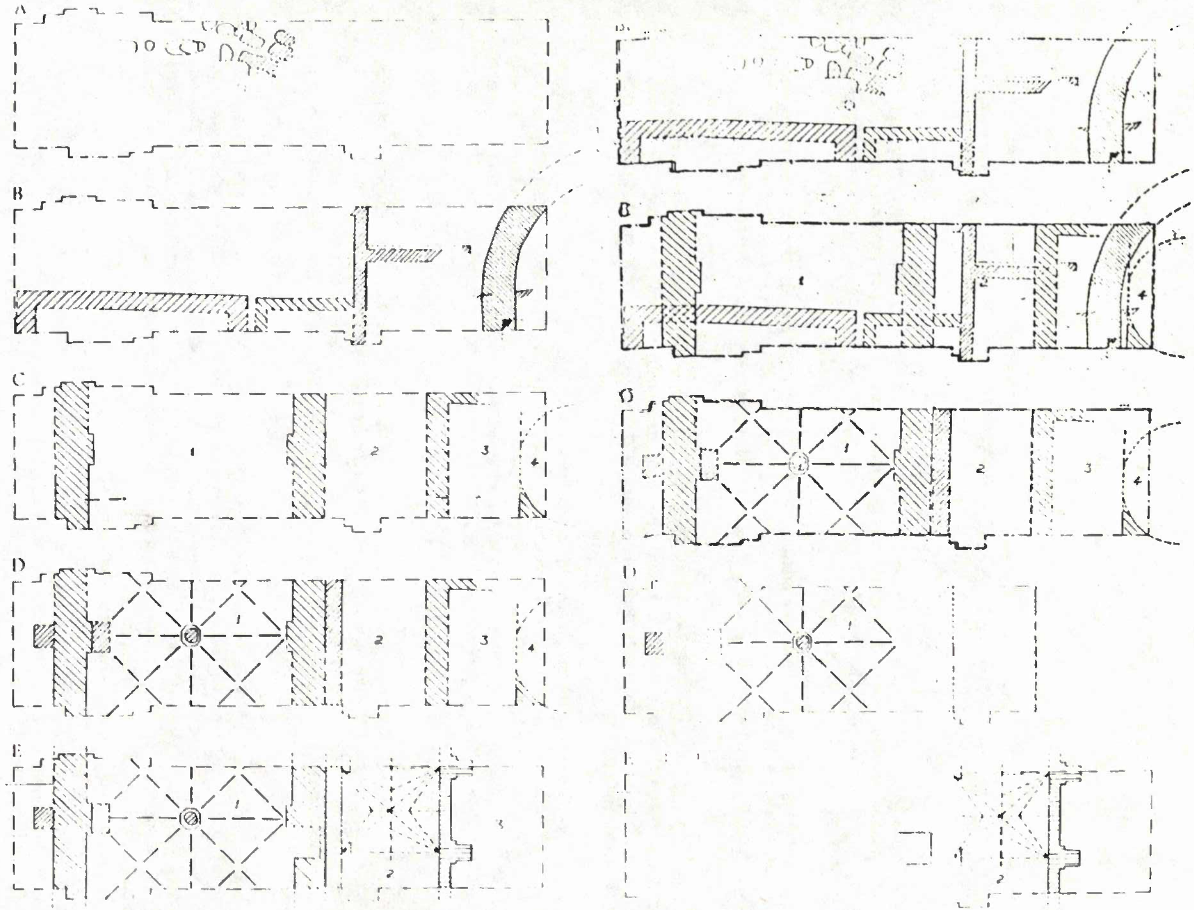


Figure 1: Successive building plans: left, usual form; right, new works overlaid/isolated.

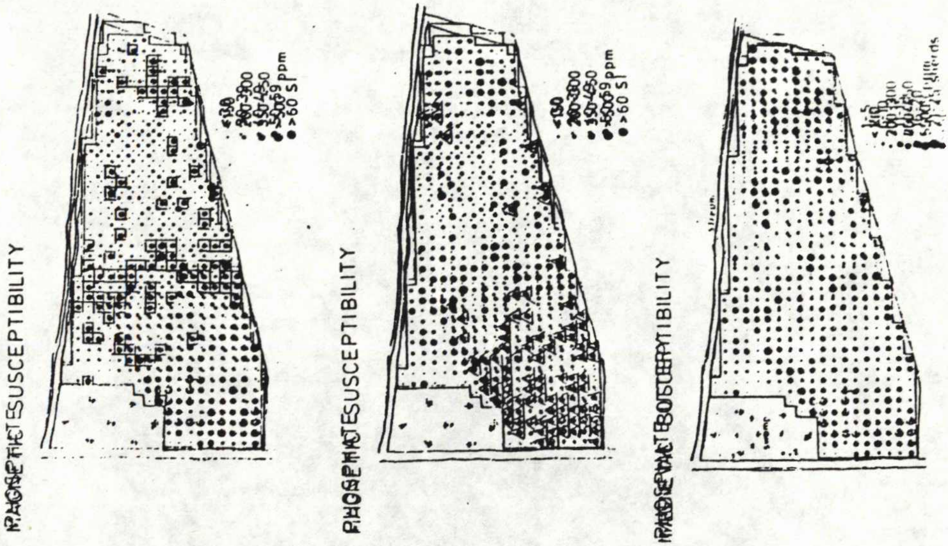
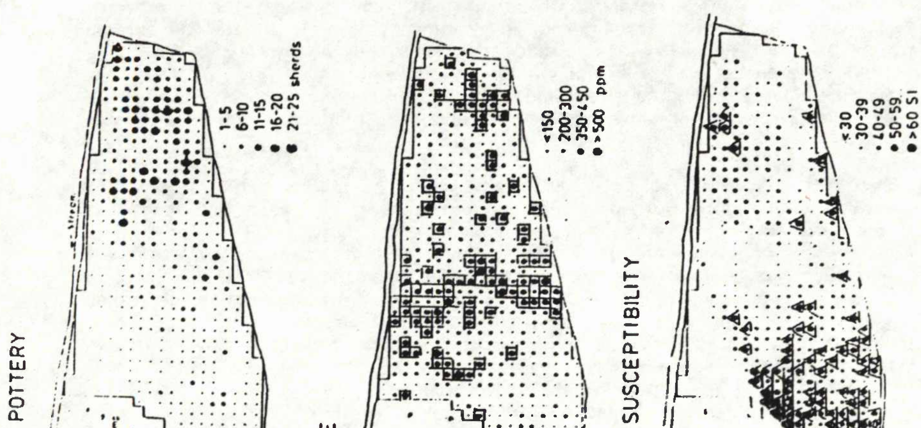


Figure 2: Specialist surveys: top, singly; bottom, overlaid.



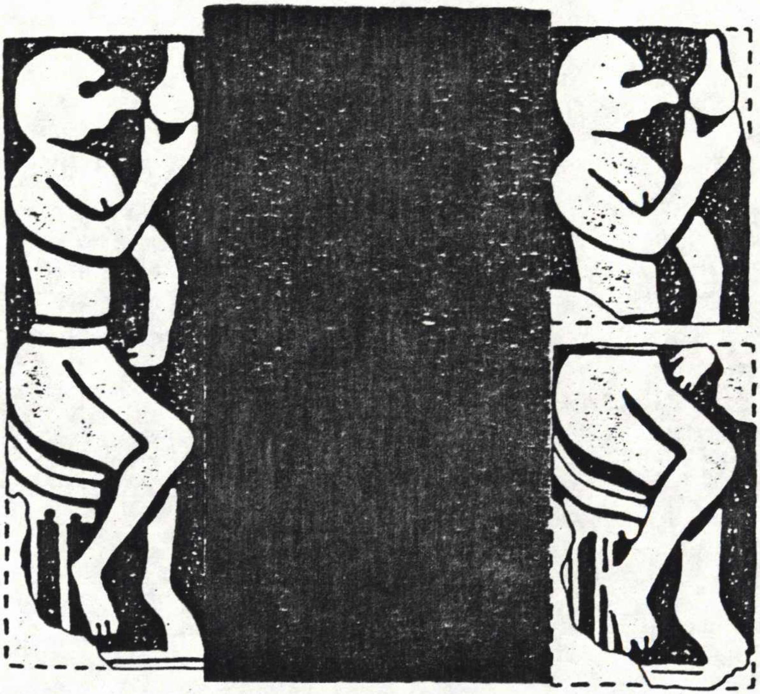


Figure 3: Designs on tiles: almost but not quite identical.

comparison in these terms. There are optimum designs and unexpected spin-offs. Some overlays instantly convey meaning (Fig. 1): others can confuse (Fig. 2). Two similar images next to each other may be overlaid by squinting, minor differences in form and colour then become enhanced (Fig. 3). Curiously, two identical strongly coloured images, when projected on adjacent identical microfiche readers, if superimposed by squinting, produce a spurious illusion of 3-D!

Such DIY overlay is the easy and direct way of comparison and so far much cheaper and quicker for short runs as illustrated in Figures 4 - 8, but when you have to compare a thousand: ships, pots, key outlines, component histograms, concentration curves, wear patterns, X-radiographs or hut plans each with each; life suddenly seems much too short (see Lindsey; Orton this volume). Luckily, as we all know, the key(board) is before us. Adequate digitising systems are now in common use for transforming both still and moving, 2-D and 3-D, pictorial input straight into machine-processable data (Biek et al. 1981; Graham; Laflin; Lindsey; Wilcock & Coombes this volume). You are free:

ever to let the fancy roam
the computer now will mind home

For various reasons we shall want actually to watch this comparison process (Fig. 9) for some time to come, but it is not really necessary. We could just get on with the real archaeology or conservation instead.

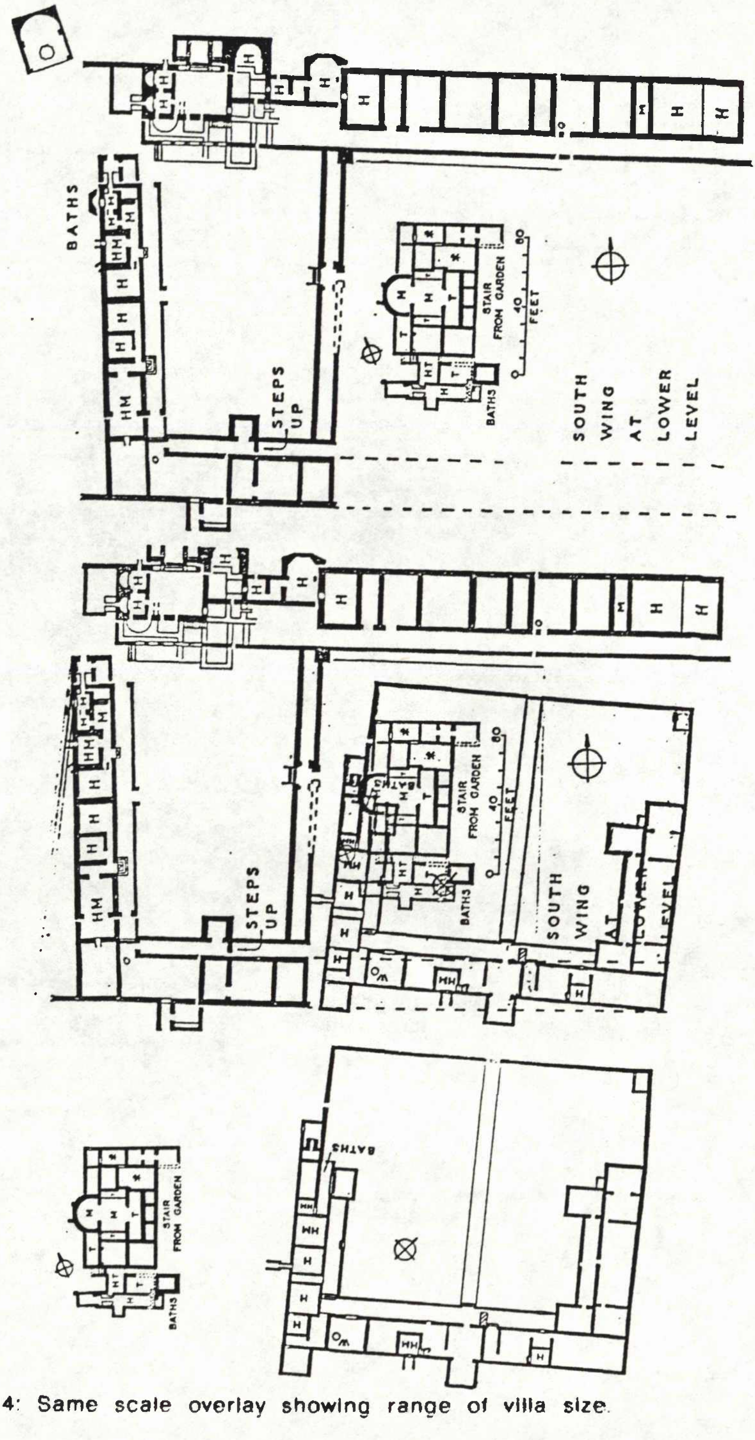


Figure 4: Same scale overlay showing range of villa size.

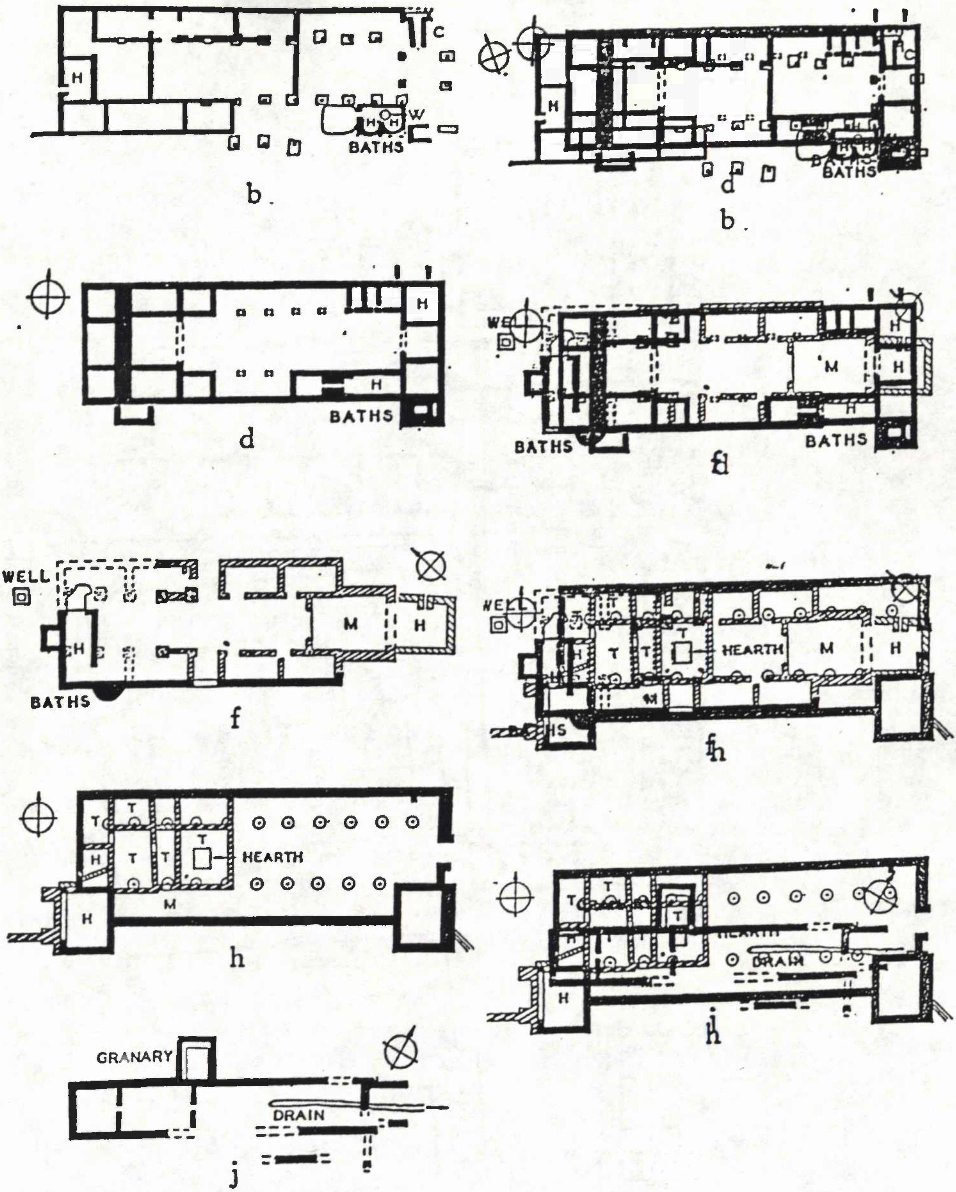


Figure 5: Same scale overlays of variations in standard villa plans.

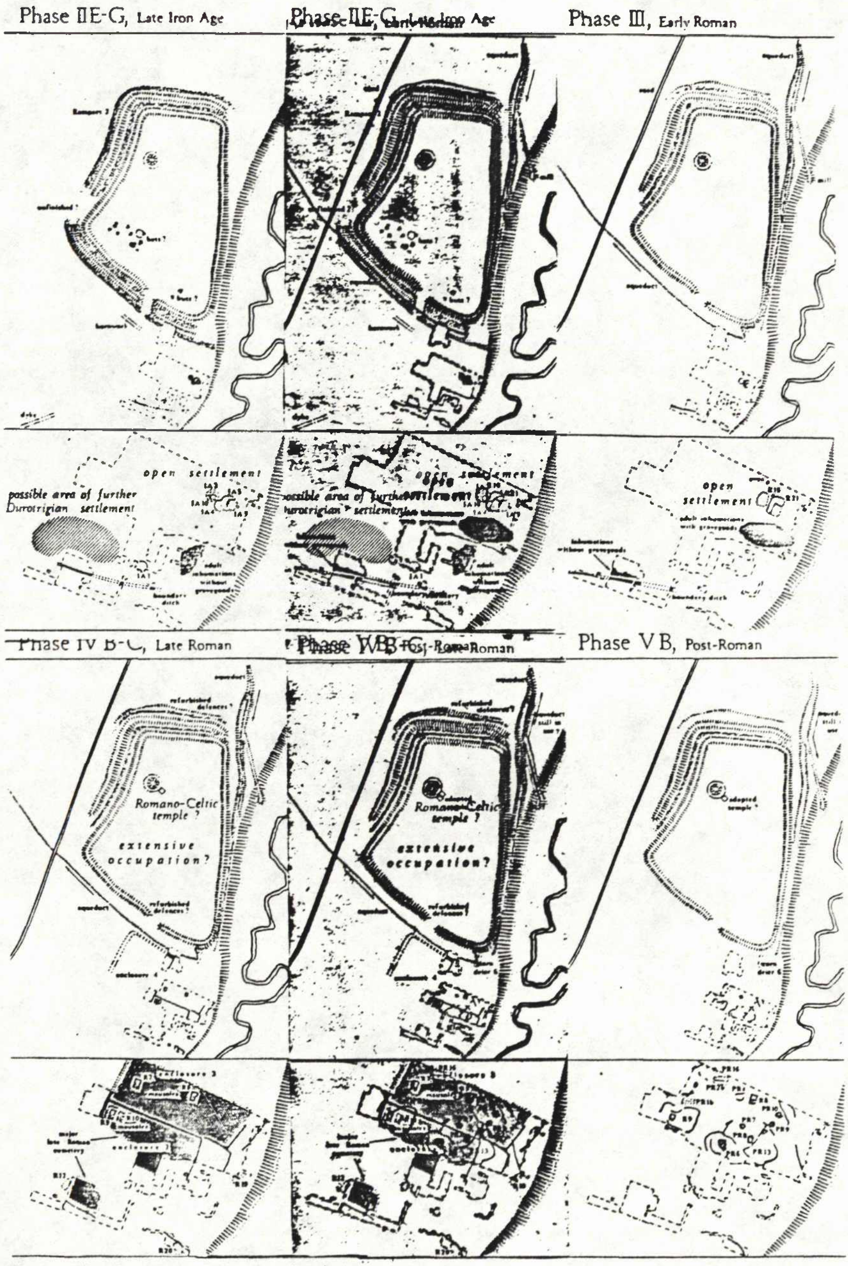


Figure 6: Period plans overlaid

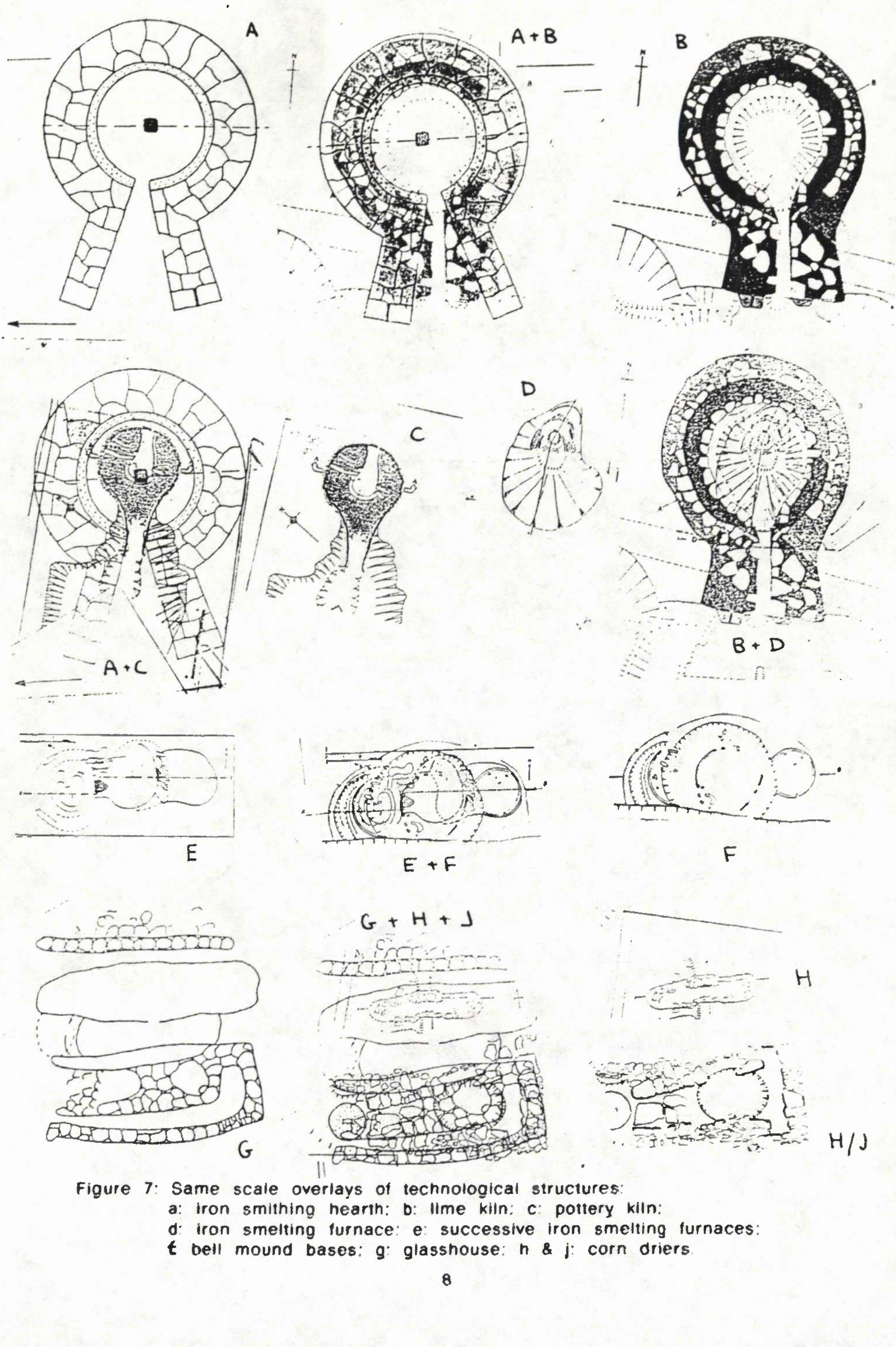


Figure 7: Same scale overlays of technological structures:
a: iron smithing hearth; b: lime kiln; c: pottery kiln;
d: iron smelting furnace; e: successive iron smelting furnaces;
f: bell mound bases; g: glasshouse; h & j: corn driers.

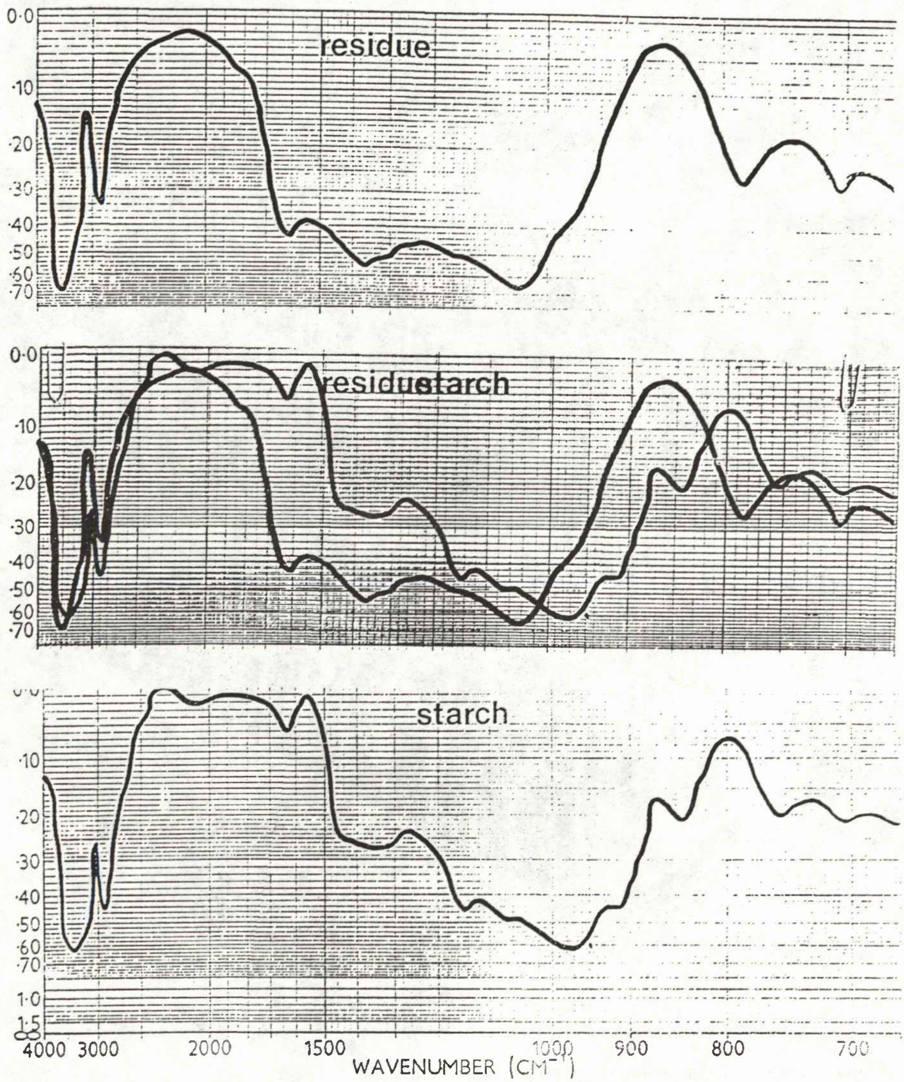


Figure 8: Infra-red curves of residue from potsherd compared and overlaid with starch for reference.

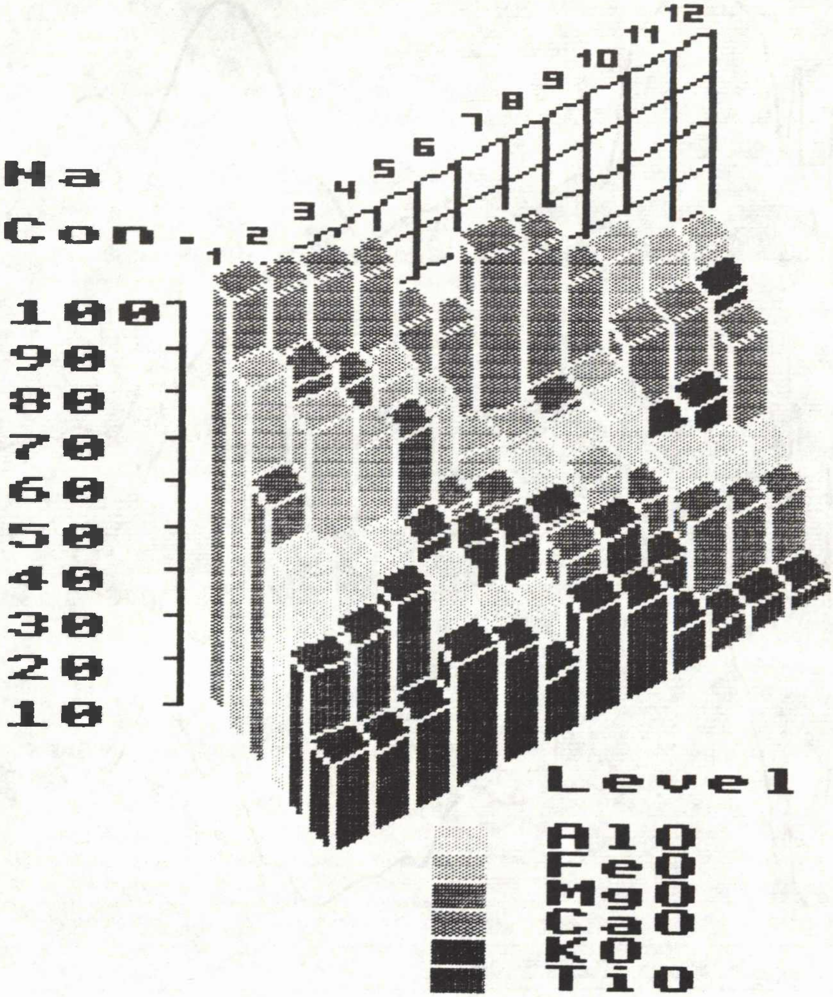


Figure 9: 3-D histograms of glass compositions.

For various reasons we shall want actually to watch this comparison(Fig 9) for some time to come. But it is no longer necessary - we could really get on with the real archaeology or conservation or whatever, instead...

E 2-or-3 D?

It was perhaps inevitable, but most unfortunate, that archaeology followed architecture and geology in 2-D recording. Digging and cutting everything up into plans and sections is an honourable tradition hard to unlearn. But this, too, is now possible. Even systems analysis has shown that it is not only possible but also imperative and urgent. We do everything with one eye covered up! All we need is to (re-)enter another (very familiar) dimension: Two eyes are better than one. This is always true, and always important. But in some places and cases it is vital - and in archaeology their number just keeps on growing once you've seen the difference (Fussell 1982)!

Our dual-channel video capacity is, again, such a normal function that we are normally unaware of it. Conversely, any modification of normal vision is unwelcome and resented - at first. Yet all that is really required is a change of focus - strictly, an unfamiliar separation of foci. A good practice ground is the regular pattern of holes on insulation board. Next time you're waiting in a phone booth, screw a piece of paper into a hole level with your eyes (to mark it) and then squint it in two. Hold it! Slowly squint further and see how many empty holes you can put between the 'two papered ones'..!? Hold it again! Return to normal vision slowly...then start again...- and so on until saved by the bell. Or stick a pin into a regular woven pattern and...

Now prepare to view a stereo pair. You just do the same but because you have two, to start with, you can squint them into one. (It's actually three, but ignore the outer two and concentrate on the central one.) Explore the depth in the top pair of Figure 10 - from the plinth in the foreground, to the columns in the middle distance, to the trees and clouds in the background. Hold this fusion! Then move swiftly down the page - from 'full' walls down to empty ground level - and back up again.

[You can of course do all this without squinting if you use a pocket stereoscope. But by the time you've freed yourself of the need, as you have just done, it will almost feel like cheating. Anyway it's much easier to do without. Remember that you may get a weaker image with a 'scope from these figs. because your eyes ('normally') cross on squinting so that 'left' and 'right' images have here been intentionally reversed throughout(Adams 1979).]

That exemplifies total stereo-recording. It applies right across the archaeological field - from various aerial and general views (Figs 11 & 12) to flint microwear (see eg Van Noten 1968); from complicated wall patterns (Fig 13) to intricate modelling in metallic decoration (Figs 14 & 15) and restless re-entrant surfaces in moulded stonework (Fig 16); and of course from skeletons (Fig 17) to bogmen (Fig 18; see also Vannier et al. 1984), and even to X-rads of artefacts, excavated (Fig 19) or buried (Nylen 1978), right down to electronmicrographs of metal surfaces (Fig 20).

It's really no good talking about it: it's just another of those personal discoveries which needs to be individually sought and found (see also Biek 1984). Above all, you need to look. Better still, do it!

Figure 10: Stereo pairs of remains and progress of excavations in abbey church.

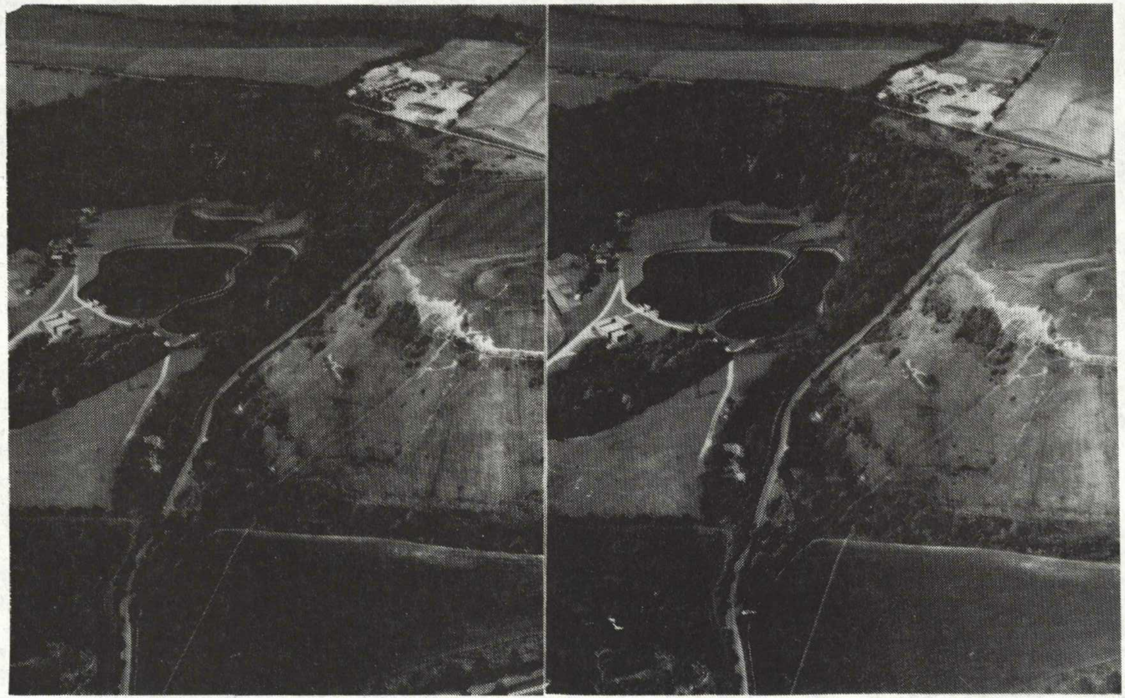


Figure 11: Stereo air photo pair.

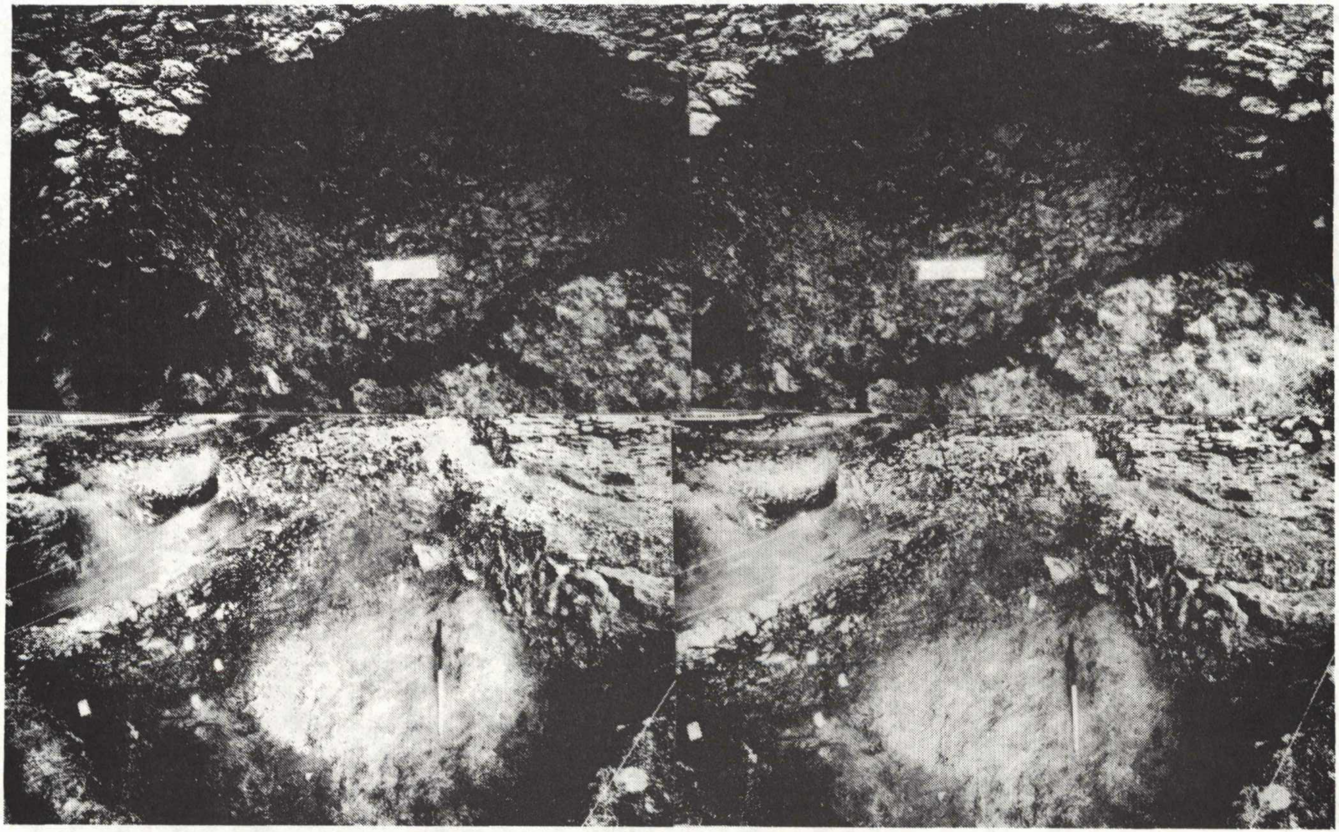


Figure 12 Stereo site photo pairs

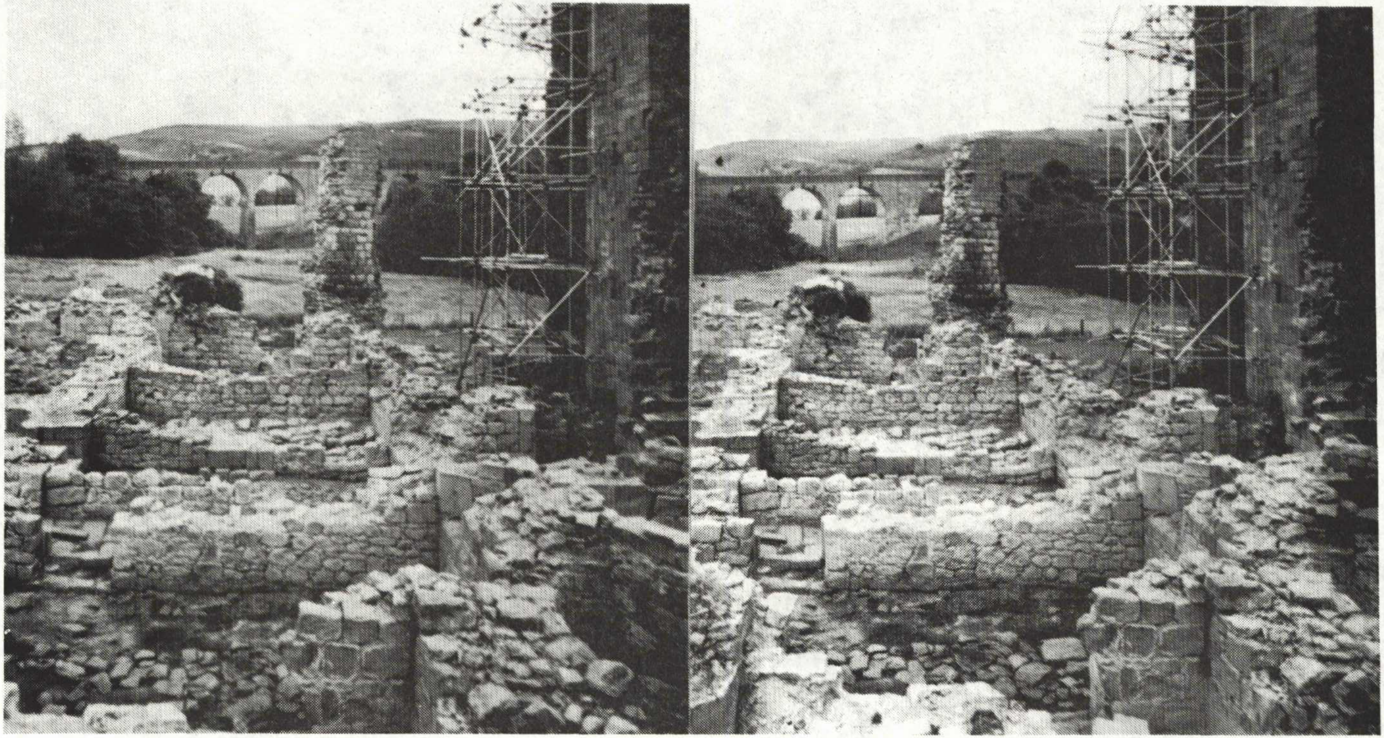


Figure 13: Stereo pair of castle ruins

Figure 15: Stereo pair of a gold torc

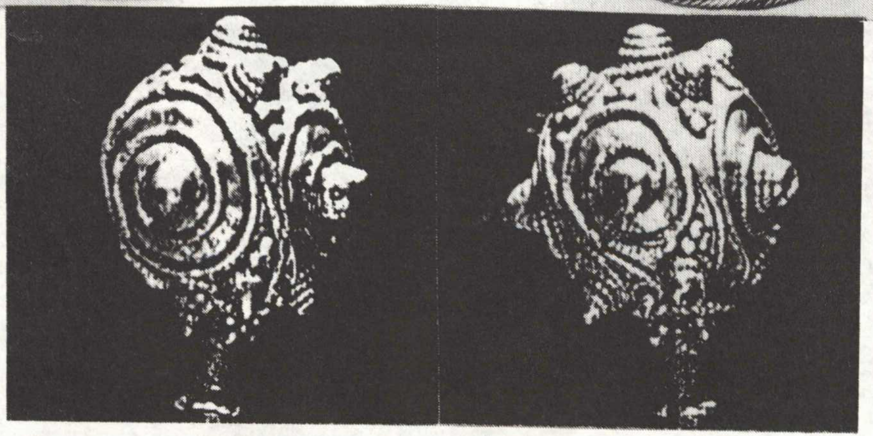


Figure 14: Stereo pair of a gilt bronze pin head

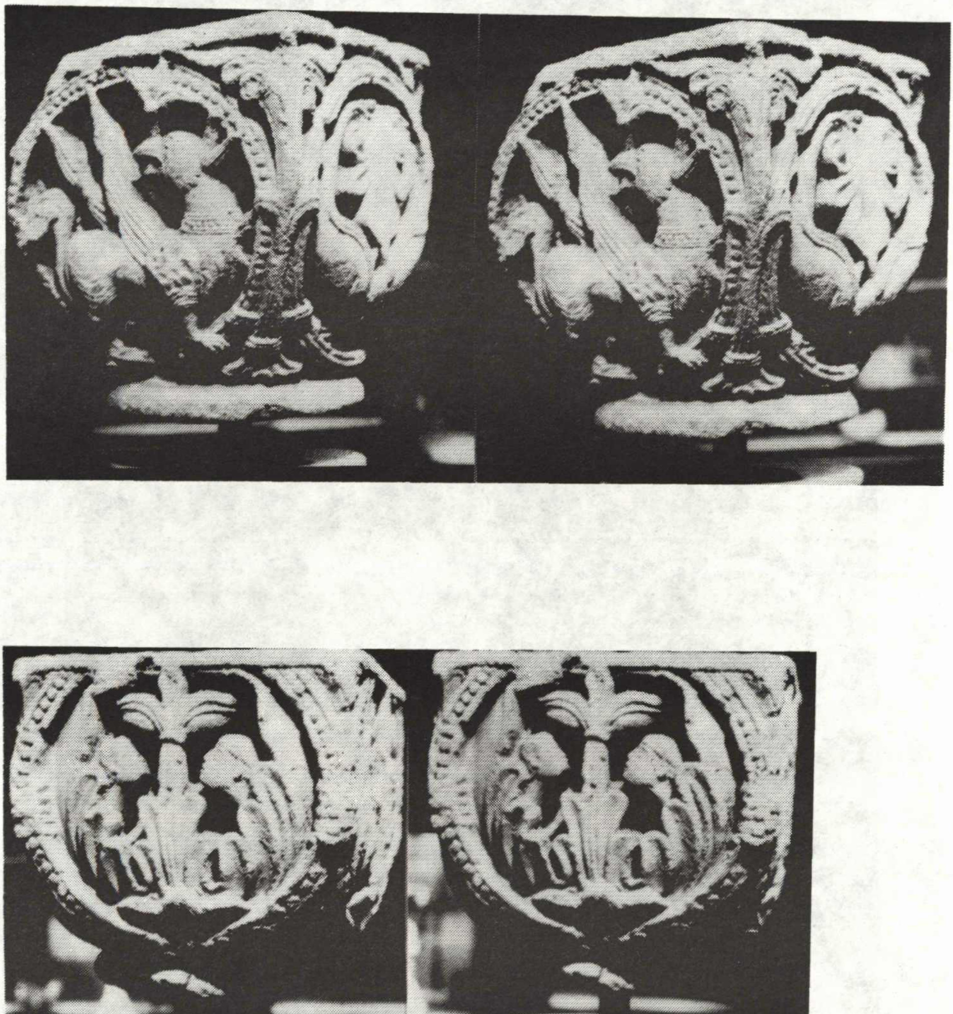


Figure 16: Stereo pairs of stone capitals

Figure 17: Stereo pair of partly excavated pelvic area

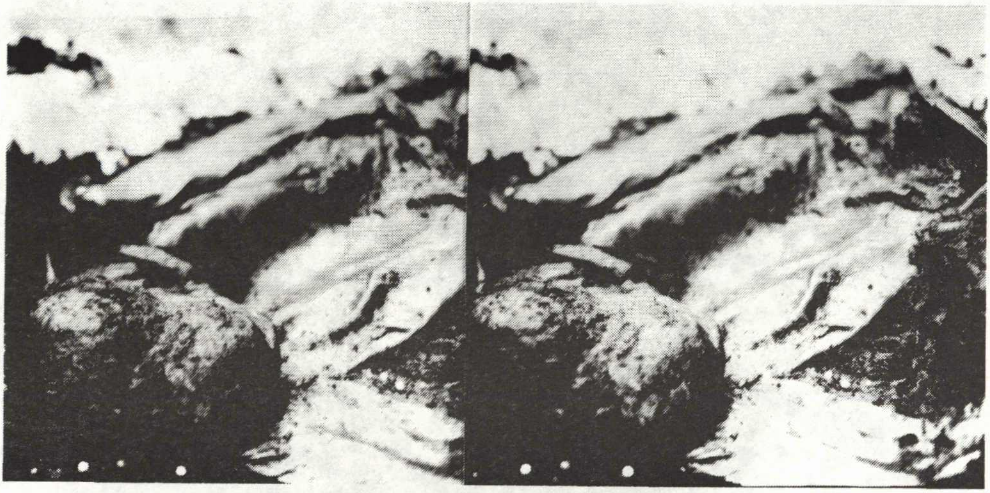
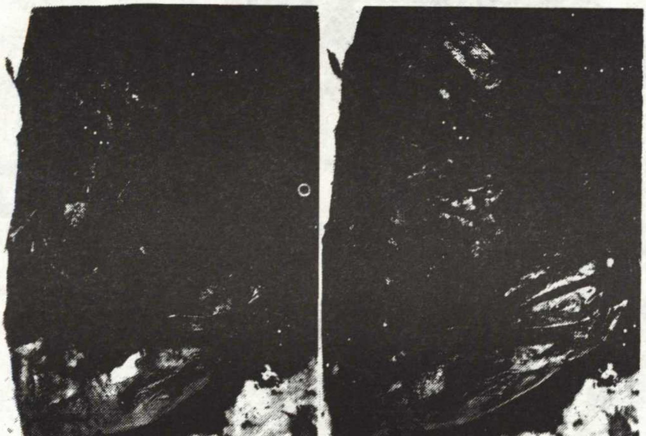


Figure 18: Stereo pair of Lindow Man (Pete Marsh)



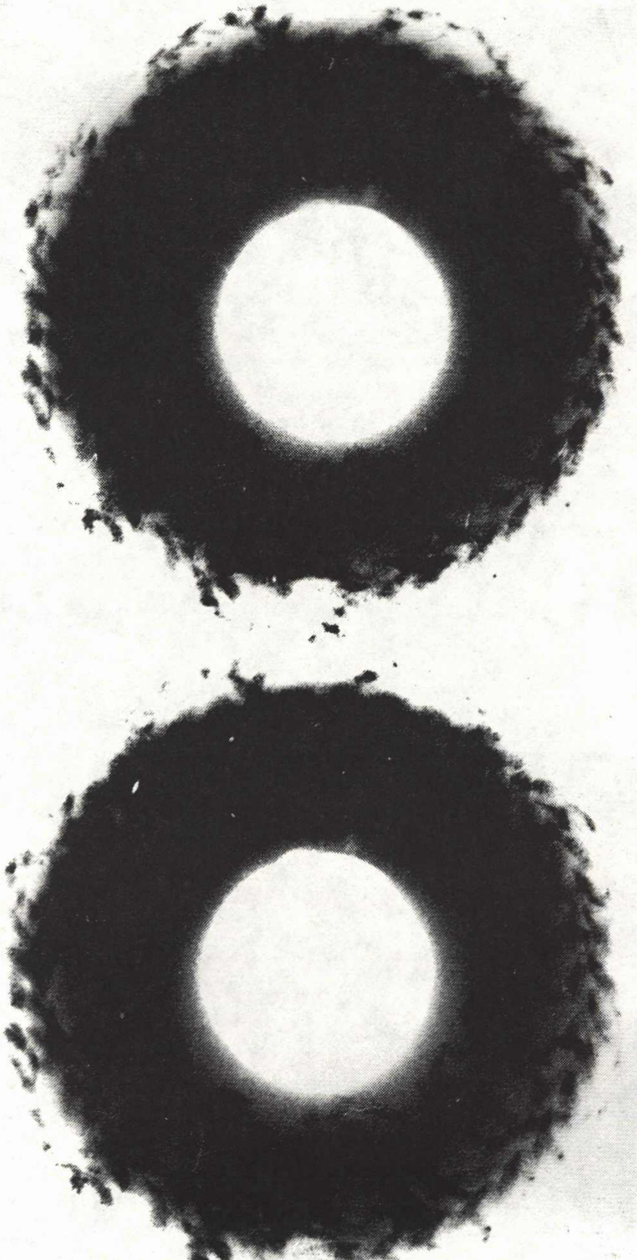


Figure 19 Stereo X-radiograph pair of translucent glass beads with antimony-opacified internal decoration

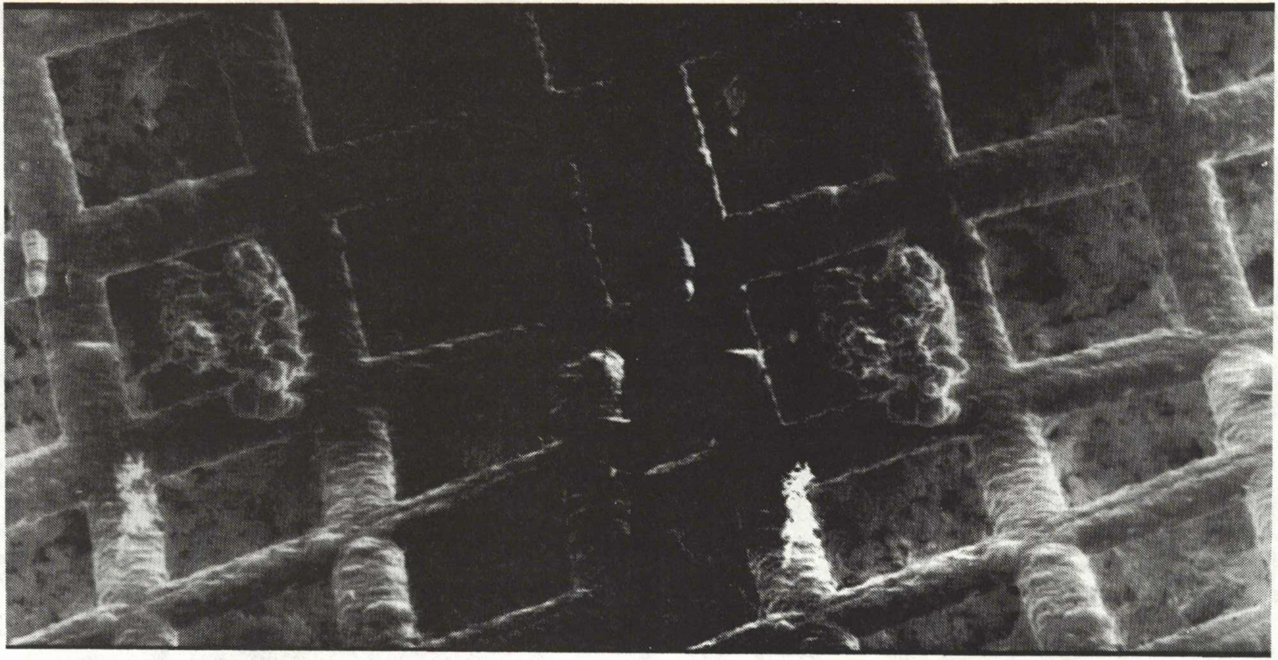


Figure 20: Stereo SEM-graph pair of copper grid: base for SEM-graphy. Negative from SEM-scope viw digital image framestore, computer memory and Photowrite machine

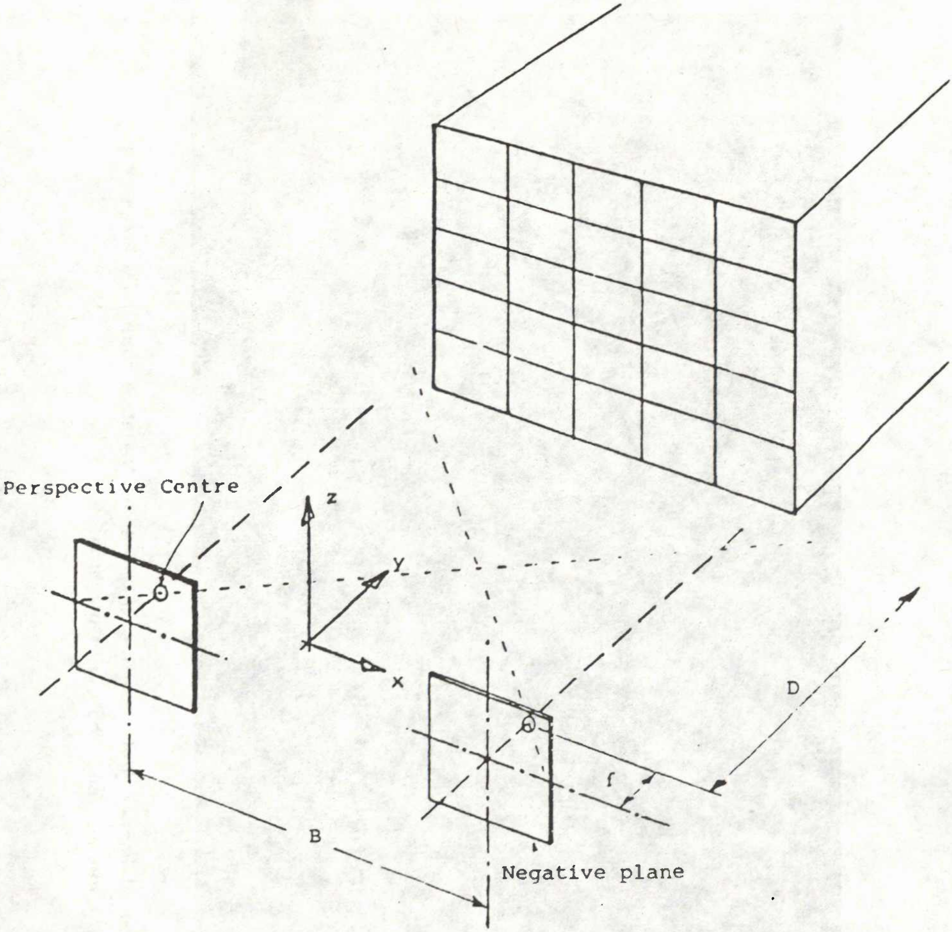


Figure 21:

ESSENTIAL DIMENSIONS IN STEREO-PHOTOGRAMMETRY

For Stereo Viewing only recommended ratio B/D = $\frac{1}{8} - \frac{1}{20}$

" Stereo measurement and plotting recommended ratio B/D = $\frac{1}{3} - \frac{1}{8}$

All you do is to 'Take Two'(Fig 21;Lindsey et al.1981). Two pictures, too, are better than one (if you've only got one camera lens) - two lenses are better than one (whether on one camera or, much better, on two). If you want to monitor progress, double up with Polaroid for instant checks (eg Carver 1983). On the dig, Take Two of every significant level. Remember the first law of comparology :

Plus ca reste la meme chose
Plus ca change...

(or, the more that remains the same, the more easily you can spot a change - as most elegantly displayed by the standard 'flicks' routine of astronomers and surveillance operatives alike!)

So camera (tripod) positions need to be fixed - for any 'time lapse' sequence of pairs - or at least accurately returned to after each intervening absence (elsewhere on site, or overnight). Number and L or R plates in each shot make life much easier. If you absolutely want to measure, also put in adequate ranging rod/rule markers.

There are two fundamental differences between trad. and stereophototal recording. First, since it's all for comparison (with similar previous and future records) actual field measurement becomes unnecessary - but if you insist see Bowyer 1981, Martin 1982, for ways which make even that easier. Only integral scaling is needed. This again, like squinting, is difficult for folks to accept. Drawing has hitherto been the basic form of published illustration, requiring rigidly controlled horizontal plans and vertical sections. And that is the second point: no drawing, no plans or sections, means no rigid area or trench excavation; instead, diagonal digging - free to follow any dipping ditch-fill, rolling rampart or weaving wall.

Obviously this provides opportunities for complete ('diagonal') rethinking and consequent changes in the actual course and technique of digging. The freedom gained, mutually, both in digging and recording, is immense. Only a minor constraint remains in the need to move work forward - or rather downward - at the same rate over a sectional area if overall shots are to show a (relatively) complete contemporary surface at each level. Special visual conventions will be needed for pits and other later disturbances, but otherwise the method is particularly suited also to deep and narrow, cramped urban excavation.

E 3: stereoview and Laservision

You now have a primary archive of 35 mm colour stereo-pairs. A DIY version of viewing uses a Baird-type stagger-slotted wheel, spun in front of two identical slide projectors showing a stereo-pair accurately superimposed on the same field of a standard screen. An electronic flip-flop shutter pair provides a more refined method. (The same technique can of course be used for 'flicks' type comparison.) Alternate 'right' and 'left' images appear on the screen at a suitable rate for the brain to merge them into a single 3-D view. This can then be video-looped.

Where a sequence or series of sequences is particularly significant such strings (of, say, 10-second stills) may be similarly joined. Indeed, a pair of video cameras would, under suitable conditions, provide a far superior, auto-monitoring routine for direct field recording. A given tape sequence can be edited in both directions showing, first, excavation going down and then, in reverse, the (original) build-up of levels and structures (cf Fig 10). Present broadcasting frequencies impose limitations on transmission, requiring viewers to wear a pair of liquid crystal glasses in phase with the interlaced stereo-pair (Robinson & Sood 1981; Harris et al.1984).

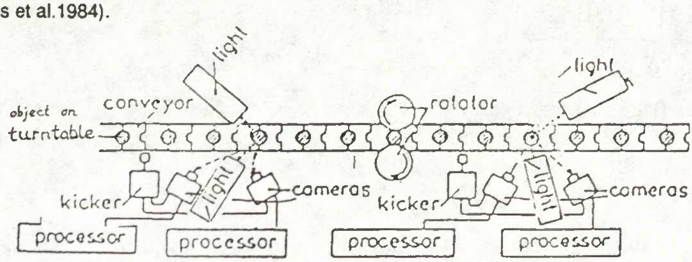


Figure 22: Layout of a round-bottle-inspector type system adapted for artefact recording. (After Price (1979) Glastechnische Berichten 52: Fig. 5)

The ultimate form of archive, with immense retrieval performance and and interactive potential, is clearly the Laservision disc (Philips 1985; Acorn 1985). Transferred either directly from transparencies or by any combination of the techniques mentioned, any single still or sequence of the whole stereo-record for a number of excavations could be random-accessed in a few seconds on either side. Together both sides can hold over 100,000 frames. The disc is 'played' optically by a laser 'needle' with no moving parts or physical contact - and hence no wear - involved in pick-up. Apart from the direct excavation record and corresponding visual cover for artefacts at all stages of conservation, solid modelling of conjectural reconstructions(Bowyer et al.1985; Woodwark & Bowyer 1986; Galton 1985; Geomod & Geoview 1985) and other forms of graphics output from data analysis can be video'd and (ultimately) loaded straight onto disc. But what really amounts to a further dimension of the system is that its data can be managed from a home micro.

E 4: other view-formats

Before this aspect is considered some other methods of data capture and storage deserve a mention. As a cheap, intermediate and/or complementary parallel archive, easily copied and distributed, stereo-microfiche is certain to find an increasing use developing from the current application in colour-mono (eg Microform 1985). An alternative with different attributes is holography, actually available now in an equally cheap and disseminable form (Holofax 1985). One of the (incidental) great advantages of this form of record is that any 'impression' (mould, die) can be transformed into the 'cast'- and a complex structure (skull) viewed from the 'inside' - merely by turning the hologram up and over! Also, a certain amount of magnification is feasible - by inserting a lens between the spot light and the hologram!

As yet Holofax lacks full colour but this, also, has now been achieved (Bazargan 1985). Computerisation of holograms is still a somewhat esoteric activity but it has definitely arrived. If you put the great speed of TV-holography (ESPI) with the enormous memory of videotape you get so much more than is dreamt of in their separate philosophies (Winther 1985). Even an underwater holographic camera is under development (Watson & Britton 1985).

Some adaptation of the kind of 'conveyor belt' scanning unit in common industrial use, such as the'round bottle inspector'('RBI', see eg Fig 22: after Price 1979), to provide an automatic continuous primary 'mass record' of the great flood of small finds, is worth exploring. Another fascinating prospect (British Telecom 1983B) is the transfer of Ordnance Survey maps onto Laserdisc. Ultimately this must develop into a fully 3-D visualisation of the actual terrain from SPOT (eg Dorsett et al. 1984), instantly and universally accessible, and overlayable on TVDU with geological, geophysical, soil and other specialised survey data (NOAA 1985)- as well as specific location and distribution maps, with zoom between any scales.

Perhaps this is the place just to mention the fourth dimension. It is clear, even from watching 2-D moving pictures, that an extra capability within the mind's observational powers is brought into play as soon as there is movement - especially when it is not our own. It's the old lamprey reflex to danger. But even when the whole picture moves - because we do or the camera takes us - the extra dimension of time is expressed directly and very powerfully.It is only continuous recomputation, of the position of every significant point within our field of view, that keeps us (quite literally) in touch.

Because it started to happen long before we actually knew what we were doing, we may in many cases not be aware of it even now - until we notice that, at a certain point, something goes missing. Surely we could see that'trace of a wall' there, as we were walking along? But when we come to photograph it - even in stereo - we just can't demonstrate it to anyone!

So: slowly, ever so slowly, but quite surely, we need to start thinking ahead, to the time when normal practice will include not only the stereoview but also the movie, and ultimately the stereo-movie, as a matter of course. But that is another story.

L 1: interaction and expert systems

At whatever stage of the available image data bank, the interactive capability of even a small micro is so far beyond present exploration as to be for practical purposes unlimited. The most relevant and mind-teasing application currently and easily accessible is the new exhibition 'Treasures of the Earth' in London at the Geological Museum (Mercer 1985). The totally visual data bank is on a Laservision disc, with video text on associated audio-channel. Linked with each physical exhibit is an array of interactive sequences which can be interrogated in different ways by visitors with different directions and levels of interest. The development of this principle has been of great concern to a number of educational researchers for some time and several types of linked multi-level programs are available (eg Beech 1983; Heaford 1983; Parsloe 1984). The impact on (particularly) archaeological teaching - or rather learning - will undoubtedly be metamorphic!

A National Interactive Video Centre has been established (NIVC 1985) with broadly based support. The latest developments may be discussed and tried out there with assistance at all levels. As was pointed out some time ago (eg Biek 1974) one of the major benefits of studying computers has turned out to be the direct feedback into improving the human learning machine. But there is clearly also an equal reverse flow into machine learning. Once this symbiotic relationship has been fully accepted the continuing reflections will, laser-like, not only immensely enhance human capacity for learning but also create a hitherto unimaginably powerful machine thinking tool (cf Ryan; Todd et al. this vol.)

The link between this and the basic data capture/storage facility is made more efficient, sophisticated and elegant by expert systems (eg Biek et al. 1981). Some advances for archaeology have been made in this direction but as for interactive Laserdisc programs, and because of the difficulties detailed by Wilcock(this vol.), this field remains very largely unexplored. Some existing projects, like the National Bronze Age Implement Index, are clearly crying out for the treatment.

The process can be fanned out along all specific lines of enquiry, but perhaps an equally great benefit will arrive - once again in reverse - as a more general wave front. The still new discipline of archaeology is still trying to find itself... Once the process of transferring knowledge from domain specialists to expert bases has begun, the very questions and progressive development of the activity itself will inevitably clarify the underlying concepts and structures.

But if as Hedges (1980) has argued there is an essential difference between the'hierarchical' and 'holistic' natures of 'Science' and 'Archaeology', then it is not only the model, or the 'metaphor', of the one that is inappropriate to the other. The very 'logic' of (after all, 'scientific') computer 'reasoning' will need to be modified to take account of the 'central concern' of humanistic knowledge with Man in the totality of his cultural experience.

While we are gauging the limits and relationships of archaeological knowledge, the necessary modifications to standard computer logic will, again inevitably, become apparent. Paradoxically, we may need to go well into and beyond the fuzzy domain to reach that infra-structure for archaeology which most of us, including SERC, are impatiently waiting for.

L 2: LEOSPEX

A start has been made on a pictorial diagnosis system for semi- and non-artefactual small finds and fragments. Apart from its immediate use, it is also meant to encourage other workers to deposit their specialised experience cumulatively in this way and is intended, eventually, to merge with the total analytical system envisaged as part of the LERNIE concept. At the same time instant linkages will be formed with the excavation archive, and growth will be monitored by a 'shell' of the kind of 'self-programming programs' and 'link-seeking routines' described by Michie(1982), Michie & Johnston (1985) and Shapiro (1981), to develop the system's learning capability as it grows.

Serially numbered colour stereo-pairs, including multiple views where necessary, are videotaped in random sequence. The equivalent of 15-20,000 specimens in still pairs is accommodated on one side of a Laserdisc. In this context, where user compensation is inevitably minimal, the photography must be exceptionally faithful. Each specimen is classified broadly (Fig 23) and the pattern is further developed from other properties until a type identification is reached which is linked to the unique serial number.

Input into the data bank is by screen-touch; only the reference label needs to be typed in. The screen-board acts both as a prompter and as an illustration of the range of material since the pictorial frames show actual specimens. At any stage of both input and output - which in effect run on the same program - there is both zoom, and linkage with all other specimens of the character pattern at that level, available for direct visual comparison.

The diagnostic search may be conducted along two main routes, or a combination of them: 1. for a totally strange specimen, a sequence of selective prompting questions based on the actual programming path is followed step by step (the long hard way!); 2. hunches may be spot-checked by calling up an image by number through the alphabetical type index. Intermediate scenarios are offered by the inherent links at various levels. Sometimes one of the reference images could prompt a memory or line of search. Otherwise a 'rapid scan' may just strike lucky, or offer a clue. Selection/response is by screen-touch throughout. Ultimately, again, there will be a fully automatic search facility based on the pictorial characteristics and linked to a sequence of simple robotests. But the system's most exciting and unforeseeable facet is its generation of new links and 'compound interest' type of progression into 'new knowledge'.

RNIE : other bits - human and synthetic

The remaining segments (Fig 24) are doing very well in other contexts, thank you, mainly in the development of increasingly rapid and comprehensive data management, but also in the more palatable (and in the end totally) visual ways of presenting the results of data analysis(eg Fig 25; NIVC 1985; Bayard-White 1985; Heyworth forthcoming: see also Fig.9 above; Atkins 1985; Woolley 1985; Ledbetter & Cox 1985; Alvey 1985. See also McNett 1981; Acorn 1985; Pluto 1985). So here again - and this, after all, was what triggered LERNIE off - we are moving towards histograms of specialist activity, pyramids of degrading agencies (eg Biek 1963), distribution maps of resource gaps, and piecharts of areas of research.

	0	1	2	3	4	5	6	7	8	9
0	SURFACE	(clean)								
1	FORM	(powder)	(discrete layer)							(clear shape)
2	COLOUR	(colourless)	(white)	(blue)	(green)	(yellow)	(brown)	(red)	(purple)	(grey/black)
3	TEXTURE	(smooth)								
4	DENSITY	(low)								(high)
5	HARDNESS	(soft)		<finger nail			<knife		<emery	(hard)
6	REFLECTANCE	(low)								(high)
7	MICROVIEW	(amorphous)								
8	ELEMENTS	15%Al Si: 50%	Na / K	Ca / Mg	Mn / Ti	Fe 30%	Cu / Ag Au	Sn / Zn Pb	P S / Cl other halogens	C 50%
9	ASSOCIATION (base)	stone	soil	clay	lime	glass	metal	slag	vegetable	animal
	%	Min. Max.	→							→
X	FREE DESCRIPTION	stone	soil	clay	lime	glass	metal	slag	vegetable	animal
	(base) %	Min. Max.	→							→
Y	REFERENCE LABEL	FRAME No.	SITE NAME	COUNTY	No.	NGR	PERIOD	CONTEXT	SOURCE	DATE

Figure 23: LEOSPEX touch-selection screen

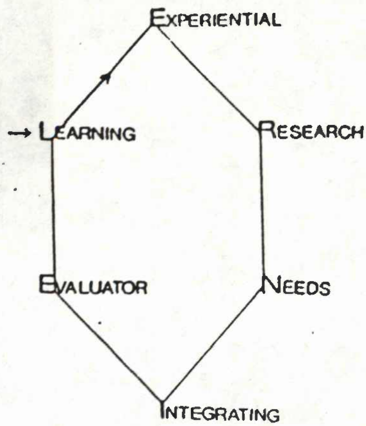


Figure 24: The structural formula of LERNIE.

It will have become obvious that this comprehensive 'inner-peripheral' view has a direct bearing on all the various considerations involved in this Conference. It underlines the inadequacy of the Harris matrix, and the importance of simulation in pottery studies; it embraces fuzzy logic and it illustrates the human implications of the accelerating developments in computer usage - especially as they affect thinking and learning, education and training - and 'literacy': the very word begs the question!

Here it is vital to recall that, particularly in archaeology, the only really effective 'teaching' is by demonstration and example, and interactive video is ideally suited to both. Even more crucial is our fundamental attitude to recording and publication. As demonstrated above, they are deeply interdependent. Both are now qualitatively and quantitatively inadequate. As this comes to be more generally accepted we need, now, to start changing direction, however gradually. Archaeology can follow current scientific practice and embrace the concept of on-line publication (Lavell this vol.; ASLIB 1985; Lock 1985; Gibbins 1984). But by its very 3-D nature it is particularly suited to move out ahead, straight into the kind of direct single-step record-retrieve multi-optive stereo-video system now available. When you think about it, with or without systems analysis, it's just plain common sense!

The synthesis ('Level 4') can be successfully compressed into directly expressive tables and charts etc (eg Fraser 1983) with a miniscule bit of videotext where absolutely insisted upon. Important issues of more general interest can be fully ventilated by video-conferencing (British Telecom 1985A). Ultimately this will all be done instantly and individually, as it is by phone today, with or without optional audience participation and recording, by the kind of running global videologue we watch on TV and US research workers are already using all the time. Two unimaginable incidental bonuses of such a living video data bank are instant availability of new material and total lack of language barriers.

Here, most clearly, the human implications are uppermost - as of course they should be throughout. Set against this great release for the questing spirit must be an equally great effort of creative foresight. For one thing, we need really to consent to this manifest general movement away from the written word and drawn illustration in books, as a method of data transfer, and towards the digitised image - and that means, patently, not only away from all activities related to normal report/book production by printing, but also away from normal site planning and even normal photography, and towards electronic cameras, stereo-video data management, artificial intelligence and Laservision. The effects of such realignment must be provided for at this incipient 'design' stage.

Another factor is even more deeply personal.

There is no doubt all this will work but it can only do so, financially or any other wise, by the general co-operation of individuals. It actually induces collaboration but it also requires the submergence of individual priority in the pooling of experience and resources. And that is very difficult to take - it is perhaps the overriding human problem, though for at least 2000 years now it has been shown to be perfectly soluble. We all look at things from slightly different angles, fortunately but inevitably, and we still see ourselves in a competitive jungle where you have to hack through others' verbiage to gain light for your own. But one woman's myth is another man's raison and we have, after all, got used to looking at the same TV frame or microfield, even if on separate monitors or VDU's, at least at the same time.

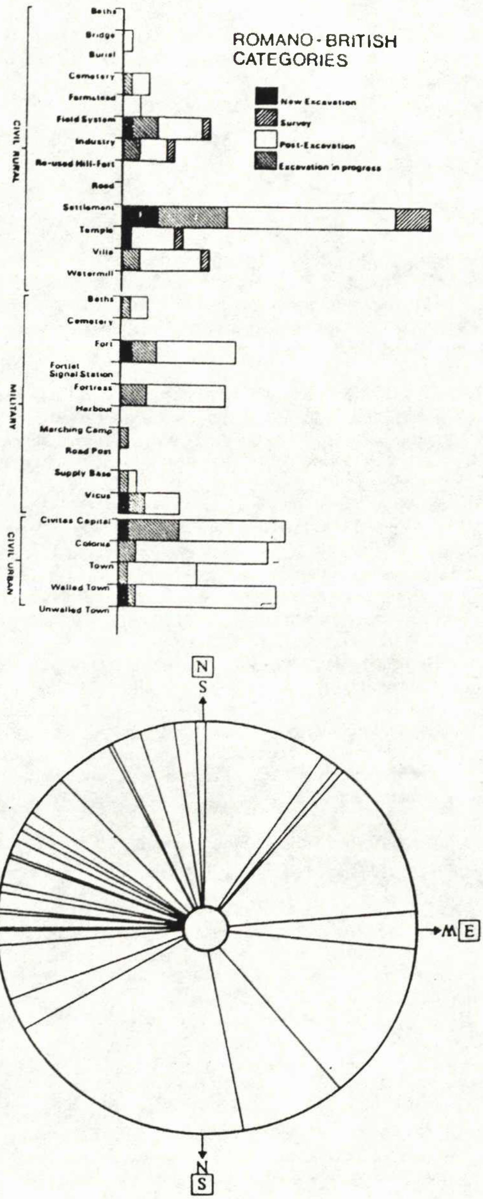


Figure 25: Typical examples of visual reporting

That 'rapid scan' shows the absurdity most clearly. Even without doing a systems analysis on systems analysis we are pierced by this laser vision: we've got our priorities fack-to-bront! The primary aim is always assumed to be cost-effectiveness. But is it? We are energised by the prophet motive, not the profit motive, in this field. If we transfer commercial concepts into it we get shunted down some irrelevant dark tunnel and totally diverted from our real aim. Which is to discover the detailed structures of our ancestral societies and the relationships between them, and to communicate our findings directly and reliably to our fellows and those who follow. We need to find out how best we can do this, before we start to consider how we can best pay for it.

LERNIE : the final reckoning

When we do come seriously to consider this we find it can be done easily enough. If we add together all the surveying, planning, section and other drawing, illustrating, manual data analysis, report drafting, typing, checking, typesetting, proof-reading, printing and distribution costs - not forgetting all the waiting time, from trench (planning hold-ups) to press (proofs), and weighting for waiting, but generously not counting non-quantifiable frustration energy-loss - and add up the lot so spent of last year's # 10 million odd, we're in for a pleasant shock: We could have done it all the stereo-video way instead and had enough left over to pay all the volunteers a living wage!

And that is not counting all the hidden savings in time, energy and (here particularly) frustration - never shown on balance sheets - due directly to instant and direct access to comparative material in colour 3-D pictures and without language barriers, not to mention consequent avoidance of multiplication the world over (eg Biek 1974).

So let's forget about the real world - after all, it is we who really make it by winning over quangoes and finance officers to share our vision. What we need specifically are seminars and fellowships to examine the developments of communication tools in other fields - especially such as that other bigger and outer kind of space research - and creatively to integrate them for our purposes. And what we, like all other multidisciplinary disciplines, need overall is a continuing, informed and committed polylogue - free from traditional prejudiced and time-locked 'decisions', 'straight' (vertical) thinking, preconceived 'aims', pompous 'policies', bogus 'deadlines', fake 'cash limits', hyped estimates, fumbled 'earmarking' and all the rest of the hung-over catchwords (objectives, strategies, targets, tactics...) of the classical pre-high-tech administrators' make-believe vocabulary.

Instead, a progressively developing, supremely flexible, changing-course capability (Biek 1974) will allow constant and instant response to the ever accelerating changes in stimuli and conditions which are threatening us - a facility akin to the homing agility of missile seekers, the panic reflex of the Stock Exchange or the evasive action of banks.

So what have we got? (Dr Johnson would agree there's no need to dangle a noose - talking to the computer concentrates the mind wonderfully, too. But actually why 'computer', now? It's really a data sorter - the contraction, 'darter', is very apt.) We've got total cover and a general cyclic flow of colour 3-D video information, bits and strings and sequences and things, and we've got it for less than we're spending now (Fig 26). It's all a bit like surfing: we can't really control it any more than we can the sea, only learn to recognise the tides in the affairs of men and use them creatively. Yet it can be done, and done most beautifully. And it is an acquirable skill. But it needs the use of all our imaginative powers and the concentration of all our faculties -

> see past life steadily
> and see it whole...

As always, we have the most cost-effective system - of fitting our particular bits into the overall mosaic of the way we are and what we can become - without actually trying. It's only a beginning, but it's there for all to share, straightaway. We say it with pictures and it's all on disc. As a spin-off, we shall also get good at seeing and directly comparing two different 3-D images at the same time - one double-take in each naked eye. It's all in the mind.

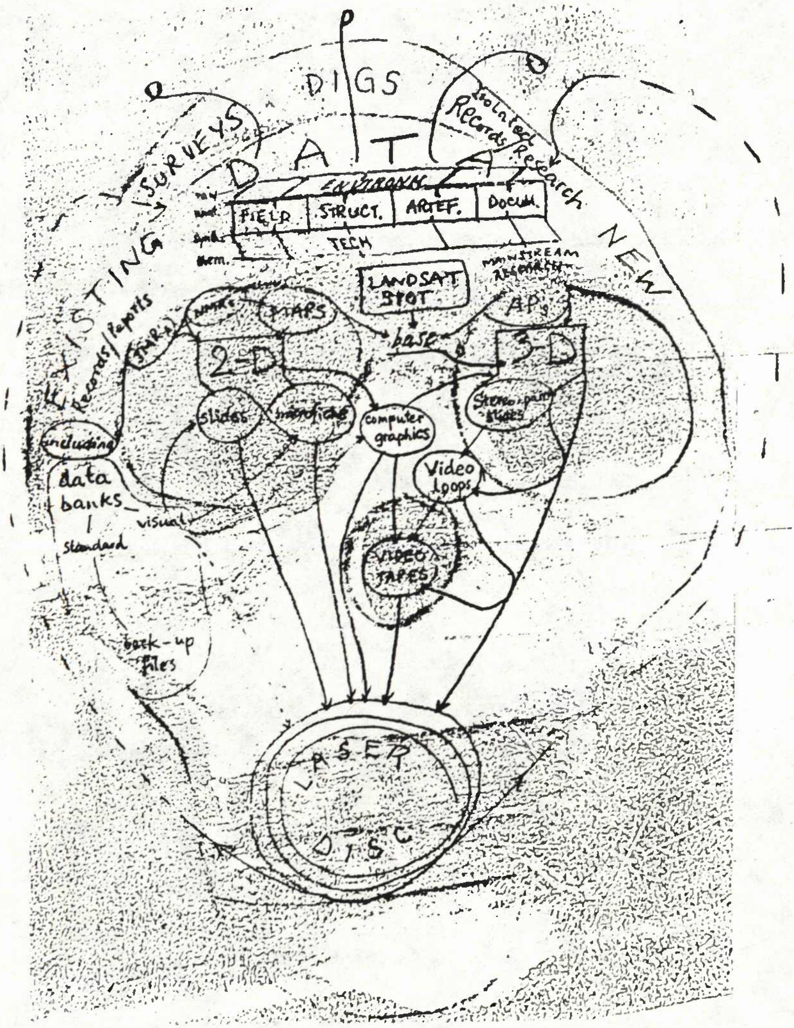


Figure 26: Flow diagram for VARDOL (Visual Archaeological Recording & Display Online).

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REFERENCES

Acorn 1985 Viewpoint - interactive video workstation. APP 58. Acorn Computers Ltd., Taplow.

Adams, L.P. 1974 Stereoscopic viewing of image pairs with the naked eye. Photogrammetric Record 8, No44, 229-30. Also see Phot.Rec. 8, No46, 552-6).

Alvey 1984 The Alvey Programme of Advanced Information Technology. The Alvey Directorate, Department of Trade and Industry, London

ASLIB 1985 Online Notes from the Online Information Centre. Also see 'The invisible ingredient (Euronet DIANE)'.

Atkins, S. 1985 Interactive technology: the Domesday Project, Media in Education & Development 18 (Sept)

Bayard-White, C. 1985 Interactive Video Case Studies and Directory. Council for Educational Technology, London

Bazargan, K. 1985 'Natural colour holography', Journal of Photographic Science. 33,

Beech, G. 1983 Computer-based Learning. Wilmslow: Sigma Technical Press (Wiley).

Biek, L. 1974 'Progress with LERNIE', Computer Applications in Archaeology 59-63.

Biek, L. 1984 'VISAR: Conference April 27th 1984', Trans.Assoc.Stud.Conserv.Hist.Build.(ASCHB) 8 for 1983, 28-32.

Biek, L., Hawker, B.M., Lindsey, N.E., and Lupton, G.N., 1981 'LERNIE VIII', Computer Applications in Archaeology, 8-19.

Bowyer, A. 1981 'Computing Dirichlet tesselations', Computer Journal. 24, 162-6.

Bowyer, A., Graham, D. & Henry, G. 1985 'The measurement of 3-D features using laser triangulation', Proc.7th Intern. Confce on Automated Imaging and Production Control, Birmingham 1985, 313-22. IFS Publications, Bedford.

British Telecom 1983A Confravision and Videostream. PH 3375, 3388, 3391, 3470.

British Telecom 1983B Instant data location with video maps. PH 3467.

Carver, M.O.H. 1985 'Provisional scheme for an integrated archaeological recording system', Bulletin of the Sutton Hoo Research Committee 3

Chiarmonte, P. 1984 'The development, management and preservation of art and architectural microform collections', Art Libraries Journal, Autumn/Winter, 26-45.

Dorsett, J.E., Gilbertson, D.D., Hunt, C.O. & Barker, G.W.W. 1984 'The UNESCO Libyan Valley Survey, VIII. Image analysis of Landsat satellite data for archaeological and environmental surveys', Libyan Studies 15, 71-80.

Fraser, D. 1983 Land and Society in Neolithic Orkney, British Archeological Reports, British Series117, Oxford.

Fussell, A. 1982 'Terrestrial photogrammetry in archaeology', World Archaeology 14, 157-72.

Galton, N. 1985 Solid Modelling : UKSC Graphics Scenario, IBM UK Scientific Centre, Winchester.

GEOMOD, GEOVIEW 1985 3-D interpretation packages, Lexidata Ltd, Hook.

Gibbins, P. 1984 'Electronic publishing - first convergence of many disciplines', Journal of Information Science, 8, 123-9.

Harris, M.R., Geddes, A.J., and North, A.C.T. 1984 'A versatile stereo viewing system for use with colour graphics displays', in Colour in Information Technology and Visual Displays, Publication No.61, 75-80. IERE Publications, London.

Hawker, B.M. et al. 1981: see Biek, L. et al. 1981

Heaford, J.M. 1983 Myth of the Learning Machine: Theory and Practice of Computer-based Learning Sigma Technical Press (Wiley) , Wilmslow.

Hedges, R.E.M. 1980 'Physical science and archaeology', Interdisciplinary Science Review 5, 129-37.

Heyworth, M.P. forthcoming 'The role of inductively coupled plasma spectrometry in glass provenance studies'.

Holofax 1985 Making holograms - the easier way: Holocam Systems. Holofax Ltd, Rotherwas.

Ledbetter, L., & Cox, B. 1985 'Software-ICs', BYTE June, 307-16.

Lindsey, N.E. et al. 1981: see Biek, L. et al. 1981

Lock, S. 1985 'Two cheers for the computer?', British Medical Journal 290, 1609-10.

Martin, P. 1982 'Un systeme de telemetrie tridimensionnelle a ultrasons pour la recherche archeologique', Notae Praehistoricae 2, 83-90.

McNett Jr., C.W. 1981 'Computer graphics in the analysis of archaeological data', in Gaines, S. (ed) Data Bank Applications in Archaeology, 90-9. University of Arizona Press, Tucson.

Mercer, I. 1985 'Computer-controlled videodisc: a new medium for museums', unpublished lecture notes: Geological Museum exhibit.

Michie, D. 1982 'Experiments on the mechanisation of game-learning', Computer Journal. 25, 105-13. Also see ref. in Wilcock this vol.

Michie, D, & Johnston, R. 1985 The Creative Computer: Machine Intelligence and Human Knowledge. Penguin, Harmondsworth.

Microform 1985 The published catalogue now lists over 200 colour microfiche. Oxford Microform Publications. Also see Chiarmonte, P., 1984 above.

NIVC 1985 An introduction to interactive video. London: National Interactive Video Centre.

NOAA 1985 'Water surveillance', Landsat Data Users' Notes, April.

Nylen, E. 1978 'The recording of unexcavated finds: X-ray photography and photogrammetry', World Archaeology 10, 88-93.

Parsloe, E., and Hoffos, S. (eds) 1984 Interactive Video. Sigma Technical Press (Wiley) , Wilmslow.

Philips 1985 Professional laservision disc systems for interactive application. 3122115/66411 & 68201 for VP 831 and 835. See also eg Ixer, R., Videodisc Newsletter 1984, No3. London: University Audio-Visual Centre.

Pluto 1985 Pluto Designer Software. Io Research Computer Graphics, Barnet.

Price, S. 1979 Round bottle inspector, Glastechn.Ber. 52, 251-4, Fig.5.

Robinson, M., and Sood, S.C. 1981 'Real time depth measurement in a stereoscopic television display'. Paper presented at the Real Time 3-D Viewing Conference. Institution of Electrical Engineers, London.

Shapiro, E.Y. 1981 'An algorithm that infers theories from facts', Proc. 7th International Joint Conference on Artificial Intelligence.

Simpson, A. (ed) 1982 Planning for Electronic Mail. Gower, Aldershot.

Vannier, M.W., Marsh, J.L. & Warren, J.O. 1984 'Three-dimensional CT reconstruction images for craniofacial surgical planning and evaluation', Radiology 150,

Van Noten, F. 1968 'Quelques outils tjongeriens remarquables', Helinium 8, 149-53.

Wallach, H. 1985 'Perceiving a stable environment', Scientific American 252 (May), 92-8.

Watson, J., and Britton, P.W. 1985 'Engineering measurement from underwater optical holograms', Journal of Photographic Science, 33,

Winther, S. 1985 'Effective data acquisition and retrieval of holographic interferograms', Journal of Photographic Science 33,

Woodwark, J.R., and Bowyer, A. 1986 'Better and faster pictures from solid models, Computer-aided Engineering Journal (forthcoming)

Woolley, B.C., 1985 'New images of Britain', The Listener 25 Apr.