ABSOLUTE POLLEN ANALYSIS: AN EXAMPLE OF THE USE OF THE 'HOME COMPUTER' IN ARCHAEOLOGY

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Small crowds around the computer magazines in larger newsagents testify to the fact that the home computer has now achieved widespread popularity. Indeed, the computing press estimate that, in 1983, ownership of home micros will reach the one million mark (Jones, 1983, 34) - one leading home computer, the Sinclair ZX81, has already sold over one million machines around the world. The prices of these computers continue to plummet, so that a reasonable home micro can now be purchased for the same price as a hi-fi or video recorder.

1982 was the Year of Information Technology and the Department of Industry's IT82 project stressed the educational value of the smaller micro - the DOI have been sponsoring a scheme to place a microcomputer in every school in the country, although they do have an 'approved' list of machines and most schools are only too willing to point out that one micro will not go a long way amongst several hundred children. Nevertheless, the seed of mass 'computer literacy' is apparently sown. Closely linked to the DOI scheme, albeit coincidentally, is the BBC Computer Literacy Project, made manifest in two television series on computers (with more promised), a Basic course in conjunction with the National Extension College, a referral service for those interested in micros, and (most significantly, from the point of view of this paper) their 'own' microcomputer, built by Acorn Computers of Cambridge, based on their Proton design, updated to meet the rigorous BBC specifications.

Much is made of the versatility and expandability of the BBC micro, but is it of any potential use to an archaeologist? Home computers are largely employed, one suspects (and there is little evidence to counter this suggestion), for games-playing, a purpose for which the BBC machine is, admittedly, admirably suited. It has, however, found an enthusiastic following in the world of education: it is reported that over 80% of micros purchased by schools under the DOI scheme are BBC Model Bs (Anon., 1983, 10).

At this juncture, a thumbnail sketch of the machine might be helpful - the following comments largely concern the 32K Model B, although they also apply to the 'upgraded' Model A. Of the 32K RAM available, just over 29K can be utilised by the user under normal operating conditions; however, the eight different 'modes' mean that anything between 1 and 20K of that 29K can be taken up by the memory-mapped screen display. This is not the place for a detailed description of the computer's display capabilities, but three examples that may be of particular interest to the archaeologist may be considered.

In the teletext mode (similar in appearance to Ceefax or Oracle), the display occupies only 1K and provides 23 lines of 40 characters, with eight still and eight flashing colours, as well as block graphics; whilst, at the other extreme, the high-resolution mode 0 provides a 32-line, 80-character display with two colours (which can be defined by the user from a palette of 16 colours in theory - in practice, more can be achieved), but it also provides graphics resolution of 640 by 256 pixels, although at a cost of 20K. The ideal compromise exists in mode 4, which gives 32 lines of 40 characters, two colours, and screen resolution of 320 by 256 pixels, using 10K of memory.

The machine will work quite comfortably with an ordinary television and cassette recorder, but performs best with high-performance monitors, particularly those of the RGB variety, and with floppy disks, for which it has a fairly sophisticated disk operating system (but at additional cost, naturally!). Interfaces are provided for printers, both parallel and serial, a 1MHz extension bus (to which EPROM programmers or graphics tablets could be attached), a user port (for robot arms, for example), an analogue input (for joysticks or the monitoring of experiments), while the RS423 serial interface can be used to communicate with other computers, from micros up to mainframes. There are still further possibilities for expansion: the computer can be interfaced to floppy disks (from single 100K to dual 400K units), a teletext decoder (to download pages of telesoftware), a Prestel decoder, and, most importantly, to a second processor. This second processor can be an additional 6502, or a Z80 (allowing the use of CP/M - a BBC micro running CP/M would cost around £1500 in all), both 8-bit chips providing 64K additional RAM and effectively doubling the operating speed of the machine, already one of the fastest microcomputers available; in fact, it has been rated third after the 16-bit Olivetti M20 (costing £2754) and the DAI (£684) on a series of eight benchmarks (Pountain, 1982, 111). However, the promise of a 32-bit processor with 128K of RAM is probably the most interesting facet of the machine's expandability.

The 'firmware' is similarly interesting. The BBC Basic resident in the computer has features allowing elements of structured programming and there is easy access to assembler language - in fact, the two may be combined to great effect. There is room for the addition of other language chips - Pascal, Forth, etc. - as well as word-processing packages or special applications programs; future plans include the use of ROM cartridges, for which the computer is already partially prepared.

At about the time of the launch of the BBC micro, the Department of Ancient History and Classical Archaeology at the University of Sheffield had begun a project to survey the extramural settlement at the Roman fort of Brough-on-Noe in Derbyshire with the aid of a resistivity machine and involvement with this led to the belief that a microcomputer would be useful to interpret the results of such a survey. The Department acquired a BBC machine and, within one month, a program had been written in BBC Basic which worked and has been undergoing regular improvements ever since, producing a dot-density plot of the survey square. Computer presentation of geophysical surveys is quite common, but a more unusual application that demonstrates the suitability of the BBC computer for archaeological data interpretation will now be discussed in detail.

The work of M.V. Andrews on the vegetational history of the island of Colonsay in the Inner Hebrides, incorporating the archaeological evidence, employs the technique of absolute pollen analysis and it was felt that it would be a relatively simple matter to write a program which would produce pollen diagrams, having performed the necessary calculation first.

The basic concepts of pollen analysis are well known - that, under certain circumstances, pollen becomes incorporated and preserved in deposits such as peat bogs. This can be extracted, each species counted, and represented diagrammatically relative to the other species as a percentage of:

a) the total number of pollen grains and spores counted per level
b) the total number of pollen grains from land plants
c) the total arboreal pollen.

There are obvious problems inherent in this, since a change in the proportion of one species affects the others and sedimentation rates affect all species at one level, thus confusing the interpretation for archaeologists seeking small-scale changes in the environment. These can be overcome by the use of absolute pollen methods, complemented by a series of radiocarbon dates to determine the rate of accumulation, and therefore pollen influx, per unit time.

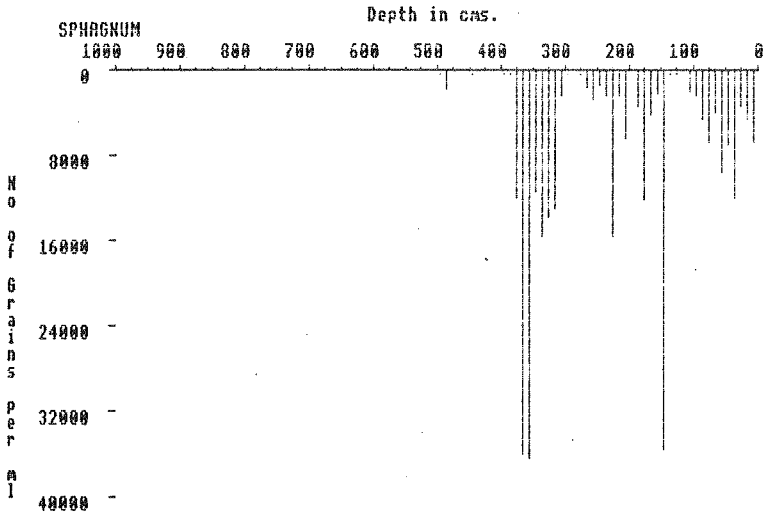
Absolute pollen analysis has been shunned by those who claim it is too long and complex a process. The only way it varies in preparation and counting from previous methods is that the volume of peat from which the pollen is to be extracted has to be measured accurately and a tablet of calcium carbonate, containing a certain number of 'exotic' pollen grains (e.g. eucalyptus) added. Counting is undertaken in the ordinary way, with the exotic grains recorded as an extra species, until a predetermined number is reached. So far, very little extra effort is involved. The part of the process which causes most anxiety is the calculation that follows and determines the number of grains of each species contained within each millilitre of peat. This can be done in several ways and the one described here is loosely based on Moore and Webb (1978).

Each batch of pollen pills is supplied with a certificate stating the mean pollen content of the tablets, with a standard deviation which has been calculated using aliquots. A set total of grains of pollen and spores (excluding exotics) is identified for each level. By calculating the proportion of exotic grains counted, the fraction of pollen identified in each millilitre can be assessed for each species at each level.

This takes a considerable amount of time if done by hand, but only a fraction of a second on a computer. The data can then be stored or used to construct a hard-copy diagram, taking minutes rather than a few days, as it would by hand.

It was decided to use a modular approach in writing the package of pollen data-handling programs. The raw data for each species is entered into a 'writing' program, which then saves it onto an ordinary cassette tape in the form of a data file; this means it can then be read by each of the three main interpretation programs. The data is placed on the tape in the following form: the first piece of information is the maximum depth of the sample, next the name of the species, and then the number of levels. The main body of data follows this, with the exotic count for each level, then the species count; it takes approximately 25 seconds to write 50 levels onto tape, 40 seconds for 150 levels. Ideally, all the species for one sample should be written onto the same cassette - two copies of each species' data-file often being useful. Obviously, copies of the data-writing programs are kept as a back-up.

It took two weeks of spare time to write the essential package, consisting of the one data-writing and three interpretation programs: POLLEN for absolute pollen, POLLEN% for relative or percentage calculations, and POLLCONF which provides the 95% confidence limits of the absolute calculation. The percentage/relative program provides a percentage pollen diagram of type a), since it includes all species, but it allows comparison of the data with other published pollen spectra, since published



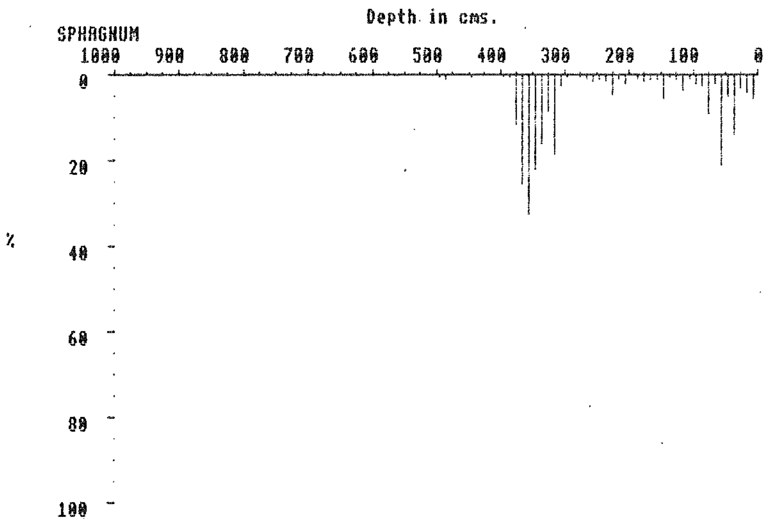


Figure 1 Examples of the printout from the POLLEN (top) and POLLEN% programs. Both diagrams were produced using the same data.

diagrams utilising the absolute technique are rare. The exotic figures for each level are treated as dummy readings, the actual count for each being calculated as a percentage of the number of grains normally counted.

POLLEN, the absolute program, uses the exotic and species counts to calculate the original concentration per millilitre. The data are read in, calculated, and plotted onto the x-axis (representing the depth of the sample) in the form of a bar chart, automatically placing each level at the correct depth. The x-axis represents a maximum sample depth of 10 metres, adequate for work on Colonsay. The y-axis (the number of grains) can be scaled by the user, according to the results as they are presented - thus readings under, for example, 1000 or reaching tens of thousands can be made to fit into the available space on the screen.

When a satisfactory display has been achieved, the user can 'dump' the screen onto a dot-matrix printer with bit-image graphics capability, taking just under 90 seconds, by means of a resident machine-code 'dump' routine. By running the program again after each diagram has been dumped and reading-in a new species, an entire diagram can be produced - taking, in all, about two-and-a-half minutes for each species (including the time taken to produce the hard-copy), or 40 minutes for a diagram consisting of 15 species. The program POLLCONF is available to plot the 95% confidence limits of the absolute pollen diagram and this works in much the same way as POLLEN, although the calculations are rather more complex. For all programs, the option is available to omit the x-axis labelling, thus making the final pollen diagram easier to read.

Whilst the diagrams produced are by no means suitable for publication as they stand, they are an invaluable aid to the interpretation of a sample and can be used by draughtspersons to produce a pollen diagram to a particular house-style, if so desired. Nevertheless, the addition of an XY plotter (costing several hundred pounds) would probably enable diagrams of publication standard to be produced.

Although pollen diagrams have previously been implemented on computer, they have normally used mainframes or the expensive 'desktop' type of microcomputer (King, 1976; Vuorinen & Huttunen, 1981). The advanced graphics facilities of the BBC microcomputer mean, however, that it is possible to demonstrate that a useful pollen analytical package can be produced for a home micro.

It must be stressed that the package is in a prototype form and is by no means as 'user-friendly' as it might be, although it does contain instructions for its use. Future developments will include an 'automatic' numerical zonation of the pollen assemblage, probably allowing the choice of several different techniques of zonation. However, most future work will go into making the package as easy to use as possible.

Since the original geophysical interpretation program GEOPHYS and the POLLEN package, a number of other archaeological uses for the BBC micro have suggested themselves: the mapping of oblique aerial photographs; three-dimensional representations of geophysical surveys; a package of programs for the soil scientist or environmental archaeologist; a suite of statistical implementations; computer simulation, using systems theory, although a version of the DYNAMO language for the BBC machine would be helpful here. The only real limitation, at the moment, is the amount of data handled and the desired screen mode for display. The amount of available memory is soon likely to be a problem of the past, however - with the use of a 32-bit second processor and paged memory, even the largest archaeological problem would become feasible, at a fraction of the price of the current technology, whilst processing speed is bound to increase even further. Database applications, such as the Central Excavation Unit's MLRPS package for the recording of excavation data, are also within the capabilities of this home computer, although they almost certainly demand the use of floppy disks. In the Department of Ancient History, Dr D.L. Kennedy's Aerial Photographic Archive for Archaeology in the Middle East will be computerised with the aid of the BBC machine.

So, is there a place for the home computer in archaeology? The new generation of home micros, pushing ULA chip technology to its limits, must surely bear consideration against the aging and expensive Pets and Apples; for all its faults (and all micros do suffer from such faults), the BBC micro outperforms and outprices the older generation of micros and is set to give the new 16- and 32-bit machines a run for their money. Even the £50 ZX81 now has the capability of one megabyte of memory and an envisaged one gigabyte. Does this not mean that it is time for the archaeologist to reconsider just what he or she means by a computer? As in most things, it will surely prove to be a matter of 'horses for courses', but the home computer has now established itself as a very useful tool for the archaeologist.

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