

COMPUTER AND STRATIGRAPHY:  
PROFILE DRAWING FROM PLANS (°)

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Abstract

The Prehistory and Human Paleoecology Research Group, based at Turin University, Italy, is developing a program in computer-aided field procedures. This program parallels closely the excavation principles and field recording methods of the Turin unit. Computer processing of serial "horizontal" input can generate "vertical" information, e.g. stratigraphic profiles, which eventually feed back into digging strategies and control. An interim report on experiments is given.

The problem

Since a few years the PHP Research group based at Turin University is developing a program in excavation techniques. Its aim is to contribute to the evolution of archaeological and para-archaeological field procedures and their underlying principles, which in our opinion lie well behind other areas of archaeology in terms of maturity and effectiveness. Only recently it became possible to include experiments with computer-aided systems in our program at Turin.

Since 1978 we are exploring possibilities in computerizing field procedures and more particularly the excavation techniques. Our central idea is bringing the computer into the field and to the site. Not as much physically, however, for the pleasure to have a console aside, as rather ideally, as an interactive mind with the archaeologist's mind. Basic to this approach is the assumption that computers could cooperate in orienting the strategies of archaeological fieldwork. They should cooperate with the scientists in dealing with substantial, not trivial, aspects and problems of their tasks, such as are faced at the crucial step of excavation and field decisions.

Computers should cooperate in giving timely directions or predictions

for the excavation as well as suggestions for the best way of recording the evidence. But to such a goal they still need to be "trained", so to speak. The user must also invent ways to exploit the specific potential of specifically designed computer systems for field archaeology. Let us phrase this as the problem of getting the best out of "field archaeological" computers right in the field. We think that archaeology has taken only a few and vacillating steps in this direction.

While deciding a priority scale for experiments in computer-aided field procedures, we selected the drawing of profiles as one of the most peculiar tasks in scientific excavation. This is not a problem in itself, of course. But nevertheless it is likely to become a time problem - if not a higher-level problem - in cases of wide or entangled excavation settings. We also considered a characteristic feature of our excavation methods. In our system, we rely heavily on sequential, "horizontal" recording in symbolic graphical form (i.e., dig plans). Dig plans must store all relevant information for deriving both stratigraphic (i. e. "vertical") information and coarse-sediment information.

Coarse-sediment data can then be used for selected interpretive poses, climatic inference for example, as is well known stratigraphic profiles can be used for a number of descriptive or interpretive purposes as well. When excavation is such as to destroy vertical sections as it progresses, automatically deriving profiles from sets of dig plans becomes meaningful and potentially helpful.

### The archaeological context

The in-field computer-aided activities we are developing are closely co-ordinated with the excavation principles and site recording methods of our research unit at Turin. An earlier account of their philosophy was already published (FEDELE 1976); although it emphasises the geoaerchaeological aspects, it also outlines a view of excavation principles. Since the time that report was offered ( and in spite of several delays) our theoretical perspectives have evolved and a few refinements have been tested in a number of site conditions. A summary of the relevant portion of the Turin method follows.

We acknowledge in our approach that the maximum information - not just for traditional archaeology but for behavioral and paleoecological interpretations - must be extracted from the terrain at the dig-

ging stage. Several types of information may be captured exclusively at either the site, excavation or digging point in the process.

Excavation is well known as a most crucial stage in the course of archaeological strategy. Our times are adding new dimensions to this long recognized reality, dimensions brought about characteristically by all sort of pressures from both the world outside and the archaeologists' attitudes inside ( salvage or rescue situations, time and money pressures, data storage and quick publication, then science - new instead of old!). It is in this context that we need our minds and the associated and interacting mind of a computer. Our approach focuses upon formal distinction between two series of units ("cut" units and "sediment" units), the drawing of seriated plans in digging, and a strong emphasis on sediment recording. Sediment recording principles have developed into what the senior author has called "analytical stratigraphy" (FEDELEms.1976).

In the theory of archaeological deposits, two sets of units are to be distinguished. One set comprises the operational units: the basic unit in our system is the cut ( taglio, in Italian), a dissection unit which is defined geometrically. If one thinks of an archaeological or paleoecological deposit as of a structure, simultaneously natural and cultural, a cut is the minimum action of "disassembling" that we are willing to accept as a unit in terms of structural and spatial control. If it is homogeneous in nature, it is better. We normally cut a site according to "natural", not conventional, strata.

Inherent in this definition is flexibility of the concept. The concept must be highly adaptable in the light of practical purposes. Each time, a cut may be the single amount of dissection performed on a quarter of a square meter of a site during removal of an inch-thick layer of sand; may be the digging of half the fill of a small stakehole; or may be a cubic meter of mixed debris from a heap of reworked deposit. Cuts are each recorded onto a sheet ( TAG sheet; fig. I). We use now the "second generation" or "approximation" of our standard recording sheets.

While the cut refers to the contact of excavators with the deposit, the other set of units, the elemental sediment units or ESUs, is linked to the structure of the deposit intrinsically. ESUs approach layers in concept: they only differ for relative "elementalness". ESUs are stratigraphic units. The term has been suggested for the smallest geologically homogeneous entity as perceived in excavation. Excavators of the future will be probably able to perceive smaller units than we do, but this does not change the value of the defini-



tion. An ESU is, in other words, the smallest sedimentary body contained between 2 consecutive recognizable discontinuities; and this is based on a criterion of relative elementalness.

Upon recognition in digging each ESU is given a code and/or a number (for example GDL3; cuts are instead numbered sequentially, site by site). It is formally recorded first on cut sheets, then on appropriate standard sheets for the "geology" of the site. The nature of the sedimentary body and of the interfaces (boundaries or limits) separating units must be determined in order to define an ESU. The coarse fraction of sediments (stones, etc.) must be recorded quite exactly, albeit symbolically; everybody now knows that the orientation of layers and stones is meaningful. Its most meaningful attributes should be identified and recorded, site by site or locus by locus.

What is important to remark here, is that ESU's boundaries and cut boundaries can be non-coincident. In our usual practice, a sediment unit is normally excavated and studied through several cuts, according to horizontal and often also vertical subdivisions.

Once defined geologically and controlled spatially by cuts, ESUs can be filed and arranged into sequences, almost automatically. This is not a problem. We may remark that similar approaches in handling and ordering stratigraphies have been independently developed in England in the past years (Winchester Research Unit; cf. HARRIS 1975, BARKER 1977, ch.10). The use of computers for the particular task of arranging sequences of events - sediment units are taken here as events - has been suggested from time to time (cf. previous editions of the Birmingham Conference).

These are the essentials of "analytical stratigraphy". Its goal is deposit analysis. Its rationale is the desire formally and unambiguously to isolate constituent elements or events, then to put them in order. This approach is obviously amenable to automatic improvements; we are currently providing it with additional details.

Summing up, an excavation may essentially proceed by close spatial control (cuts), routine drawing of symbolic plans, and recognition, analysis on-site, and sampling of sediment units or layers. The emphasis on sediment recording and evaluation is well expressed by the recording system as a whole. Formal mapping of space relationships is a basic device for data storage which is applied to both sedimentary and non-sedimentary (biogenic, including cultural) en-

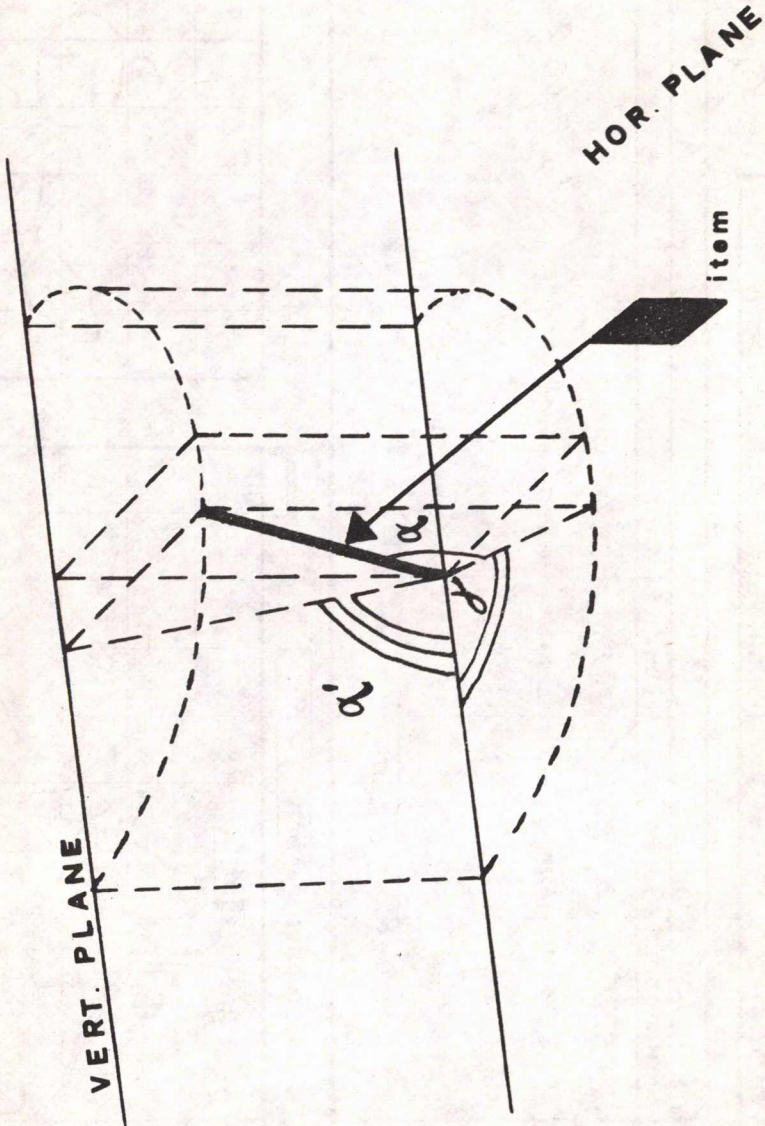


Fig. 4

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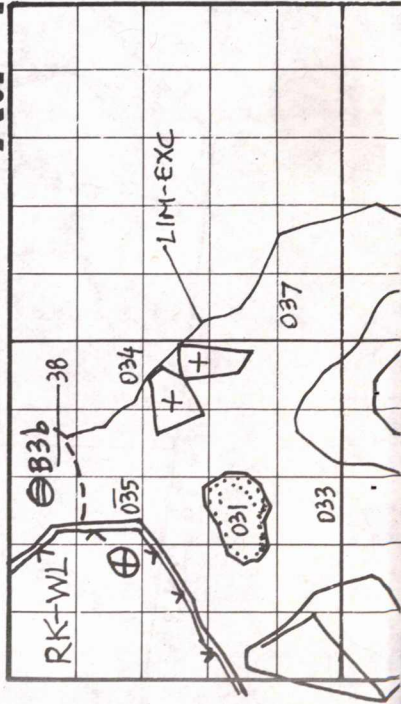
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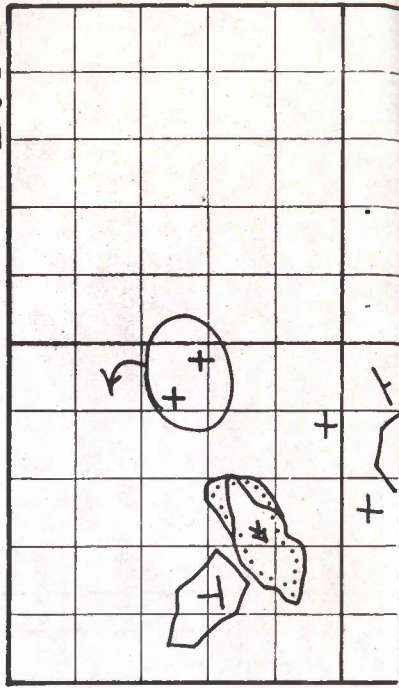
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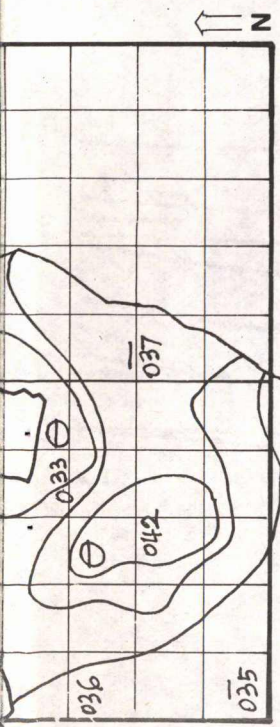
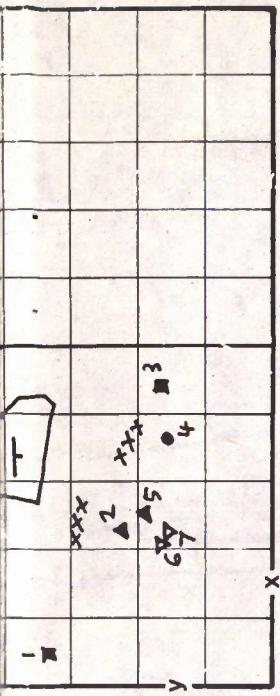
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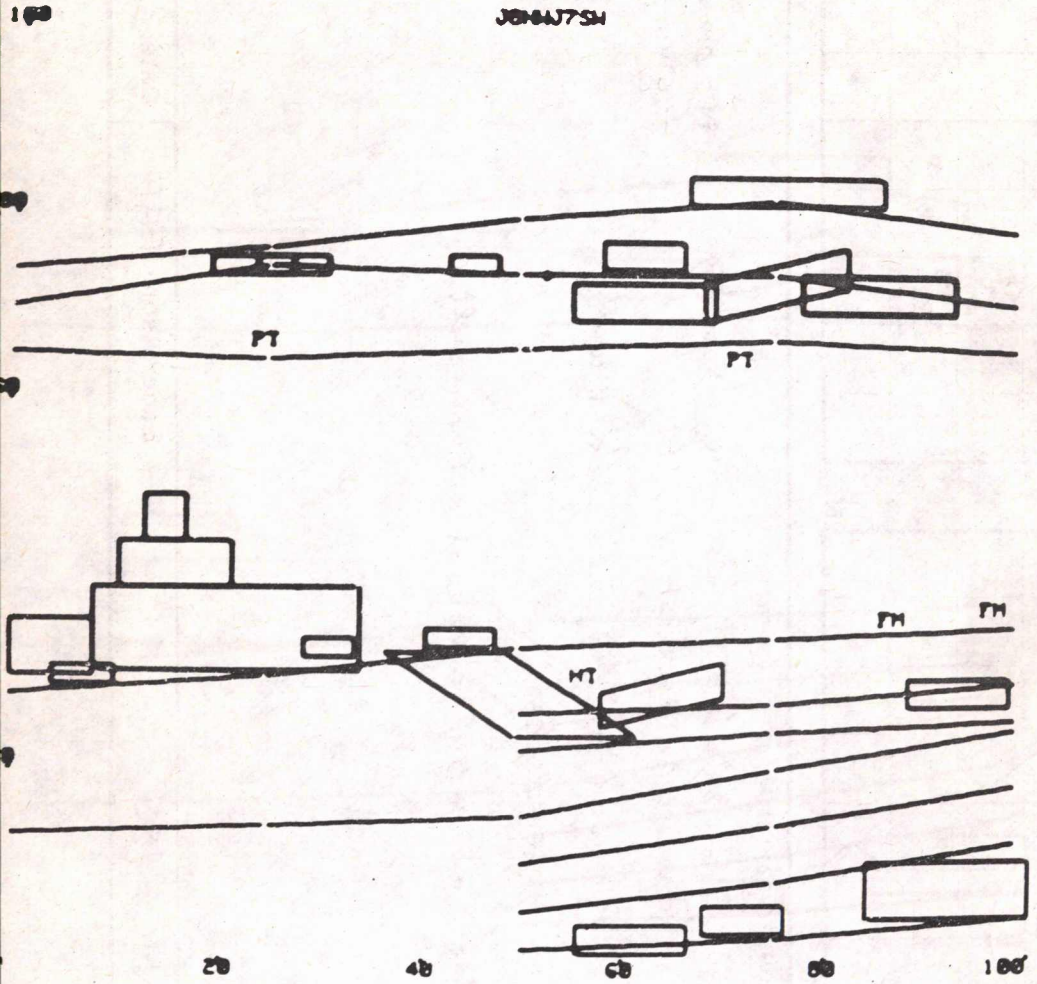


Fig. 5



titles.

Attention for the cultural items in the overall inventory of the bodies from a site, we maintain, cannot be the prime task of the archaeologist while he acts as an excavator. The excavator's task for which he is wholly responsible is "disassembling" and sampling the site correctly. Any item in it has the same relevance from this "site" view of things, either it is cultural or noncultural.

#### From horizontal to vertical information

The "cut plans" in our system are primarily intended for the record of the changing "micro-landscape" and the sedimentary "contents" of the terrain which is dug. Rules for plotting and drawing have to be defined, site by site; they may also vary from place to place at a single site. Cut plans regularly include stones greater than a stated size, surface contour lines and other micro-morphologic traits, natural and artificial features. All the spatial attributes and relationships of these components are expressed by means of a suitable notation, which includes inter alia strike and dip values and morphoscopic types of the stones.

As already mentioned, the relevance of the structural variables of the deposit as potential raw data for sedimento-climatic, taphonomic and paleo-behavioural inferences, has been repeatedly demonstrated. Impressive improvements ( and hopefully automatization) must be expected in these still comparatively rough techniques of field archaeology.

Now, detailed sections of deposits may be drawn from seriated cut plans. Since cuts are correlated in excavation with layers or sediment units, such sections can be translated into detailed stratigraphic profiles. When real sections can be reproduced on paper, they may provide useful checks for the profiles obtained from seriated plans: they might, for instance, point out the main sediment layers. We doubt that drawings from visible sections can ever match those from seriated plans in fineness.

All the information stored in the cut plans and the cut sheets can be used for a variety of purposes in the laboratory. We have approached so far the problem of profiles. From a general standpoint, computer processing of serial horizontal input can generate vertical information; stratigraphic profiles are only a technical rendering of this

information.

If, according to the current standards and the economy of site operations, the hand-made generation of cut plans in excavation is reliable and fast, then the possibility of getting profiles made automatically and almost simultaneously looks like an acceptable improvement of procedures. If it can become an in-field operation, we anticipate that this special kind of computer-aided deposit analysis is of potential help in deciding directions for the excavation itself (cf. FEDELE 1976, fig.4). This is only the first step.

Having a knowledge and a "choice" of stratigraphic profiles while the excavation goes on, is of course susceptible of feeding back into digging strategies and control (I). This is especially true in those cases when "balk" excavation is not allowed.

#### The computer program

Profile drawing from plans with the aid of a computer entails acceptable compromise between the excavator's constraints, tempered by his plasticity and power of decision, and the computer's work, with its effectiveness of processing. Routine procedure is in four steps:

1. in-field recording onto "cut" and "item inventory" sheets
2. in-field coding onto computer 80-column cards
3. punching of cards or transferring onto magnetic tape
4. computer run

1. Each cut sheet includes two cut plans, A and B, usually scaled 1:10. Plan A represents the "top" of the cut, i.e. the upper boundary surface of the unit to be taken off. Plan B is called the "contents" of the cut, i.e. the items taken off with the cut and the observations made in the course of cutting. "Items" comprise sediment elements (stones etc.), biogenic elements (artifacts and "ecofacts", in Binford's, 1964, terms), and features.

2. Coding is the operation by which the computer input is generated. The input comprises the reading of cut plans in sequence as they are intercepted by the specified profile. Reading is by hand; automatic reading could substitute hand reading when the computer is suitably interfaced for visual input (with a light-pen or the like). "Reading for profile" has two aspects:

2.1 reading of cut boundary values; values are converted into rectangular co-ordinates read at reference and optional points along the profile line (see fig. 2 for the list of entries)

2.2. reading of items and optional checking with the item inventory (see fig. 3 for the list of entries).

Stones and "polygonal" items are coded according to their width, height, strike and dip. But strike and dip values, as orientation attributes, must be corrected for their projection effect onto the plane of the profile. The geometric basis for the "projection" correction of such elements is shown in fig. 4. Spherical objects are defined as no-strike, no-dip items.

3-4. These are obvious stages in the routine.

The "Profile" Program has been implemented at the Turin University Mathematics Department by means of a DIGITAL PDP II/40 Computer. This computer has a memory capacity of 256 K bytes. It is connected with a VR I7 DISPLAY monitor controlled by a VT II GRAPHIC DISPLAY processor, interfaced with the FORTRAN language of the system through an ASSEMBLER (DYFUNC) routine. VR I7 DISPLAY MONITOR can be used in connection with a light-pen to interact in various ways with the video image.

A square grid is first traced on the tube display screen and a scale factor is given to the computer. The scale has been chosen as to allow real areas 1 square cm wide in excavation to be perceived on the screen (= 10 by 10 video-points).

The set of cards representing the cut boundaries is fed into the computer first. Then the set of cards representing the items on the section (finds, stones, features) is fed into the computer. The computer discriminates stones from biogenic items and features. Stones are automatically displayed in their spatial projection onto the profile, albeit diagrammatically (they are approximated by quadrangular figures; morphoscopical improvements are being tested, according for instance to a "shape menu" approach; cf. MAIN et al. 1977). Features are outlined on the screen as cut boundaries are, while biogenic elements are plotted as point-like symbols (Fig.5).

From step 2 to step 4, a matrix/profile amounting to a hundred cards in coded form requires some 30 to 45 minutes for coding and 40 to 60 minutes for punching. A single run for screen display requires 3



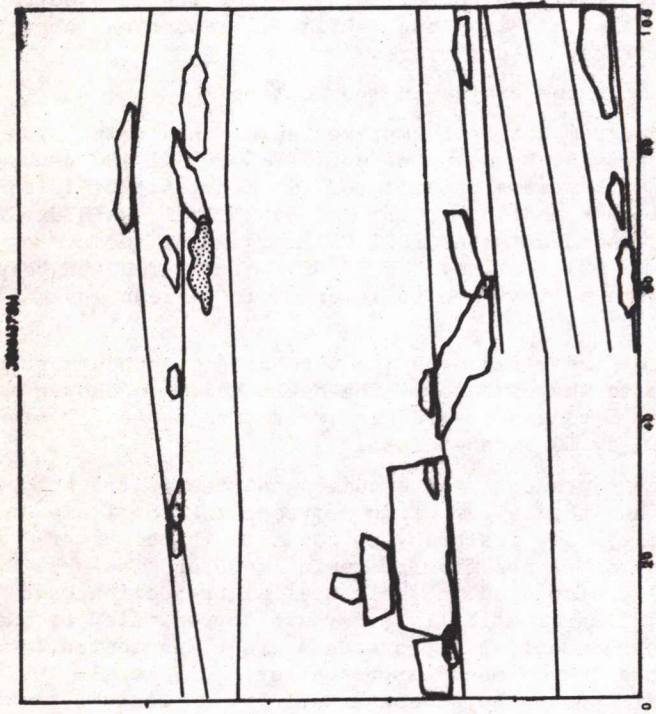


Fig. 6

minutes. The screen is eventually photographed, unless the computer is fully interfaced with a plotter so that profiles are printed out on paper directly.

Output profiles can then be used as they come out of the screen, or can be redrawn for more realistic rendering (Fig.6).

### Do computers have an "archaeological" soul?

Computers have been very widely used in archaeology as a serviceable tool to speed up data analysis or the sheer handling of data ("data reduction" etc.). They have not been used so much as fully interactive participants in field operations. They have become instrumental in detecting patterns of relationships in various sorts of data, but this function is again superimposed on the data, not effective when the data are generated.

Even in the uncommon instances of their having been taken into the field, it seems to us that they have been treated as just desk machines. (The beginning era of microcomputers could now improve the presence of computers in the field). Computers have been essentially asked to behave as archivists, accountants, or quick statisticians. That means underexploitation; computers may perhaps feel a little frustrated, they should come of age and become "archaeologists"!

If they are to be used at all, computers may well have an archaeological "soul". By enhancing it archaeologists might advance significantly the state of their art. Computers should be "educated" to work in the field as well as archaeologists should accept and become accustomed to their new partners on-site. Specificities of archaeological reasoning and scientific excavation, and specificities of computers, should be brought to merge so as to explore new areas and/or higher levels of efficiency in fieldwork.

Once we realize, sad as it is, that excavation tools have hardly progressed beyond the 19th century stage, we cannot help considering that innovation has to be sought for. Computers should also become of service in the latter context. But experiments are needed.

Computers must be increasingly thought of as a component in the ove-

call "excavation system", the system of excavation operations (FEDELE 1976): a component which interacts with the others, and by interacting modifies and can be modified.

Conventional excavation techniques must evolve and, in the writers' opinion, computers as "archaeological minds" must evolve with them. Otherwise scientists in this field will not cope with their job effectively, in face of the increasing pressures on the scientific management of their data-bases. We hope that the plea we are making is not unsubstantiated, although the experiment we have reported is a minuscule step.

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#### Notes

(1) As to feed-back circuits in excavation strategies, may we mention that we experience the same kind of effect when we get routine grain-size analyses of sediment units at the site - by cascade sieving of the debris - and this information turns out to be useful in distinguishing and correlating the sediment units we are digging. Cf. FEDELE 1976, 1976b.



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