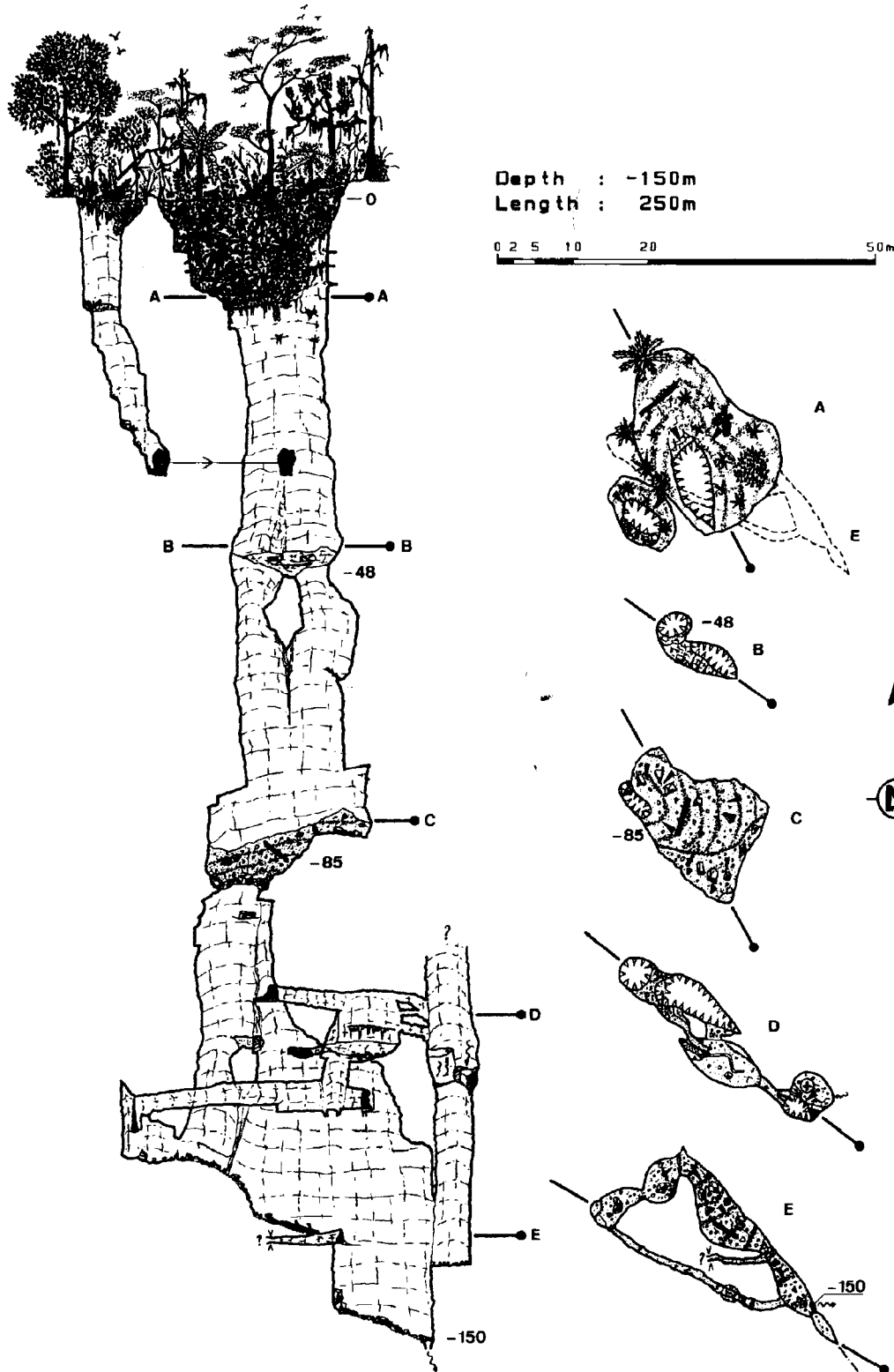


Compass & Tape

Volume 14, Number 3, Issue 47

Throat Pit



Survey and Cartography Section



The Survey and Cartography Section (SACS) is an internal organization of the NSS that is devoted to improving the state of cave documentation and survey, cave data archiving and management, and of all forms of cave cartography.

Membership: Membership in the Section is open to anyone who is interested in surveying and documenting caves, management and archiving of cave data and in all forms of cave cartography. Membership in the National Speleological Society is not required.

Dues: Dues are \$4.00 per year and includes four issues of *Compass & Tape*. Four issues of the section publication are scheduled to be published annually. However, if there are fewer, then all memberships will be extended to ensure that four issues are received. Dues can be paid in advance for up to 3 years (\$12.00). Checks should be made payable to "SACS" and sent to the Treasurer.

Compass & Tape: This is the Section's quarterly publication and is mailed to all members. It is scheduled to be published on a quarterly basis, but if insufficient material is available for an issue, the quarterly schedule may not be met. *Compass & Tape* includes articles covering a wide range of topics, including equipment reviews, techniques, computer processing, mapping standards, artistic techniques, all forms of cave cartography and publications of interest and appropriate material reprinted from national and international publications. It is the primary medium for conveying information and ideas within the U.S. cave mapping community. All members are strongly encouraged to contribute material and to comment on published material. Items for publication should be submitted to the Editor.

NSS Convention Session: SACS sponsors a Survey and Cartography session at each NSS Convention. Papers are presented on a variety of topics of interest to the cave mapper and cartographer. Everyone is welcome and encouraged to present a paper at the convention. Contact the Vice Chair for additional information about presenting a paper.

Annual Section Meeting: The Section holds its only formal meeting each year at the NSS Convention. Section business, including election of officers, is done at the meeting.

Back Issues: SACS started in 1983 and copies of back issues of *Compass & Tape* are available. The cost is \$1.00 each for 1-2 back issues, \$0.75 each for 3-6 back issues and \$.50 each for more than six back issues at a time. Back issues can be ordered from the Vice Chair.

Overseas Members: SACS welcomes members from foreign countries. The rate for all foreign members is US\$4.00 per year and SACS pays the cost of surface mailing of *Compass & Tape*. If you need air mail delivery, please inquire about rates. All checks MUST be payable in US\$ and drawn on a U.S. bank.

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From the Editor

Most all of the cave maps that we see in *Compass & Tape*, at the convention Cartographic Salon, in our local grotto publications and a significant proportion of those in the *NSS News* are done by American cartographers. And though we Americans make some pretty good maps, there are many international cartographers who do fantastic and innovative work. This issue of *Compass & Tape* features maps from some of the best international cartographers. Raul Puente from Mexico did the map on page 5. Many of his fine maps are published in the *AMCS Newsletter*. Alan Warild from Australia produced the very innovative map on page 6. British cartographer Colin Boothroyd made the map of Good Luck Cave (which contains the Sarawak Chamber) on page 17. And finally, the superb map on the cover of this issue was done by Pierre Yves Jeannin, a Swiss cartographer. Check out more examples their work in the publications listed.

Front Cover: Throat Pit, Pozo, Oaxaca Mexico
Cartographer P.Y. Jeannin
(from *Proyecto Cerro Rabon Report, 1990-1994*)

Back Cover: The Perfect Shot
by Ralph Hartley

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SUBMISSIONS

All types of materials related to cave survey and survey data, cartography, and cave documentation in general, are welcome for publication in *Compass & Tape*. Manuscripts are accepted in ANY form but are most welcome on 3.5 inch diskettes either IBM compatible or Mac format or via email. Typed material is next best although we will accept handwritten material as long as it is legible. Artwork is any form, shape or size is also welcome

Send all submission for *Compass & Tape* to:

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Letters to the Editor

The following letters are in response to Larry Fish's article "How Common Are Blunders in Cave Survey Data?" (Compass & Tape, Volume 14, No. 46). Fish's rebuttal follows.

From Bill Mixon:

Larry Fish writes, in his article on blunders in *Compass & Tape* Volume 14 No. 46, "Because of the way the statistics work, any loop error greater than two standard deviations over the prediction has a 95.4% chance of being blundered."

I'm not an expert at statistics, but I don't think that's how statistics work. Assuming the distribution of loop errors, suitably scaled by length of loop and so on, is a standard distribution, which is dubious but generally assumed, the correct statement is that if there are no blunders at all in the survey and the instrument readings have the average errors Fish used in his computation, then 95.4 percent of loops will have total errors within two standard deviations of the expected average. This means that, even in the complete absence of any blunders, 4.6 percent of the loops he looks at will not, and half of those, or 2.3 percent, would be tallied as blundered. (The 4.6 figure includes both tails of the distribution, loops that are "too good", as well as loops that are "too bad.")

Given the strong dependence of the "blundered" criteria on the assumed compass error, as shown in his graphs, a considerable excess of alleged blundered loops over the expected 2.3 percent could well reflect the fact that the actual compass errors are greater than his test assumed. In a three-dimensional maze like Lechuguilla or Lilburn or a cave with lots of tight crawls like Wind or Groaning, it seems likely that average compass errors might very well exceed 2 degrees, especially with Suuntos, which can be very difficult to sight accurately on inclined

shots or from awkward places, and a 10-degree compass error doesn't strike me as all that impossible. Of course, the figure of 2.3 percent is itself only an average outcome to be expected when there is a large number of loops (and all other assumptions of the test are met).

One in forty perfectly ordinary loops will be called blundered by Fish's test, and if an underestimated compass error figure is used, many more than that. A better test would be something like four standard deviations, but even then one might detect only the exceptional loop that contained a lot of shots really difficult to make. No doubt all of the survey data sets that Fish has analyzed do contain some blunders, but he hasn't helped to count or find them.

From Bob Thrun:

In *Compass & Tape*, Volume 14, No. 46 Larry Fish presented the number of loops with blunders that COMPASS found in several caves. This is not a very meaningful figure. COMPASS finds a set of overlapping loops. A single blunder can be in many loops. The amount of overcounting depends on the survey network topology, where the blunders are, and even the order that the data are presented to COMPASS.

Figures 5 and 6 of my article, "A Comparison of Simultaneous and Sequential Closure Adjustment Methods" in *Compass & Tape*, Volume 14, No. 44 show the same network, a 4 by 4 grid with 9 small squares forming one big square. If a minimal length set of loops were found, such as in Figure 5, a blunder in the interior of the network would be in two loops, while a blunder along the perimeter would be in one loop. This alone would overcount blunders. COMPASS overcounts even more.

Figure 6 shows the overlapping loops that COMPASS finds. There are two places where a

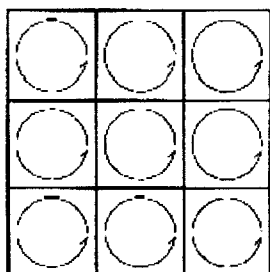


Figure 5. Fundamental cycles of a graph.

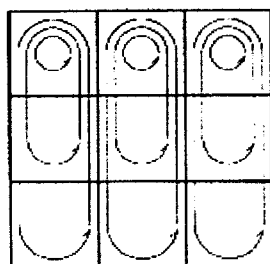


Figure 6. Overlapping loops found by COMPASS.

From "A Comparison of Simultaneous and Sequential Closure Adjustment Methods" by Bob Thrun in *Compass & Tape*, Volume 14, No. 44

single blunder would appear in 6 loops.

I suspect that Lechuguilla has less than 365 (1142 times 0.32) blunders. Fulford Cave and Cave of the Winds, each with two loops with blunders, might actually have only one blunder.

Incidentally, COMPASS understates the loop length by one survey shot.

Rebuttal from Larry Fish:

Bill Mixon and Bob Thrun have raised several issues in their letters that I would like to address. I'll start with Bill's letter. First, in my article, I stated that a loop that exceeds the predicted error by two standard deviations has a 95.4% chance of being blundered. As Bill points out, this

not exactly correct. The actual situation is more complicated.

If you have 100 loops in which there were only random errors, you would expect that, on average, only about 4 of them would exceed two standard deviations. If you have more than 4 loops, it means that these loops cannot be explained by random processes. In other words, if more than 4.6% of your loops exceed two standard deviations, the excess can probably be explained by blunders. You will notice that, with the exception of Roppel, all the caves in my chart have significantly more than 4.6% of their loops exceeding two STD's.

But that is only part of the picture. It is important to note that the threshold is at two standard deviation. Most of the loops were much greater than two standard deviations. As you move beyond two standard deviations, things change rapidly. Only one in 80 should exceed 2.5 STDs. Only one in 384 should exceed three and only one in 2149 should exceed 3.5. Bill makes an argument for using four STDs as the threshold, but only one in 15,789 should exceed four. Personally, I'd be suspicious of any loop that exceeded two and pretty nervous about any loop that exceeded 2.5.

Bill makes passing reference to counting "both tails" of the distribution and counting "loops that are "too good," but that isn't the way it works. If you were to repeatedly resurvey a loop, the errors of each resurvey would cluster around the final station in a "cloud" of points. The points furthest away from the "real" location of the final station would represent the "tails." Thus, "both tails" represent the largest errors.

Bill quibbles with my choice of 2 degrees for compass errors. But, part of the point of the article was to raise questions about what the real value should be. Two degrees was chosen as a starting point because I've seen this value given

Comp/Inc STD	Tape STD	Lech % Blnd.	Wind % Blnd.	Lilburn % Blnd.	Roppel % Blnd.
0.5	0.025 ft.	79.5	75.4	68.5	68.5
1.0	0.050 ft.	56.1	52.9	39.5	25.5
1.5	0.075 ft.	40.5	36.4	22.3	7.5
2.0	0.100 ft.	32.0	25.8	14.7	2.4
2.5	0.125 ft.	26.0	19.6	12.2	0.3
3.0	0.150 ft.	21.2	16.1	10.5	0.0
3.5	0.175 ft.	17.3	13.8	9.7	0.0
4.0	0.200 ft.	14.1	11.8	8.8	0.0
4.5	0.225 ft.	12.6	10.2	8.8	0.0
5.0	0.250 ft.	11.4	9.2	8.4	0.0
5.5	0.275 ft.	10.2	8.2	7.6	0.0
6.0	0.300 ft.	9.2	7.7	7.6	0.0
6.5	0.325 ft.	8.3	7.1	7.6	0.0
7.0	0.350 ft.	8.0	6.4	7.6	0.0
7.5	0.375 ft.	7.4	5.9	7.6	0.0
8.0	0.400 ft.	7.0	5.4	7.1	0.0
8.5	0.425 ft.	6.6	5.2	7.1	0.0
9.0	0.450 ft.	6.4	4.9	7.1	0.0
9.5	0.475 ft.	6.2	4.3	7.1	0.0
10.0	0.500 ft.	5.8	4.1	7.1	0.0
10.5	0.525 ft.	5.7	3.9	7.1	0.0
11.0	0.550 ft.	5.5	3.8	7.1	0.0
11.5	0.575 ft.	5.5	3.8	6.7	0.0
12.0	0.600 ft.	5.1	3.6	6.7	0.0
12.5	0.625 ft.	4.9	3.1	6.7	0.0
13.0	0.650 ft.	4.7	2.9	6.7	0.0
13.5	0.675 ft.	4.6	2.9	6.3	0.0
14.0	0.700 ft.	4.5	2.9	6.3	0.0
14.5	0.725 ft.	4.3	2.8	6.3	0.0

Table 2 from "How Common are Blunders in Cave survey Data?" by Larry Fish, *Compass & Tape*, Vol. 14, No. 46

as the accuracy for Suunto compasses. If you read the second half of the article, the 2 degree value is clearly called into question. For example, I pointed out a "Compass Points" article that found 6 degree errors when experienced surveyors were tested on a simple above-ground survey course. I also estimated that the compass STDs for Lechuguilla and Wind are 7.5 and 5.5 degrees. (Note: In the article, there is a typo in the chart and the "7" digit is missing from the Lechuguilla data.)

Bill says that he wouldn't be surprised to see compass errors of 10 degrees, but could a 10 degree error ever be called random? Would you

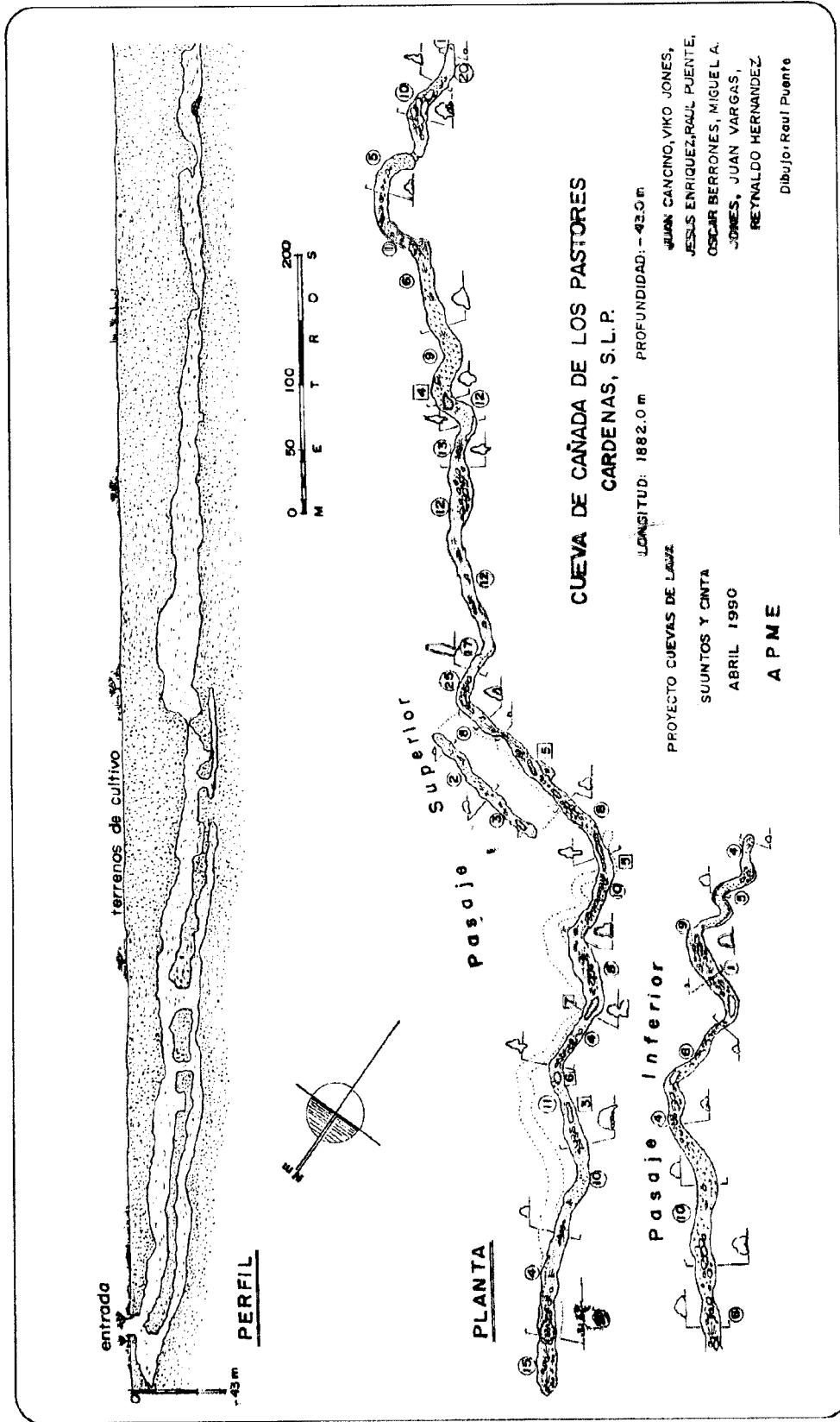
ever expect an entire cave with compass STD's of 10 degrees? No matter whether you call them random errors or blunders, I think that I would want to resurvey any survey with 10 degree compass errors.

Bob Thurn's critiques are more to the point. Yes, when you have interconnected loops, a single blunder may be counted more than once. And yes, under some circumstances, COMPASS will over-count blunders. (In fact, COMPASS uses this overlap of loops to help zero in on blundered shots.) However, it should be pointed out that once you have determined that a loop has a blunder, there is no way to know if there are actually two, three, four or more blunders. So, under the same circumstances, you can also under count blunders.

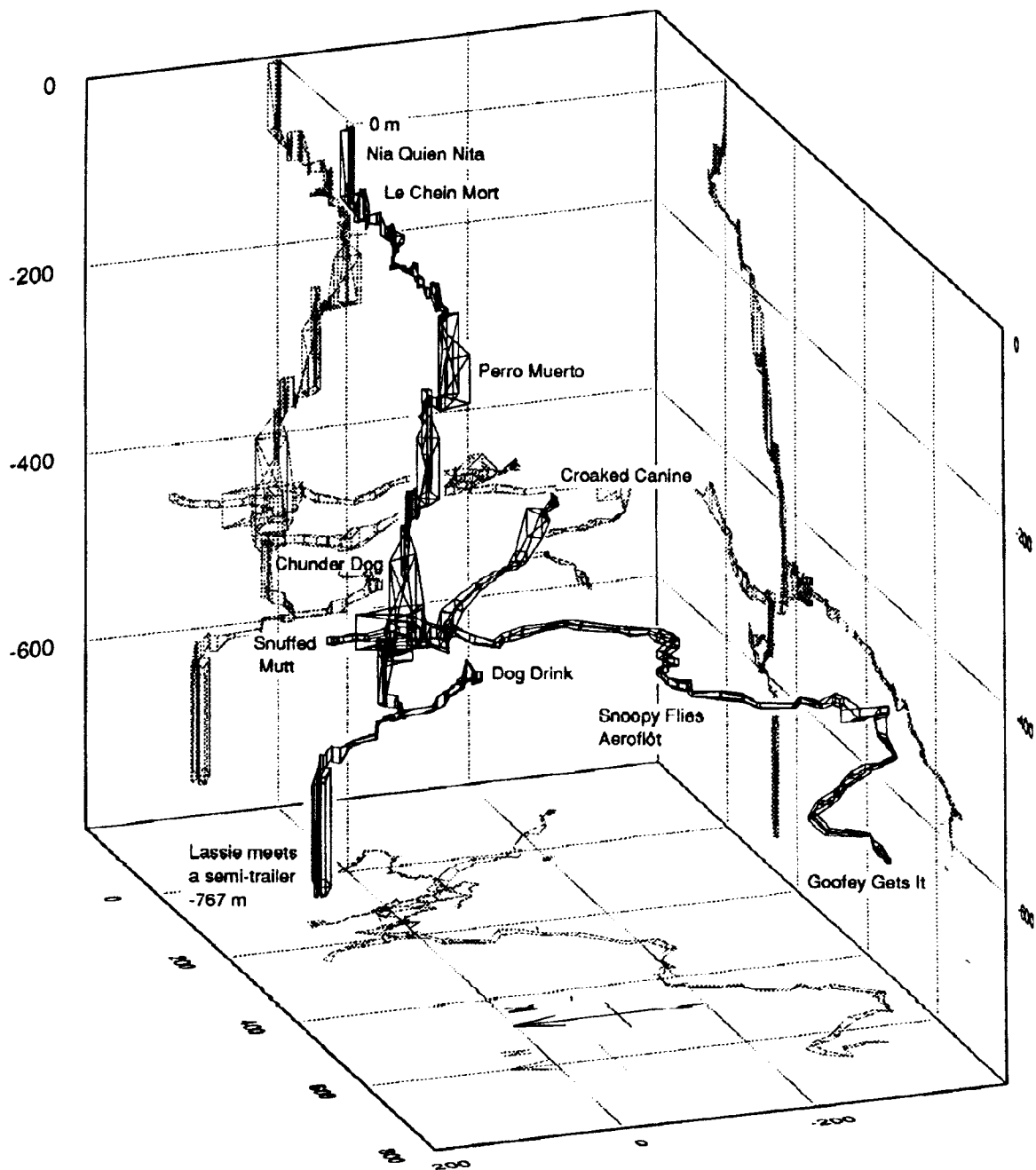
Bob and Bill seem most concerned that I haven't calculated a precise value for the number of blunders for each cave. But that wasn't the point of the article. What I wanted to do was raise some questions about the prevalence of errors. Here are the important questions:

1. What are the standard deviations of our instruments? Before you can make any determination of the quality of a survey, you have to know the quality of the measurement you can expect from your instruments. I have seen numbers in print in the range of one to two degrees, but it seems more likely to be in the range of three to seven degrees.

2. How common are blunders? Everything I see suggests that they are fairly common, particularly if you don't do back sights and rigorously double check your data. Even if you disagree with the number of blunders I have calculated, there are lots of other things that indicate that blunders are fairly common. For example, when Paul Burger (one of the pickiest surveyors I know) resurveyed Cave of the Winds, he caught one blunder in every twenty shots. When I asked Jim Borden why Roppel data was so superior to the data from the rest of the caves, one of the things he sighted was finding and fixing all blunders.



From AMCS Activities Newsletter Number 19, Cartographer, Raul Puente



NIA QUIEN NITA

- Dead Dog Cave

767 m deep 3.1 km long
Zongolica - Chilchotla,
Edo. Oaxaca, México
Surveyed by Santa Ana '90,
using tofophil, January 1988
and February 1990

© Santa Ana '90

From AMCS Activities Newsletter Number 19, Cartographer: Alan Warild

2000 NSS Survey & Cartography Section Meeting Minutes

June 28, 2000

NSS Convention - Elkins, West Virginia

by George Dasher, Secretary

The 2000 meeting of the Surveying and Cartography Section of the National Speleological Society was held on Wednesday, June 28th, 2000 in conjunction with the NSS' annual convention. The Convention took place in the Band Room at the Elkins High School, in Elkins, West Virginia. Attending were the following 32 members and friends of the Section:

Linda Andrews, Robin Barker, Roger Bartholomew, Jim Borden, Kevin Carriete, Barry Chute, Hubert Crowell, George Dasher, Nevin Davis, Thom Engel, Harry Fair, Frank Filz, Mike Futrell, John Ganter, Bob Gulden, Ralph Hartley, Bob Hoke, Rod Horrocks, Paul Jorgenson, Pat Kambesis, Chuck Laun, Doug Medville, Nancy Pistole, Andrew Slater, Scott Stepemuck, Dave Taylor, Bob Thrun, Carol Vesely, Cyndie Walck, Bill Walter, Arnie Wesibrot, Jim West

Chairman Carol Vesely called the meeting to order at 1:05 pm. She first introduced the five officers present herself, Roger Bartholomew, George Dasher, Bob Hoke, and Pat Kambesis and then she said that the previous meeting's minutes had been published in the Compass and Tape and there had been no corrections. She then asked the officers to give their reports.

Roger Bartholomew gave his Vice-Chairman report. He said he was currently looking for papers for the 2001 Convention, and that things had gone pretty well for the 2000 Convention. He said he

had gotten no papers by the 2000 Convention deadline, and that he had then sent everyone emails and postcards, and had received some papers.

Secretary George Dasher said that he had done nothing in the previous year.

Treasurer Bob Hoke said the Section has a lot of money about \$4300 at the end of last year, \$2800-plus of which is available for use. He said that the Section is making about \$1 per issue of the Compass and Tape. John Ganter added that this profit is due to the generosity of the D.C. Grotto, who is printing the C&T at present.

Bob said he had a list of people who should renew their membership, and he also said he had the required forms to join the Section. Carol asked if there was a lot of new people, and Bob said, Yes, there were a lot of unsolicited people who wanted to join the Section. Bob said that he felt this new influx of members was entirely due to the Section's webpage.

Editor Pat Kambesis then reported that she had wanted to have the next issue printed by this meeting, but that this had not worked out. She said she had enough material, but had not had time to complete the layout.

Carol said that, as had been approved at the last meeting, there would be a special issue of the C&T dedicated to the Cartographic Salon. This issue

The 1983 Convention of the

N.S.S. SURVEY & CARTOGRAPHY SECTION

will be held at 4100 Hwy. 100, Elkins, West Virginia, the
1983 N.S.S. Survey & Cartography Section
will be held at the convention.

General Officer

General Officer

General Officer

General Officer

General Officer

For more information contact: John Garrow
1011 Hwy 740
Elkins, W. Va. 26039
13-100-0001

Notice from the Survey and Cartography Section's first meeting which was held in Elkins, West Virginia at the 1983 NSS Convention.

would explain about the maps and the judging criteria. She also said she would like to see this special issue become a tradition. Carol said that Scott Schmidt had completed the 1999 Cart Salon issue, but that it had not yet been printed, and that Rod Horricks planned to do the 2000 issue.

Bob Hoke said that he routinely searched the exchanges of the D.C. Speolograph and sent out copies of the C&T to each cartographer he did not know. Bob also asked if the special issue would be paid for out of the membership's dues, and Carol said yes. Bob asked who was printing this issue. Carol said, You! She also said that the 1999 special issue was almost done, and that there were only two maps missing.

Rod Horricks then gave a report on the 2000 Cartographic Salon, and he said he had tried to continue the tradition begun by Hazel Barton and Don Coons; however, he had only divided the Salon into

two categories novice, where it was the entrant had never won an award in the Cart Salon, and experienced, where the entrant had previously won an award.

Rod also said he had dropped the Master Category and had divided the judging up between his two categories. He had used six judges, three for each category. He also said that 67 maps had been entered in the 1999 Salon and 30 in the 2000 Salon, and he hoped this wasn't the start of a downward trend.

There was some discussion of the Salon. Jim Borden said that this year's Salon had been located in a very good display area, and that the maps were all very high quality maps. Rod said he had divided the judging sheet into four sections, and George Dasher said that the vertical control, a mandatory item, had been omitted from the sheet, and that the

old George Veni scoring sheet had just provided for a “Yes” or “No” on the mandatory requirements, not a rating of the mandatory items. He thought the “Yes” and “No” method was better than the rating method. Rod said that Steve Reames would be the chairman of the 2001 Salon in Kentucky. Rod also expressed an interest in chairing the Salon again.

George Dasher then said that he thought the Cart Salon had been very well run this year, and everyone joined in thanking Rod Horricks.

Bob Thrun then gave a brief report on his “Introduction to Surveying workshop, which he said had taken place in two sessions, between 9 am and 12 pm in a classroom on Monday morning, and at 1:30 pm in Bowden Cave on Tuesday afternoon. Bob said that Ralph Hartley had been a big help on Monday, but that he had no help at all on Tuesday. This had been a big problem, as he had had to split himself between his four in-cave survey groups on that day. Bob said that the class had been limited to 25, but only 21 people had attended. He also said he had printed handouts for 40 people, and Carol asked if this was appropriate for publication in the C&T or if it could be put on the SACS website. Carol also asked if Bob would be willing to do his workshop again, and Bob said “Yes, if he could get some help.”

Carol then gave a report on her and Pat Kambesis’ sketching class. She said they had had 29 students, of which only about one-third were beginners. She said that no one attended the class who was new to surveying, and Bob Thrun added that his attendees were mostly new to surveying. Carol said the sketching classroom work had taken place on Tuesday morning, with the in-cave part in the afternoon this had again been in Bowden Cave. She thanked Pat, Cyndie Walck, Don Coons, Vivean Lotland, Nancy Pistole, and Dan Legini for their help with the workshop.

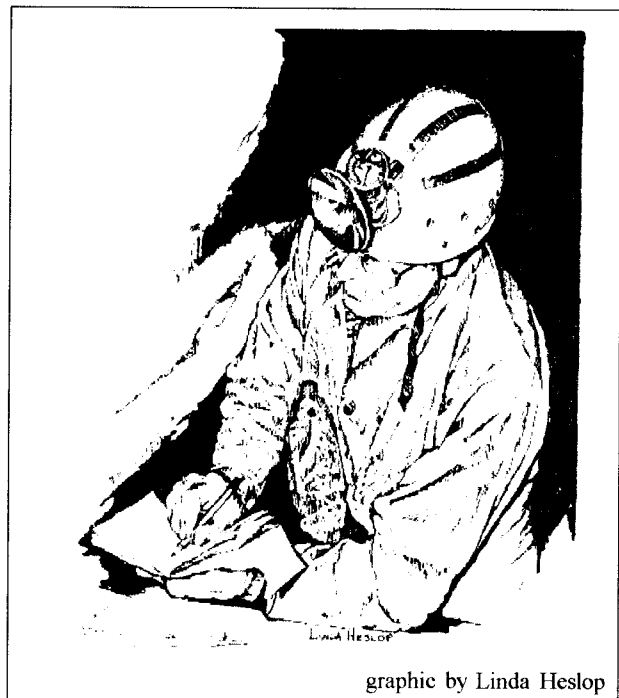
Both Carol and Pat said their students had done well and Carol said they had compared their sketches to each other to and to several photos they had taken

of the cave. Carl also thanked Paul Jagnow for making the little compasses and rulers that they had given each person to use. Bob Hoke asked if he could have a list of the workshop attendees, so that he could mail each of them a copy of the C&T.

Carol next asked if there was any Old Business, and when there was none, moved to New Business. (Secretary’s Note: I forgot to mention, under Old Business, that there had not been a single response to the computer-reduction-program questionnaire that I had been asked to put together by the Section two years ago, and which had been subsequently published in the C&T.)

Under New Business, Hubert Crowell said that he had retired from the Convention Survey Contest, and asked if anyone wanted to continue it. Bob Gulden said he had set up the OTR compass course behind the OTR pavilion, but that only one person had run it.

George Dasher said that he wanted to step down as the SACS secretary because he felt he was being overworked and starting to make some serious mistakes. Bob Gulden mentioned that this mistake was



graphic by Linda Heslop

losing the New Trout map. George also said he had also planned to step down as coordinating the Cart Salon, but that he would stay on as that, as he was doing nothing at present but giving advice, having the medal made, and maintaining the lists of winners.

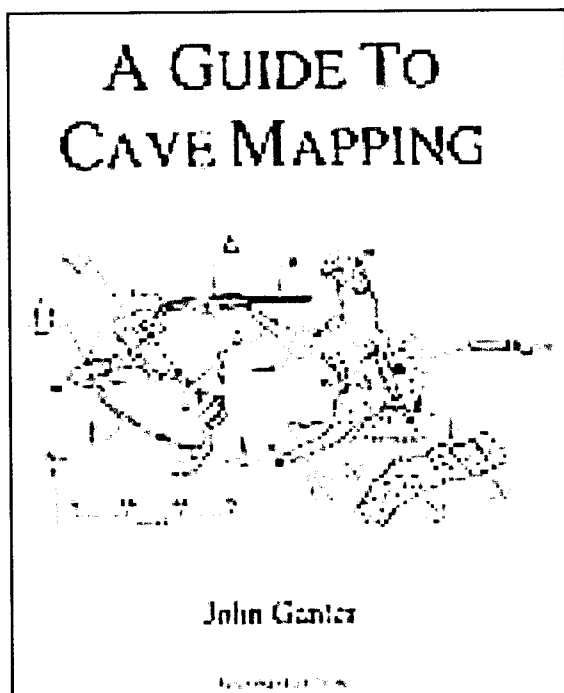
There was no additional new business, and Carol asked if there were any announcements. John Ganter said that it was 17 years ago, at the Elkins 1983 Convention, that the Section had been formed. He said he had recently found a card announcing that first meeting in the Elkins Pizza Hut, and he also said that the Section had quickly grown to over 200 members after it was formed.

Carol announced that Mike Walsh had given a talk in the International Session that pretty-much said, "Come to Mexico and Survey!! There are tons of leads and caves!"

George Dasher said that there was now a revised cave-surveying publication for sale at the NSS Book Store, and John Ganter announced that this was his Guide to Cave Mapping. John said that he had gotten the issue out early in 2000.

Carol said there was no more New Business, and that the elections were next. There was some discussion and in the end it was agreed that Bob would continue as Treasurer, Roger as Vice-Chair, Carol as Chair, and George as Secretary this last was despite the fact George said he would not be attending the 2001 Convention. Arnie Weisbrot made a statement of thanks to these people for their work, and for continuing to be the Section's officers.

Paul Jorgenson then made a motion to adjourn the meeting, which Arnie Weisbrot seconded. Everyone was in favor of adjournment, and the meeting was ended at 1:45 pm.



• A Guide To Cave Mapping by John Ganter is now available in a second edition.

This new edition reflects many of the developments in cave mapping practice and technology over the last 10 years, including:

- Sketching to scale and direction
- Computer survey plotting
- How traditional cave maps and computer-generated cave models compare
- World Wide Web sources of information
- Updated Bibliography
- Many new "Lessons Learned" on cave mapping and publication in the caving community.

The Guide is now available from the NSS Bookstore (<http://www.caves.org>) and other speleovendors

Survey and Cartography Session Abstracts NSS Convention 2000, Elkins, West Virginia

The Cartography Papers Session was held in two parts this year, one directly after the SACS Meeting on June 28th and the second on Friday afternoon, June 30, 2000. A good variety of papers were presented and both sessions were well attended. Following are the abstracts for the papers given.

Carto, a Software Tool for Cave Cartography

Ralph Hartley

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Carto is a tool intended for use by a cave cartographer. It is primarily intended to allow the preparation of conventional two dimensional maps in electronic form. The program has two main parts, a morphing system and a cad system. The morphing system takes as input processed survey data and scanned images of the in-cave sketches. The user marks the points on the image that correspond to stations and the program stretches the image so that the stations appear at their surveyed positions. Superimposing the morphed images produces a composite sketch that can serve as a working map. The cad system can then be used to "trace" over the sketch with standard map symbols, as well as user defined symbols. The cartographer can then experiment with different layouts, and either print the final map or distribute it in electronic form. Changes in the survey data (due to closing loops etc.) can be automatically reflected both the composite sketch and in the map symbology. A demo of the current state of development of the tool will be given. Carto (executable and Java) source is available free of charge from <http://www.psc-cavers.org/carto>.

Drafting a Simple Cave Map Using Vector Drawing Software - (Demonstration)

John Ganter

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Many cavers who use computers still draw maps manually. Ink on drafting film remains fast and effective for large maps, but drawing software can save significant time for small maps that have a lot of repetitive text. So what is the learning curve like and how do you get started? I will walk through a simple map drawing demo. First we will open a TIF file from a pencil-drawn draft map that has been scanned. We'll drop this on a "background layer" to trace over. Then we will switch to a "drawing layer" and trace the draft using the BeziGon tool. Finally we will add some text and move it around for the best layout. And the map is done. If there is time, we will look at Styles and the Graphics Hose, both of which can greatly increase productivity. I will use Macromedia Freehand, but the concepts demonstrated apply to Adobe Illustrator, CorelDraw, and other similar products.

High-Precision Surveys with a Brunton Compass

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A Brunton compass must be tripod-mounted to meet its full potential. With care, readings can

be interpolated to 0.1-0.2 degree with a magnifying glass. Sighting ease and precision can be improved by optical tricks, customized tripod mounts, sharpening the pivot, and sharpening the needle point with a shaped dab of lacquer. Older designs without magnetic damping have more precise needles. The compass must be calibrated to true north, preferably by sighting on Polaris and correcting for time and latitude. Correcting for needle eccentricity can reduce error considerably. With a transit, a compass course with at least 4 radiating lines is staked out, and a sinusoidal pattern of discrepancy in compass readings indicates the eccentricity. Without this correction, average closure errors are about 0.1% over multiple-station loops at least 500 meters long. To level the ballfield, Brunton entries in NSS survey contests have omitted the eccentricity correction. This correction reduces closure errors to within 0.05%, as shown by numerous loops in cave and surface surveys. Tripod mounting minimizes deflections caused by metal parts in helmets, eyeglasses, etc., and steeply inclined shots can be made accurately. Alternate foresights and backsights are most convenient, but repeated readings are required to catch blunders. These methods are not suited to all conditions, but surprisingly difficult terrain can be negotiated. They are best suited for specialized purposes, such as geologic mapping or running base lines through major passages.

How Accurate are Our Cave Surveys?

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In one of the earliest papers on cave survey errors, Denis Warburton compared the actual loop misclosures in cave surveys with theoretical expected errors. Following this lead, the CMAP survey data reduction program does a similar comparison. For this study the BCRA Grade 5 error specification was used instead of the CMAP defaults. The BCRA grade is the only standard that has a widespread acceptance, at least in some

countries. The most informative plot seems to be error ratio versus traverse length on a log-log plot. The plots consist of a cloud of points that can be used to judge a survey's accuracy, or at least its internal consistency. Many cave surveys of different types were studied. No survey met the expectations of the BCRA specification, though a few were close. A typical survey might have 2 to 4 times the Grade 5 errors. Poor surveys have 5 to 7 times the BCRA errors. The dispersion of the clouds was always wider than would be obtained from a single random error distribution. It may be possible to characterize the accuracy of a survey from the shape and size of the point clouds. The amount of adjustment or percentage adjustment are possible alternatives to error ratio for characterizing survey accuracy.

Reflectorless Total Station Survey and Three Dimensional Modeling of LickCreek Cave

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Reflectorless Total Station high precision survey technique was used to survey the ceilings and breakdown piles in the Rain and Cathedral Rooms in Lick Creek Cave, Cascade County, Montana. The survey employed a single baseline of 57.691 meters in the horizontal plane, by 26.743 meters in the vertical plane and utilized a single total station closure technique for stations referenced to the defined baseline. Point data were collected at approximately 5 degree intervals. A pseudo-random data collection technique was employed to normalize the differential distribution of sample point densities collected using the semi-system-

atic method. Horizontal and vertical circle closures for control network stations were within 3mm +2ppm making Least Squares Adjustment of loops unnecessary. Visualization of room geometries employed Delaunay Triangulation minimum distance algorithm based sub-routines in both Matlab 5.1 and Arc/Info 7.6. Triangulated irregular networks (TIN) were created for both ceiling and breakdown pile geometries. From the TIN'S, plan view contour maps were rendered in Arc/Info 7.6 and three dimensional volumetric representations were rendered using a grid normalization and iterative smoothing algorithm employed in Matlab 5.1. The resulting models accurately represent the rooms' macro-morphologies. Employment of the technique facilitates the survey and volumetric representation of large cave rooms, and shows promise for near real-time three dimensional mapping of cavernous karsts.

Visualization of Cave Survey Data in 3D Using ArcView GIS

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ArcView GIS is a popular desktop GIS used by Cave and Karst Managers to store and manage cave survey and inventory data as well as perform GIS analysis. The ArcView GIS 3D Analyst extension provides additional tools and capabilities that can be used to visualize cave survey data and other GIS layers in 3D. Several methods and techniques are available to incorporate cave survey data into the 3D Analyst, including surface drapes, direct 3D data conversion, incorporation of 3D DXF files, model construction using 3D panels, and other methods. An overview of current approaches and techniques will be presented, along with a discussion of issues and shortcomings that future work will need to address.

Wakulla 2 Expedition—3D Mapping

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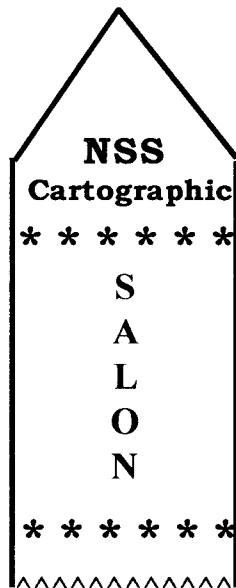
Baa0500@aol.com

During the 3 month Wakulla 2 Expedition, a total of 10 million wall points were imaged within Wakulla Spring, FL (averaging about 100 meter water depth). The total distance of passage that was digitally imaged was 6,409 meters, however, multiple passes were made through the same passages. Mapping missions resulted in traversing 21,256 meters of passage.

The Digital Wall Mapper (DWM) was designed and built for this expedition and has 32 sonar transducers spiraled around the front end which measure the distance to the walls 4 times/second. An inertial measurement unit keeps track of the location of the mapper using ring laser gyros and accelerometers. Nickel metal hydride batteries power the electronics as well as the motor that propels the unit through the water. The DWM is about 2m long and weighs about 150kg. It is neutrally buoyant and balanced to rest horizontally in the water.

The sonar produced a dense, precise image of the passage walls with detail unavailable through traditional forms of survey. The ring laser gyros accurately recorded angular changes by the DWM. The accelerometers built up error and mapping paths were significantly corrected by 38 cave radio locations. Additionally, passage locations were adjusted by matching sonar profiles.

The point cloud of wall points makes a complete map as is. However, the next step is to mesh the points into polygons to form solid walls and permit digital fly-throughs of the cave.



NSS Cartographic Salon 2000

Elkins, West Virginia

Rod Horrocks, Salon Chairman

This year's Cartographic Salon had a total of 30 entries. There were two major categories: the Novice Category for those who have never won an award in any of the NSS Cartographic Salons; and the Experienced Category, for those who have won awards at previous NSS Cartographic Salons.

The judges for this year's salon included Steve Reames, Pat Kambesis, Walt Hamm, Nancy Pistole, Jim Kennedy, and Rod Horrocks. Judging took place from Monday through Wednesday of convention week and awards were presented on Thursday evening. In addition to the Medal, a total of 6 Honorable Mention Awards were given (green ribbon) and 5 Merit Awards (blue ribbon).

The Cartographic Salon Critique Session was held on Friday morning. The judges were available to answer questions on this year's judging criteria. The session was very well attended, both the cartographers who had entries in the salon and by folks who were interested in cartography in general.

Medal Award

Canadian River Cave, Pocahontas Co., WV,
by John Ganter

EXPERIENCE CATEGORY

Merit Awards (blue ribbon)

Hubbards Cave, Garfield Co., CO
by Hazel Barton

My Cave, Pocahontas Co., WV,
by John Ganter

Askon Hollow Cave, Fayette Co., PA,
by Walt Hamm

Honorable Mention (green ribbon)

Cueva Sakutzul, Alta Verapaz, Guatemala
by Nancy Pistole

Upper & Lower Kane Caves, Bighorn Co., WY,
by Bob Richards

Wind Cave, Eddy Co., NM
by Hazel Barton

NOVICE CATEGORY

Merit Award (blue ribbon)

Pfeiffers Mouse House, Kendall Co., TX,
by Robin Barber

Strangford Cave, IN, Co., PA,
by Keith Christenson

Sunset Cave, South Hilo District, Hawaii,
by Dave Bunnell

**Novice Category
Honorable Mention (green ribbon):**

Three Sinks Ice Cave, Flat Head National Forest,
by Kevin Glover

Crystal Cave, South Hilo District, HI,
by Dave Bunnell

Withrow Springs Cave, Madison Co, AK,
by Matt Covington

Esquire Cave, Hardy Cave, WV,
by Peter Penczer

Woodward Cave, Centre Co., PA,
by Keith Christenson

Why To Cave, Giles Co., VA,
by Raymond Sira

Experienced Category:

SALON ENTRIES

Cueva Del Rey Marcos, Alta Verapaz, Guate-
mala, by Nancy Pistole

Novice Category:

Cueva Del Rio Rocja Pemech, Alta Verapaz,
Guatemala,
by Nancy Pistole

Blessing Mountain Wells, Lycoming Co., PA
by Keith Christenson

Davis Farm Cave, Bartow Co., GA,
by Brent Aulenbach

Cave of the Bells, Lincoln National Forest,
by Kevin Glover

Hang Thuy Tien, Lao Cai Province, Vietnam,
by Mike Futrell

Cenote Chac Mol, Ruintana Roo, Mexico,
by Andres Matthes

The Pit, Quintana Roo, Mexico,
by Hazel Barton

Cudjo's Cave,
by Jim West and Kenneth Storey

Sistem Bukit Assam, Gunung Buoa, Sarawak,
Malaysia,
by Mike Futrell

Grapevine Gulch Cave, Calaveras Co., California,
Matt Leissring

New Section of Fault Cave,
by Derek Wolfe

Tham Naam of Wat Phomachan, Ratchasima
Province, Thailand,
by Mike Futrell

Correction to Cartographic Salon Awards List for 1999:

John Ganter received an honorable mention (green ribbon) for his map of Penick Spring Cave, Kentucky

Notes on Adobe Acrobat for Cave Maps

John Ganter

Adobe Acrobat or portable document files (PDFs) are a way to preserve the formats of documents while making them readable by almost any computer. The files are compact, can include colors, and will print to whatever printer the user has available (but see limitation below). The Adobe Acrobat Reader is free from Adobe (<http://www.adobe.com/products/acrobat/readstep.html>). It is available in Windows, UNIX, Macintosh, etc. versions. You will find many PDFs on the web, especially catalogs and other documents that have complex layouts.

Acrobat files include vectors, not just bitmaps like GIF and JPEG files. What this means is that you can zoom in to microscopic levels without the graphics becoming "pixelated." This makes Acrobat ideal for things like cave maps and other intricate drawings.

Acrobat 3 had sheet size limitations that excluded large cave maps. Fortunately, Acrobat 4 can now handle 200 inch x 200 inch pages (this is the maximum for Mac OS and Windows NT; Windows 95/98 is 129 by 129 inches). That is 16 feet by 16 feet.

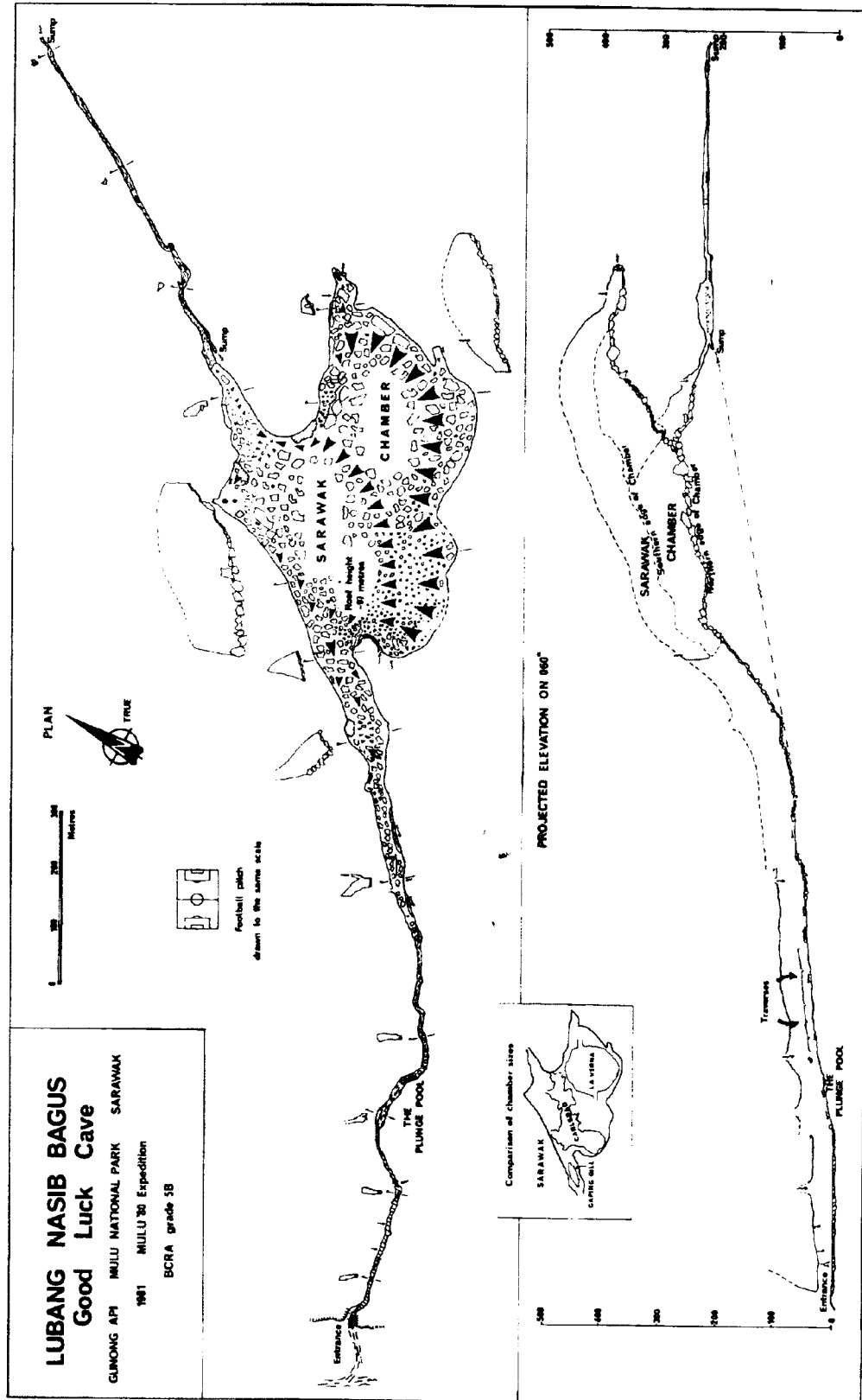
So how do you produce PDF files? Some graphics and CAD programs can export directly to PDF, although some may still be at version 3 (such as Freehand 8.0). If you buy the Adobe Acrobat 4.0 package (formerly known as Acro-

bat Exchange) for about \$230, you can generate PDF files from any application. You just print to Adobe Acrobat instead of a printer.

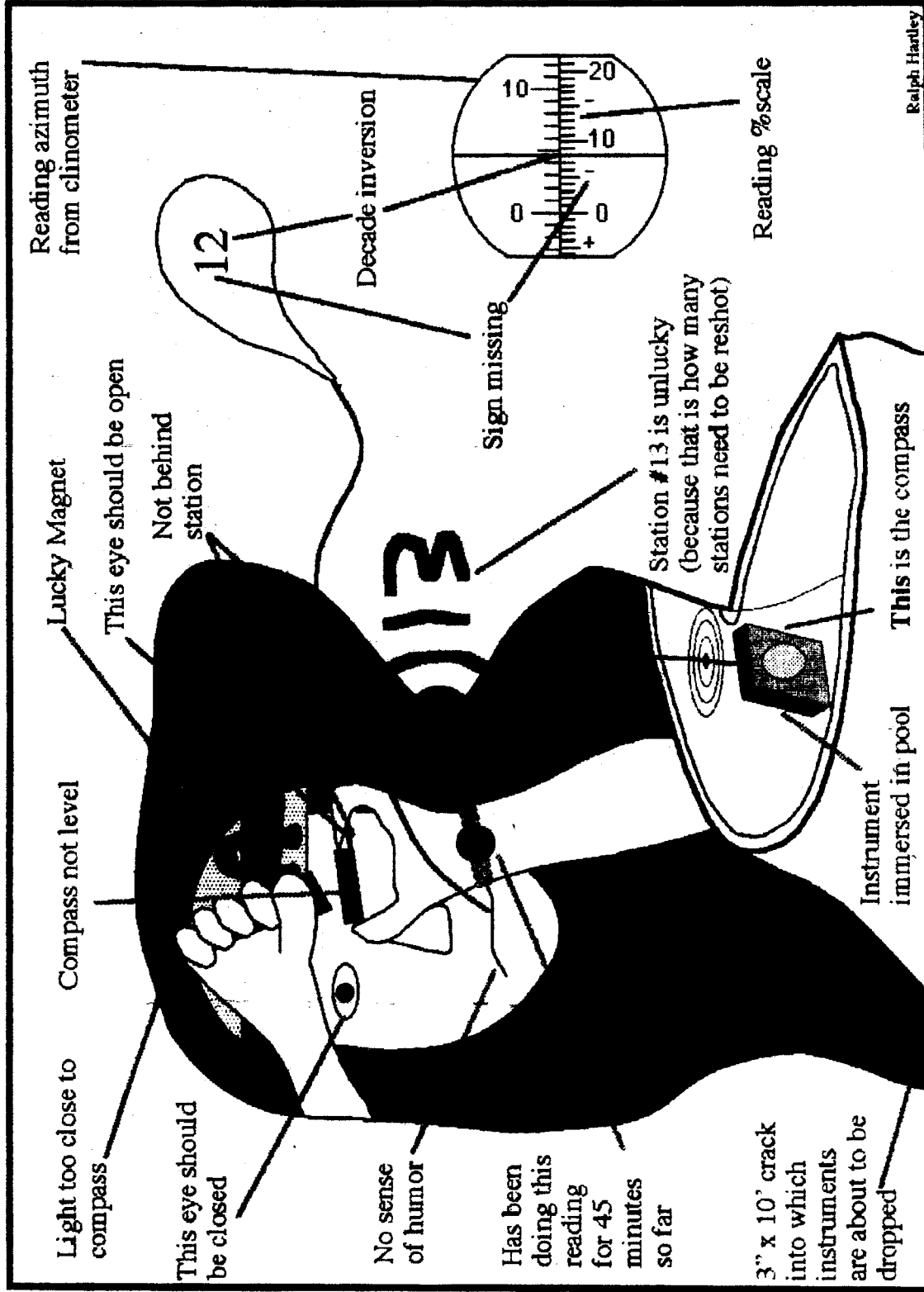
You can then distribute the PDF files by email, FTP, floppy, etc. I recently "distilled" a 78 by 36 inch color cave map into a 622 KB file. That is 6.5 foot long map, in complete detail and color, in a file that will fit on a floppy disk. This is very convenient, especially for reviews of large maps. There are real advantages over paper, especially since plotting, large-format copying, and postage are not getting any cheaper.

What about printing? Unfortunately, Acrobat Reader can only print with the "shrink to fit" method. This means that someone receiving my PDF file can only print it on a single page. If they have a large plotter, that's fine. If they have a letter-size printer, it's not. Acrobat Reader will not even "tile" the page with letter-size sheets. Hopefully, future versions will allow this.

I expect we will see more and more maps distributed as PDF files. (It is also a good way to distribute cave reports that have color photos and other graphics. In one step, you can go from Word or any other layout software to a PDF. Web formats like HTML are still not this easy.) I still like paper, but cost and convenience are significant factors that are driving me towards PDF.



From "Caves of Mulu '80", Cartographer: Colin Boothroyd



Ralph Harley

The Perfect Shot