

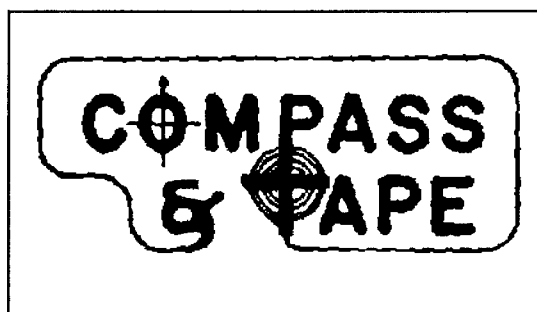
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VIEWING DEFINITION AND CONTROL FOR STAGE-4 CAVE MAPS

by

Fred L. Wefer

1. INTRODUCTION

In recent papers in this journal Wefer (1989a & 1989b) introduced the concept of "stages" in the development of the computerization of cave mapping, and presented the design of a 3D icon which visually shows both the current viewing direction and scale of Stage-4 cave maps.

A Stage-4 cave map is a map designed to be viewed on the computer graphics screen. The information content of the cave map is conveyed via lines, symbols, text, and polygons comprised of pixels on the screen. Extensive use is made of color. The content of the map can be changed at the option of the viewer. Any portion of the cave may be viewed in any 3D direction at any reasonable scale, all at the option of the viewer. Sequences of changes in both viewing and content can be defined interactively by the viewer and played back in a movie-like fashion. The hardware and software which make all this possible are integral parts of the map.

A computer program now called Interactive Cave Map (ICM) was used by Wefer et al (1983) to illustrate the application of interactive computer graphics to cave mapping. ICM is written in FORTRAN and makes extensive use of a Commercial Off The Shelf (COTS) software product called TEMPLATE (a graphics package based on the proposed CORE graphics standard). ICM has continued to be used by this author in the past seven years as a prototype for Stage-4 cave mapping.

This paper discusses the definition of viewing and its interactive control for Stage-4 cave maps. A caver explores a cave on the computer by interactively changing the viewing, hence it is important for the modern cave cartographer to have at least a basic understanding of the subject of viewing in computer graphics. The north/scale icon discussed by Wefer (1989b) is used in the illustrative examples of this paper.

2. VIEWING DEFINITION

The subject of 3D viewing in computer graphics is a complicated one best learned from a course (or at least a textbook) in computer graphics (see e.g., Giloi (1978), Newman and Sproull (1979), Foley and Van Dam (1982), or Harrington (1983)). The presentation below is presented in terms of viewing a Stage-4 cave map. It contains some considerable simplifications which, it is hoped, will make this esoteric subject somewhat easier to understand.

2.1 COORDINATE SPACES

Two coordinate spaces are commonly employed in computer graphics, device space and virtual space. Device space is defined in terms of the physical graphics display device, e.g., the computer graphics screen. Coordinates in device

space (the textbooks sometimes call these "physical device coordinates") are typically in units such as centimeters or inches. Virtual space is defined in terms of the objects (the caves) displayed on the screen. The units of coordinates in virtual space (the textbooks sometimes call these "user coordinates" or "world coordinates") are whatever is appropriate for the application.

In cave mapping applications it is common to use a virtual space Cartesian coordinate system in which the +X axis points east, the +Y axis points north, and the +Z axis points upwards. This is a right-handed coordinate system in which the units of all coordinates are meters (or feet).

One of the important processes performed by the graphics hardware and software is the mapping from virtual space to device space, so that a cave passage which is hundreds of meters long can be displayed on a screen which is only centimeters across. This process is here referred to as viewing.

2.2 VIEWING PARAMETERS

In order to understand viewing in computer graphics, it is necessary to understand the following seven related entities, each of which is discussed below:

- o Device Viewport,
- o View Point,
- o View Site,
- o View Vector (line of sight),
- o View Attitude,
- o Virtual Window, and
- o View Scale.

The caver is assumed to be seated in front of a rectangular area on the computer graphics screen called the device viewport (see Figure 1). The device viewport is really a rectangular parallelepiped whose front face is a rectangle on the graphics screen. Considerable simplifications occur when the device viewport is a cube, and ICM takes full advantage of this.

The position of the caver's eye (for simplicity we pretend that the caver has only one eye) is called the view point. The point at which the caver is looking is called the view site. In program ICM the view site is at the center of the device viewport.

The directed line beginning at the view point and passing through the view site is called the view vector or more commonly the line of sight. The view vector defines the direction in which the caver is looking.

The orientation of the caver's head is called the view attitude, an angle specifying a possible rotation of the caver's eye about the line of sight.

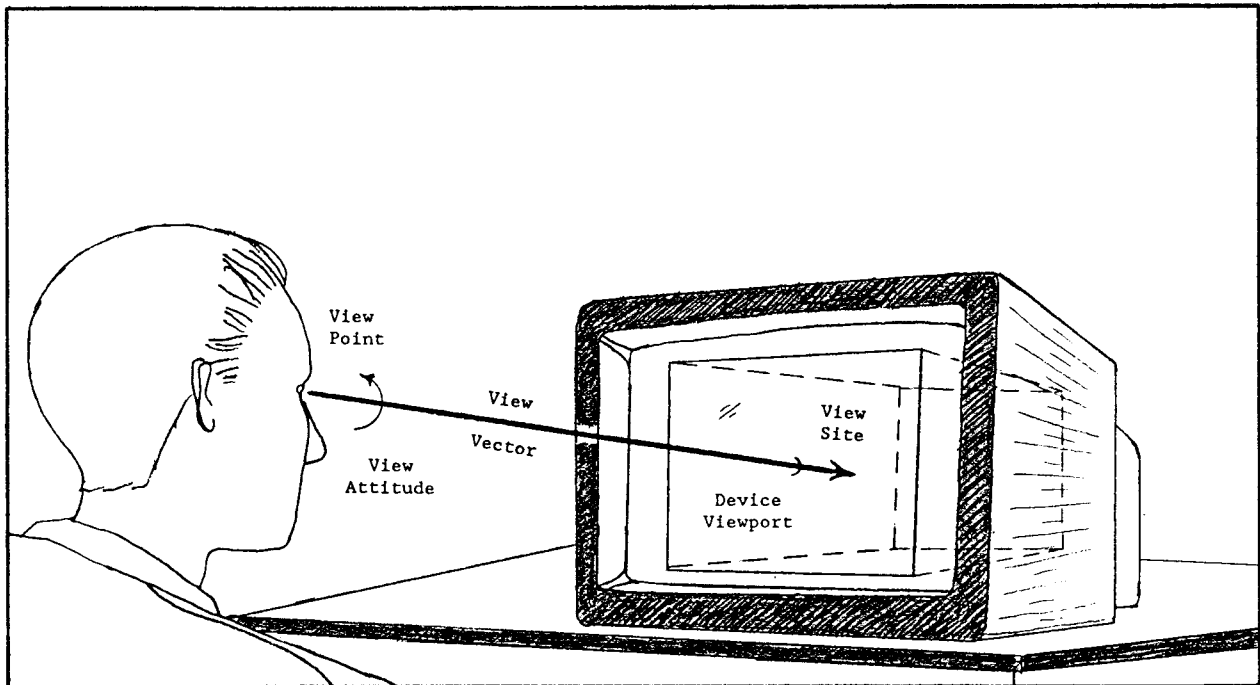


Figure 1. The View Point, View Site, View Vector, View Attitude, and Device Viewport are illustrated in Device Space. In program ICM the device viewport is a cube. The view site is at the center of the device viewport.

The cave being viewed is contained within the virtual window, a rectangular parallelepiped whose sides are parallel to the axes of the virtual space coordinate system (see Figure 2). Again considerable simplifications occur when the virtual window is a cube, and ICM takes full advantage of this also.

The view scale specifies how large the cave appears when displayed on the screen, hence how much of the virtual window appears within the device viewport.

Conceptually much of the job of the viewing process in computer graphics is to make the view vector as defined in device space (the caver sitting in front of the graphics screen) coincide with the view vector as defined in virtual space (the line of sight in the cave). It is usual to force the device space viewing parameters to be fixed (constant), hence from here on we need consider only virtual space viewing parameters.

2.3 VIRTUAL SPACE VIEWING PARAMETERS

In order to provide interactive control of viewing, a Stage-4 cave map needs to allow the caver to define/redefine in virtual space the view vector, the view attitude, and the view scale. This may be done by providing interactive control of the following entities:

- o Center Coordinates,
 - * X coordinate of the center point (X),
 - * Y coordinate of the center point (Y), and
 - * Z coordinate of the center point (Z).
- o View Angles,
 - * Azimuth angle (A),
 - * Dip angle (D), and
 - * Bank angle (B).
- o View Scale,
 - * Relative scale (S) and
 - * Vertical exaggeration factor (V).

The view vector was defined in Section 2.2 by two points through which the view vector passes, namely the view point and the view site. The line of sight (view vector) can also be specified by the XYZ coordinates of one point through which the line of sight passes and by two angles which specify the direction of the line of sight. We pick for that one point the view site.

The XYZ coordinates of the view site are here called the center coordinates because they are the coordinates in virtual space (in the cave) of the point which appears at the center of the device viewport (center of the screen). The angles which specify the direction of the line of sight are the azimuth angle (A) and the dip angle (D). The azimuth angle is just the azimuth of the line of sight. The dip angle is the dip (or vertical angle) of the line of sight. These two angles are identical to the azimuth and dip read from the compass and clinometer during the surveying process (see Wefer (1987) for formal definitions).

The view attitude mentioned above has also been specified by the view-up direction or more simply by the bank angle (B). The bank angle is not recorded in cave surveying, since for the compass and clinometer to work properly this angle must be made zero (B equals zero means the horizon is horizontal). The video tape of a Stage-4 cave map presented by Wefer et al (1983) was developed without providing user access to the bank angle. User access to B has since been added to ICM because it allows the definition of more realistic movies. The three angles A, D, and B constitute the view angles.

The virtual space center coordinates and view angles are illustrated in Figure 2 below.

To complete the viewing definition, one other entity is required, viz the view scale. The absolute numerical scale is not of much use; however, the relative scale (S) (relative to the way the map is initially created) is quite useful. If vertical exaggeration is applied to the map, then an additional parameter is required to specify the vertical exaggeration factor (V). Note that the absolute scale of the map is shown graphically by the north/scale icon discussed in Wefer (1989b).

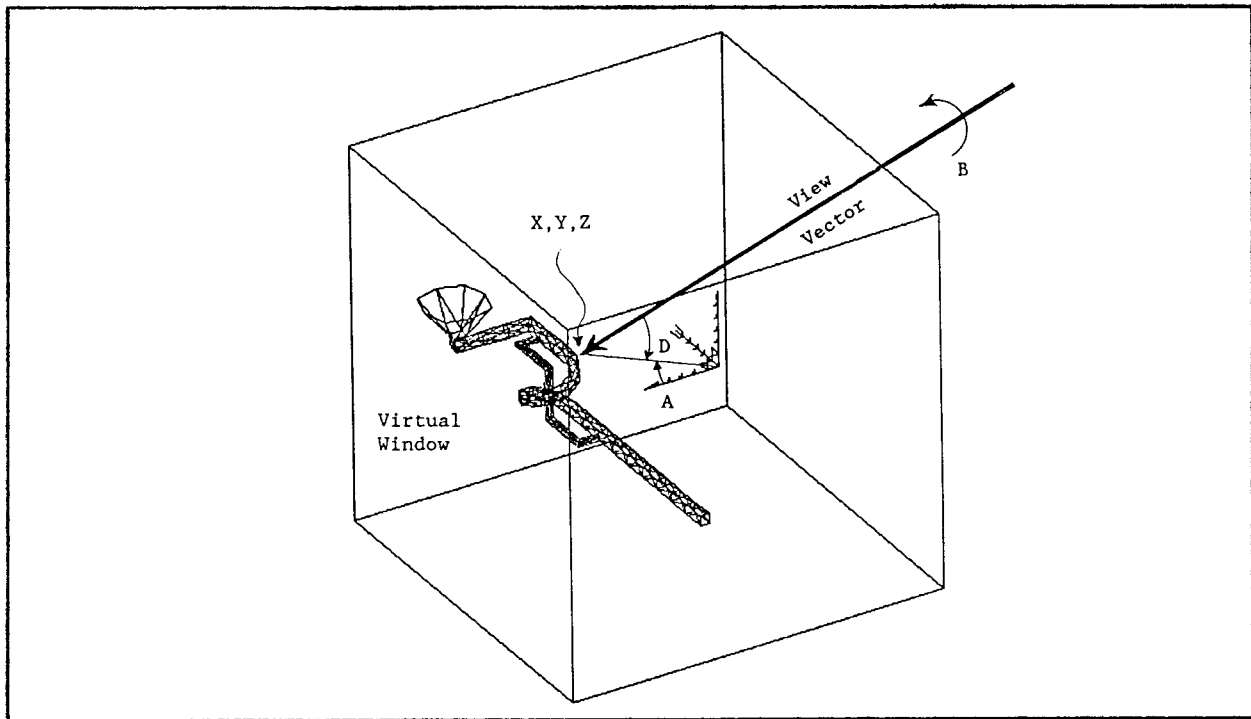


Figure 2. The View Vector, View Angles (A,D,B), Center Coordinates (X,Y,Z) and Virtual Window are illustrated in Virtual Space. In program ICM the virtual window is a cube.

These eight parameters (A, D, B, S, V, X, Y, and Z) completely specify the viewing for a Stage-4 cave map. An alternative description would use both the view point and the view site to define the line of sight. This would require six Cartesian coordinates (XYZ coordinates for both the view site and the view point), the bank angle (B), the relative scale (S), and the vertical exaggeration factor (V), nine parameters in all.

It should be noted that the above discussion assumes that orthographic projection is used, i.e., perspective is not applied during the viewing process. If perspective is to be applied, then at least two additional viewing parameters must be specified, ten in all. These are the locations of the view point and the view plane along the view vector. The view plane is the plane onto which virtual space objects are projected. This view plane projection is then mapped into the device viewport.

Experience with ICM has shown that orthographic projection is preferable to perspective projection for at least three reasons: (1) viewing control is much easier to understand and perform, (2) relationships between points on the map are easier to understand, and (3) with a CORE based graphics package, perspective is applied in software making dynamics, i.e., rapid viewing changes producing movie-like effects, in perspective impossible. For some examples of perspective applied to Stage-3 traverse line maps, see Schaecher (1986) and Hibbard and Santek (1989).

Readers well versed in computer graphics will note that the above discussion has been greatly simplified (see Section 8 below). Readers not well versed in computer graphics will probably doubt the truth of that statement.

3. A LITTLE HISTORY

Very little has been written on the subject of 3D viewing of cave maps. Wefer (1980) gave a very brief history of his efforts at providing viewing options for computer generated maps, a history which is expanded upon a little here.

These efforts were applied mainly to Butler Cave Conservation Society, Inc. (BCCS) surveys in the caves of Burnsville Cove, West-central Virginia. The maps consisted of traverse lines only. The ability to plot traverse lines as an aid in producing cave maps was implemented sometime before 1970. These maps were just Calcomp plots of the XY coordinates of the survey stations sequentially connected by straight lines (Stage-2).

It was obvious that if one plotted the XZ coordinates instead XY, then one would get a profile looking north. If one plotted the YZ coordinates instead of XY, then one would get a profile looking west. It was an easy step to use a little analytic geometry to produce profiles in any direction, and only a slight additional enhancement to produce longitudinal traverses.

The author produced his first traverse line maps viewed in an arbitrary direction, i.e., arbitrary azimuth and dip of the line of sight, versus dip = -90.0 degrees (plan view) or dip = 0.0 degrees (profile view), in 1979. These were produced on a Megatek-5000 CRT refresh stroke graphics terminal instead of a plotter. An example of such a map is shown in Figure 3 below.

The user interface in this program can best be described as dreadful. It was a Question and Answer Interface (QAI) in which the azimuth and dip of the line of sight, the center coordinates, and the scale of the plot were all cyclicly asked for via FORTRAN WRITES and answered via FORTRAN READS. All six viewing parameters had to be entered in each cycle. Vertical exaggeration and bank angle were not implemented.

A significant enhancement to this embryonic version of ICM was the implementation of a Command Language Interface (CLI). This provided quick access to any viewing parameter which needed to be changed, without having to deal also with parameters which did not need to be changed. The two character commands employed were a little cryptic, but were easy to implement in FORTRAN on a 16 bit machine. The CLI viewing commands were of three types:

P= n.nn sets the viewing parameter "P" equal to "n.nn" ,
P+ n.nn increases the viewing parameter "P" by "n.nn" , and
P- n.nn decreases the viewing parameter "P" by "n.nn" ,

where: P is one of the viewing parameters (A, D, S, X, Y, or Z), and
n.nn is the command value (degrees, dimensionless, or meters as appropriate, always positive).

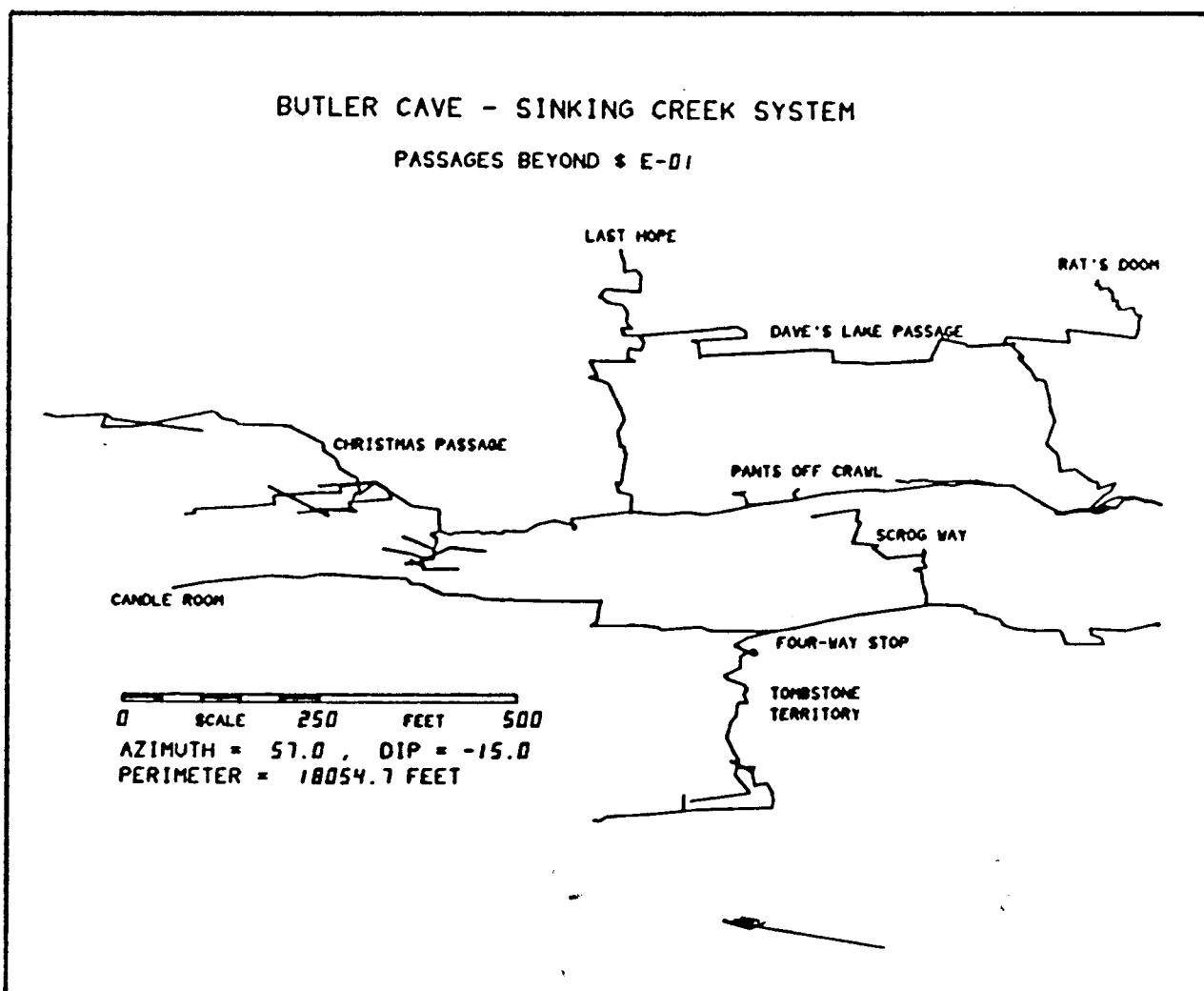


Figure 3. Orthographic projection of the downstream area of the Butler Cave-Sinking Creek System, adapted from Wefer (1980). Note the digital display of the azimuth and dip of the line of sight. The blob just above this figure caption is an unintelligible north arrow plotted in the horizontal plane.

Program ICM was rehosted during 1981 from a Data General Nova-3 to a VAX 11/780 and rewritten to use the COTS graphics package TEMPLATE. The new version of ICM was designed to run on Megatek 725x color raster graphics terminals (state of the art at the time). This may have been the start of Stage-4 in the computerization of the cave map.

The CLI was retained but was not as frequently used as was the GMI. The GMI was used by Wefer et al (1983) in preparing their presentation for the 1983 NSS Convention. Both the CLI and the GMI were later extended to include the viewing parameters B and V.

Details of the GMI (including some program code) were presented in a paper intended primarily for TEMPLATE graphics programmers (see Wefer (1985)). With only minor modifications, the same GMI is still used today for viewing control in program ICM.

4. STAGE-4 REQUIREMENTS

Three overriding considerations influence the choice of mechanism for the interactive control of viewing for Stage-4 cave maps, viz: (1) the viewing is changed quite frequently, (2) trial and error is integral to the process, and (3) the user is not necessarily an expert in computer graphics.

Stage-4 cave maps are viewed on a computer graphics screen, typically an area of approximately 11 x 14 inches or smaller. When the cave is displayed at larger scales (higher magnifications) the entire cave may not fit on the screen. The way the caver looks at different portions of the cave at higher magnifications is to change the viewing. This results in the viewing being changed quite frequently. This in turn means that the user interface must be fast and efficient.

In some situations the caver knows exactly where he wants to go in the cave. It should be easy to get there, i.e., to set the exact desired viewing parameters. Because the viewing is changed so frequently, a minimal number of steps should be involved in getting to any desired viewing state, and the current viewing state must be easy to determine.

Stage-4 cave maps provide the caver the opportunity to "explore" the cave by repeatedly changing the viewing. This is basically a trial and error process and is a natural part of exploring a cave on a computer. The word "error" here means a situation in which the caver is lost or perhaps just went down the wrong passage. This means that undoing a just completed viewing change is a common operation. The undoing should be as fast and efficient as was the doing; moreover, the exact method of undoing a change should be obvious. It should also be possible to get back easily to a predetermined standard viewing state.

Stage-4 cave maps are designed to be viewed by cavers who are not necessarily experts in computer graphics. This means that the user interface must be easy to understand, easy to learn, and easy to use. It should, at the very least, seem "natural" to cave surveyors.

The above discussed considerations result in the following seven requirements for the user interface for Stage-4 cave map viewing control:

- o It must be fast and efficient,
- o It must involve a minimal number of steps to get to any desired viewing state,
- o It must clearly display the current viewing state,
- o It must allow setting exact desired viewing parameter values,

- o It must support undoing as well as doing:
 - * Undoing should be as fast and efficient as the doing,
 - * The method of undoing a change should be obvious, and
 - * Returning to a standard viewing state should be easy,
- o It must be easy to understand, easy to learn, and easy to use, and
- o It must be natural for cave surveyors.

5. STAGE-4 DESIGN ELEMENTS

The requirements for viewing definition and control for Stage-4 cave maps are presented above. Exactly how these requirements are satisfied is the decision of the system designer. More than one solution exists. A list of design elements which, by experimentation via program ICM, have been found to satisfy the above requirements is shown below.

- o Use the viewing parameters discussed in Section 2.3 above,
- o Display the current viewing state digitally on the screen,
- o Provide two different interfaces for viewing control:
 - * A Command Language Interface (CLI), and
 - * A Graphics Menu Interface (GMI),
- o Both interfaces:
 - * Allow changing only those viewing parameters which need changing,
 - * Permit exact desired parameter values to be set, and
 - * Provide an option to put the viewing into a standard state,
- o The Command Language Interface (CLI):
 - * Allows user to input either parameter change or new parameter value,
 - * Handles all parameters in exactly the same manner,
- o The Graphics Menu Interface (GMI):
 - * Requires user to select the parameter change,
 - * Handles all frequently changed parameters in the same manner,
 - * Allows user to specify size of the menu on the screen, and
 - * Employs adaptive coding to maximize efficiency.

The eight-parameter (A, D, B, S, V, X, Y, and Z) viewing specification presented in Section 2.3 is employed in the user interface. The azimuth (A) and dip (D) of the line of sight are natural parameters because of their correspondence with the angles measured by the compass-person during the surveying process.

The Cartesian coordinates (XYZ) of the point in the cave displayed at the center of the screen are also natural, in the sense that if you want a particular survey station at the center of the screen, then make the center coordinates equal to that station's coordinates.

The relative scale (S), and the vertical exaggeration factor (V) are only occasionally used in traditional cave mapping. The former is implicitly used in enlargements of certain areas of a map, the latter in 3D renditions usually also showing surface features. The bank angle (B) has no obvious counterpart in traditional cave mapping.

The eight viewing parameters are digitally displayed at the bottom of the screen (see Figure 6 of Wefer (1989b) and Figures 5 and 6 below for examples). These digital readouts are updated whenever a viewing change is made, so that they are always current. The vertical exaggeration factor is displayed immediately after the relative scale, but only when it is not unity.

Having two different user interfaces available means that the caver can employ whichever is more comfortable. The CLI commands and the GMI options are identical, hence the caver really has to learn only one interface to know both. The caver can switch interfaces instantly while viewing a Stage-4 cave map.

Having each frequently changed parameter accessible for change at any point in time makes the process fast and efficient. If a particular parameter does not need to be changed, the caver does not have to take any action relative to that parameter.

If the caver knows the exact desired value of a viewing parameter, it is possible to set that exact value using either interface. Input techniques like "sliders", "valuators", and similar "widgets" do not work well in such situations. The chosen input techniques provides exact control.

While exploring a big cave system on a computer it is possible to get lost. A reset option (command "RS") returns the user to a standard viewing state which is, of course, user defined, for example:

```
A_tDB = (0., -90., 0.)  
S=1.  
XYZ = (0., 0., 0.).
```

This viewing state is a plan view with true north vertical on the screen, a relative scale of unity, and the origin of the coordinate system at the center of the screen. Whatever vertical exaggeration factor (V) is in effect is preserved. While sloggng my way up long wet pitches in deep caves I have many times wished for such an option! With the origin of the virtual space coordinate system at the entrance of the cave, "click" and you are there.

The CLI allows the user either to input the parameter value (via commands of the form "P= n.nn") or to input the change to be applied to the parameter (via commands of the form "P+ n.nn" and "P- n.nn"). All eight viewing parameters are handled in the same way.

The GMI allows the user to select the change in viewing parameter. This is a result of providing a GMI to CLI commands of the form "P+ n.nn" and "P- n.nn". All viewing parameters are handled in the above described manner except the vertical exaggeration factor (V). Experience with ICM has indicated that once V is set, it is seldom changed. This means that its control need not be as efficient as the control of the more frequently changed parameters. Not including V in the GMI also results in a simpler and more compact menu.

The size of the menu can be changed by the user while viewing a map. This means that until one becomes familiar with the locations of the options in the menu, the menu can be made large and easy to read. After the user is familiar with the interface, the menu can be made much smaller, thereby reducing the inevitable interference between the menu and the cave being displayed.

Different graphics systems provide different input hardware devices for graphics input. Adaptive coding means the computer program knows what computer it is running on and uses techniques particularly appropriate for that computer in order to increase the efficiency of the interface. For example, graphics menu selections are made on a Megatek 7255 graphics terminal with a single button joystick, while on a SUN 3/260 graphics workstation this is done via a three-button mouse. The program should know which system it is running on and make appropriate use of the available input device.

6. THE ICM GRAPHICS MENU INTERFACE FOR VIEWING CONTROL

The portion of the ICM GMI for viewing control is shown in Figure 4 below.

```
1000  -X+ -Y+ -Z+
100    -X+ -Y+ -Z+
10     -X+ -Y+ -Z+
1      -X+ -Y+ -Z+
30.0   -A+ -D+ -B+
10.0   -A+ -D+ -B+ -S+
1.0    -A+ -D+ -B+ -S+
0.1    -A+ -D+ -B+ -S+
```

Figure 4. The Graphics Menu Interface for viewing control used in program ICM is illustrated. The letters (X, Y, Z, A, D, B, and S) indicate the viewing parameter to be changed. The numbers (1000, 100, 10, 1, 30.0, 10.0, 1.0, and 0.1) indicate the amount of the change to be applied. The "+" or "-" signs indicate the direction of the change and are the only pickable objects in the menu.

6.1 BASIC VIEWING OPERATIONS

The viewing control menu contains eight rows and five columns. At the left end of each row is a number indicating the amount the viewing parameter is to be changed ("n.nn" in the CLI discussion above). The top four rows control

viewing parameters X, Y, and Z (the center coordinates). The bottom four rows control viewing parameters A, D, B, and S (the view angles and the relative scale).

An example of how the menu works will make the operation clear. Placing the cursor of the pick device (joystick or mouse) on the "-" sign to the left of the "A" in the row beginning with 10.0 and pushing the button decreases the azimuth of the line of sight by 10.0 degrees, as illustrated in Figure 5 below. Moving down one row, but otherwise picking the same thing would decrease the azimuth by 1.0 degree. Similarly, picking the "+" sign next to the "X" in the row beginning with 100 would increase X by 100 meters.

Note that only the "+" and "-" characters can be picked in this menu. If the user places the cursor on any other character and pushes the button, nothing happens (or at user option, a message is displayed in the alphanumeric window of the screen).

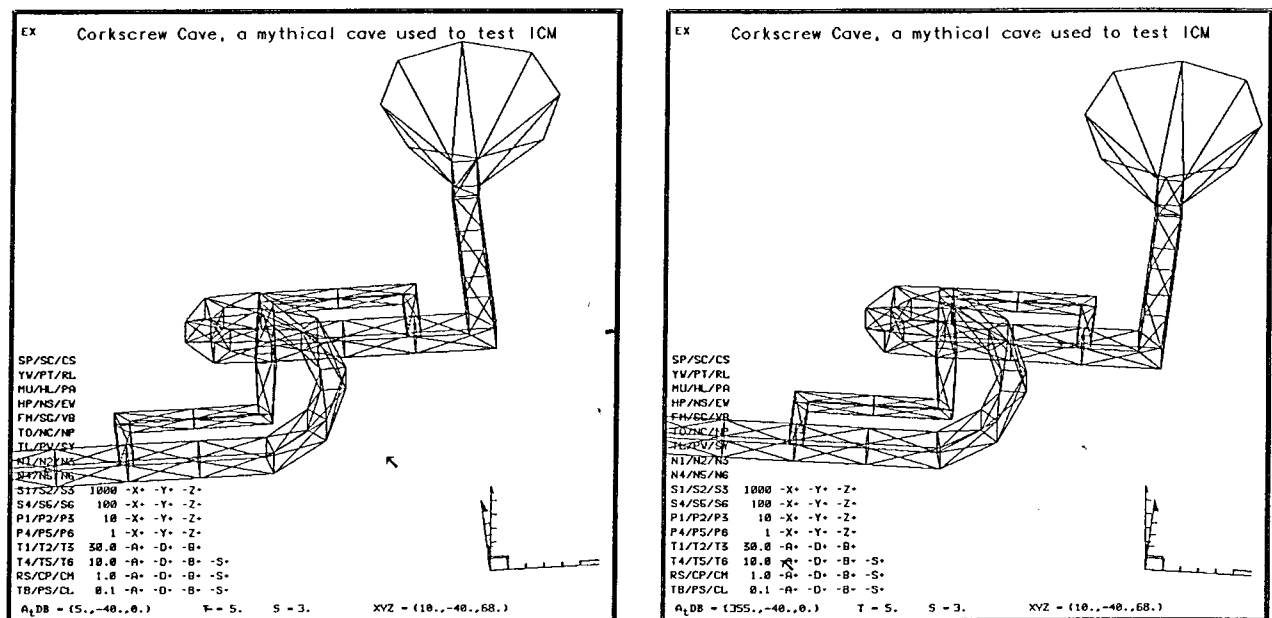


Figure 5. Decreasing the azimuth of the line of sight by 10.0 degrees using the ICM GMI for viewing control. The same change could be accomplished via the CLI by entering the command "A- 10.0". Note the pinned north/scale near the lower right corner of the viewport.

The cave shown in hardcopies of Stage-4 cave maps in Figure 5 above is a fictitious cave used for testing program ICM. The spiral passage, vertical shaft, and sinkhole entrance have been very useful in debugging the FORTRAN subroutines which draw passage walls from cross sections. It is used again in Figure 6 below.

6.2 ADAPTIVE CODING

Adaptive coding is best understood by an example. Using the menu shown in Figure 4, the user can cause a clockwise rotation in azimuth by 90 degrees in several ways. The most straightforward way is by picking the "+" next to the "A" in the 30.0 degree row of the menu, three times in succession. Adaptive coding provides other more efficient ways.

On a Megatek 7255 the user can place the joystick cursor on the same character, then press down and hold the joystick button until three changes have been applied. ICM detects that the joystick button is being held down and repeats the viewing change until the button is released. Each viewing change takes about one second to apply (the time between the application of changes is user settable).

On a SUN 3/260 the user can place the mouse cursor on the same character, then press the right (number 3) mouse button. ICM applies three times the selected change. Pressing the center (number 2) mouse button causes ICM to apply twice the selected change. Pressing the left (number 1) mouse button causes ICM to apply exactly the selected change.

If the caver prefers to employ the CLI, a menu option called "CL" on a portion of the GMI not shown in Figure 4 switches ICM to keyboard input of command language commands. The command "GM" switches the program back to the GMI. Other options of the GMI and the corresponding commands of the CLI are discussed in later papers of this series.

6.3 EXPLORING A CAVE

This section shows a sequence of viewing changes presented to give the reader a glimpse of what it is like to explore a cave with ICM. The plots are hardcopies from a SUN 3/260 workstation equipped with a three button mouse. The following discussion explains what was picked using the GMI to change the viewing, and also lists the CLI command equivalents. If you get confused, looking at the pinned north/scale at the lower-right corner of the screen should help.

The upper-left plot in Figure 6a is the initial state for the sequence. The digital readouts indicate that this is a plan view ($D = -90.0$ degrees) with a relative scale of $S = 1.8$, and with the point in the cave whose coordinates are $X = -40.0$, $Y = 30.0$, and $Z = 40.0$ meters at the center of the screen. We also see that the north is "true north" and that the north/scale tic marks are 5 meters apart. The bank angle remains 0.0 degrees throughout the sequence.

The upper-right plot in Figure 6a shows the effect of picking the "+" sign to the right of the "A" in the "30.0" row via mouse button number 2. The CLI equivalent of this is the command "A+ 60.0". The azimuth of the line of sight has been increased to 60.0 degrees. Note the rotation of the pinned north/scale along with the cave.

The lower-left plot in Figure 6a shows the effect of picking the "+" sign to the right of the "D" in the "30.0" row via mouse button 2. The CLI equivalent of this is the command "D+ 60.0". The dip of the line of sight has been increased to -30.0 degrees. The 3D nature of the map is now apparent.

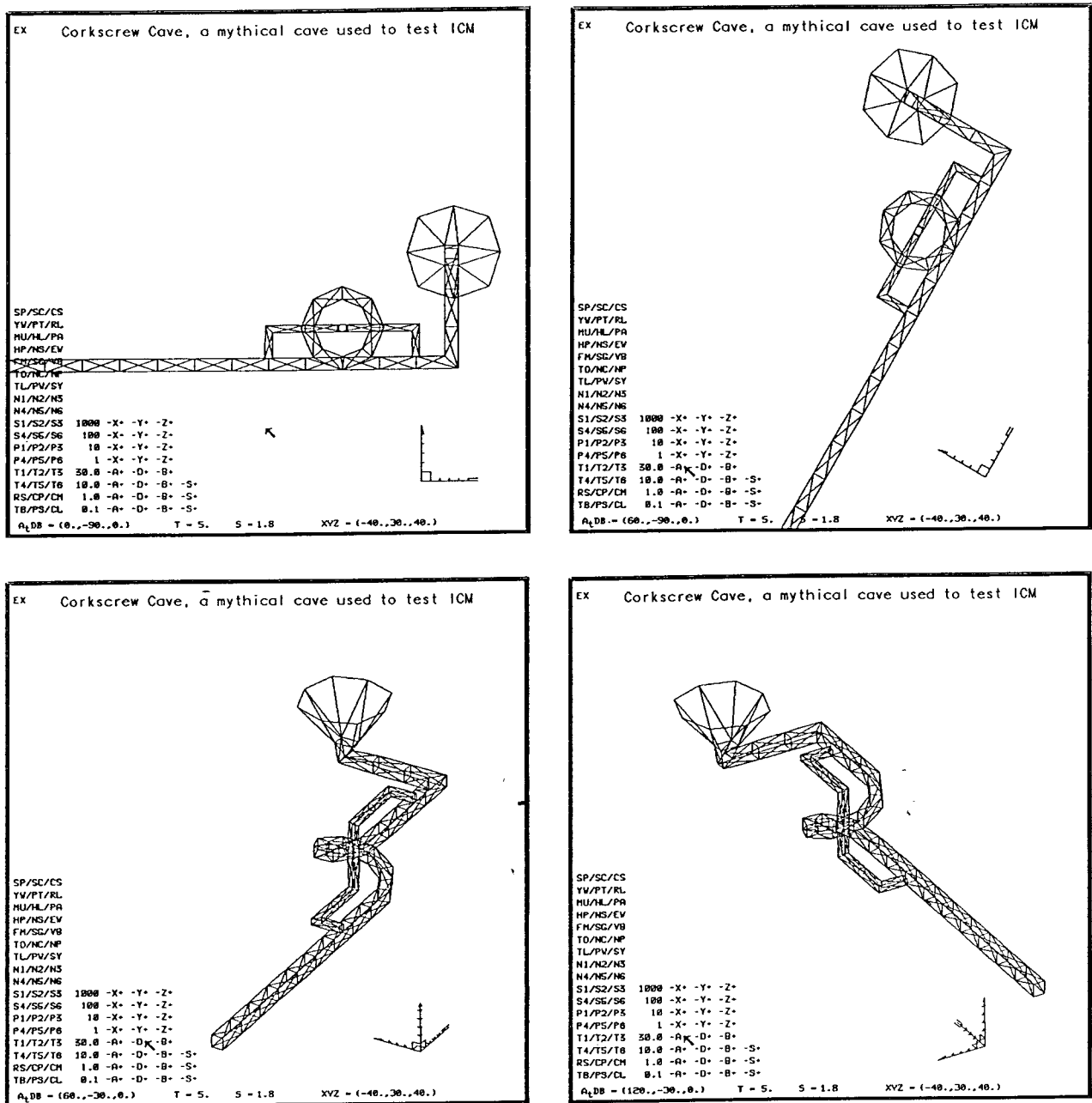


Figure 6a. Hardcopies of an example of a sequence of viewing changes used to explore cave passages on a Stage-4 cave map.

The lower-right plot in Figure 6a shows the effect of picking the "+" sign to the right of the "A" in the "30.0" row via mouse button number 2 again.

The sequence is continued in Figure 6b below. The upper-left plot in Figure 6b shows the effect of picking the "+" sign to the right of the "S" in the "1.0" row via mouse button number 1. The CLI equivalent of this is command "S+ 1.0". The relative scale of the map has been increased to 2.8 .

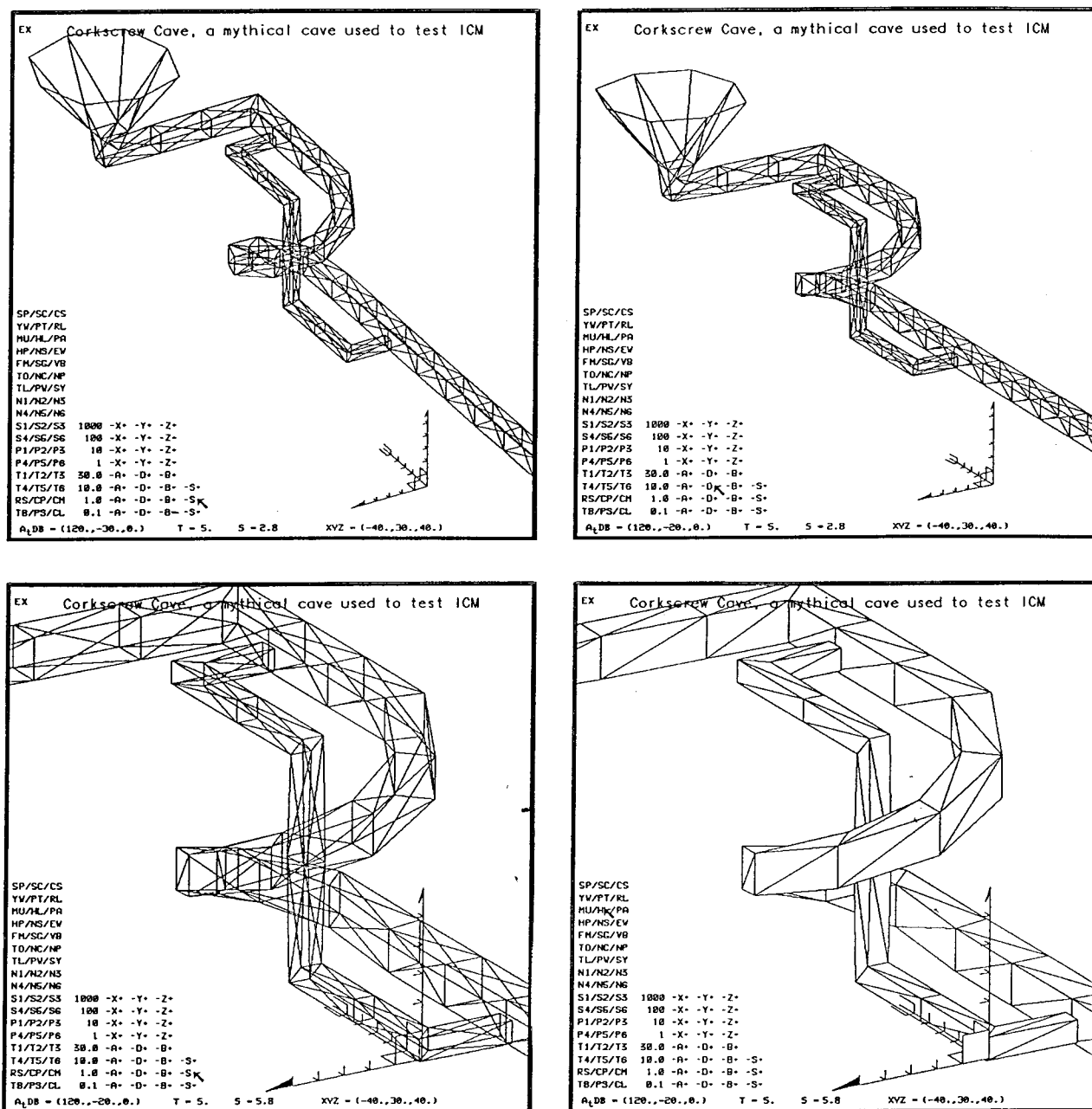


Figure 6b. Hardcopies of an example of a sequence of viewing changes used to explore cave passages on a Stage-4 cave map.

The upper-right plot in Figure 6b shows the effect of picking the "+" sign to the right of the "D" in the "10.0" row via mouse button number 1. The CLI equivalent of this is the command "D+ 10.0". The dip of the line of sight has been increased to -20.0 degrees.

The lower-left plot in Figure 6b shows the effect of picking the "+" sign to the right of the "S" in the "1.0" row via mouse button 3. The CLI equivalent of this is the command "S+ 3.0". The relative scale of the map has been increased to 5.8. Because of the increased magnification, only a small portion of the cave is now visible on the screen.

The lower-right plot in Figure 6b shows the effect of picking the menu option "HL". This is not a viewing change. Picking this option instructs ICM to remove all lines which would not be visible were the cave a solid object and the limestone transparent.

6.4 NUMBER OF VIEWING STATES

The lower-right plot in Figure 6b was included to make the point that viewing options constitute only a portion of the options available in ICM. And that brings up an interesting question. Considering only viewing options, how many meaningfully distinct viewing states are there?

In ICM the number of "meaningfully distinct" viewing states depends strongly on the cave being viewed. To get a rough idea, suppose one is exploring a cave whose maximum extent in X is about 1,000 meters and in Y and Z only 100 meters, essentially one long straight horizontal passageway. Then one can estimate the number of meaningful X values at about 10, Y at about 2, and Z perhaps only 1. Experience with ICM has shown that, except for some special cases, a change in A and D of about 10 degrees is required to get a significantly different view, hence there are 36 meaningfully distinct values of A and 18 of D. The number of relative scale values used is typically about 5.

The number of meaningfully distinct viewing states for this cave is just the product of all these. It is approximately 65,000! With a traditional cave map, or even a Stage-3 cave map, the number of viewing states is normally not more than 3, i.e., the map may contain a plan view and perhaps two profile views in different directions.

7. SUMMARY AND DISCUSSION

Viewing in computer graphics is a subject which is inherently somewhat complicated. The discussion presented herein has sought to make it a little more understandable. Viewing control in 3D is one of the most important operations performed with Stage-4 cave maps. The constraints imposed by: the viewing being changed quite frequently, the trial and error nature of exploring a cave, and the caver not being an expert in computer graphics, all must be taken into account. The requirements for viewing control for Stage-4 cave maps have been defined.

The ICM graphics menu interface and its corresponding command language interface make viewing control relatively easy to perform. These interfaces are: fast and efficient, involve a minimal number of steps, allow setting exact parameter values, support undoing as well as doing, are easy to understand, learn, and use, and are natural for cave surveyors.

The next paper of this series discusses other options available in ICM, in particular those used to control the content of Stage-4 cave maps.

8. SOME TECHNICAL NOTES

This section is included for readers familiar with the terminology and technical details of CORE. In this paper the term "viewing" is used to describe several operations. In ICM the cave data (station coordinates and labels, cross sections, symbols, etc.) are read from data files stored on disk. This data is used as inputs to 3D graphics primitives (lines, text, and polygons), which then pass through the modelling system (coordinate system operations) and viewing system ("real" viewing operations) and are stored in graphics segments and display list subroutines. When the caver interactively changes the "viewing", ICM applies a different segment image transformation to two segments, one containing the cave, the other containing the pinned north/scale to produce the requested view of the cave. See Wefer (1985) for more details.

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CARTOGRAPHIC SALON

announcement by George Dasher

All entries must be delivered to George Dasher or posted in the Cartographic Salon exhibition area by Monday afternoon, July 9, 1990; or mailed to George Dasher (108 Shawnee Drive, Buckhannon, West Virginia 26201), postmarked no later than June 1, 1990. Cost is one dollar per entry.

Entries must be representations of caves or cave-related features. It is strongly suggested that copies be entered, not originals. There is no restriction on the method of presentation and innovative techniques are encouraged. The length of cave should be listed on the map or on a separate paper, since the maps will be judged in categories based on length. In addition, maps can be displayed in the Salon but --at the cartographer's request-- not judged.

Judging will occur at Convention, and a critique of the Salon and the Salon entries is scheduled for the Friday morning of Convention. This critique is open to all interested individuals, as well as the cartographers of the individual maps.

All maps will be donated to the NSS unless previously specified by the entrant. (If the entrant will not be at Convention, he or she can specify in writing that a third person can pick up the map, or the map will be returned by mail, provided the return postage is included with the entry fee.) No map will be reproduced without the entrant's or cartographer's explicit authorization.

THE CALIFORNIA CONVENTION

by Carol Vesely

As I understand it, the primary responsibility of the Vice Chairman of the Survey and Cartography Section is to organize the Section's sessions and events at the annual NSS Convention. Being from California, the location of this year's convention, its not surprising that I was selected as vice chairman for this year. This article is to fill you in on what promises to be one of the best conventions ever.

General

The 1990 NSS Convention takes place in Yreka, California from July 9 to 13. The organizers have been working hard for over a year now to insure that this convention will be one of the best yet. The location is superb. Camping will be at a fairgrounds, with several buildings where exhibits, including the map and photographic print salons will be held. The vending area, vertical contest and a food concession stand will so be at the fairgrounds, but sessions will be held about three miles away at a Community Center and high school. Food will also be available at restaurants and fast-food places within easy walking distance of the campground. An attractive, park-like area complete with picnic tables and shade trees located in the center of fairgrounds will serve as a fine gathering place. There are both lava tubes and limestone caves within easy day-trip distance of the convention and several pre- and post-convention trips planned. There will be the traditional events such as the Howdy Party, Banquet, etc. plus some additional California events such as a wine tasting party and ice cream

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social. I won't go into all the details. Instead, I will concentrate on those items which pertain specifically to our section.

Survey and Cartography Session

The convention program has not yet been finalized so I do not know what day our session will be held, but rest assured that since I am also the organizer for the International Exploration Session, the Survey and Cartography Session can not be scheduled at the same time. Actually, I am trying to make sure that our session does not compete with the U.S. or California Exploration Sessions either, but I can't promise you this.

The Survey and Cartography Session is only as good as you make it. Its not too soon to start thinking about topics you might want to present. Last year Robert Cronk gave a talk about surveying in Rumania, which was extremely interesting and very well received. I would like to hear from anyone with experience surveying with cavers from other countries, where different techniques are used. Specific topics I would like to cover include: book keeping and data recording; standardization of sketching; drafting and publishing and reproducing maps of large cave systems. If you are involved in any large scale cave survey projects or have some suggestions of topics you would like to see addressed, please contact me.

Survey and Cartography Luncheon and Meeting

At the convention planning meeting that I attended in December, we discussed various options for the location of section luncheons. There will not be any general cafeteria at this convention as there has been at some others in the past. There are several reasonable restaurants nearby, but we were concerned that if the meetings were held at a restaurant everyone might have to fork over several bucks to eat and the restaurant might frown on those who wanted to brown-bag it. The other possibility would be to have the meetings at the patio or central park area at the fairgrounds. People could buy their food at the nearby concession stand and no one would feel excluded. The convention committee was going to investigate the restaurants before making a decision, but so far more people were in favor of having the section meetings at the fairgrounds.

Map Salon

As I mentioned earlier the Map Salon will be held in a large exhibit hall located at the fairgrounds. Because only cavers will have access to the fairgrounds, the building will be open to allow map viewing anytime during the day or evening. There will be other events, exhibits and vendor sales going on in other buildings nearby, so the Map Salon will not be isolated.

I have spoken personally with Convention chairman, Michele Richardson, and she has assured me that the Map Salon will be allowed to present awards on Thursday night immediately before the Photo Salon. We will have enough time to call the medal and all the ribbon winners onto the stage for recognition.

I think one of the primary purposes of the Map Salon should be to educate cartographers, and cavers in general, about what makes a good map. By the time the map salon occurs George Veni, George Dasher and I should have the new point system worked out for judging. The new system should make this the best map salon ever. All maps will receive points in a series of categories, thus providing contestants with specific feedback on the strong and weak

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points of their maps. In addition to providing useful information to the cartographers, I would also like to educate cavers in general about maps. I would like to see a large posterboard, explaining the judging criteria and categories, displayed at the entrance to the Map Salon room. Then, by each of the winning maps there could be a score sheet showing how many points that map received in each category. (To avoid potential embarrassment, score sheets would not have to be displayed for maps that did not win a ribbon, if the cartographer objects.) The poster and score sheets would be very informative even to the non-cartographers, and of even greater benefit to those wishing to enter maps in future salons.

Another idea worth considering is trying to find a way to get donations from speleo-suppliers, so that we can offer actual prizes instead of just ribbons to the map salon winners. Wouldn't it be great to win a new compass, survey tape, drafting pen or survey book for all your hours of effort drafting a map? If anyone thinks this is a good idea and would care to help solicit donations, please let me know.

Cartography Workshop

In the past I have led a beginning cartography workshop at other conventions and regionals. This has always been well received and I think another one should definitely be held this year. However, I will be rather busy at convention this year and wouldn't mind if someone else took over this responsibility. Running the workshop requires about half a day and is actually quite fun. I have slides of maps, overhead transparencies that show the map making process, handouts of map symbols and descriptions of projects that I have used in the past. In addition, the convention committee will be charging a fee for the workshop to cover supplies. If anyone is interested in running this workshop please contact me.

Meanwhile I would like to organize an advanced cartography workshop. Rather than teach neophytes the basics of how to draft a map I would like to have a discussion amongst experienced cartographers. We could address such topics as: how to portray complicated, multi-level cave passage, how to publish maps of large cave systems, new equipment and techniques and other topics.

Other Workshops

At past conventions there have been workshops on beginning surveying techniques and an introduction to sketching. I hope we can provide similar workshops this year, but someone must volunteer to organize them. I spoke with program chairman Gary Mele to assure that the survey workshop proceeds the beginning cartography workshop as this is the more natural order of things. If you are interested in organizing either of these workshops please contact Gary or me.

Join Us

The California Convention has the potential to be one of the most exciting and different conventions in recent years. But a convention is only as good as we make it. Please volunteer your time and ideas by giving a presentation, participating in a discussion session or contributing in any way you can to making this a truly memorable convention.

Please send abstracts, ideas etc. to: Carol Vesely
709 S. Primrose. Ave. #A Monrovia, CA. 91016 or call me at (819) 357-6927.

THE NSS CARTOGRAPHY SALON ORGANIZATION AND JUDGING CRITERIA

by the SACS Cartographic Salon Committee

The following is an explanation of how the NSS' Cartographic Salon works, and the criteria by which the maps are judged. The intent is to provide uniform standards by which the maps can be fairly judged, and to aid cartographers in developing better cave maps.

The Cartographic Salon is held each year at the National Speleological Society's annual Convention. Prior to the Convention a Salon announcement is placed in the NSS News. Maps can then be mailed to the Salon Chairperson, or they can be hand-carried to the Convention. A nominal fee of one dollar is charged to cover the costs of the ribbons, the medal, and other Salon expenses. Maps can also be posted at the Salon solely for display. These maps must be indicated as such and will not be charged the one dollar fee.

Prior to, or at the start of the Convention, the Salon Chairperson will select three judges from different parts of the country to judge the submitted maps. These judges --and the Salon Chairperson may be one of the three-- will be experienced cave map cartographers and will not have maps entered in the Salon that year.

Usually the judges will divide the maps into three classes determined by the length of the caves. The length of the classes may be modified at the judges' discretion, based on the number of maps and their cave lengths. If warranted by enough or unusual entries, the judges may create special classes such as Color Usage, Computer Cartography, Complex Representations, Topo Overlays, etc.

The judges first look for certain mandatory features, without which a map will not be considered for an award. Second, the judges will look at various quality factors and assign appropriate point values to each factor. All maps are assumed to begin with ten points for each factor. If less than ten points are given for an item, the judge will provide the reason for the deduction in the "Comments" portion of the judging form.

Following the first round of judging, where the judges each will work individually, the point totals will be tallied for all the maps by combining the judges' scores. A maximum of 210 mandatory points is possible, plus 18 perk points for a total of 228 points. All maps scoring more than 200 points (a figure the judges may raise or lower based on the year's entries) will receive at least an Honorable Mention (Green Ribbon). From the Honorable Mentions picked within a length class, the judges will confer and nit-pick to select a winner for the class. That winner will receive not a Honorable Mention, but rather a Merit Award (Blue Ribbon).

Finally, the judges will confer and nit-pick among the Merit Awards and select the Salon's overall Medal Winner. The Medal winner will not be given the Merit Award in that map's length class. Instead, that Merit Award will be given to the next best map in the Medal Winner's length class. The Merit and Medal winners will be selected independently of the point totals.

CAVE NAME:				JUDGE:																						
CLASS: (check)	<input type="checkbox"/> 0-500 M <input type="checkbox"/> 0-1640 Ft	<input type="checkbox"/> 500M - 1.6Km <input type="checkbox"/> 1640 Ft - 1 Mi	<input type="checkbox"/> > 1.6 Km <input type="checkbox"/> > 1 Mi	<input type="checkbox"/> SPECIAL																						
MANDATORY REQUIREMENTS: <table style="width: 100%; border: none;"> <tr> <td style="width: 60%;">Cave Name</td> <td style="width: 20%; text-align: center;">Y</td> <td style="width: 20%; text-align: center;">N</td> </tr> <tr> <td>Obvious Entrance or Connection</td> <td style="text-align: center;">Y</td> <td style="text-align: center;">N</td> </tr> <tr> <td>North Arrow</td> <td style="text-align: center;">Y</td> <td style="text-align: center;">N</td> </tr> <tr> <td>Bar Scale</td> <td style="text-align: center;">Y</td> <td style="text-align: center;">N</td> </tr> <tr> <td>Vertical Control</td> <td style="text-align: center;">Y</td> <td style="text-align: center;">N</td> </tr> <tr> <td>Date</td> <td style="text-align: center;">Y</td> <td style="text-align: center;">N</td> </tr> <tr> <td>Cartographer or Survey Group</td> <td style="text-align: center;">Y</td> <td style="text-align: center;">N</td> </tr> </table>						Cave Name	Y	N	Obvious Entrance or Connection	Y	N	North Arrow	Y	N	Bar Scale	Y	N	Vertical Control	Y	N	Date	Y	N	Cartographer or Survey Group	Y	N
Cave Name	Y	N																								
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Other Comments -- (please use the back of this form if necessary)																										

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After the awards are posted, a Cartographic Salon workshop and discussion will be held in the Cartographic Salon at 10:30 am on the Friday of the Convention. The purpose of the Cartographic Salon is not to glorify the so-called best map, but to provide a forum for discussion and learning from which all cave cartographers may benefit.

All critique forms will be returned to those cartographers present at the workshop and discussion on Friday. Those critique forms not picked up will be mailed to the individual cartographers by the Salon Chairperson. All maps not picked up at Convention will be donated to the National Speleological Society. Maps can be picked up by a third party provided the cartographer has informed the Salon Chairperson in writing that this is the cartographer's wishes. Maps will be returned by mail, provided the cartographer has given or mailed the Salon Chairperson the required postage before the end of the Convention. No map will be reproduced in any way without the cartographer's express permission.

The following is a discussion of the criteria by which the maps will be judged.

Mandatory Requirements:

Cave Name: All cave maps must have a name. This name should neither be too bold or too hard to locate. Abbreviations should not be used in the cave name.

Obvious Entrance or Connection with the Rest of the Cave: All cave maps must have an entrance or a connection with the rest of the cave. If this entrance or connection is not obvious on the map, it should then be marked and made obvious. If the map is of a section of the cave, then the connection of that section with the rest of the cave should be obvious or marked. If the map is a quadrangle that connects to other quadrangles, then the places where a cave passage "runs off" the edge of the quadrangle are considered as the obvious connection and do not have to be further marked.

North Arrow: All cave maps must have a north arrow. This arrow should point to true north and, if the cartographer wishes, can include a subordinate magnetic north arrow. A magnetic north arrow by itself is not to be desired; however, if it is shown--either with or without a true north arrow--a date must be displayed with the magnetic north arrow.

Bar Scale: All cave maps must have a bar scale. This bar scale must include the linear units. The cave map can include two bar scales, one for meters and one for feet. Ratio scales, such as 1:600, or written scales, such as 1" = 50', are not desired because, when the map is reduced or expanded, the scale will then be inaccurate.

Vertical Control: All maps must have some kind of vertical control. Usually this is shown as either a profile or as vertical symbols. Both methods can be utilized together. If a profile is used, there should be a vertical bar scale. If vertical symbols are used, the map should be noted as to whether the units are in meters or feet. These vertical symbols should include cave elevations, pit depths, ceiling heights, and water depths, as needed. Instead of the two popular North American methods of showing elevations, the cave map can utilize contours, either drawn inside or outside the cave passage.

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Date: All maps must include a date. Features change, both inside and outside of the cave. Although the magnetic north arrow is often used as the cave map date, the cave map date should be separate from the magnetic north arrow date.

Cartographer or Survey Group: All cave maps must include the cartographer or the survey group's name. Thus, if someone is interested in the cave--be they either a geologist, biologist, or another exploratory group--they can contact the cartographer or the original survey group concerning the cave.

Quality Factors:

Balance and Layout: Does the cave map appear well balanced to the eye? Are some areas of the map blank while other areas are crowded? Did the cartographer make good use of his or her space?

Drafting-Technical Quality: How technically correct is the drafting? Are the line widths consistent? Do the lines end and blend well, without blobs of ink? Are the symbols drawn well? Are the symbols correct? Are the outside walls of the cave obvious?

Visual impact: Does the cartography make the map the cave seem interesting or boring? Overall, how 'good' does the map look?

Lettering: Is the lettering even and consistent? Is it too small or too big? Is it all evenly spaced, both horizontally and vertically. Is the lettering easy to read?

Detail Thoroughness: Is there too little detail? Is there too much detail? Does it extend into every passage? Is it consistent throughout the entire map? Is the detail easy to understand or is it confusing? Are even the more mundane floor features shown? Is ceiling detail shown? Does the detail match the legend or the list of symbols utilized? Would a caver be able to use the map to navigate through the cave?

Vertical Control: How well is the vertical explained? Has the cartographer adequately dimensioned ceiling heights, pit depths, cave elevations, and water depths. Are there too few symbols to fully comprehend the vertical nature of the cave? Horizontal caves are no exception! Is the Profile View large enough and well centered enough to be understood? How well does the Profile View match the Plan View? All cave maps which use vertical symbols and all maps of caves with more than one entrance should have a zero datum. This datum should be a precise, labeled point and should be included on any profiles. Leader lines to each vertical symbol's exact location in the passage may or may not be used. If elevation symbols are used, this elevation can be of either the cave floor or the individual survey station, but the technique used should be noted on the map.

Legend or Symbols Credit: Is there a legend or is a symbol credit given? All non-standard cave symbols should be explained or formatted into a legend.

Still other items can be used to enhance the cave map. These include, but are not limited to: Site Details, such as geology and surface features; Complex Representations, such as multi-level caves or cave passages; and Imaginative Innovations, which enhance the

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understanding up the cave. Up to two "Perk" points are given to these items if they are well executed.

Finally, there are many secondary features which are often included on the cave map. The use, or lack of use, or poor usage of these features should be considered when the judges assign point values in the various categories.

Cultural Location: This is usually included on all cave maps. A few maps, however, because of the sensitive location of the cave, do not include the cultural location. Abbreviations should not be used in the cultural location.

Precise Geographic Locations: This is a hot potato. Some cartographers include them, others do not. If latitudes and longitudes are used, then which latitude and longitude should be stated on the cave map; i.e., are they north, south, west, or east? If UTM is used, then the UTM zone should be stated on the cave map. If state plane coordinates are used, then which state plane coordinate system should be stated. Elevations are always above some datum, such as Mean Sea Level. This should be noted on the cave map. Abbreviations are not recommended.

Cross-Sections: These are very important and can often be used to easily determine the relationships of the various cave passages to each other. When at all possible, they should be included on the cave map. Detail inside the cross-sections should be shown and this detail should match the detail on the Plan and Profile Views. Cross-sections should only be omitted in the most complex, crowded maze caves, and only then after much soul-searching and teeth-gnashing. Cross-Sections can either be drawn next to the cave passage or away from the passage and then flagged with letters or numbers. Cross-Section lines should be arrowed to show the direction of view, and they should be consistent and should not be confused with passage lines or detail.

Type of Survey: This is very important. While North American cave surveyors disdain from using grades, the map should be noted as to its type, i.e., Topofil, Brunton and pace, or Suunto and fiberglass tape. In addition, loop closure accuracy may also be included.

Borders: All maps should include a border, some include double borders. Maps have won green ribbons in the past without borders; however, this is the exception, not the rule.

Length and Depth of the Cave: Most maps include the length and depth of the cave. The linear units must be included. The length of caves can be measured by one of two methods, surveyed or horizontal length. If no method of measure is noted on the map, it is then assumed that the length is the surveyed length. The depth of the cave is the difference between the elevations of the highest and lowest station or point in the cave.

Personnel: it is always a nice touch to say who helped map the cave; however, this is occasionally omitted.

Credit can be given to the project leaders, the people who reduced the data, and the cartographers. A thank you can also be given to the landowner or the appropriate government agency.

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Survey stations should not be shown on the final map, except if the map will be used for future geological, biological, paleontological, etc. work.

State or Province Cave Code Numbers can be displayed on the map. This should be done in an unobtrusive manner but it can be placed in the title block. The code number should not be included in such a way that the reader must have "inside" knowledge of the survey to understand the code.

An unobtrusive artistic drawing of the cave entrance or some feature in or around the cave can be included if the cartographer so wishes. These can enhance the map a great deal.

Unobtrusive notes on the geology, biology, history, or whatever can be included on the map if the cartographer so wishes.

Copyrights are also common on many cave maps.

The SACS Cartographic Salon Committee was comprised of George Dasher, Bob Gulden, Tom Kaye, Doug Roberson, George Veni, and Carol Vesely.

31 December 1989

BOOK REVIEW

by Rich Breisch

Courbon, Paul, Claude Chabert, Peter Bosted and Karen Lindsley (1989) Atlas of Great Caves of the World. St. Louis, Missouri: Cave Books, 8 1/2 x 11 inches, softbound, 369 pages.

In the Fall 1986 issue of Compass and Tape, I gave a very favorable review of Atlas des Grandes Cavities Mondiales written by Courbon and Chabert. This review is about the English translation of that book. In actuality, Atlas of Great Caves of the World is not just a translation, but also an update of the world's great caves. Bosted translated the book from French to English and then added new material about recent explorations. The sections on the United States and Mexico have the most additions of new caves and maps. Lindsley designed the book and provided an index and table of contents, features which the French edition did not have. Chabert updated cave lengths and depths. Art Palmer wrote the preface to the English edition and expanded on his introduction to caves of the United States.

Both books start with an introductory chapter which lists world record depths, lengths, largest rooms, deepest pits, etc. It also lists largest caves in various nonlimestone rock types, such as lava, granite, salt, conglomerate, and gypsum. Surprisingly no one has compiled a list of long sea caves of the world.

The following chapters are organized by continent. It seems unusual to me that North and South America are treated as one continent, while Europe and Asia are treated as two; but that is a small matter. Each continent is organized by country within that continent. For each country there are two lists, one of its deepest caves and a second of its longest caves. The cutoff criteria varies from country to country. For example, the section on France describes 51

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caves with depths greater than 500 meters. The depth criterion for the USA is 200 meters, and it has 22 caves greater than that.

The book has about 200 maps of caves which are either more than 700 meters deep, or over 30 kilometers long, or are of special interest. Often maps have not been redrawn even though significant discoveries have been made in them since 1986. Especially for European caves, the 1986 maps are shown with new depth or length records listed at the edge of the map.

The world's longest cave is, of course, Mammoth Cave in Kentucky. It is over three times as long as the next longest cave, Optimisticeskaja in the USSR. USA has nine of the 32 caves in the world which are longer than 40 kilometers. We also have 359 caves which are at least 3 kilometers in length; the top 100 of which are listed in the atlas. The USA has far more long mapped caves than any other country, with Spain and France following.

The USA does not possess really deep caves. Columbine Crawl Cave in Wyoming has a depth of 472 meters, and Lechuguilla Cave is second deepest at 458 meters. By my count, 12 countries have a total of 269 caves deeper than Columbine Crawl. They include Algeria, Morocco, Canada, Iran, Lebanon, Norway, Poland, West Germany, Papua New Guinea, and other countries which, at least to me, do not stand out as countries with large numbers of world class caves. This book is very valuable in removing regional biases about the significance of our own explorations. I found it very enlightening to compare the maps and depth figures of our caves against the deep caves of Europe, Asia, and Australasia.

Several characteristics of the book I really liked. One is that there is no reference to English units of measurements. (An exception to this is the name "1000' Waterfall" on the map of a Canadian cave.) Some translators might have also included lengths or depths in feet or miles instead of just meters, but Bosted and Lindsley have chosen not to do that. Finally American cavers are moving towards a more international outlook when it comes to measurements!

A second improvement is providing data about more small countries even though their caves are not large when measured on an international scale. Caves in the following countries are briefly described but were not mentioned in the French edition: Angola, Anguilla, Antigua, Barbuda, Cambodia, Chad, Cyprus, Dominican Republic, Dutch Antilles, El Salvador, Equatorial Africa, Mauritania, Niue, Palau, Paraguay, Somalis, Vanuatu, and Vietnam. My review of the 1986 book noted that Easter Island, Pitcairn Island, and Antarctica all had caves but were not mentioned in the book. I now note that Easter Island is included under Chile, but Pitcairn and Antarctica are not listed. Possibly their caves are still unmapped.

The authors did an excellent job at compiling this book from hundreds of sources from around the world. I recommend this book for cave explorers with an international bent, cave mappers, and armchair cavers. A book like this is necessary for a person to appreciate the variety and difficulty of the world's caves.

SURVEY INSTRUMENT MAINTENANCE UPDATE

by Ian McKenzie, Alberta Speleological Society, Canada

With the rising cost of Suunto survey instruments, caving suppliers like Bob & Bob are instead offering Sisteco instruments, less expensive but similar in appearance and operation to the Suunto. Sistecos are a little easier to read, with larger numbers on the compass or clino wheels, but there are internal design problems that make them prone to trouble.

Suunto compass or clino modules are kept firmly in place within the aluminum body by a set screw, tension against the rubber ring which also provides a partial dirt and moisture seal and four flanges fitted into slots in the body of the instrument. Sisteco instruments have none of these design features except for the set screw which I have found to be improperly set in at least one instrument, and instead rely on a nominal dab of glue to prevent module rotation. This glue is brittle and will crack after very little use, allowing the module to rotate internally causing misalignment of the crosshair and viewing lens with the viewing port.

Because of this problem and the lack of a proper seal, it is imperative that Sisteco instruments be sealed around the face perimeter with epoxy prior to use. If hard use eventually cracks this epoxy, rotation and dirt infiltration will result, and repair will be necessary. Disassembly and repair procedures have already been described in "Suunto Instrument Maintenance" in Compass & Tape volume 5 number 1, but the following additional information for Sisteco instruments should be noted.

Sisteco bodies have no hidden slots to intersect. I managed to excavate through the aluminum body under the back plate from the drill hole with a sharp knife, to admit the prying screwdriver. It should be noted that a hand drill rather than a power drill is to be used for all drilling, as a power drill is too difficult to control and may damage the module. Don't worry if you bend the backplate out of shape when removing it; it flattens out nicely with a hammer. The two problems of rotation and moisture/dirt infiltration can be solved by applying a thin veneer of silicone seal or bathtub sealant around the rim of the module face, being careful to keep this off the viewing lens and wiping any excess from the external module face and body rim once the module has been replaced. More silicon seal around the module body prior to replacing the back plate should provide a non-brittle, impact resistant bond. Light taps with a hammer onto some sort of punch (a screwdriver will do) around the rim of the replaced Sisteco backplate will re-countersink it, Suuntos are flush. After allowing the silicone to dry, seal the face in the usual manner with epoxy to protect the silicone from abrasion. Smearing the epoxy with your finger gives a smooth, comprehensive finish.

Another occasional problem with both Sisteco and Suunto clinometers is sticking of the clino wheel. There is no way to repair this problem without major surgery. After disassembling the instrument and draining the fluid in the regular manner, carefully drill through the middle of the face of the module with a 3mm bit to access the brass screw, and loosen this off until the wheel swings freely; too far and the wheel will rub on the side of the module. Don't be alarmed by the excessive swinging of the loosened wheel; this will be damped when the fluid is replaced. This surgery requires careful resealing of the drillhole with a bit of plastic (from another smashed instrument if you've got one) and a soldering gun to ensure fluid cannot leak; the seal can be tested by gently squeezing the repaired module to see if fluid weeps through the patch. If its okay, add a layer of Crazy Glue for insurance.

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The repaired module looks horrible, has a bubble in it and may be less durable than before, but a sticky clino is as good as garbage anyway so you have nothing to lose by trying. If nothing else, you will have the experience, extra parts and extra fluid for your next repair job if you make a major mistake the first time.

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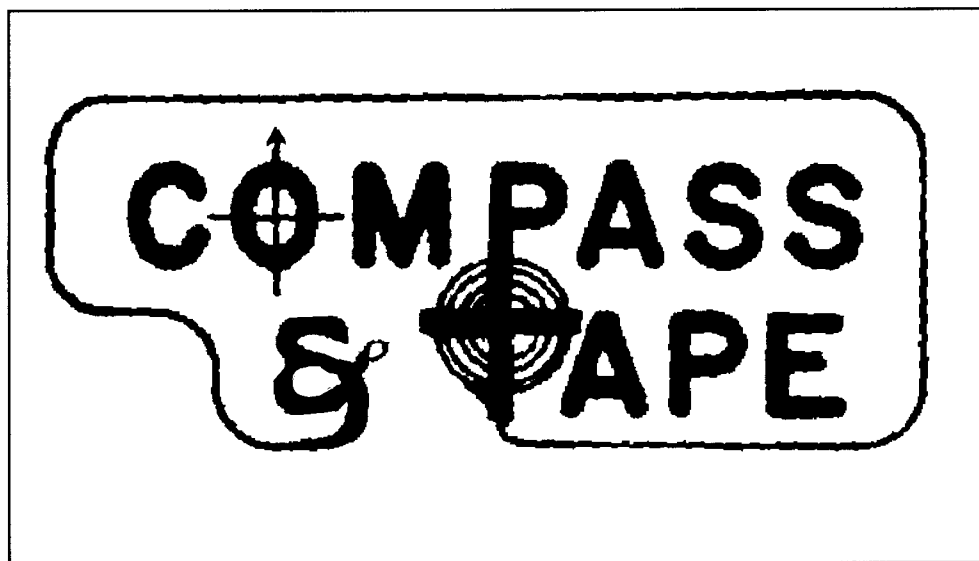
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