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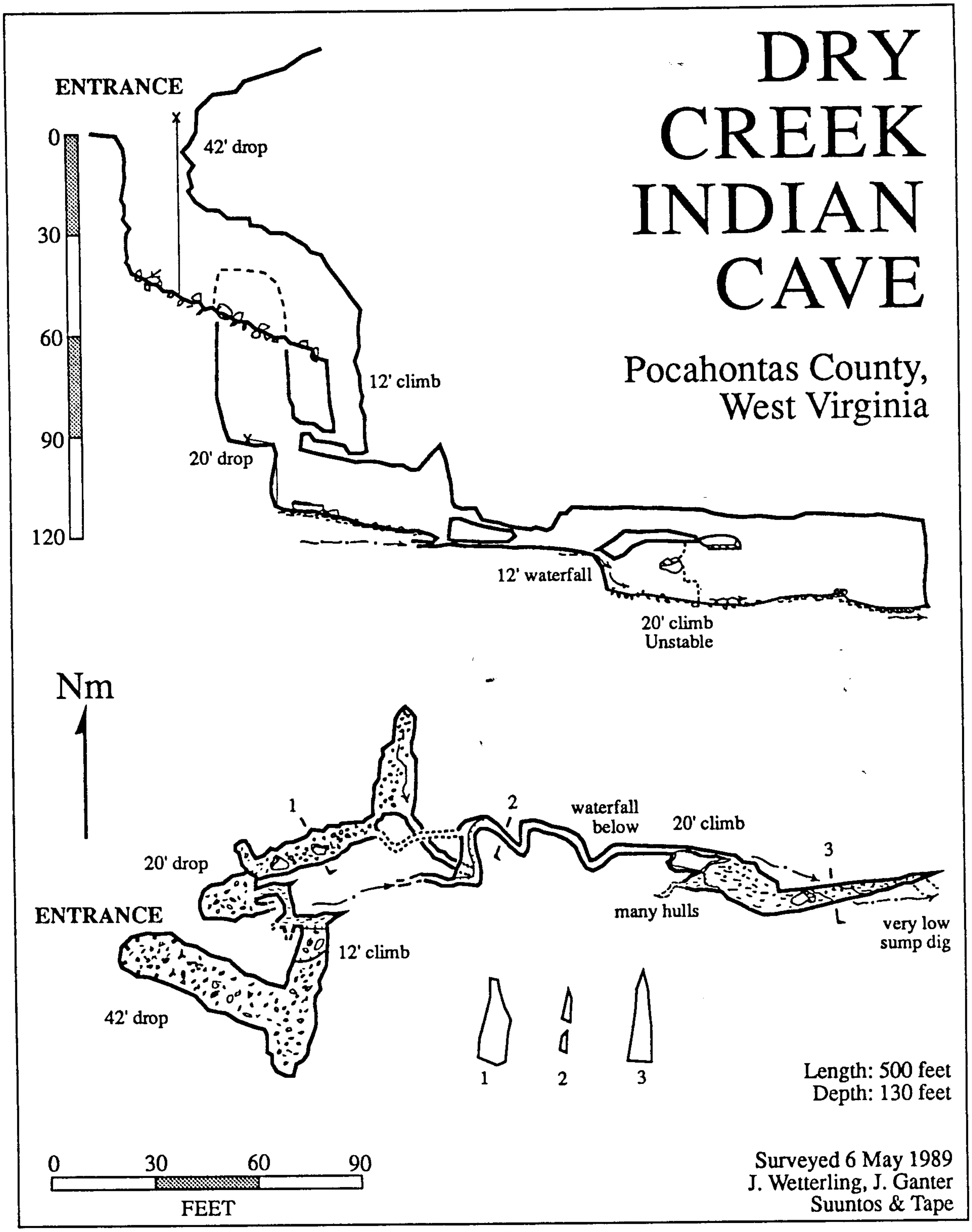

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Survey and Cartography Section - 1988/1989

Chair:	John Ganter	Rd. 6 Box 338 Bedford, PA 15522	814-356-3553
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CAD For Cave Mapping: A Cautious Assessment

by John Ganter

Abstract

It has been suggested that CAD packages may reduce the burdens of cave map drafting. I constructed some simulated caves and performed timing tests to investigate the suitability of CAD for cave map compilation and drafting. I discovered dramatic increases in processing time as the maps increased in complexity. While vector (line drawing) approaches have inherent limitations for present cave maps, some methods of breaking down large cave maps into parts (tiling, Blocks) may apply. It appears that CAD cave mapping is only practical with very fast microcomputers, and that a number of conceptual and practical problems remain. In particular the issue tends to highlight the distinctions between sophisticated tools and skilled tool users.

1. Introduction

Computers have changed cave mapping, like they have changed everything else, by taking on tasks which are boring, repetitive and uninteresting. The person is left with more time to think, judge and ask questions. Recent increases in detail and care put into cave maps can be attributed, in part, to mappers being able to avoid the tedious hours of manual survey reduction common in earlier days.

Besides number crunching, computers have more recently been turned to use on visual and spatial problems; it has been said that the 1960s were the era of computer numbers, the 1970s the era of computer words and the 1980s the era of computer graphics [1]. Computer graphics are valuable mostly for time savings so great that they make new things possible, e.g. displays of exceedingly complex data from numerical simulations. They also reduce simple drudgery. Computer-Aided Design (CAD) is ideally suited to the sort of trial-and-error design involved in solving physical problems with new mechanical devices. The designer of a driveshaft, for example, can access a library of all the needed standard parts. Shafting, joints, bearings, etc. are quickly available on the screen, along with their complete specifications (diameters, material, cost, etc.) The designers using CAD can think, judge, and change their mind with a tractable virtual medium. What if the shaft ends are out of alignment by 1-37/64 inches? Done in seconds. How does that effect the shaft angle? The answer appears. The modern CAD package is carefully designed to facilitate these types of interactions.

Because the CAD package is available, and it handles spatial information in what is (at least superficially) a visual format, it has been used for cave mapping. This will probably turn out to be a good thing, although we may have to shift our emphasis to see that CAD is not the only way to map things with the aid of computers. At present, however, there are two problems.

First, CAD is not well suited to the geometric irregularity of caves, and the extensive uses of texture and detail that "advanced" cave mappers use. CAD is suited to geometric regularity, a form of complexity where many shapes are defined by a few and/or repeated commands [2]. CAD is discrete and digital; present cave maps are continuous and analog. This problem is an interesting reflection and extension of the art-or-science issue in cave mapping. I will not consider this issue explicitly, although it will figure in my suggestions that graphic skill in making maps is more necessary than ever when computers are the medium.

Second, there are serious practical limitations to what CAD can do. Questions remain about how to segment large cave systems, the effects of adjusting loops or adding passages after drafting has been done, etc. Furthermore, performance declines dramatically as the map becomes more complex; CAD is pretty much unusable on anything less than a fast PC based on a 80286 processor.

2. Distinguishing Skill and Needs from Tools

A couple of years ago, a caver who had been developing software for plotting cave surveys made an interesting remark at the NSS Convention. He suggested that there should be a separate class in the Cartographic Salon for maps drafted by computer-aided means. While this might have some merit for encouraging improvement, I think it is symptomatic of a view where the human fits the machine, instead of vice versa. My response is that our visual system, our skill at drawing and drafting, and our means of communicating have been evolving for tens of thousands of years. Our goal has always been to use skill to go far beyond the limits of any particular medium (e.g. cave walls, bark, paper, polyester drafting film, etc.) Why change the rules? Computer-aided methods must match analog (manual) methods before they can go beyond.

People started to draw on cave walls, then moved to parchment and paper. Quality shines through; mediocrity looks worse and worse. Maps are made and valued for their utility. In use the map becomes transparent. Through it the user sees relationships among things. Design (solving a visual problem with thought) and skill (getting it down on the medium) have evolved, but the technology was always analog until very recently. We should separate design and skill from tools, recognizing that beauty or a mess can each be produced with either low or high technology (**Figure 1**). In this figure, technology crosses from analog to digital at the center of the diagram; we have passed from tube pens ("Rapidographs") to the first computer drawing program (Sketchpad) and on to more sophisticated packages. Skill varies from Unskilled to Skilled with no particular division.

We have not written off the artists of Lascaux, or Leonardo because they didn't have drafting film. The drawings and sketches in *Scientific American* can be used as classic examples of clarity and beauty

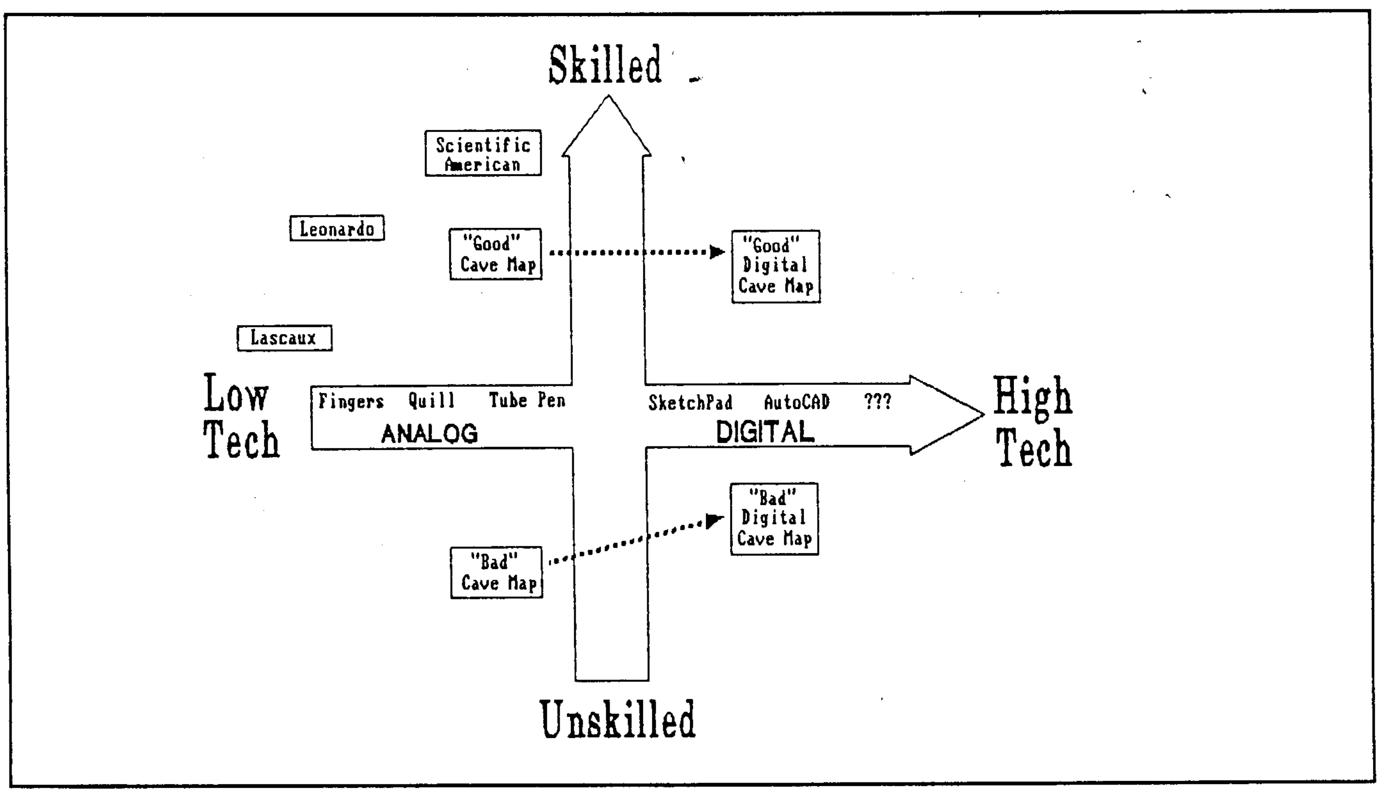


Figure 1 Skill and Technology shown as orthogonal variables. The boxes are some suggested plottings for drawings and cave maps.

produced only with pen and airbrush. Will this skill be improved by the use of digital media? Maybe. But at present, this media may only provide speed and tractability. Someone said, "A word processor does not a writer make," and the same applies to the visual era of computer use.

Closer to home the question is whether we can go from "amateur" or "bad" cave maps to those on par with analog maps. Or will we simply make bad maps that happen to be in a digital medium? I guess the question comes down to this: Can you give an expert cave cartographer a CAD package and have them produce maps of pen-and-ink quality? My answer is: Not yet. A "bad" cave map may get a little better in digital form, simply because the mechanics (line quality, etc.) are more uniform. This same uniformity or stiffness hampers the skilled mapper, and their product will tend to decline in a digital medium. There are three reasons.

2.1 Picture Limitations

Good cave cartographers use skill to make maps which are, at present, highly detailed. A great deal of cave mapping involves areal symbols (sand, clay, gravel, water), not the points and lines of CAD. In this discussion, we have to take this requirement for detail as a given, something that has evolved to meet our needs and desires [3]. CAD does not lend itself to producing the same textures used by a good analog cartographer. The difficulty or awkwardness in controlling visual variables like typographic style and line weight in a CAD package is is part of this problem. The human-machine interface is not optimal for freehand sketching, particularly of detail.

2.2 Machine Limitations

As cave maps grow, they rapidly acquire large numbers of features which must be stored and manipulated within the microcomputer. The capability for processing this information is limited, and it appears that maps of moderate size or complexity can only be processed by 286 and 386 class machines having math co-processors [4]. Jim Nepstad points out that he does not mind waiting 23 seconds for the line plot (about 11800 survey stations) of Wind Cave to appear on his CAD system [5]. But a line plot is by no means a map. Drawing a map is an interactive, look-do-look operation. Waiting for the system to update and display the map quickly erodes productivity and leads to a great deal of frustration (**Figure 2**) [6].

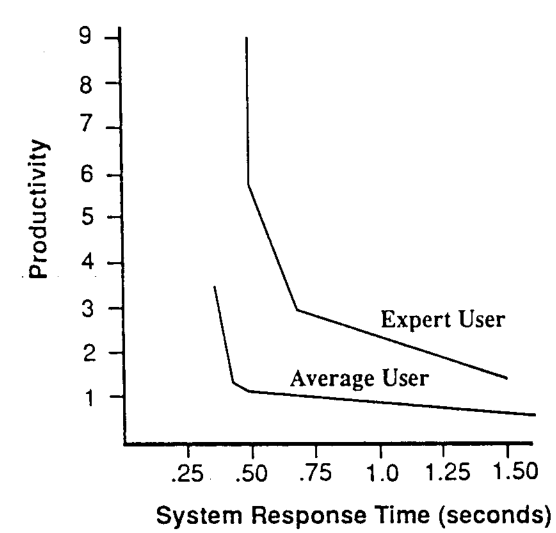


Figure 2 System Response Time vs. Productivity.

2.3 Practical Limitations

It is unobvious how cave networks, once drafted, can be transformed if passages are added or loops adjusted. Many hours of work will be lost unless passage details, etc. move with parts of the map.

2.4 Effects of the Limitations

Let's examine the varying effects of these limitations. A small cave or a simple map (or both) do not tend to run up against limitations. Machine limitations appear in the form of the tolerable response time. In order to keep this response time bearable, you can make small complex maps or larger simple maps but not both. This tradeoff can be visualized as a triangle, which grows larger with faster machines (**Figure 3**).

The Picture Limitations present an interesting issue. We really have never decided what we want cave maps to be. Do we want realism (a lot of detail) or abstraction (simple relationships with minimal detail)? Jim Nepstad [7] demonstrates abstract, stylized maps with AutoCAD, since the purpose of mapping Wind Cave is for "Resource Management." It is therefore not surprising that he also mentions the AutoCAD facility for Attributes; "tags" which can contain text information linked to specific locations. One sees that for this purpose the map can be highly stylized. For these users, it might even be enough to construct a schematic showing only basic relations like approximate direction and connectivity (like a subway or other transportation map).

To others this is oversimplification. To many cave mappers the details are a big part of the message. To the scientist who is interested in speleogenesis, they may be vital clues. I am interested in cave maps because I am an amateur geologist. I sketch, and later draw, joints, bedding planes, faults, details. To me, Nepstad's "Main Passage, Highland Creek Cave" (cover of *Compass & Tape* 6:2, Fall 1988) says little. What I want to see underneath the map is form. What I want to see underneath form is process. Why is the cave there? Why does it look the way it does? All I see here are AutoCAD curves. But as a record of exploration or a road map, it is fine.

Turning back one issue to the Summer 1988 *Compass & Tape* cover, we see an illustration of other needs. Here is a moderately-detailed map of a fairly complex cave. It is part of the long-term Organ Cave project, which included broad geological and hydrogeological studies [8]. Because the work spanned over 20 years, and had to be accomplished by cavers of varying talents, extreme detail was completely impractical. It appears that a map like this is a candidate for CAD drafting. The Practical and Machine

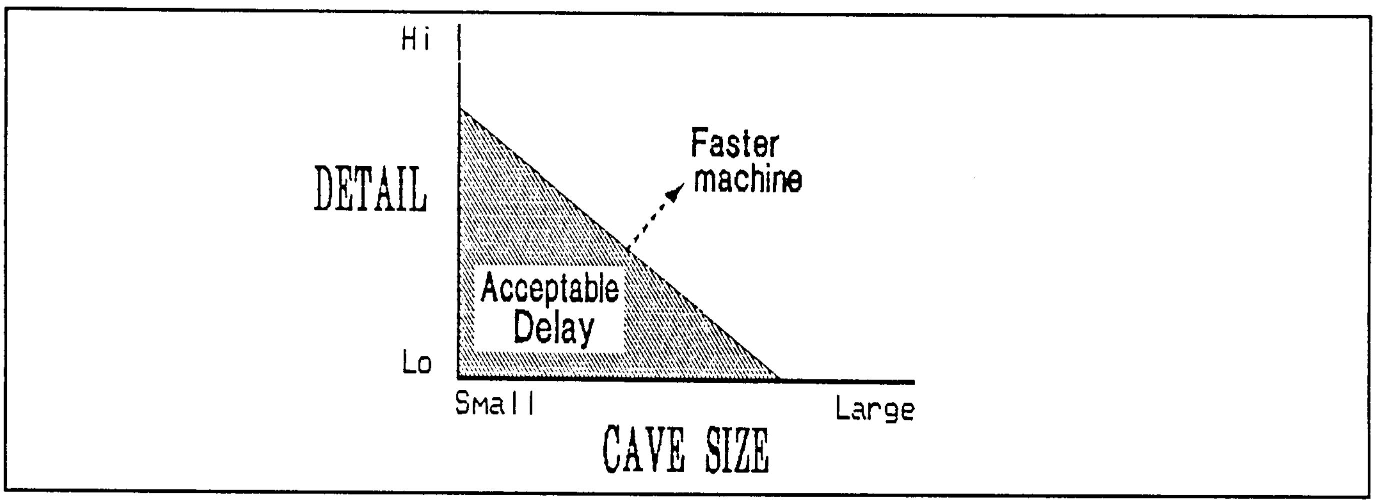


Figure 3. Region of acceptable response time between amount of detail and cave size

Limitations remain.

3. Data Models: The Vector and Raster Approaches

Before proceeding into the testing, it's useful to draw back and see where CAD approaches fit into computer technology. If you look at a picture on a computer screen, you can be fairly sure that underlying it are numbers, and the numbers are arranged in either a raster or vector scheme. These are sometimes termed data models; there are two types. A raster is a regular grid of pixels which can be in either on (1) or off (0) state. (Things get more complicated for colors or levels of grey, but we'll stick to monochrome.) A vector is a line with a beginning and an end point described by coordinate pairs (**Figure 4**).

Looking further into the machine, we see that underneath the data model is a data structure which makes it work. For the raster, this is an array of 1s and 0s; for the vector, a couple of lines of numbers specifying the line width (and usually some more information) and the starting and ending coordinates. Notice that the raster is described by integers, while the vector has decimal places for greater precision and storage requirements.

Going another level deeper, we see a file structure. Here the data structure is collapsed into compact form by setting up an implicit ordering. The raster may be abbreviated to a starting row and column "address," then a third number specifying the length of "run" for the line. Encountering this example, the program would move to row 6, column 2, then make a line for 10 moves to the right. While the vector can also be abbreviated, we can see that the raster has an inherent advantage since it has an ordering of rows and columns; it has implicit structure.

We have used a simple line as an example, but everything extends to the more complex pictures that one sees on the screen. The costs and benefits apply here as well. A raster picture in a "Paint" package is not an object; it is just a bunch of pixels. If you accidentally erase some, they can't be recovered unless you draw them again (unless of course the whole screen is saved). Contrast this with a vector approach in a CAD package where everything is stored as an object described by a series of coordinates. If you want to change some part of the object (size, etc.) this is easily done. Basically, Paint and CAD packages have opposite approaches to drawing things. Paint assumes that most of the space will be filled with intricate detail, and that operations on individual objects will be limited. CAD assumes that most space will be empty, and that movement and manipulations of objects will be required. The problem with cave maps is that they use space in both ways. We will return to this idea after seeing how CAD fares in some timing tests.

4. A Line Expressed

AutoCAD is a $3000 mechanical engineer's dream. It does things that are very nice for someone designing machines, like automatically drawing dimension lines, reproducing objects in patterns (Arrays), storing things to be used repeatedly (e.g. fasteners), etc. It has a fairly clumsy "command line" interface; you tell it how to do things in words. The first thing that I did with my borrowed copy was to start drawing cave walls, using my mouse as a device to translate movements of my hand for the machine.

4.1 Ways to Make Lines

I found three ways to make lines. The first is called a Trace. One specifies the Trace width, then starts laying them down. Each is a one segment line; they do not connect. You can build up a few hundred of them into what looks like a line (**Figure 5**), but there is no coherence. A Trace is like laying carabiners down end to end in a line.

A polyline or Pline is different. It is assumed to be one coherent line made up of many segments between points. It can be moved as one whole thing, and all the pieces move with it. One point can be

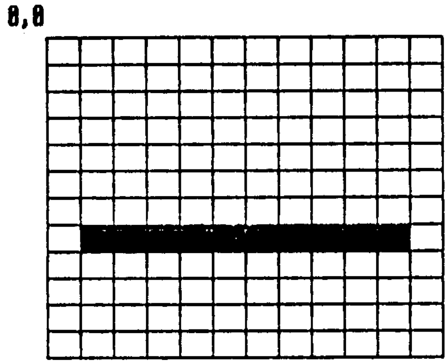
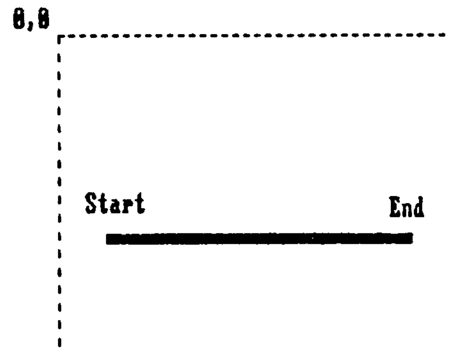
	RASTER	VECTOR
Data Model		
Data Structure	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	.03 — Line Width 1.00 2.37 — Start Point 6.79 2.37 — End Point Y coords X coords
File Structure	6,2,10 Starting Row Starting Column Run Length	.03,1.00,2.37,6.79,2.37
Structure	Implicit	Explicit
Objects	None	Everything is an object
Assumes	Space is mostly full	Space is mostly empty
Application	Paint Packages	CAD Packages

Figure 4 A Comparison of Raster and Vector Approaches

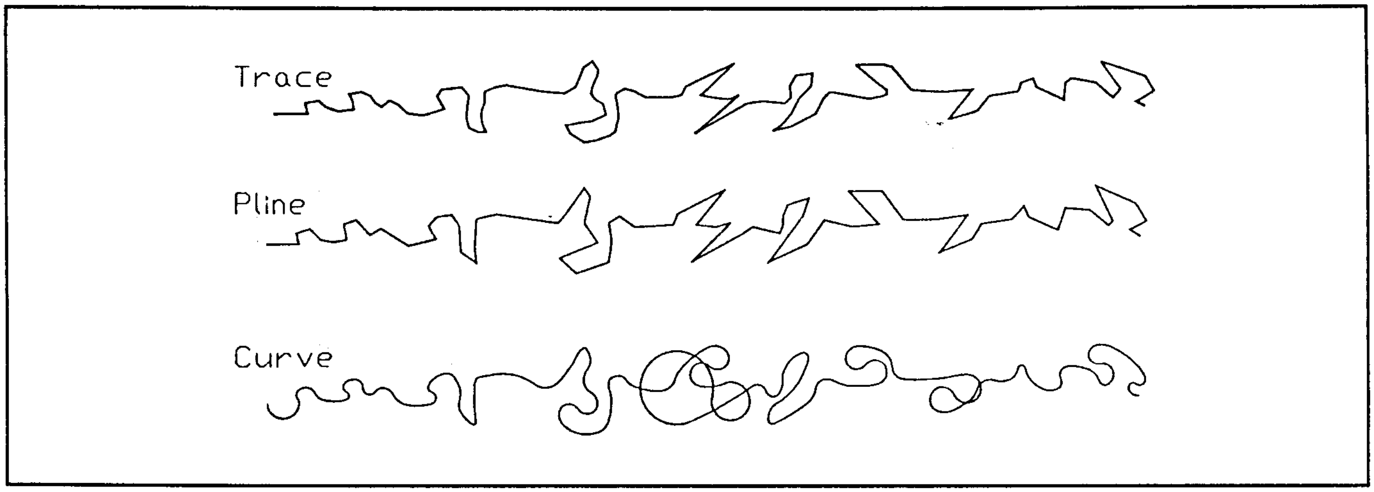


Figure 5 AutoCAD Trace, Pline and Curve

moved and the others stay connected. A Pline is like a chain of connected carabiners.

A Curve is a new line created by fitting a mathematical function to the points in a Pline. AutoCAD programmers did not plan for cave walls. When I tried the Curve command on my cave wall, it had an accident.

4.2 Lines Examined and Timed

For each of the lines I checked the number of entities that were present. An entity is one "thing" stored in the CAD data structure (Section 3). The number of entities stored in the drawing can easily be checked with the Status command. Apparently the Trace is a little more efficient in terms of how much needs to be stored, although there is some difference between the lines that I drew (**Table 1**). The Curve contained the least number of entities. This is because the Curve function changes the Pline, but as noted above it does not do well with one this complex.

Another characteristic of the test lines is the number of vectors which it takes to draw them on a printer. Here the term is used more specifically than in Section 3; it is a line drawn by the printer. I measured these by using the AutoCAD printer-plot function and noting the number of vectors processed when writing a file for my Epson printer [9].

When AutoCAD draws the database out on the screen, it is called Regeneration. It took AutoCAD a relatively long time to regenerate these lines: from about 3 seconds to almost one minute (**Table 1**). Since

Table 1 Data from the Line Tests

Line Test	Entities	Epson Vectors	Seconds to Regenerate
Trace	128	1552	3.2
Pline	78	1088	12.4
Curve	53	496	57

regeneration occurs automatically whenever the scale of the drawing is changed or it is moved (panned) horizontally or vertically on the screen, it needs to take place quickly. While it is occurring you sit and wait. This is not too much of a problem if you are simply looking at the cave traverse, but drawing a map is another matter entirely.

So just from the line tests it was obvious that there were serious limitations to using my "AT" class PC (an 80286 machine with 1024K of memory and running with a clock speed of 8 megahertz) for AutoCAD. I began to wonder if an even faster machine with a math co-processor (a special chip which handles mathematical operations) could handle the kinds of maps that I draw. Rather than expending a lot of work on a map, and then finding that the system was unworkable, I decided to simulate increasingly extensive and detailed maps and test AutoCAD's performance.

5. Partitioning a Cave System: The Idea

Cave maps and other drawings are usually divided into Layers: AutoCAD's digital equivalent to transparent flaps which are registered over the map. These can be turned "on" and "off" as needed. The layers are usually assigned different themes: one will show the survey traverse, others the walls, the labels, etc. It was obvious to me that layers are useful, but far from sufficient for breaking up a large cave map into workable pieces. Layers divide vertically, but it is also necessary to divide horizontally.

An idea for how this could be done came from my experience using AutoCAD Blocks. I had designed some piezoelectric ignitors which were held together with rivets. Since rivets are all the same, I drew one

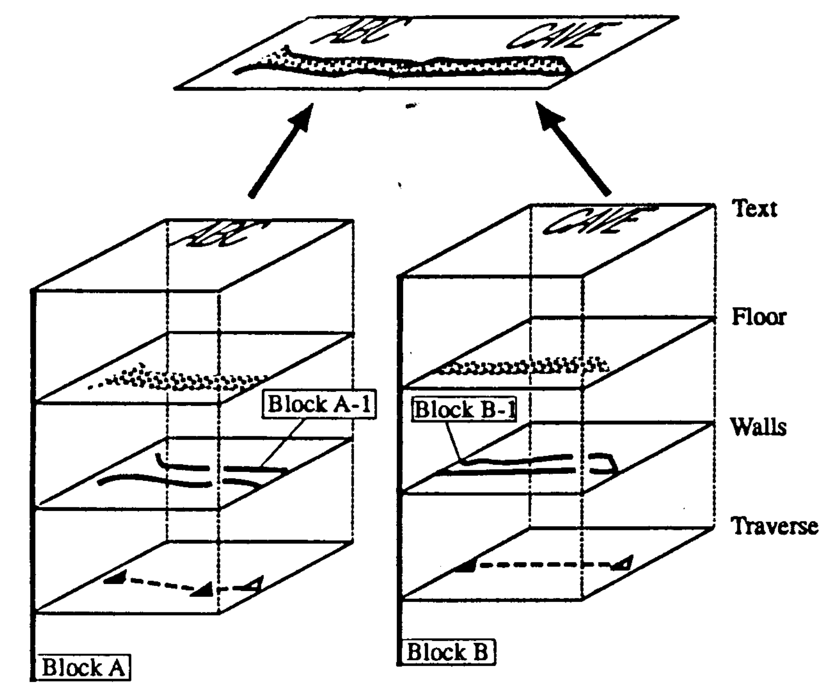


Figure 6 Tiling the area of a cave with AutoCAD Blocks. Block A and Block B, each of which have 4 Layers, fit together to map the whole of the cave. Within each of these are two smaller Blocks (A-1 and B-1) which are segments of cave passage.

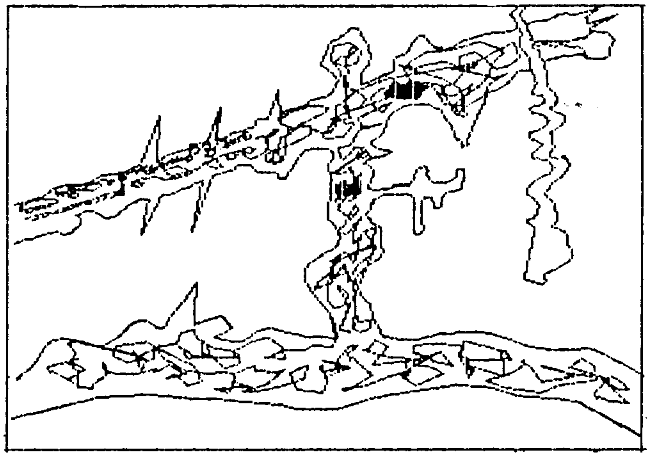


Figure 7 CAVE3-F, a simulation constructed of Traces that has 2223 entities

and saved it as a Block. Then I could summon this Block, scale and re-orient it, and insert it whereever I needed a rivet. Blocks can be made up of many smaller Blocks as well.

So I figured that the area in which a cave lies could be "tiled" with Blocks in a regular grid pattern -- unlike my rivets these blocks would all be different of course. The boundaries for each tile would be specified by coordinates; whenever a passage was within those coordinates, it would be on that particular tile. All the tiles would have common Layers for Text, Floor Detail, Walls and the Survey Traverse (**Figure 6**). To minimize regeneration delays, only one tile would be worked on (drafted) at a time. The tiles would only be put together into a composite for display and plotting (**Figure 6, top**).

And the passages lying within each tile themselves would be Blocks (**Figure 6, Block A-1 and B-1**), so that they could be changed if necessary (e.g. if other passages were found, or a survey traverse was closed).

6. Partitioning Tested

6.1 Building Simulated Cave Maps

With this idea in mind, I set out to build a simulation. Since I often draw at 25 feet per inch, and my display measures 7.5 inches wide and 5 inches high, I decided to make each tile measure 175 feet by 125 feet. I then drew a "cave" with lots of joints, squiggly walls, etc. using Traces only. I called this CAVE3 and with floor detail it contains 2223 entities (**Figure 7**). **Figure 8** shows the detail and a bar scale.

Next I used CAVE3 as a tile to make a 2 by 3 tile cave system called CAVSYS. Normally of course all the tiles would be different, but I didn't feel like drawing 5 more to match CAVE3 (**Figure 9**).

In order to get some idea of how this all might relate to real surveys, I used Jim Nepstad's SMAPCAD program [10] to convert a large SMAPS cave survey database over to an AutoCAD line plot. The survey (SELMEH) consists of 5 caves and 496 stations. Keep in mind that it is a line plot only.

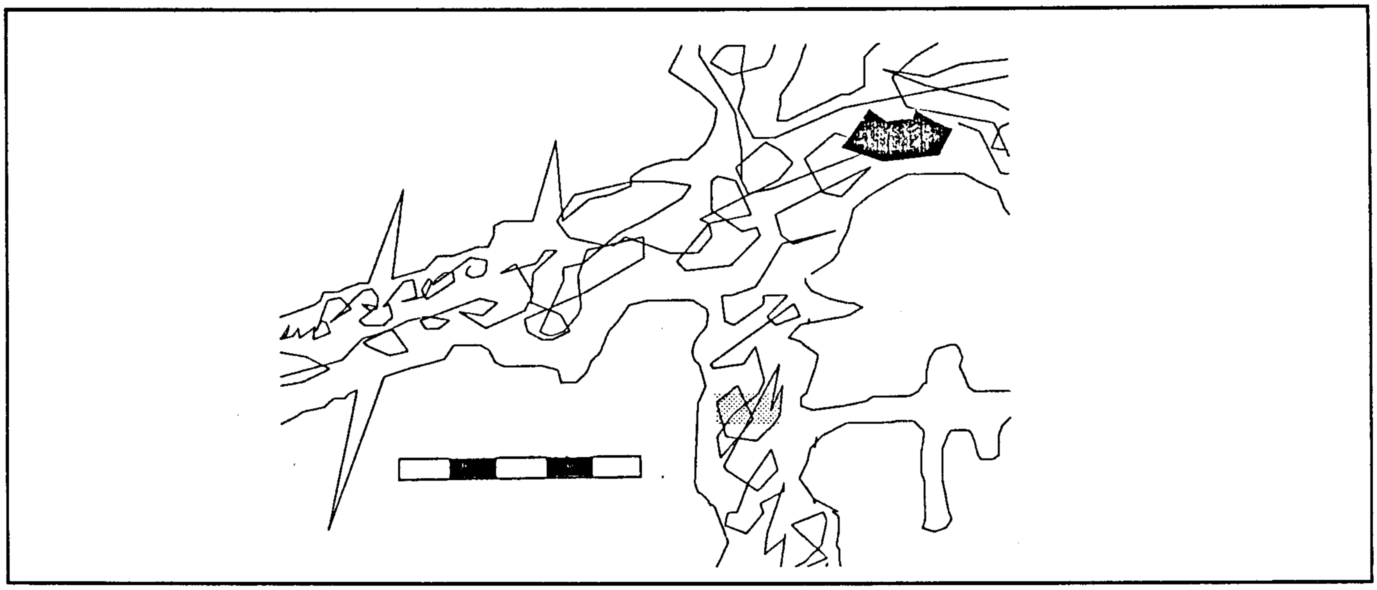


Figure 8 Zoomed portion of CAVE3-F showing floor detail and 25 foot bar scale

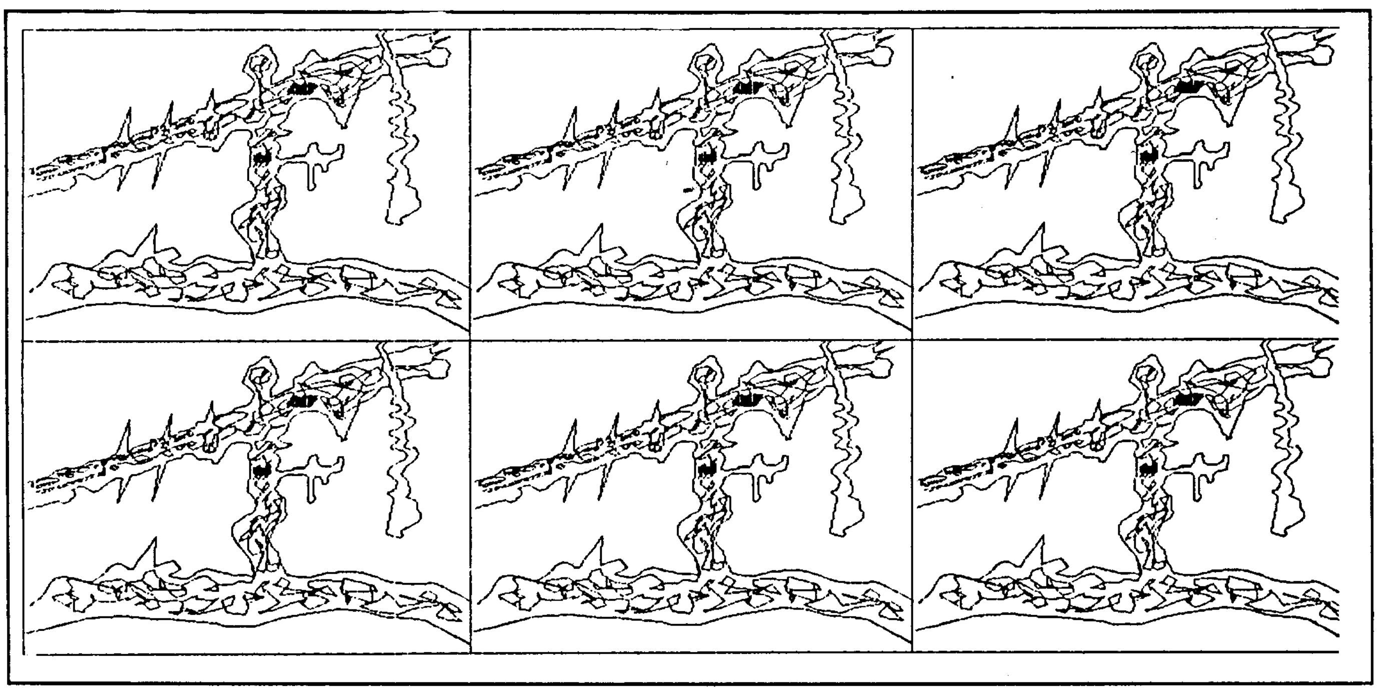


Figure 9 CAVSYS-F with floor detail on

6.2 Test Results on a 286-8 PC

CAVSYS was a simulated area measuring 250 by 525 feet, containing what looked to be a few hundred feet of fairly detailed cave map. It comprised 13796 entities and my 286-8 PC-AT was dying (**Table 2**). A regeneration required nearly 5 minutes of disk and RAM thrashing. Clearly I was not going to be doing a whole lot of cave mapping on my PC-AT.

Table 2 Data from the Line Tests and Cave Map Simulations

Line Test	Entities	Epson Vectors	Regen on 286-8	Regen on 386-16
Trace	128	1552	3.2	1.2
Pline	78	1088	12.4	0.4
Curve	53	496	57	1.6
CAVE3	2223	6592	27	5
CAVE3-F	2223	15312	56	9
Selmeh	1546	2600	62	9
CAVSYS	13976	37616	156	34

6.3 Test Results on a 386-16 PC

I then moved the whole business (lines and simulated caves) to the Deasy GeoGraphics Lab at the Penn State Geography Department. There I used a much faster machine, an IBM Model 80 with 2 megs of RAM, running at 16 megahertz with 1 Wait State and a math coprocessor. This machine has a 386 rather than a 286 processor. I also used AutoCAD version 9. Performance improved dramatically, particularly in math-intensive lines like the Pline and Curve. The result was that regeneration times became much more reasonable, although CAVSYS with floor detail turned on still required nearly one minute (**Figure 10**).

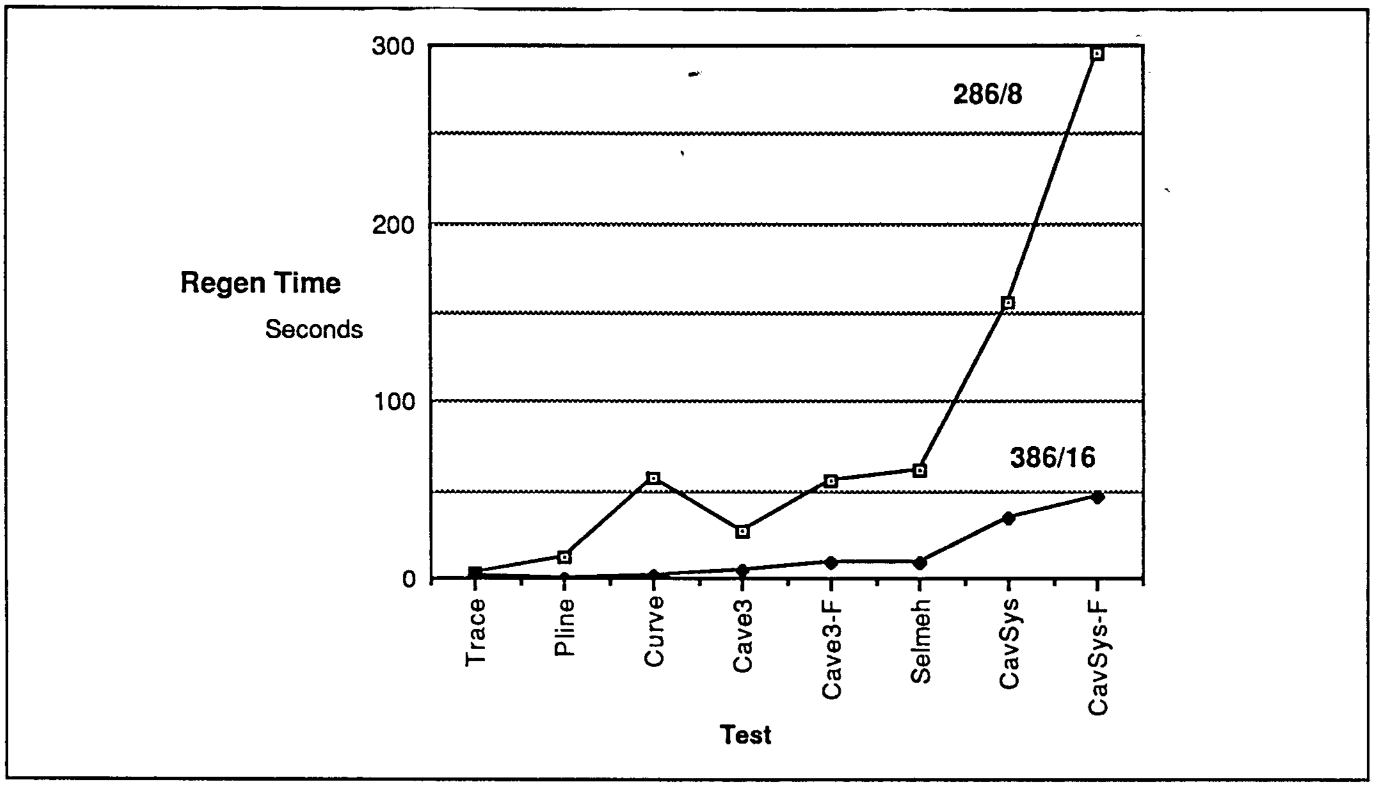


Figure 10 Regeneration times for the various tests on 286/8 and 386/16 machines

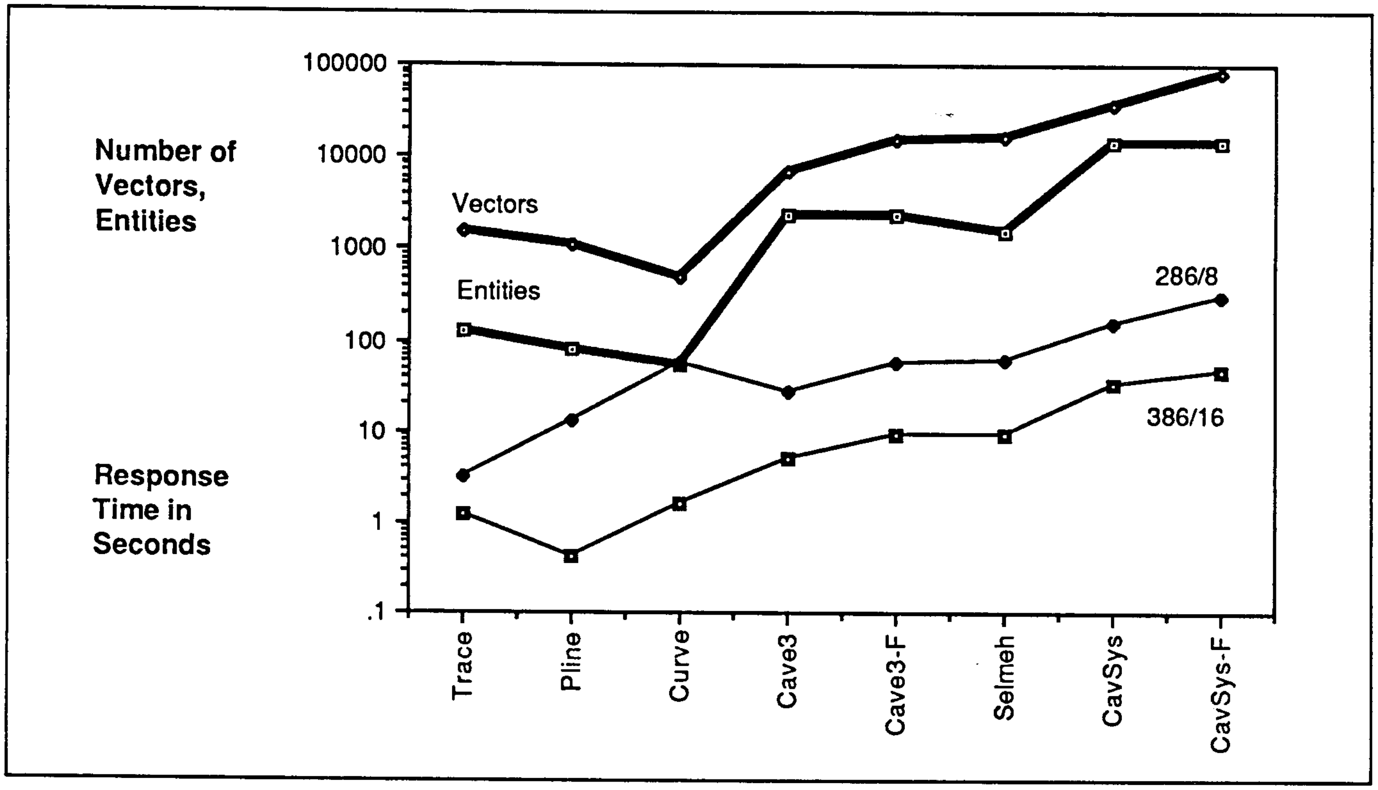


Figure 11 The number of vectors and entities, and the regeneration times in seconds, for the tests

6.4 Discussion of the Results

6.4.1 Response Times

The 386/16 machine and AutoCAD Release 9 decreased the processing times for the Pline considerably, although the Curve remains computation intensive (**Figure 11**). In general there is a speed advantage of 6 to 7 times the 286/8 machine, although response times for both are increasing nearly exponentially on the simulated caves.

6.4.2 Number of Vectors and Entities

The number of entities increases steadily through the Lines, while vectors drops off. Between CAVE3 and CAVE3-F the number of entities stays the same, reflecting the fact that the floor detail was simply turned off in CAVE3. The vectors count is thus higher when the floor detail is on.

6.4.3 Extrapolation of Results

I was interested in trying to bridge between my simulations and real cave maps. My main question was: how much cave map does a line plot correspond to? I put together my data from Deasy GeoGraphics with that furnished by Jim Nepstad for Wind Cave where he uses a 386/16 with 6 meg of RAM and a math coprocessor (**Table 3**) [4]. The first thing that I discovered is that the Wind Cave installation seems to be drawing about 10 times as fast: .0019 seconds/station vs. .018 seconds/station. (I suspect that this might be because my station labels were turned on and Jim's are almost certainly off.)

First, I eyed up CAVE3 and decided that it would probably take me about 30 stations to survey. Then

Table 3 Extrapolation of Study Results

	Wind Cave Line Plot	Selmeh Line Plot	CAVE3-F Simulation
Stations	11,800	496	30 est.
Response Time at Wind Cave	23 sec. (.0019 sec/sta)	-----	-----
Response Time at Deasy GeoGraphics	-----	9 (.018 sec/sta)	9
Line Plot Entities	36,698 est.	1546	93 est.
Cave Map	877,200 est.	36,955 est.	2,223

I determined a relationship between number of stations and entities with the Selmeh data, and used it to predict the entities in the CAVE3-F line plot:

$$\frac{\text{1546 ents. in Selmeh plot}}{\text{496 sta. in Selmeh plot}} = \frac{\text{3.11 ents}}{\text{station}} \times \frac{\text{30 sta. est.}}{\text{in CAVE3-F}} = \frac{\text{93 ents. est.}}{\text{in CAVE3-F plot}}$$

Next I used this information to predict the number of entities that might be in a Selmeh map and a Wind Cave map, as follows:

$$\frac{\text{93 ents. in CAVE3-F plot}}{\text{2223 ents. in CAVE3-F map}} \times \frac{\text{1546 ents. in Selmeh Plot}}{\text{?? ents. in Selmeh Map}} = \text{36,955 ents.}$$

This is not a realistic prediction, given the difference in detail and purpose discussed earlier. But we do seem to be dealing with rather large numbers of entities in extensive maps. Jim Nepstad reports that only about 5% of Wind Cave has actually been drawn as a map, and it will be interesting to see how this increase affects the system performance.

6.5 Suggested Enhancements to the Study

There are several ways in which this study could be done differently or extended. It would be interesting to use Plines instead of Traces, since this would decrease the entity count. In the extrapolation, Selmeh probably would not be as detailed since it is a large system but there would be lots of floor detail in the generally wide passages.

It would be interesting to see and compare information on performance from others who are using CAD for moderate-sized cave maps, e.g. the work of Miles Hecker [11]. With more data, perhaps we could come up with some parameters to describe the relationships in Figure 3. A potential user could thus determine what hardware they would need for a particular size cave and mapping scale/style.

7. Conclusions and Some Thoughts on Alternatives

So we have seen that CAD has potential for helping out cave mappers. It is not ideal because it is sold for a much different purpose. Even if we accept the limitations in the visual quality of the maps which it lets us create, there are problems with performance on large maps which contain many lines and symbols.

Some other ideas:

Returning to the vector/raster distinction, perhaps we need to consider a two-stage approach: CAD for survey plotting and management, Paint for final or partial drafting of area symbols. Another possibility would be working within the AutoCAD data structure and using some sort of condensed codes for area symbols. Also AutoCAD does no line simplification even when drawing at relatively small scales. A simple Nth point elimination would speed display considerably.

Certainly the average PC user is going to have to buy new hardware in order to use CAD for cave mapping. PCs are getting faster and cheaper for CAD, but specialized display hardware is still expensive since it is business-oriented. This suggests that it might be worth considering true graphics computers like the Macintosh II and Amiga. I started playing with a Mac IIx while waiting for the Model 80 to grind through the simulated caves, and have not thought about computer graphics the same since. It is now painful for me to watch a "fast" 386 PC try to draw something complex on the screen. One Mac package, Canvas, integrates both vector and raster approaches in drawings. How well this type of software will handle lots of complexity and large maps is not known. It is interesting to note that several raster Amiga packages can be used to produce large murals by printing many smaller tiles.

In closing, there is a lot of work to be done and shared. Many alternatives need to be explored and compared. I hope we will see detailed presentations of initial conditions, assumptions and conclusions in a fairly objective manner.

8. Acknowledgements

Thanks to Bill Storage who reviewed an early manuscript and shared his perspective on CAD in mechanical engineering. Jim Nepstad provided information on his work at Wind Cave National Park. Alan MacEachren and David DiBiase, both of the Penn State Deasy GeoGraphics Lab, assisted with hardware and software.

9. Notes

1. **E. Teicholz and B.L. Berry, eds.** *Computer Graphics and Environmental Planning*. Prentice-Hall, 1983, p. xv.

2. For a discussion of geometrical and combinatorial complexity, see Chapter 5.4.2.1 in **J.H. Ganter,** *Digital Representations of Karst: A Prospectus*, forthcoming.

3. This idea is developed in "50 Years of Cave Mapping: A Brief Overview," *Compass & Tape* 6:2, Fall 1988, p. 9-15.

4. John Smyre was probably the first to report this problem, in a paper at the 1985 SACS Session (see "SACS Activities at Convention '85," *Compass & Tape* 3:1, Summer 1985, pp. 12-13). At the time nobody really understood what he was talking about since micro CAD was still on the horizon; I believe his work was done on CAD and computer-aided cartography systems at Oak Ridge National Laboratory.

5. Letter to J. Ganter, 15 March 1989.

6. This graph is redrawn from **Thomas Kucharvy,** "Opening Graphics Markets: A Surprise Role for PC CAD," *Computer Graphics Review* April 1989. The original source is Nth Graphics.

7. **Jim Nepstad,** "CAD Applications at Wind Cave." *Compass & Tape* 6:2, Fall 1988, pp. 3-8.

8. Paul J. Stevens (1988) *Caves of the Organ Cave Plateau, Greenbrier County, W. Va.* W. Va. Speleological Survey Bulletin 9.

9. The only explanation given for how this works is that "AutoCAD scans your drawing from top to bottom, sending horizontal strips of the drawing to the plotter." (AutoCAD v. 3.52 Ref. Manual, p. 308). If these strips are being counted as "vectors," than the number of vectors should depend on the scale at which the plot is to be produced and the characteristics of the entities. For example, a wide Pline would require many vectors to draw. This seems to be the case, although I got very strange results when I tried to make analogous measurements using an Apple Laserwriter. This is probably because it is a PostScript device that plots in a much different manner.

10. See **Jim Nepstad,** "A SMAPS-AutoCAD Interface," *Compass & Tape* 5:1, Summer 1987, p. 12

11. **Miles Hecker** ("Micro-Based CAD for Cave Map Drafting." *Program of the 1988 NSS Convention*, p. 26) reports on use of AutoCAD to draw complete maps of 3 and 6 mile long caves. His earlier efforts are noted in *Compass & Tape* 4:1, Summer 1986, p. 13-14.

REGIONAL SURVEYS AND WHERE TO FIND MORE CAVES

by George Veni

It took more than ten years of work, but in May 1988 The Caves of Bexar County was finally finished. The city of San Antonio is centrally located in Bexar County, Texas, and, if not for that fact, most of the 208 caves described in the book would not have been mapped, discussed or even discovered. Most of the caves are not very big or exciting, but when they are only 10-15 minutes away from home its easy to gather a large amount of information over the years and produce a detailed county survey.

The book has a basic similarity to other volumes produced by the Texas Speleological Survey and organizations in other states. It has opening sections on history, geology and biology, followed by detailed descriptions and maps of all the known caves. Also, as in previous TSS works, there is a section on rumored and potential caves (potential caves being, for example, sinkholes that blow air and would likely open up with some digging). Sixty-two rumored and potential caves are discussed.

As I was writing-up all this information, I felt there had to be some effective graphic means of displaying where caves are likely to be found. The result of that pondering was the "Probability Map for New Cave Discoveries in Bexar County." (Figure) The problem with many past regional surveys has been that they tell you what caves are known, some tell you approximately where they are located, but none that I know of tell you where your chances are best for finding new caves. This map satisfied that need.

The probability map was developed by considering four primary factors: geology, presence of known caves, degree of urbanization, and degree of exploration. Each of these factors has both positive and negative influences upon the likelihood of finding new caves. For example, in considering the geology, the Edwards Limestone, Austin Chalk, and the lower member of the Glen Rose Formation, are good cave-forming units. The Anacacho Limestone, Pecan Gap Chalk, and the upper member of the Glen Rose are generally less cavernous.

Known caves were used, not only as indicators of caves existing in the area but of the types of caves within that area. However, for each cave known there is one less to be discovered. Urbanization of an area usually rings a death knell for most caves, yet the opening of new roads for housing developments increases accessibility for discoveries. Soon after a road was built to within 30 m of one well-known cave, 13 other caves were found within a one-mile radius.

The factors of knowing where caves exist and the degree of accessibility to certain areas are related to the last factor: the degree of exploration. One ranch, as an example, has excellent caves, excellent geology, and is not paved over by development. However, it has been so thoroughly walked and most of its sinkholes have been dug into, that the probability of finding a new cave is rather poor.

A couple times some odd-ball factors were considered as I developed the probability map. The most notable was at the Camp Bullis Military Reservation where, for many years, the standard policy has been to fill in caves with cement. As a result I dropped the probability rankings one notch where they crossed the fence onto camp property.

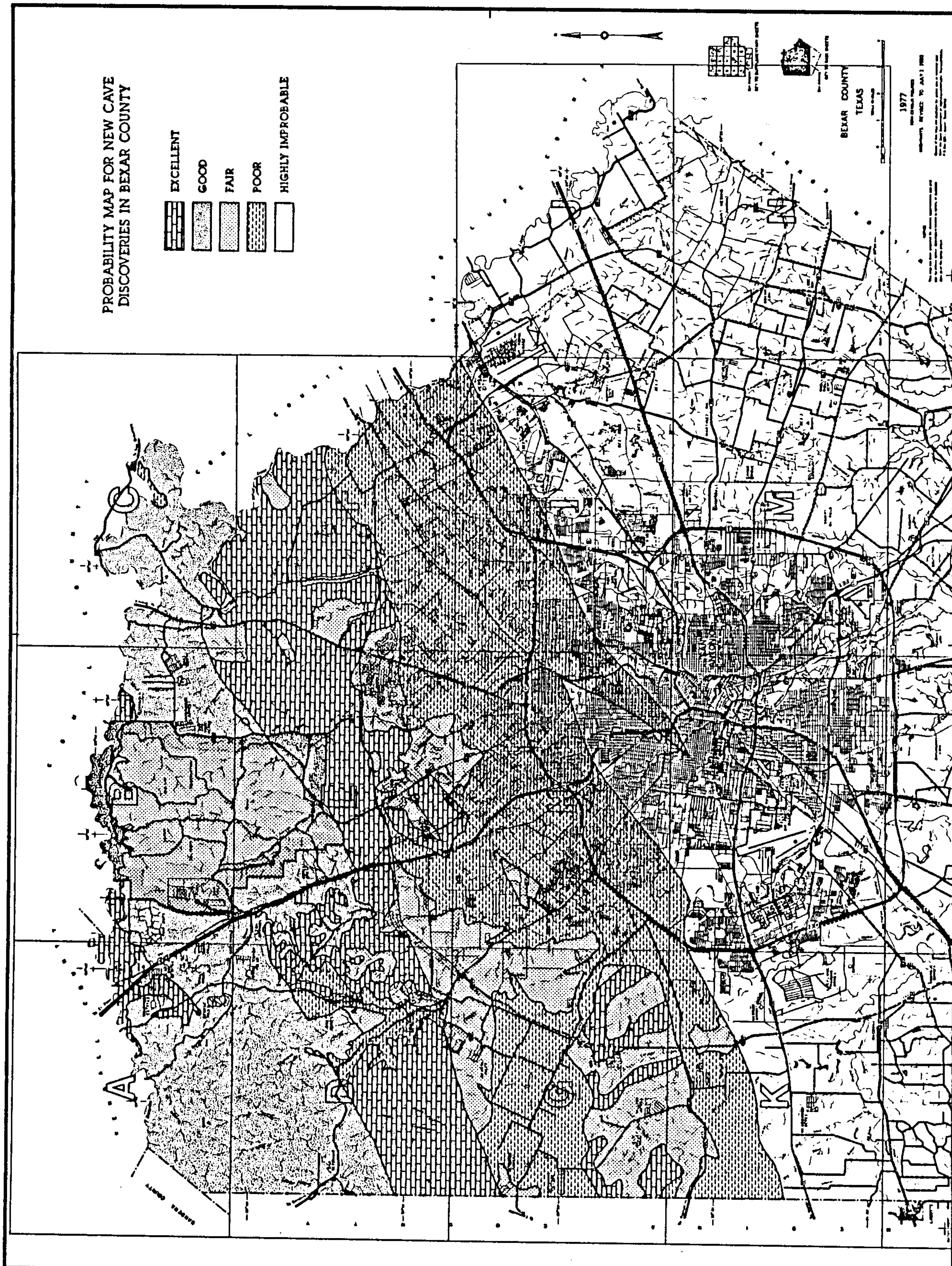
The map does not try to definitively say where caves will or will not occur, but rather to give approximate guidelines of where cavers might spend their time more productively. The map also does not address the size of caves to be found, although generally the areas more prone to have caves are also more prone to have bigger caves.

In doing the cartography I developed two previous maps, geology and cave locations, onto a standard base map. This tremendously helped in transferring their data to the probability map. First I transferred the geologic boundaries. Second I transferred the locations. Where cave clusters occurred, I reviewed the history to determine if the area had been played out or was still productive. Next I considered the base map itself, which was a county road map from which I could determine the degree of urbanization. With all the factors then on the same map and at the same scale it became easy to combine, adjust, and redefine boundaries to a probability scale.

In retrospect the final map came out too cluttered. Perhaps with a rural county the use of the county road map would have been fine, but for urban Bexar County it might have been best to redraw a simpler map showing only the main highways. Fortunately the degree of reproduction for the book was excellent, so that if you strain your eyes through the clutter its possible to make high resolution locations of certain areas based on the roadways.

What I have found is that intensive regional surveys lend themselves to the production of cave probability maps. Anyone undertaking such a task will find they need a good understanding of the region's geology, and exploration history. They will also rapidly discover that its sometimes hard to rigorously quantify areas as having "excellent, good, fair, or poor" cave potential because of the heavy dose of subjectivity that creeps into the equation. Nonetheless, such maps can be useful tools and I'd like to think mine had some positive influence on the 40 new caves found in the past year since <u>The Caves of Bexar County</u> became available.

(<u>The Caves of Bexar County</u> (300 p, hb, 184 maps, 46 photos) is the second in the Speleological Monographs series published by the Texas Memorial Museum, 2400 Trinity, Austin, Texas 78705, from which it can be purchased for $24 (Texas residents add $1.92 sales tax), plus $2 shipping.)


PROBABILITY MAP FOR NEW CAVE
DISCOVERIES IN BEXAR COUNTY
EXCELLENT
GOOD
FAIR
POOR
HIGHLY IMPROBABLE
BEXAR COUNTY
TEXAS
1977
BEXAR COUNTY TEXAS 15

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KARST FEATURES MAPS

by David A. Hubbard, Jr.,
Virginia Division of Mineral Resources

The Virginia Division of Mineral Resources has published two regional (1:250,000-scale) maps depicting sinkholes and cave entrances in the Valley and Ridge physiographic province. Selected Karst Features of the Northern Valley and Ridge Province, Virginia (Hubbard, 1983) and Selected Karst Features of the Central Valley and Ridge Province, Virginia (Hubbard, 1988) are intended as regional characterizations of karst areas for planning purposes.

The final map products depict sinkholes as red dots and irregularly shaped red areas, cave entrances as open or solid red triangles, and classify rock units on the basis of carbonate rock constituents and age. Noncarbonate rock units are depicted by 10 percent screened gray areas. The base map on which the the karst features and carbonate rock units are indicated is a composite constructed of negative separate plates and includes the transportation routes, cultural features, and water features. The transportation and cultural features are screened 30 percent and appear dark gray. Water features printed in blue ink also are screened. The topographic separate plate was not used in the development of the base map.

The generation of the karst maps is a complex procedure, involving the plotting of data and scale conversions. Cave entrance locations from Douglas (1964), Holsinger (1975), and the Virginia Speleological Survey are plotted on 7.5-minute (1:24,000 scale) topographic maps. Some of these cave entrance location coordinates are inaccurate and result in mislocation of cave entrances. Sinkholes are identified from stereoscopic examination of low-altitude (13,500 feet) aerial photography using a Bausch & Lomb Zoom 95 Stereoscope and plotted on the topographic maps. Field checks reveal that the sinkhole features observed range in size from a minimum width of 30 feet to a maximum extent of 11,500 feet and include such features as blind valleys, dolines, karst windows, closed poljes, ponors, and uvalas. Numerous sinkholes found in the field were not observed on the aerial photography because of resolution limits and other difficulties in recognizing low-relief features on aerial photography. After the sinkhole and cave data are recorded, a carbonate rock map is developed for each 7.5-minute quadrangle from published and manuscript maps on file at the Virginia Division of Mineral Resources. The map divisions employed are based on lithologic and age relations and consist of six carbonate rock units and one unit that includes all noncarbonate rocks. Following the plotting of the karst and geologic data, the sinkholes, cave entrances, carbonate rock divisions, and quadrangle corners are drawn in oversized symbols and lines on quadrangle overlays. Each of the overlays, 83 quadrangles for the northern karst map and 81 quadrangles for the central karst map, are photographically reduced to a template size (roughly 1:250,000). Xerographic copies of the reduced overlays are pasted-up on 1 X 2 degree quadrangles (1:250,000-scale) sheets that have been grided for the overlays. Some edge effects are introduced during this procedure due to minor photographic distortion and the fact that quadrangles are not true rectangles because their longitudinal boundaries converge toward the poles. Thus, quadrangles at different latitudes have different widths. The largest problem at this stage is one of tieing the geology together from different mapping projects such that there are no inconsistencies in the carbonate rock divisions between individual quadrangles, the three different 1 X 2 degree quadrangles comprising both the northern and central map areas, or the past or future regional karst maps. This is a time consuming interpretation problem.

The carbonate rock map is traced in drafting pencil from the pasted-up 1 X 2 degree sheet onto a green-line mylar base, compiled from transportation, cultural, and water feature plate separates. The transfer of the geologic information requires considerable repositioning of the paste-up and the mylar because of shrinkage and expansion of the less stable paper paste-up. The geology is subsequently scribed onto a coated mylar to produce the plate from which it will be printed in black ink.

While keeping the green-line mylar base registered to the paste-up, the sinkholes and cave entrances are transferred to mylar overlay, with drafting tooth on one side, registered to the base mylar. The drafting of the karst features for the northern karst map in pencil was unsatisfactory. The extreme level of detail on this mylar plate necessitated its use to produce the red plate without the benefit of scribing. The penciled features were not of uniform density and the hand drawn triangles (cave entrance symbol) were not uniform. For the central karst map, a template was used in constructing the cave entrance symbols and the karst features were transferred in ink.

The final problems concern the trimming and alignment of the three separate 1 X 2 degree sheets which comprise both the northern and central karst maps. Keeping each of the base separate plates and the geology and karst plates in reference for each 1 X 2 degree sheet as well as aligned to the adjacent sheets may require multiple color proof runs.

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Hubbard, D. A., Jr., 1983, Selected karst features of the northern Valley and Ridge province, Virginia: Virginia Division of Mineral Resources Publication 44, one sheet.

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REPLY TO STANDARDIZATION APPEAL
by Robert Thrun

At the end of his article, which described how he fed cave map data into AutoCAD, Jim Nepstad asked that the cave map programs adopt some sort of standard output format. I fail to see just what the problem is. The output format of my CMAP program is very simple. It took me five minutes to write a 15-line program that reads my output files. Is he suggesting that this slight effort is too much? I am not familiar enough with other output formats to comment on them. Actually, I think that writing the AutoCAD .DXF files presents more programming difficulties. The file format is complicated and the documentation is difficult to understand.

Previous calls for standard data formats were largely ignored. Not many cavers are exchanging survey data. Where they are, they have been able to make their own arrangements. Moderate amounts of data can be converted on a one-shot basis by using an editor to move columns around. Larger amounts of data may be handled by conversion programs. Both Doug Dotson and I have written programs to read each other's files.

MAP SALON JUDGING - FURTHER COMMENTS
by George Dasher

Dear Editor:

This Cartography Salon thing may be getting out of hand. if anything is remembered from the 1988 Salon, let it be that the maps were judged for vertical expression and for usability in the cave.

NO MAPS WERE DISQUALIFIED-FROM THE 1988 SALON FOR ANY REASON. Awards were given for a variety of reasons.

I don't know if someone's map was marked down because of a lack of passage details. I personally was not judging to much by that standard; however, with so many <u>good</u> maps, it was difficult to find any sort of relevant criteria. My own maps have been marked down in previous salons because of a lack of passage detail, too much passage detail, titles too bold, titles too inobvious, passages too cluttered, misspelled words, cross-sections that did not point up the paper, and a whole variety of other reasons. Some of this seems hard (as did some of our reasons last year), but other people --such as Bill Balfour --have fared far worse than myself with far better maps.

I am sorry if we hurt someone's feelings. I am sorry we could not give so many excellent maps more awards. We were probably evangelical, we probably made many mistakes, but we did the best we could. I wrote the article for the Summer <u>C&T</u> not to generate controversy, but just to say why we did what we did.

No map was marked down because it did or did not show precise cave locations. My personal preference is that we show locations, so that we can find the maps ten years down the road, even in the often vandalized western caves. No map was marked down because it used feet or meters.

If there are two excellent maps (where both used vertical symbols and did not have profiles) and one map has "Zero Datum" and the other doesn't, in my opinion, the "Zero Datum" map will have a better chance of winning. This is not to say that the other map is not a damn good map, it is just --with so many excellent maps --the judges have to nit-pick.

I could go on and on. Perhaps we should set up some kind of point system (keep in mind this in within the Cartography Salon, not within SACS!), but then what are you going to do when, one year, some judge doesn't like your system and throws the entire thing out the window? I used to show beef cattle in 4-H. It too was a lot of subjective fun. I showed Angus and Shorthorn; some years, when faced with a Hereford judge, I would just be out of luck. I sincerely hope that people continue to enter their maps in the Cartography Salon and I hope that this does not happen there, but reason tells me otherwise.

Second Thing: I put my foot in my mouth with this Sketching Thing. I had been disappointed from caving with a bunch of inexperienced surveyors. Obviously, a person should sketch the way they feel is best. The important thing is to 'see' what is in the cave passage and put it on the paper. I like to sketch to a relative scale because I feel it is faster. Other people call my sketches shorthand chicken scratching that looks like they were crapped on by a bear. Recently, I participated in a project where I was asked to sketch to scale. One person was drawing the map and with five parties in the cave that day, he needed that extra help from his sketchers. It was very obvious that when someone dumps a bunch of sketches on you, it is far easier to draw the map if those sketches are to scale. I stand corrected.

That's about it -- back to the drawing board.

MORE ON THE MAP SALON JUDGING

by Becky Jagnow

Dear Editor,:

The exchange of letters in the last issues of Compass & Tape have highlighted some problems with the NSS map salon. In particular, I would like to comment on Mr. Dasher's article and letter concerning the Jester Cave map.

First, Mr. Dasher is to be highly commended for taking time to write down his reflections on the judging for Compass & Tape ("One Judge's View", Summer '88). Better still would have been thoughts from the other two judges as well, simply to better inform our membership. (As it is, Mr. Dasher has been left to take the heat from dissatisfied entrants!) I really appreciate his willingness to disclose his views. In the following issue he states that "I wrote that article in a hurry at Convention", which may be part of the reason that I find so much to disagree with. But at least he wrote an article!

Questions for Mr. Dasher (and the other judges) -

You state that you "wish we could have given more awards." Why is there a limit? If "all these maps were superb representations" why not give them the recognition due? There must be a lot of disappointed and confused cartographers out there. One convention-goer, himself a fine cartographer but not an entrant, said he looked and looked at the maps and couldn't find any rhyme or reason to the awards.

I found your- list of important vs. less important criteria astounding. Lack of a zero datum is more crucial to usability than having areas of the cave that are poorly represented, cross-sections that don't match the passage, and too little passage detail? If I have to choose which map to use, I'll take the accurately represented cave without the zero datum any day.

I was equally astounded to see the Jester Cave map classified with "toilet paper for our children." Especially when in the next issue you call it "as good a map as I have ever seen." Huh?

It is regrettable that the map lacked a datum which, while often worthwhile information, has not been considered that pertinent to understanding Oklahoma gypsum caves. Even a quick glance at the map reveals Jester's similarity to surface drainage patterns, and a closer look shows that it is simply a captured drainage. The entire cave follows the gentle gradient of that underground stream and it's tributaries. The few small drops that exist are clearly labeled with the vertical distance, more quickly comprehended than subtracting one datum from another. Ceiling heights are profusely noted on the map, and several cross sections provide clarification where needed. I really believe most people can understand the cave in all three dimensions from the data given.

The question of accurate locations on cave maps is so controversial that it is questionable it should be an influence in NSS judging, much less a decisive factor. I noted with amusement that, according to the <u>NSS News</u> (March '89, pg, 78), Mr. Dasher himself entered no location of ins sort on his map of Bull Thistle Cave. Jester does list county and state. But Ms. Bozeman uses other methods too, to help insure future "usability" of' the map. Perhaps one of the most effective is to send a copy to each landowner, or administering agency. A well-maintained cave log, used selectively and responsibly, also averts loss of valuable information.

Mr. Dasher, you say that should a cave location be lost it "would be a crime" and that "if 'your' caves are lost to future generations of cavers, you too were wrong." I beg to differ. What is best for the cave? It is far better to be "lost" rather than accessible to a public that is not yet adequately educated and motivated in conservation.

You mention that "if a person can add sufficient passage to their cave map, they can re-enter the map." Again, a close inspection of the Jester' map will show that there are no humanly passable leads to be mapped. In fact, a look at any map Ms. Bozeman has published will show the same thing. This reflects one of her basic philosophies - if the map is not complete, it is not sufficiently usable to merit publication. The obvious exceptions are large, complex, and/or remote systems where such a criterion could withhold valuable data for decades. Sadly, Oklahoma has not presented us with any Flint-Mammoths or Huatlas yet. (Optimism is what keeps cavers going!)

During February's Bat Count, we found a new dome above a pile of fresh breakdown in Jester's north end. It will take a lot of such natural modification for the cave to supply "sufficient new passage" for another salon entry. I'm afraid the '88 convention was the only bid the Jester map will ever make for recognition.

Much of my disappointment is personal and subjective. I know so much that the judges can't possibly see from that piece of paper on the wall. I know that Sue's maps aren't just nice, pretty drawings. They are accurate. The detail is correct and complete. I know the effort (and insanity!) that went into the five years of gathering that information.

But It is the awareness of the care and exertion that went into that one map that leads me to plead on behalf of <u>every</u> cartographer whose long hard work is reflected in that map they enter in the salon. PLEASE S&C Section:

> Let's come up with some consistent guidelines for the judging of the NSS Map Salon.
>
> Publish those guidelines.
>
> When the guidelines change (and they will), publish those changes well in advance of the entry deadline.
>
> Publish more of the judges' comments ' or send each entrant a copy of the judges' notes on his/her map.
>
> Reproduce the winning map in your publication.

This could be helpful to judges and entrants alike, And the result should be just what the S&C Section is all about - better and better maps.

MORE VARIETIES OF BLUNDERS

by Robert Thrun

In his article on blunders (<u>C&T</u> Vol. 5, No. 2), Fred Wefer said that he was not familiar with Suunto instruments and the kinds of blunders that might occur with them. I own both Suunto and Brunton- type instruments. I can not think of any blunder that is unique to Suuntos. Some kinds of errors are easier to make with Suuntos.

The Suunto clinometer, like the Brunton clinometer, has both percent grade and degrees scales. The two scales are more easily confused on a Suunto than on a Brunton. Many Suunto compasses have a backsight scale in red. Reading the red scale is the same as reading the wrong end of the needle on a Brunton.

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I have encountered a Suunto compass with an off-center pivot and I have a clinometer with a slanted hairline. These cause systematic, rather than random, errors that have equivalents with Bruntons. Suunto compasses are more subject to leveling errors than Bruntons.

I can think of a few blunders that Wefer missed. The hook or ring at the end of a tape often breaks off. If it is a fiberglass tape, the owner ties a knot in it and holds the two foot mark on the station. I have data that involved a tape shortened by 17 feet. Some survey parties subtract the distance in the cave and write the corrected distance in the book. Others record the distance as read and let the person doing data reduction correct it later. The blunder occurs when the distance is not corrected or is corrected twice.

I have had the tape reader confuse a tape in feet and inches with one in feet and tenths. I have also seen a notetaker who did not know how to write down feet and inches. He used a decimal point as a separator. Would these be systematic errors? I know of a couple of computer programs that set a flag, and then use a decimal point to separate feet and inches.

A surveyors "chain" has one foot before the zero mark finely divided in a reverse direction. It is marked only at one foot intervals after the zero mark. The one time I tried one of these chains, the survey crew could not get the routine down.

Some cavers work like land surveyors, putting the station on the ground and the instrument and target at measured distances above the stations. This has the potential for another set of blunders.

I have a set of Suuntos and a German version of a Brunton that are marked in grads. The measurements could get confused with degrees.

We all have encountered situations where the instruments were just plain hard to read because of mud and water. Is this a blunder?

Wefer apparently took his data from simple loops, which I take to be cutblocks of a graph. A great many loops can be made out of a multiply connected network. In fact, the problem is counting them all. I have looked into the problem because there are some cave surveyors who want to close the "best" loop first. Regardless of the way "best" is defined, it seems necessary to find all the loops before they may be evaluated. I suspect that it would take longer to find all the loops than to do a least-squares adjustments. I would like to see a program that repeatedly closes the best remaining loop until there are none left. A good review paper is "On Algorithms for Enumerating all Circuits of a Graph", by Prabhaker Mateti and Narsingh Deo, SIAM Journal of Computing, Vol. 5, No. 1, March 1976, pages 90-99. ACM Algorithms 491 and 492 find the cycles of a graph.

The F-statistic that David McKenzie uses (C&T V.4, Nos 3 & 4, p. 49) is a powerful tool for detecting blunders. Unfortunately, it is not comprehensible to most cavers.

PRELIMINARY IMPRESSIONS OF SMAPS 4.2

by John Ganter

Since 1985, SMAPS (Survey Manipulation, Analysis and Plotting System) has provided a PC based package for editing, reducing and plotting cave survey data. In October 1988, version 4.1 appeared; now we have another with still more improvements. Here are some first impressions.

The user interface is now based on pop-up windows. The number of options available is somewhat overwhelming to the newcomer, including the experienced 3.3 user. This is a very powerful package and requires some learning. For example, when one chooses to analyze a survey, a menu appears with some 15 options! This is a little intimidating, but if you just press B for "Begin Conversion" things roll right along. Later you can return and use such options as report destination, output precision and units, etc. if needed.

The editing functions are very impressive. You can cut and paste blocks of stations, add or remove prefixes and/or suffixes and search/replace station names. Comment lines can be inserted. For data entry, you can automatically sequence stations with or without prefix/suffixes. This saves a lot of work if you are entering a hundred stations with a 3 or 4 letter prefix. The editor also accommodates depth gauges and Topofil.

Plotting capabilities have been expanded considerably. Ticks for wall and ceiling measurements can be drawn on the plans and profiles, along with datum lines at any desired interval. A prototype of screen graphics for EGA and CGA is included; the full package is expected by late summer.

The manual is somewhat difficult to follow; an interactive tutorial is reportedly in the works. In summary, SMAPS 4.2 is intended for heavy-duty use, although many features can be left alone if not needed. It requires some learning, but no more than most word processors, spreadsheets, or whatever. Considering the market size, we are very fortunate to have such a product available at this price.

Availability: SMAPS 4.2 costs $49.95 ($10 more for export) including a 100- page manual. The vender and author is Doug Dotson, SpeleoTechnologies, Inc., P.O. Box 293, Frostburg, MD 21532. Phone 301-689-3423. It runs on a PC/XT/AT; 640k RAM and a hard disk are recommended. A number of printers and plotters are supported; the base price includes a choice of two drivers. There is a computer BBS (Bulletin Board Service), BITNET and phone support.

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Editor's Comments
by Tom Kaye

I have now done a year's worth of Compass & Tape. We have seen a lot of controversy, quite healthy controversy, in my opinion. This is perhaps not what readers of C&T have come to expect, but I have received no complaints about general content.

It has been interesting. The latest adventure was in the preparation of this issue. Lots of typed pages were sent to me, but a disk was included for only one. As I have said, in order to avoid the scrapbook appearance, I like to retype and print these articles. As you can see, the large and fancy ones, I leave alone. My retyping isn't perfect and is painfully slow. Thanks to my caving friend Beth Webb, who has a scanner at work, the retyping didn't have to be done this time. This was my first experience with a scanner. Some of you have probably been using one. The results are quite interesting and sometimes amusing. The scanner-software combination uses a spelling checking scheme (until it gives up) for analysis. The resulting file has a few "wordos", (in addition to "typos"), where a wrong word was assumed. Fortunately, the wordos are extremely few compared to the much more obvious typos. The job is then to compare the file with the typed copy and make the corrections. For a very fast and accurate typist, the typing may be as fast as this correction of a scanner's efforts. This does not apply to me; the scanner saves 'hours' of work! I did notice that the scanner is sensitive to dim copy; it takes longer to consider the page and makes more mistakes.

I would like to respond positively to the suggestions that the C&T publish the winning map of the salon. I need the map sent to me, of course. It is extremely preferable (to me, the cartographer, and the map itself) if a reduced copy is sent, instead of the original in its original size.

I take this opportunity to reiterate my feelings on being the editor. If anyone wants to take the job of editing and the stuff that goes with it, go for it. Otherwise, I don't mind continuing with my average word processing equipment and mediocre typing abilities.

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