33

A resource-based archaeological simulation

Sebastian Rahtz*

33.1 Introduction

This chapter[1] outlines one method of using a computer to assist in teaching the principles of archaeological excavation and analysis to students. It forms a part of a joint project between the Departments of Archaeology at the University of Southampton and the University of York, sponsored by the UGC/Computer Board *Computers in Teaching Initiative*; the project, known as Southampton York Archaeological Simulation System, was first mooted by Sebastian Rahtz in mid-1986, funded by the CTI in February 1987 and officially began in October 1987 (Shennan 1987a). The work described here is an offshoot of initial discussions about what Southampton York Archaeological Simulation System should do, based in particular on the issues raised at the Southampton York Archaeological Simulation System Steering Committee meeting in October 1987 at York. The current plans for the full system are outlined in Shennan 1987b, O'Flaherty 1987 and by Brendan O'Flaherty in this volume; it should be stressed that this is not intended to be a full explication of the issues and problems facing Southampton York Archaeological Simulation System, but rather a demonstration of one solution to the computer software problems.

There are four parts to the chapter:

1. A description of the problem, and the different ways it could be attacked
2. An outline of a solution based on a passive database resource
3. Discussion of how the suggested solution could be implemented using a particular piece of software (INGRES)
4. A description of a pilot version of the system based on the archaeological investigation of a cemetery

These suggestions are designed to form one part of the Southampton York Archaeological Simulation System initial evaluation procedure, before full development starts on the official 'product'.

* Department of Electronics and Computer Science,
University of Southampton,
Southampton S09 5NH

[1] I am grateful to Stephen Shennan, Julian Richards, Martin Carver, Tim Champion, Robin Torrence, Todd Whitelaw and Brendan O'Flaherty for their work on the Southampton York Archaeological Simulation System project; to Lou Burnard for thoughts about databases; to Philip Rahtz for thoughts about education

33.2 The problem

The process of excavation or other archaeological investigation is a multi-stage process involving (at least):

- the creation of an initial research design for the investigation
- the carrying out of initial work to gather the broad outlines of the problem and how it can be solved
- carrying out detailed investigation and recording in the selected area, in conjunction with continuous assessment of the results. It must be stressed that a considerable body of archaeological expertise would *not* agree with the idea that the process of recording should be affected by on-the-spot analysis of results; my defence for including such a concept in the scenario is that archaeologists still do it, and that the student should be free to make the mistakes of the past.
- analysing the full results and writing a report

The 'active' phases of this process all involve a cost, and one of the decisions made by the Southampton York Archaeological Simulation System project was that it would concentrate on this money-management aspect of archaeological investigation. The problem, of course, is that archaeology students (unlike most other science students) cannot try out classic experiments for themselves and test different approaches.[2]. Even were it possible for each 1st year student to have another go at digging Maiden Castle or Sutton Hoo, it would still be a colossally expensive process. Hence we need to *simulate* excavations on the computer. What we do *not* wish to do is simulate the behaviour of archaeologists in the same way that we might simulate Neolithic foragers ('if we give 20 diggers a trowel each, and they work for 10 days at a rate of 1 find per day, then we would get *n* coins after a week'); rather we wish to place the student in an excavation 'flight trainer', in which he replays classic investigations, making decisions for himself or herself. Just as the flight simulator has been pre-programmed with the details of the terrain around the airport, so that whichever way the pilot 'flies', the computer can reconstruct the view, so we wish to place the student in an archaeological site about which we know everything, and reveal bits to him or her as requested. A cardinal concept of this type of work, then, is that the computer is God, and knows everything about the site under investigation. The student should be free to fly wherever desired within the excavation; just as the trainee pilot will run out of fuel and crash if the plane is made to fly in circles, so the student excavator will never sort out the site if he spends all his resources on massive trenches in one corner without first doing a resistivity survey to pinpoint likely areas.

One way of providing the flight-simulator would be to set up a database of the relevant material and simply ask the student to navigate around it; this passive system is that outlined by this paper. The alternative approach is a more structured and active 'computerised tutor', which leads a student through the investigative process. While this seems more attractive in the long-term, it will involve considerable work, and although the the sucess of the solution suggested here would depend on the

[2] They *could* each investigate their own barrow or something similar, but archaeological sites are a very finite resource.

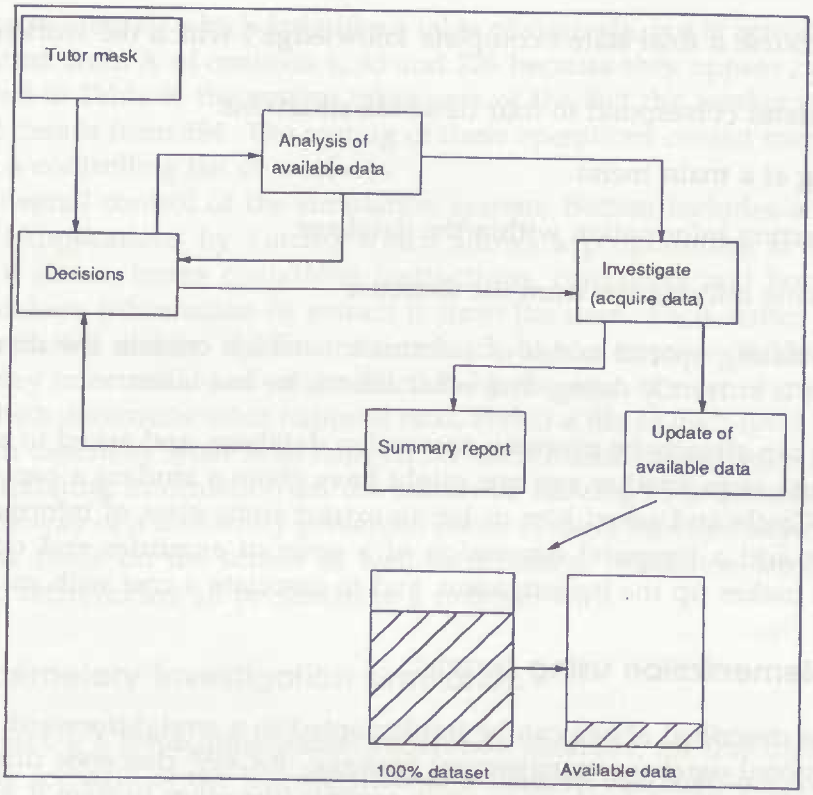


Figure 33.1: Outline of a resource-based archaeological simulation

involvement and teaching skill of a human tutor, it is easy to set up and would provide a forum for educational discussion.

33.3 A database resource

How does this translate into computer terms? If we take the complete knowledge about a given site, we can represent it in traditional fashion in a computer database;[3] this corresponds to the Level 2 and 3 archives of British field archaeology, in that it is possible to find out anything about the site by interrogating the database. What we wish to simulate is the process by which the database was created; this process may be seen as the gradual *transference of knowledge* from the main database to the student 'account'. The process is shown in Fig. 33.1, with the four possible states the worker can be in:

1. Passive state, deciding what to do next
2. Recording state, acquiring new information
3. Analytical state, examining available information
4. Change state, setting parameters for the next set of recording

[3] Many publications describe database design and management; some recent works with an archaeological or non-scientific bent are Richards & Ryan 1985, Richards 1987 and Burnard 1987.

There is of course a final state ('complete knowledge') which the worker is aiming to reach.

The four states correspond to four database situations:

1. Waiting at a main menu
2. Transferring information within the database
3. Retrieving information from the database
4. Manipulating special tables of information which contain the details of what a worker is currently doing, and what actions he has taken

The student can already be given an excavation database, and asked to answer certain questions (just as in another age one might have given a student a copy of the report on Maiden Castle and asked him or her to extract some class of information); all that is needed is add a temporal dimension of a *series* of enquiries and updates, whose progression makes up the investigation, and to associate a cost with each action.

33.4 Implementation using INGRES

The scenario described above can be implemented in a straightforward way using the INGRES relational database management package. INGRES[4] descends directly from one of the original relational database research projects (the other, System R, spawned IBM's DB2 and SQL/DS), and has been alive since the late 70s, although in its present form dates from the mid 1980s. It is well understood, and offers a classic relational system on a wide range of machines.[5] As well as the features described below, it has a full implementation of the SQL query language (Date 1987b) and embedded pre-processors for a range of conventional languages.

The database is contained in one or more tables, with associated tailorable screen forms, and a full-function 'query-by-example' retrieval system; both the workers' 'accounts' (details of current funding level etc) and journals are also held as tables, as well as utility information like the cost of actions.[6] Thus the tutor has a uniform interface for making changes to the system, which is the same as that which will be used by the student for requesting information.

The *transference of knowledge* is handled by means of conventional relational database 'views'; thus instead of viewing a base table full of data, we examine a version of it limited by certain criteria, where the 'version' is in fact merely a database retrieval, so that information is not duplicated. If we have a table of 1000 contexts, we could set up a view which limits retrieval to only those contexts whose numbers appear in another table. This means the knowledge transference consists simply of adding summary information to a controlling table; if Table A contains the contexts numbered 1 to 1000, and Table B contains the numbers 1, 33 and 776 (tagged with the worker's name to ensure that more than one person can use the system at once), then what the

[4] For a summary of what INGRES is and how it operates, there is an excellent recent survey in Date 1987a; Stonebraker 1987 describes the development of the system since the mid 70s.

[5] The system described below is implemented on an IBM PC and a SUN 3/50 workstation; it would port immediately to VAX or IBM VM/CMS INGRES implementations.

[6] *All* of INGRES' information is held in tables, even the screen forms.

worker sees is View C, which *looks* like a table of contexts, but is actually an extraction of information from A of contexts 1, 33 and 776 because they appear in Table B; when 554 is added to Table B, the system takes care of the fact the worker can now look at the context details from 554. The costing of these operations consist merely of updating a figure in a controlling list of workers.

For the overall control of the simulation system, INGRES includes a '4th generation language' (Applications by Forms) which allows a programmer to build quickly a sequence of screen forms containing instructions, comments and boxes in which to display database information or extract it from the user. Each screen has four parts: a) the information written out (instructions etc), b) one or more 'fields' (boxes) which either display information, or can be filled in by the user, c) a set of menu items at the bottom, which determine what happens next, and c) a file of high-level code (extended SQL) which describes what is to happen for each menu choice (such as displaying a help file, updating information on the screen or moving to a different screen. User control is by way of a uniformly presented menu system, function keys and interaction with simple fields on the screen as well as scrolling, multi-row tables. Data input, editing and retrieval are all presented in a uniform way.

33.5 A cemetery investigation simulation

Instead of taking a three-dimensional excavation database, for this trial system I have adopted the scenario of the investigation of a modern cemetery (CEMYSYASS); just as simple excavation games proceed by asking the 'digger' to pick squares to look at, so the cemetery investigator picks any stone from the available plan. The underlying database consists of information gathered between 1984 and 1986 in the Protestant Cemetery, Rome.[7] The underlying database structure is represented in Fig. 33.2 (cf. also Dunk & Rahtz 1988 for a discussion of the problems of representing cemetery information in a database).

The gravestone records fall into four groups:

1. The basic details about each gravestone, and a summary of the people commemorated on the stone.
2. The details of the inscriptions (*i.e.* the actual texts)
3. The details of the iconography
4. A detailed description in free text, and photographs

Corresponding to these four groups are four levels of recording available to the user of the system, which can be changed at any time; with each is associated a cost per stone.

The student working on the simulation systen can do one of three things, presented as choices on the opening screen, Fig. 33.3. One is in the main frame of the simulation system, and will keep returning to this point, always choosing between one of three actions:

[7] A project organised by the Swedish Institute and the British School in Rome, for the *Unione degli Istituti di Arceologia, Storia e Storia dell'Arte*, under the field direction of the writer; a recent description of the project is given in Rahtz 1987 and Vian & Menniti 1988.

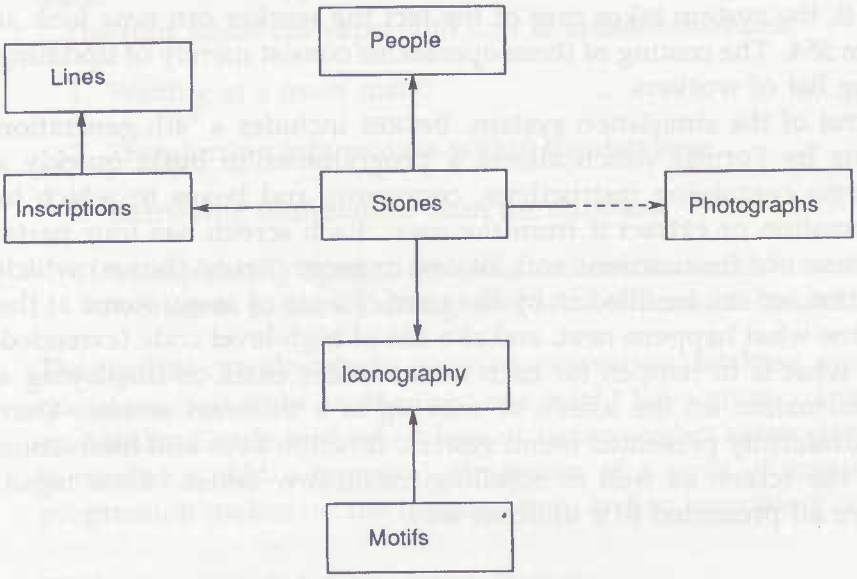
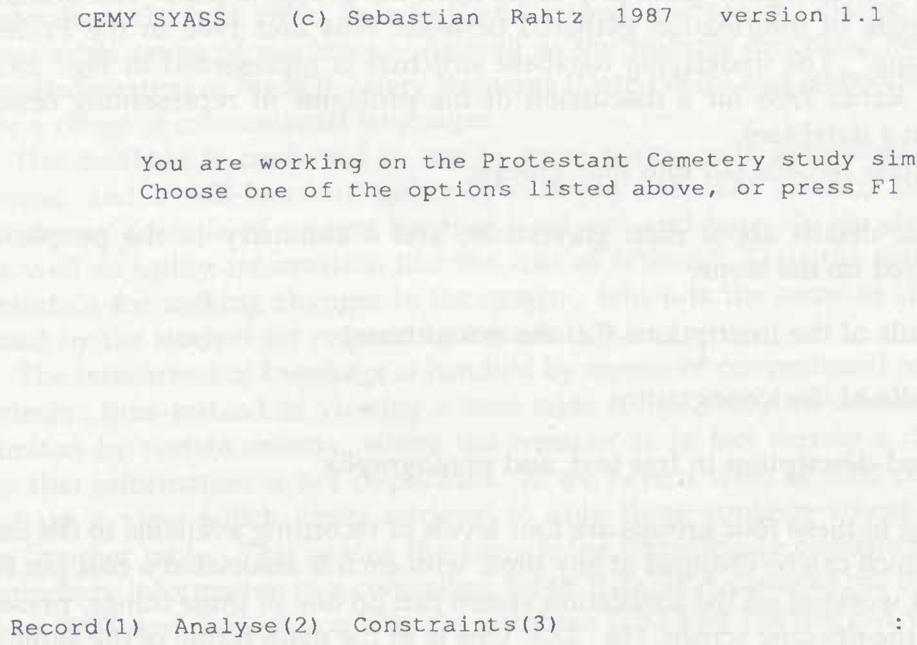


Figure 33.2: Simple database schema for Protestant Cemetery



```
CEMY SYASS   (c) Sebastian  Rahtz  1987   version 1.1



  You are working on the Protestant Cemetery study simulation.
  Choose one of the options listed above, or press F1 for help
















Record(1)  Analyse(2)  Constraints(3)                    :
```

Figure 33.3: Control frame for CemySyass

1. Record a new stone (Record); you will be asked for the number of it (see plan), and the relevant information will be transferred to your 'data account'. How much this costs will depend on the constraints currently set by you or your superiors.
2. Analyse the information available to you in your 'data account' (Analyse); there are a number of preset analyses or you will have tools to create your own.
3. Set up constraints on your recording (Constraints); this determines how much detail is available when you record a new stone. You can examine your current 'balance' of resources, and look at the journal of actions you have taken, with their costs.

Choose wisely, and all the rewards of the just will be yours.

The tutor also has access to a higher-level screen in which he can reset credit levels, wipe out records etc. You will be at this top level of the Cemetery Recording Simulation system if you are a tutor in control of the system. You may choose to go straight into the recording and analysis cycle, but you also have two other options:

1. Choose Tidy to reset all the records of the simulation exercise; each time a student records a stone, a note is made in the journal file, and the student name and stone number are added to one or more controlling record files. This option deletes all records in the journal, and all records in the control files. A future option will allow you to wipe out only those records belonging to a named student.
2. Choose Worker to inspect, edit and add to the 'workers' file, which lists all the people currently working on the simulation, what funds they have and what their recording status is. This allows you to add new students to the system, or change their funding level.

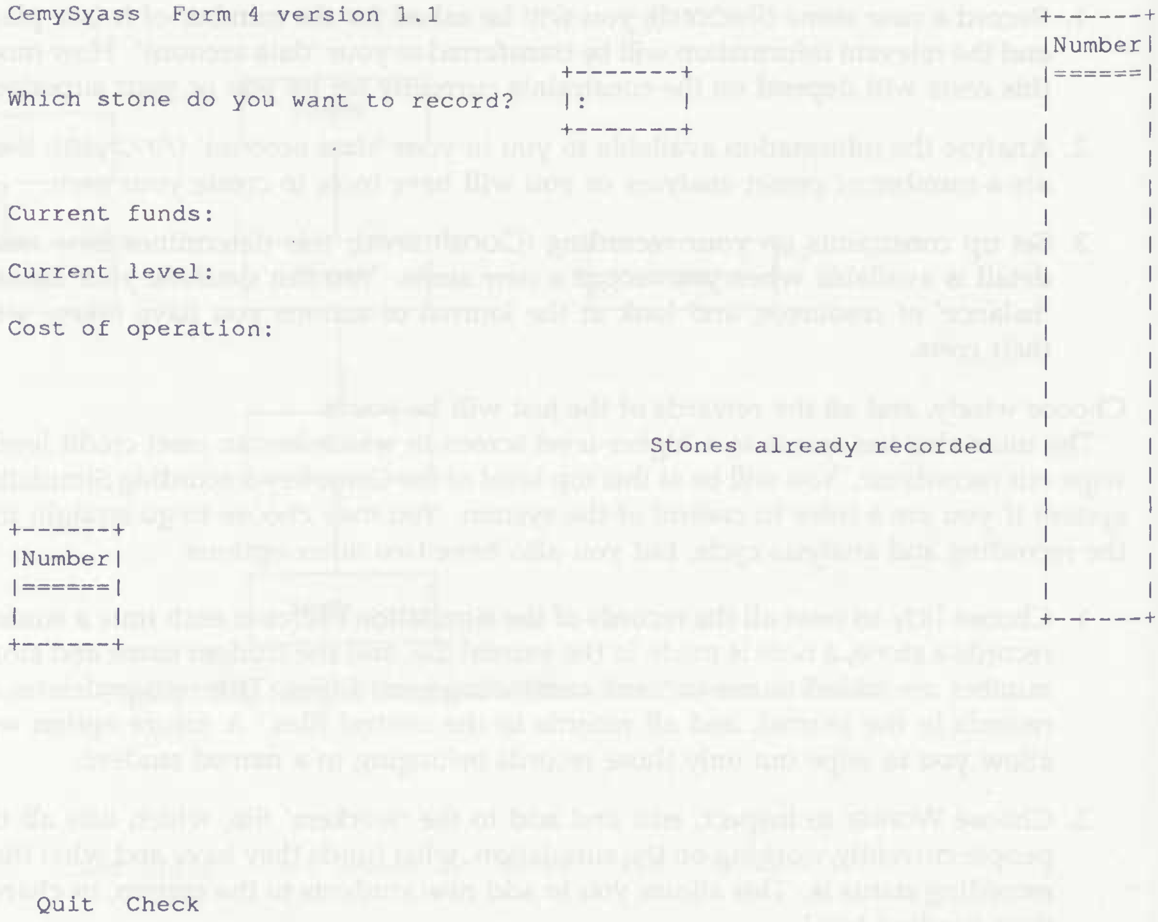
As in all the CEMYSYASS modules, the function keys are set up in consistent fashion:

- F1 gives help
- F3 exits the application
- F10 returns to the previous level
- F4 gives you an operating system shell
- F5 puts you in the system editor to write reports or make notes.

33.5.1 Recording

If we choose Record, we can record a new stone (at the currently set level), and the 'account' will be debited; this recording actually consists of adding a new stone number to one or more of the lists which control the views which the student has of the underlying database.

This module allows you to acquire new data; you will remain in this screen (Fig. 33.4) after you record a monument, so you can stay here and record as many stones as you wish. The plan (part is hwon in Fig. 33.5) shows the positions of the stones. In addition, you may choose to list the stones which you have already looked at (option



```
CemySyass  Form 4 version 1.1                                         +-------+
                                                                      |Number |
                                          +--------+                  |=======|
Which stone do you want to record?        |:       |                  |       |
                                          +--------+                  |       |
                                                                      |       |
                                                                      |       |
Current funds:                                                        |       |
                                                                      |       |
Current level:                                                        |       |
                                                                      |       |
Cost of operation:                                                    |       |
                                                                      |       |
                                                                      |       |
                                                                      |       |
                                               Stones already recorded|       |
                                                                      |       |
                                                                      |       |
+-------+                                                             |       |
|Number |                                                             |       |
|=======|                                                             |       |
|       |                                                             +-------+
+-------+





  Quit  Check
```

Figure 33.4: Recording frame, blank

Check on the menu); this will be done for you after each recording of a stone (Fig. 33.6). Note this tall box on the right-hand is an automatically-scrolling field; if there are more numbers than will fit on one screen, you can scroll the list within the box using normal cursor keys.

You can record monuments at four levels; the current level is displayed here, and can be changed in the Constraints module (return back up a level). The levels are as follows:

Level	Cost	Data recorded
1	1	physical stone details only
2	2	as 1, but adding summary person details
3	4	as 2, but adding details of inscriptions
4	6	as 3, but adding iconography details
5	10	as 4, but adding detailed descriptions

You can see at what level you have recorded a given stone by looking at the journal

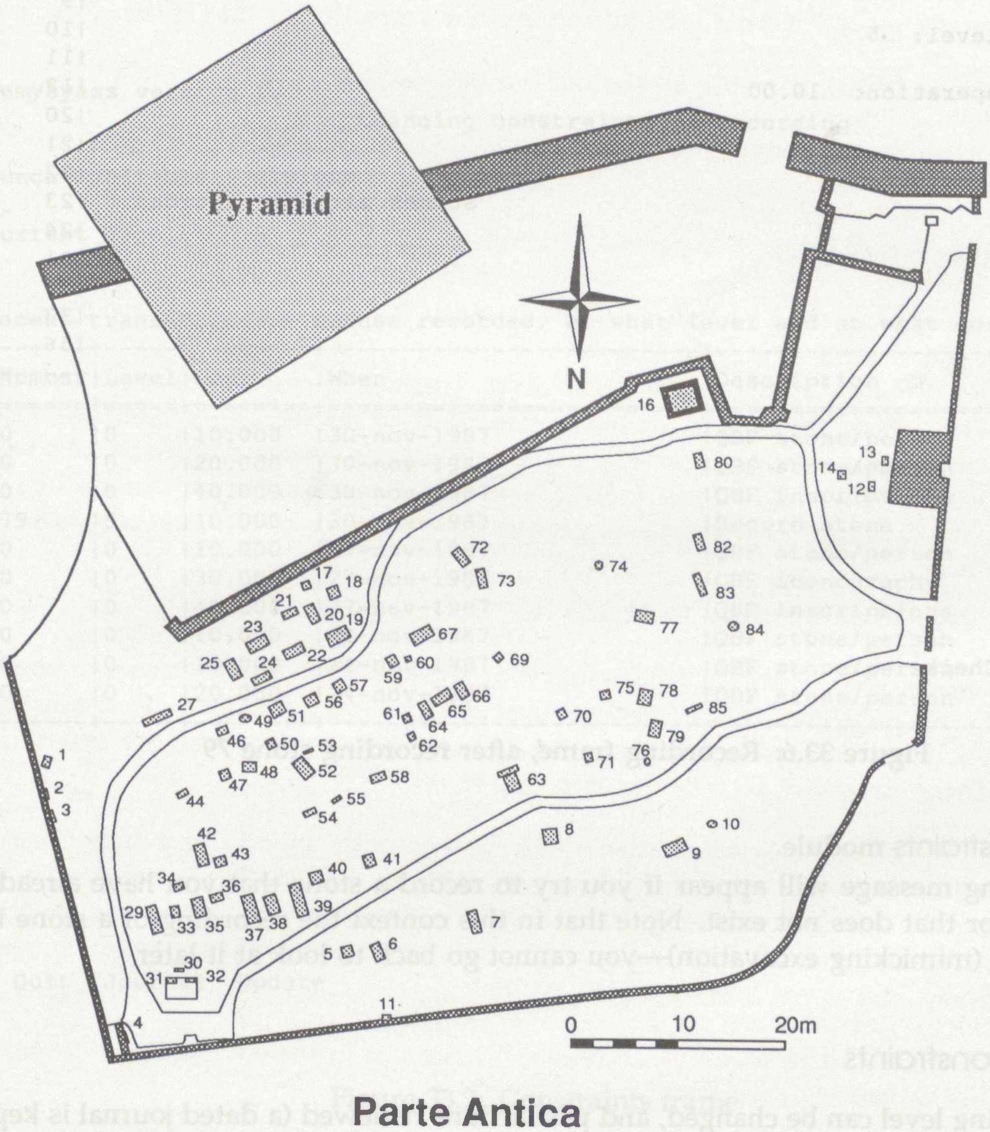
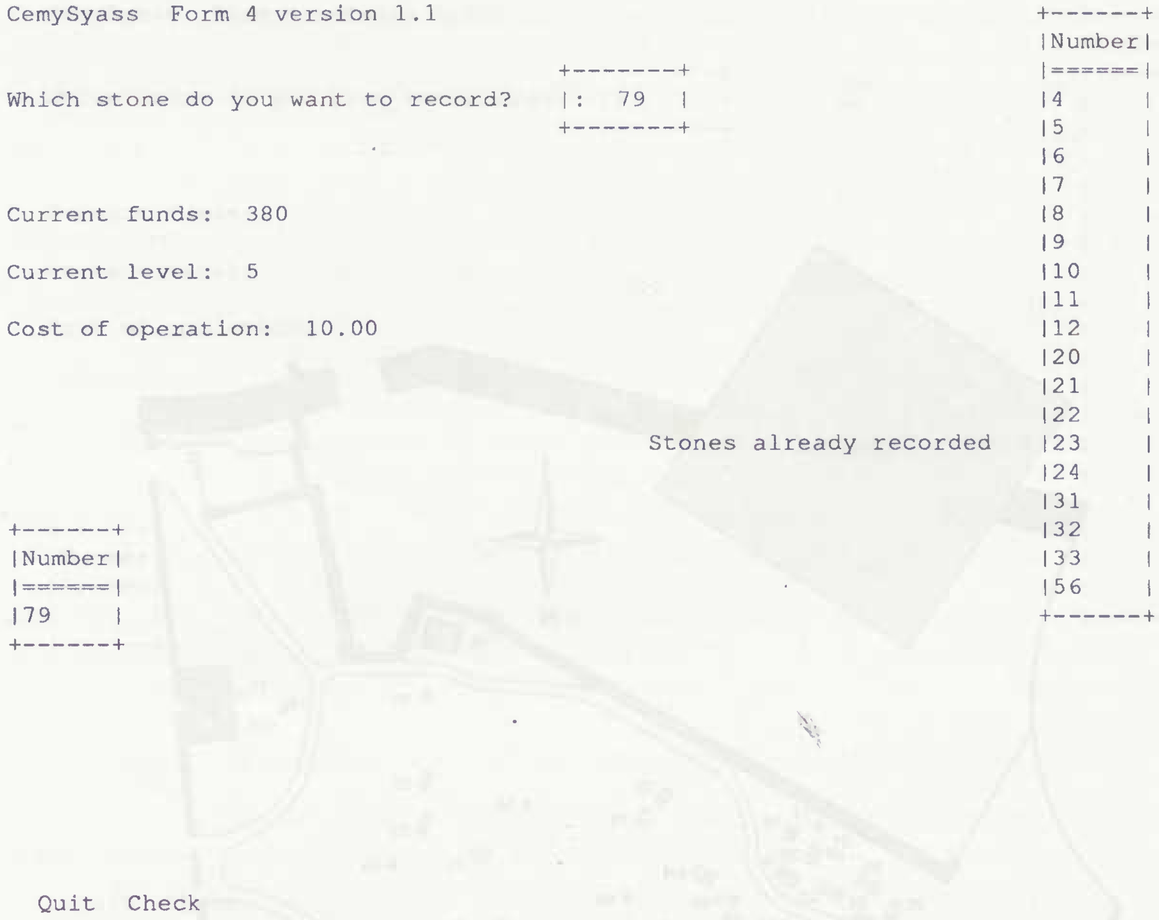


Figure 33.5: Plan of Protestant Cemetery *Parte Antica*



```
CemySyass  Form 4 version 1.1                                       +------+
                                                                    |Number|
                                         +--------+                 |======|
Which stone do you want to record?       |:  79   |                 |4     |
                                         +--------+                 |5     |
                                                                    |6     |
                                                                    |7     |
Current funds:  380                                                 |8     |
                                                                    |9     |
Current level:  5                                                   |10    |
                                                                    |11    |
Cost of operation:  10.00                                           |12    |
                                                                    |20    |
                                                                    |21    |
                                                                    |22    |
                                              Stones already recorded |23    |
                                                                    |24    |
                                                                    |31    |
+------+                                                            |32    |
|Number|                                                            |33    |
|======|                                                            |56    |
|79    |                                                            +------+
+------+




  Quit  Check
```

Figure 33.6: Recording frame, after recording stone 79

in the Constraints module.

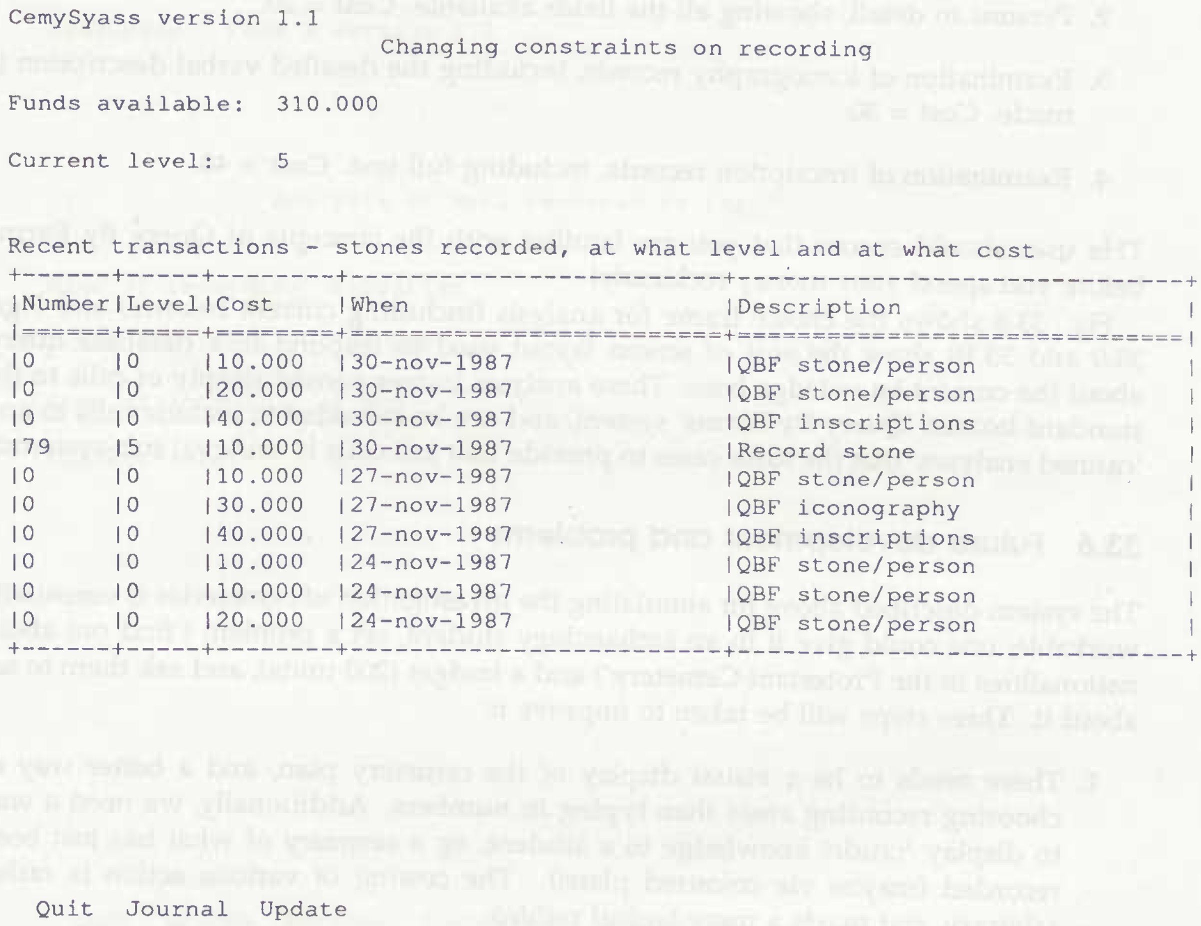
A warning message will appear if you try to record a stone that you have already looked at, or that does not exist. Note that in this context the recording of a stone is destructive (mimicking excavation)—you cannot go back to look at it later.

33.5.2 Constraints

The recording level can be changed, and past actions reviewed (a dated journal is kept of each action). This module lets you do two things (Fig. 33.7):

1. Check what you have done before to spend you funds, e.g. either record stones or undertake analyses (Journal).

2. Change the level at which you are recording stones (Update); for a description of the cost and effect of each level of recording, see the Record module



```
CemySyass version 1.1
                             Changing constraints on recording

Funds available:  310.000

Current level:   5


Recent transactions - stones recorded, at what level and at what cost
+------+-----+--------+---------------------------+-------------------------+
|Number|Level|Cost    |When                       |Description              |
|======+=====+========+===========================+=========================|
|0     |0    |10.000  |30-nov-1987                |QBF stone/person         |
|0     |0    |20.000  |30-nov-1987                |QBF stone/person         |
|0     |0    |40.000  |30-nov-1987                |QBF inscriptions         |
|79    |5    |10.000  |30-nov-1987                |Record stone             |
|0     |0    |10.000  |27-nov-1987                |QBF stone/person         |
|0     |0    |30.000  |27-nov-1987                |QBF iconography          |
|0     |0    |40.000  |27-nov-1987                |QBF inscriptions         |
|0     |0    |10.000  |24-nov-1987                |QBF stone/person         |
|0     |0    |10.000  |24-nov-1987                |QBF stone/person         |
|0     |0    |20.000  |24-nov-1987                |QBF stone/person         |
+------+-----+--------+---------------------------+-------------------------+



  Quit  Journal  Update
```

Figure 33.7: Constraints frame

33.5.3 Analysis

The current knowledge base can be queried; again, each analysis will cost the student some of his or her resources, depending on how much detail is asked for. The current method of doing this is to throw you into the normal INGRES 'Query by Forms' system to examine some of the tables of data under your control. The user can currently examine one of four classes of evidence:

1. Stones and persons summary; you will get details of the stone and a summary of the people recorded from it (if you undertook recording at that level). Cost = 10.
2. Persons in detail, showing all the fields available. Cost = 20.
3. Examination of iconography records, including the detailed verbal description if made. Cost = 30.
4. Examination of inscription records, including full text. Cost = 40.

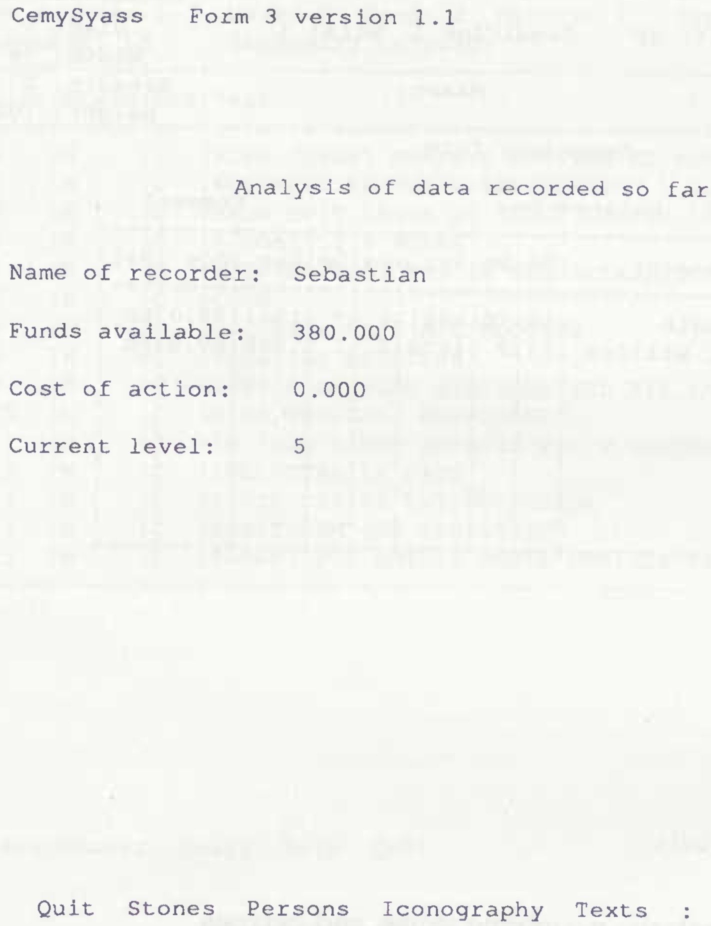
THe user should ensure that you are familiar with the concepts of Query By Forms before you spend your money recklessly!

Fig. 33.8 shows the choice frame for analysis (including current balance) and Figs. 33.9 and 33.10 show the sort of screen layout used to respond to a database query about the current knowledge base. These analysis frames consist simply of calls to the standard INGRES 'Query-By-Forms' system, and can be extended to include calls to any 'canned analyses' that the tutor cares to provide (not just calls to retrieval sub-systems).

33.6 Future development and problems

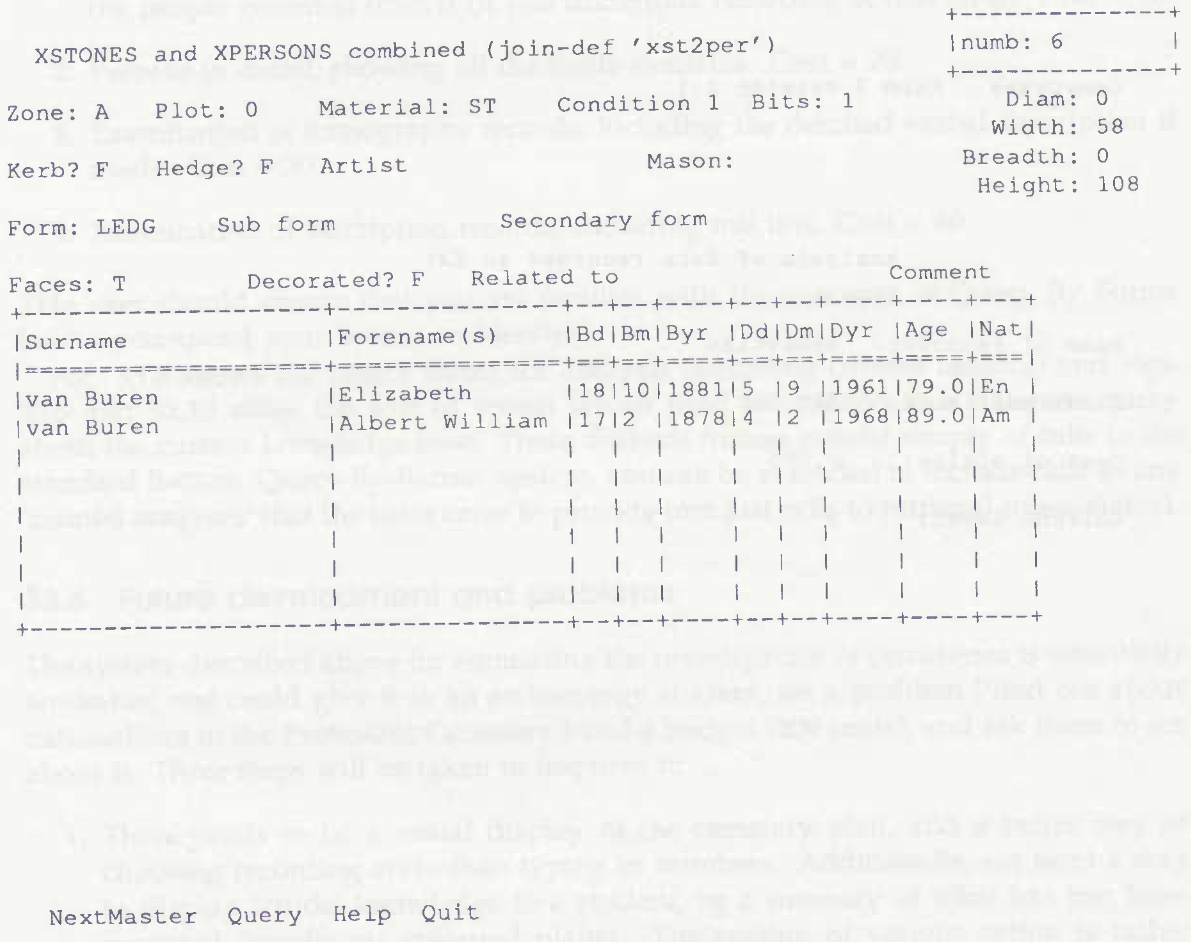
The system described above for simulating the investigation of cemeteries is essentially workable; one could give it to an archaeology student, set a problem ('find out about nationalities in the Protestant Cemetery') and a budget (200 units), and ask them to set about it. Three steps will be taken to improve it:

1. There needs to be a visual display of the cemetery plan, and a better way of choosing recording areas than typing in numbers. Additionally, we need a way to display 'crude' knowledge to a student, eg a *summary* of what has just been recorded (maybe via coloured plans). The costing of various action is rather arbitrary, and needs a more logical rethink.
2. Much use could be made of photographic records held on a videodisc under the control of INGRES; this is under investigation.
3. The number of canned analyses can be extended infinitely, from full-blown invocations of statistical routines to student use of the SQL query language; this is the easiest area to improve (note that conventional program subroutines can be called from within ABF, so there is no limit as to what can be done). Fig. 33.11 shows an example of a report format easily generated from INGRES, and Fig. 33.12 shows a simple graph produced with the Unix 'grap' utility from data generated by INGRES.



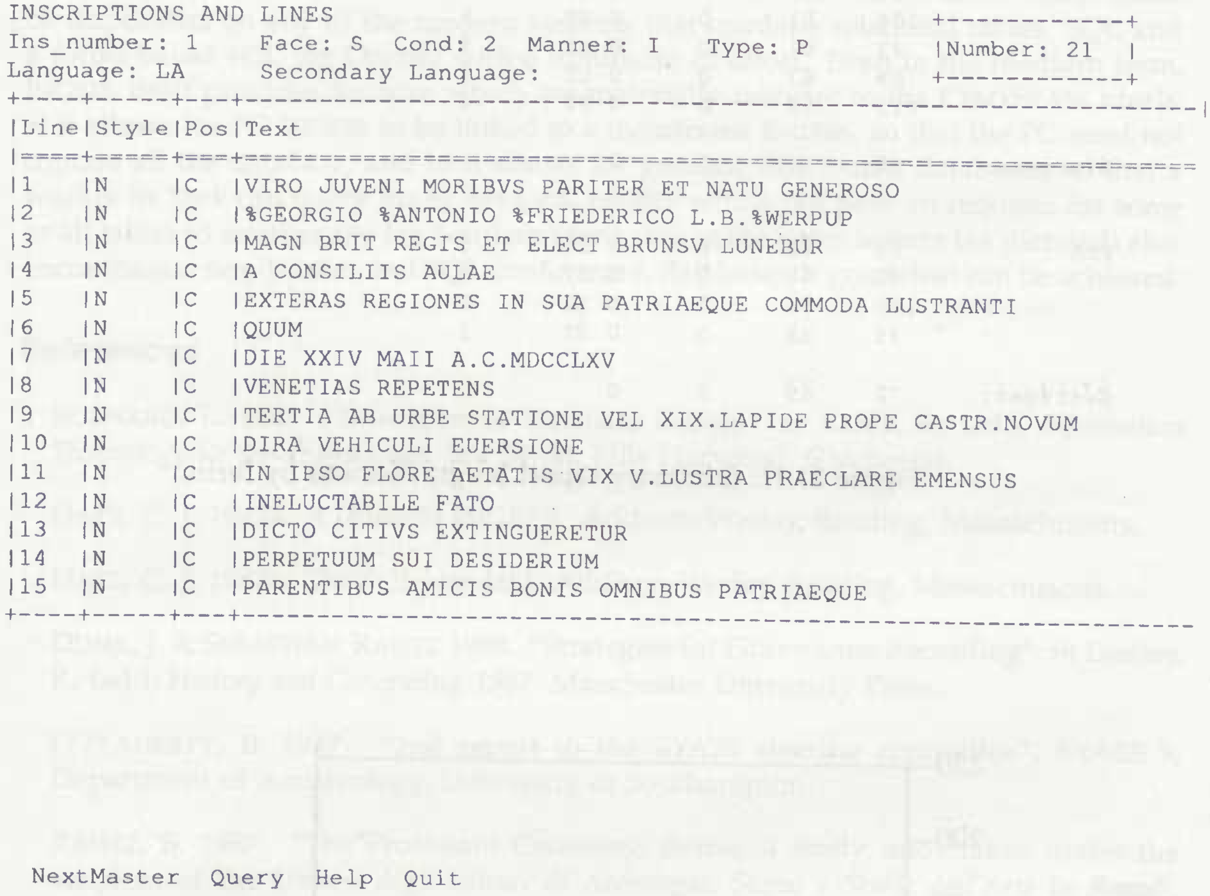
```
CemySyass   Form 3 version 1.1



                 Analysis of data recorded so far

Name of recorder:  Sebastian

Funds available:   380.000

Cost of action:    0.000

Current level:     5






  Quit   Stones   Persons   Iconography   Texts   :
```

Figure 33.8: Analysis



```
                                                                    +---------------+
 XSTONES and XPERSONS combined (join-def 'xst2per')                 |numb: 6        |
                                                                    +---------------+
Zone: A   Plot: 0   Material: ST   Condition 1  Bits: 1               Diam: 0
                                                                     Width: 58
Kerb? F   Hedge? F  Artist                    Mason:               Breadth: 0
                                                                    Height: 108

Form: LEDG    Sub form          Secondary form

Faces: T           Decorated? F  Related to                     Comment
+--------------------+----------------+--+--+----+--+--+----+----+---+
|Surname             |Forename(s)     |Bd|Bm|Byr |Dd|Dm|Dyr |Age |Nat|
|====================+================+==+==+====+==+==+====+====+===|
|van Buren           |Elizabeth       |18|10|1881|5 |9 |1961|79.0|En |
|van Buren           |Albert William  |17|2 |1878|4 |2 |1968|89.0|Am |
|                    |                |  |  |    |  |  |    |    |   |
|                    |                |  |  |    |  |  |    |    |   |
|                    |                |  |  |    |  |  |    |    |   |
|                    |                |  |  |    |  |  |    |    |   |
|                    |                |  |  |    |  |  |    |    |   |
|                    |                |  |  |    |  |  |    |    |   |
+--------------------+----------------+--+--+----+--+--+----+----+---+




  NextMaster  Query  Help  Quit
```

Figure 33.9: Analysis: examining stones and persons



```
INSCRIPTIONS AND LINES                                           +------------+
Ins_number: 1   Face: S  Cond: 2  Manner: I   Type: P            |Number: 21  |
Language: LA    Secondary Language:                              +------------+
+----+-----+---+-------------------------------------------------------------------|
|Line|Style|Pos|Text
|====+=====+===+====================================================================
|1   |N    |C  |VIRO JUVENI MORIBVS PARITER ET NATU GENEROSO
|2   |N    |C  |%GEORGIO %ANTONIO %FRIEDERICO L.B.%WERPUP
|3   |N    |C  |MAGN BRIT REGIS ET ELECT BRUNSV LUNEBUR
|4   |N    |C  |A CONSILIIS AULAE
|5   |N    |C  |EXTERAS REGIONES IN SUA PATRIAEQUE COMMODA LUSTRANTI
|6   |N    |C  |QUUM
|7   |N    |C  |DIE XXIV MAII A.C.MDCCLXV
|8   |N    |C  |VENETIAS REPETENS
|9   |N    |C  |TERTIA AB URBE STATIONE VEL XIX.LAPIDE PROPE CASTR.NOVUM
|10  |N    |C  |DIRA VEHICULI EUERSIONE
|11  |N    |C  |IN IPSO FLORE AETATIS VIX V.LUSTRA PRAECLARE EMENSUS
|12  |N    |C  |INELUCTABILE FATO
|13  |N    |C  |DICTO CITIVS EXTINGUERETUR
|14  |N    |C  |PERPETUUM SUI DESIDERIUM
|15  |N    |C  |PARENTIBUS AMICIS BONIS OMNIBUS PATRIAEQUE
+----+-----+---+--------------------------------------------------------------------
```

Figure 33.10: Analysis: examining an inscription

```
Form        Height Wid    Diam   Br. Mat.  Cond.

PLG           102  102     0      0 ST      1
               82   82     0      0 ST      4
              111   60     0      0 ST      4
               79   65     0      0 ST      4
              106   72     0      0 ST      3
               74   57     0      0 ST      3
              104   51     0      0 ST      4
               93   81     0      0 ST      3
               89   67     0      0 ST      4
              113   59     0      0 ST      4

 Averages:     95   70     0      0


PLW            64   90     0      0 ST      1
               42   50     0      0 ST      1
              148   96     0      0 ST      1
               35   38     0      0 ST      2

 Averages:     72   69     0      0
```

Figure 33.11: Summary report on gravestones by form

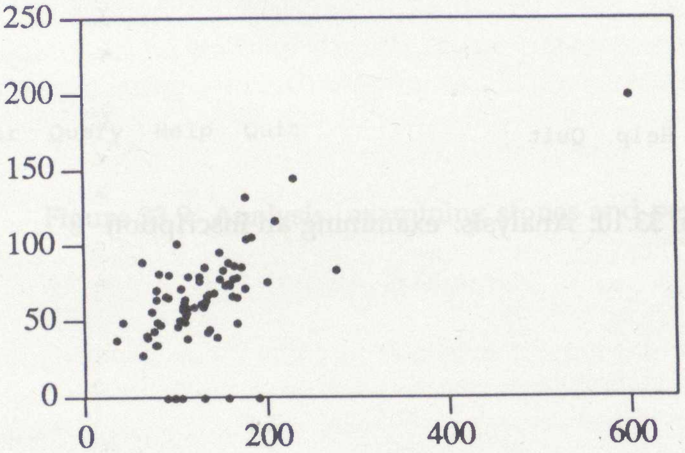


Figure 33.12: Simple graph of gravestone width against height

There are problems with the use of INGRES; on a PC it is huge (10 megabytes of system) and slow (albeit identical to the mainframe versions, which is very convenient). It works well on the SUN workstation under Unix (though it would seem sluggish to those used to micro-based applications), but this restricts its availability on some campuses. The interface is old-fashioned (although the ABF system makes it very easy indeed to build complete, consistent applications), and integration with graphics requires genuine programmer effort (it is not clear whether there is a system of which this is *not* true).

The overwhelming advantage of a resource-based system based around information held in a relational database is the classic one of *independence*; the same setup could be duplicated on any of the modern systems that combine relational tables, SQL and a forms-based 4GL (eg Oracle) with a minimum of effort. Even in the medium term, INGRES itself provides features which are materially relevant to the CEMYSYASS ideals: a) it allows for PC INGRES to be linked to a mainframe INGRES, so that the PC need not contain all the database, and b) it allows for genuine distributed databases, so that a worker in York can query his or her local INGRES which can pass on requests for some or all tables to another site (eg Southampton). When the latter feature (as planned) also encompasses non-INGRES, but SQL-conformant, databases, a great deal can be achieved.

References

BURNARD, L. 1987. "Principles of Database Design". *in* Rahtz, S., (ed.), *Information Technology for the Humanities*, pp. 54–68. Ellis Horwood, Chichester.

DATE, C. J. 1987a. *A Guide to INGRES*. Addison-Wesley, Reading, Massachusetts.

DATE, C. J. 1987b. *The SQL standard*. Addison-Wesley, Reading, Massachusetts.

DUNK, J. & SEBASTIAN RAHTZ 1988. "Strategies for Gravestone Recording". *in* Denley, P., (ed.), *History and Computing 1987*. Manchester University Press.

O'FLAHERTY, B. 1987. "2nd report to the SYASS steering committee", SYASS 9, Department of Archaeology, University of Southampton.

RAHTZ, S. 1987. "The Protestant Cemetery, Rome: a study undertaken under the auspices of the *Unione degli Istituti di Arceologia, Storia e Storia dell'Arte in Rome*", *Opuscula Romana*, 16.

RICHARDS, J. D. 1987. "Archaeologists and the Computer". *in* Rahtz, S., (ed.), *Information Technology for the Humanities*, pp. 159–169. Ellis Horwood, Chichester.

RICHARDS, J. D. & N. S. RYAN 1985. *Data Processing in Archaeology*. Cambridge University Press, Cambridge.

SHENNAN, S. 1987a. "Formal report to the CTI...", SYASS 8, Department of Archaeology, University of Southampton.

SHENNAN, S. 1987b. "The Southampton-York Archaeological Simulation System", SYASS 5, Department of Archaeology, University of Southampton.

STONEBRAKER, M., (ed.) 1987. *The INGRES Papers*. Addison-Wesley, Reading, Massachusetts.

VIAN, P. & ANTONIO IPPOLITO MENNITI, (eds.) forthcoming 1988. *The Protestant Cemetery, Rome: Parte Antica.* Unione Internazionale degli Istituti di Arceologia, Storia e Storia dell'Arte, Rome.