UNDERWATER SPELEOLOGY

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Original Painting by John Potter

UNDERWATER SPELEOLOGY

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EQUIPMENT

Magazine Submissions — We welcome all news items, articles, Letters to the Editor, photos, slides, cartoons, and other items of interest or importance to the cave-diving community from all members, subscribers, and other interested parties. They should be sent directly to the Editor (see address on left column). We can also use text processed in most IBM-compatible formats. (Please contact the Editor directly for details and arrangements.)

Advertising — The NSS-CDS Board of Directors has approved the reinstitution of paid commercial advertising for *Underwater Speleology*. Please contact the Editor for information and arrangements (see address on left column).

The NSS and Cave Diving — Founded in 1941, the National Speleological Society joins together thousands of individuals dedicated to the safe study, exploration, and conservation of caves. The first cave-diving information ever published in the United States was in a 1947 *NSS Bulletin*. In 1948, NSS divers were responsible for the first cave dives in the United States using scuba. Prior to 1973, cave diving within the NSS was on a purely local level. That year saw the creation of the NSS Cave Diving Section to provide a vehicle for information exchange. Today, with over 850 members, the Cave Diving Section promotes safe cave diving through semi-annual workshops; cavern- and cave-diving training programs; warning-sign installations; search, rescue, and recovery through the National Cave Rescue Commission; cave exploration and mapping; several texts and publications on cave diving; and the bimonthly magazine, *Underwater Speleology*.

NSS Membership — The National Speleological Society welcomes the interest of anyone who has a sincere concern about the safety, study, exploration, and conservation of caves, wet or dry. You may join the NSS either by writing directly to its main office (National Speleological Society, Inc., Cave Avenue, Huntsville, AL 35810) or to the Cave Diving Section. Annual membership is $25.00 and includes subscription to the NSS's monthly magazine, *NSS News*, as well as voting privileges and discounts on publications and conventions.

CDS Membership — As a sub-organization or "section" of the NSS, the Cave Diving Section is subject to the bylaws and ethics of the NSS. Membership in the Cave Diving Section is open to anyone who is a member in good standing of the NSS. Annual membership is $5.00 per year and includes subscription to the CDS's bimonthly magazine, *Underwater Speleology*, as well as voting privileges and discounts on publications and workshops.

Subscription — If you do not wish to join the NSS and CDS, but would like to keep current on cave-diving events, exploration and technology, you are invited to subscribe to *Underwater Speleology* for $15.00 per year.

SHECK EXLEY BEQUEATHS CATHEDRAL CANYON TO CDS

At the 1991 Cave Diving Section Winter Workshop, premier underwater-cave explorer, Sheck Exley, announced that he has left Cathedral Canyon, the main entrance to the Cathedral/Falmouth Cave System, to the Cave Diving Section in his will in a living trust, so that it will be accessible to future generations of cave divers.

Sheck was the founding Chairman of the NSS-CDS at the time of its creation in 1973, and has since then been responsible for a tremendous amount of exploration, survey, mapping, and technological and philosophical innovations. His cave-diving career is now into its fourth decade. Sheck has set both the current penetration record (10,939' in Cathedral Canyon) and depth record (867-881' on a mixed-gas dive in Mante, Mexico). He is also famous for his classic text based on accident analysis, *Basic Cave Diving - a Blueprint for Survival*, and for co-editing the original *NSS Cave Diving Manual*.

Sheck has written an outstanding chapter on the history of cave diving, which makes fascinating reading, for the forthcoming *NSS Cave Diving Manual - an Overview*, to be released at the Spring Workshop, and his brand new full-length book, *Caverns Measureless to Man*, published by Cave Books of St. Louis, will also soon be available.

On behalf of CDS members—indeed, on behalf of all cave divers present and future—the NSS-CDS Board of Directors wishes to express deepest heartfelt gratitude for this magnanimous and inspiring gift. We all hope that it will be a very, very long time before the terms of the bequest ever come into effect, and that Sheck will enjoy many more happy years of fulfilling underwater-cave exploration. ■

JOE PROSSER RECEIVES SHERWOOD SAFETY AND CDS OUTSTANDING SERVICE AWARDS

Retiring CDS Training Chairman Joe Prosser was the recipient of this year's Safety Award presented by Sherwood Scuba at the 1991 Winter Workshop. The Award is presented to deserving individuals who have contributed greatly by their long-term and continuing efforts to cave-diving safety. Recipients are chosen on alternating years by the Boards of Directors of the NSS-CDS and NACD.

The Award carries with it a $500 monetary gift, which Joe has turned over intact to the Cave Diving Section for the continued promotion of safe cave diving.

Joe was also presented with the Cave Diving Section's highest honor, the Outstanding Service Award. Both awards recognize Joe's many years of service to the cave-diving community in his capacity as CDS Secretary-Treasurer, CDS Training Chairman, CDS Chairman, and author, coauthor, and/or editor of *Cave Diving Communications*, the *NSS Cavern Diving Manual*, the *NSS Instructor's Manual*, the *NSS Student Cave Diver Workbook*, and numerous articles, pamphlets, training materials, and other diving literature. Joe is the guiding force behind the *NSS Cave Diving Manual - an Overview*, which will be available at the CDS Spring Workshop. (As a point of interest, Joe and Sheck made their first cave dive together back in 1966.) ■

ELECTION RESULTS

Results of the 1991 Election for the CDS Board of Directors were quite close and we thank all candidates for running. Lamar Hires was elected as Training Chairman. Frank Howard and Mark Leonard were reelected to the Board, and Kelly Brady comes on as a new Board member.

In a meeting of the new Board, Frank and Mark were talked into continuing on as Chairman and Vice-Chairman respectively, Bill Foote and H. V. Grey will continue on as Treasurer and Secretary, Dan Lins will continue at Leadership Coordinator, and Kelly Brady will serve as a Director at Large, a position he has already begun to fill with enthusiasm. ■

TERRY DeROUIN CHAIRS CDS SPRING WORKSHOP

Terry DeRouin has once again stepped forward to assume the vital and very demanding responsibilities of coordinating this year's Spring Cave Diving Workshop, to be held at the Branford High School in Branford, Florida over the Memorial Day Weekend, May 23-25, 1992. Terry co-chaired last year's very successful and heavily attended Spring Workshop, and brings his experience to bear on the 1992 Workshop.

Because of the extreme awkwardness of the timing of both the Christmas and New Year's holidays this year, as well as the ongoing problem of recruiting volunteers who are both willing and able to take on the complex administrative tasks involved with producing a successful workshop, the CDS Board of Directors voted this year to host only a single workshop. So you will want to make definite plans to attend this year's Spring Workshop. Details and pre-registration information will be forthcoming in the next issue of *Underwater Speleology*. ■

NSS CONVENTION - CALL FOR CAVE-DIVING PAPERS

by Steve Ormeroid (NSS #19017)

The NSS Convention is going to be held this year in Salem, Indiana August 3 - 7, 1992. The Cave Diving Section of the NSS will be proudly presenting papers and programs at the Convention on August 5. You, too, can be a part of this exciting program. Help show the cavers of the country what we have accomplished.

Contact Steve Ormeroid at:

Work: 513-644-2559
Home: 513-642-7775
Fax: 513-644-1906
629 West 4th St.
Marysville, Ohio 43040 ■

NEW POLICY CHANGES FOR DIVING STATE PARKS IN FLORIDA

by Lamar Hires, Training Chairman (NSS #23991)

Effective *April 1, 1992,* the following changes in dive regulations for Florida State Parks, *including Peacock Springs,* will go into effect:

1. In order to dive twin cylinders, you must be Apprentice or Full Cave certified. Cavern and Intro to Cave Divers will no longer be allowed to use double cylinders.

2. Cavern and cave divers diving with an open-water diver will be prohibited from carrying lights in the water.

3. All instructors must present the Commercial Permit to teach at all state parks including Peacock Springs. The permit cost is $100 and is good for two instructors. (It is non-transferable; and only one permit is issued for the two instructors. The CDS encourages active instructors to purchase their commercial permit from the Peacock Springs Park Rangers to help them show that they are generating revenue at Peacock.)

4. The Entrance Fee at Peacock will be between $2 and $5. Payment will be through an honor system (where you put money in an envelope, and tear off a stub and put it on your windshield). For non-instructors, a $40 annual permit is available for diving in all state parks. Evasion of payment of fees will result in a citation with a mandatory court appearance.

The Cave Diving Section encourages all active cave divers to support the state parks by purchasing the annual pass. The passes are good for a full 12 months and can be purchased from the park rangers on your next dive trip.

SPECIAL NOTE: Peacock Springs will be closed due to flooding after Feb. 26 until the flood recedes. (Check with local dive shops for conditions and reopening.) ■

YANA SPRINGS UPDATE

by Gene Broome (NSS #29196)

On Feb. 4, 1992, Lamar Hires and Gene Broome met with the Lafayette County Board of Commissioners and the Blue Springs Recreation Park Committee to discuss the possibility of reopening the Yana Springs site to Cavern and Cave Diving.

They made several proposals for this endeavor with the most favorable option being the leasing of the site for diving. In this proposal, the NSS-CDS would lease the site for the pursuit of cavern and cave-diving from the county on a yearly lease. The Section would then be responsible for providing site insurance as well as maintenance costs for its normal upkeep and cleanliness.

Only certified Cavern and Cave Divers would be allowed to utilize the Springs area with a limited number of yearly memberships being sold to those so qualified to dive there. A limited number of Special Instructor Memberships would also be sold for the use of the system as a training location for all students involved in sanctioned certification classes.

The Park has a bathhouse, concessions, and camping, which would also be available to the member. Certain restrictions and rules would be placed on the site's utilization and a Managing Committee would be formed to implement and administer all policies as set forth for the System.

In order for this endeavor to become a reality, it is imperative that strong support be given this project by all who would wish to participate. And since the Section would have to commit to the necessary funding of the project in terms of the lease and insurance policy, it is very important that members be encouraged to participate through the initial funding needs which now face this in order for this to become a reality.

Donations are now being accepted from members and businesses to provide such initial funding needs. We must raise about $10,000 in order to have all costs covered for this plan to be implemented with yearly membership fees providing future funding requirements. Any donations will be greatly appreciated for this effort to once again allow us the privilege of diving such a tremendous system as Yana. And for those making donations of $100 of more, special recognition will be made at the "Open House" activities which will officially mark the opening of the site complete with a social and related activities.

The implementation of this program is planned to be underway for diving by April 15th, 1992.

All interested persons who wish to apply for membership must immediately send all such requests.

Donations and requests for membership must immediately be sent to CDS Treasurer Bill Foote at 1433 S.E. 8th St., Ocala, Florida 32671. ■

RESTRUCTURING OF STANDING PROGRAMS

by Kelly Brady and Dan Lins

(NSS #26061 and #28779)

With Contributions from Steve Ormeroid, Frank Howard, Lamar Hires, and Bill Foote

The CDS "Standing Programs" and "Program Coordinator" system is being restructured and updated to reflect current CDS interests and activity. The results of this restructuring will be greater efficiency in meeting our goals and increased service to the cave-diving community.

Very little written information exists relating to our Standing Programs and Program Coordinators. The first step now is to redefine and clarify each position, its responsibilities, and the "products" it should produce (such as articles and presentations). The next step is to develop support materials to help each coordinator do his job. This can be as simple as a list of addresses or a checklist of things to do for the year. After this is complete, we then need to fill each position with someone who is interested in working to improve the CDS and aid the cave-diving community. In most cases, we already have people in these positions. The final step is to put in place a management structure that will keep the ball rolling.

The following outline contains the purpose and specific goals for each program. It is flexible, meaning that it is changeable to reflect the changing interests of the CDS. Our hope is that it will evolve and mature into a workable, highly effective system. Comments, suggestions, and critiques are requested to help us create the best possible system. Please address your comments to CDS Board Member Kelly Brady (address in the front of this issue).

NSS-CDS STANDING PROGRAMS OUTLINE

ABE DAVIS AWARD

Mission: To promote self-nomination for this award (recognizes completion of 100 safe cave dives) and issue awards to those who fulfill requirements.

Goals:

1. Produce an article describing the award and its background for use in future publications.
2. Publish one article per year informing members about the award.
3. Write or update short description of award for CDS Member's Manual.
4. Develop or update instructor materials regarding administration and (implementation) of the award.
   - Each CDS student should receive an Abe Davis Award application.
   - Consider sending out form with Introduction to Cave Diving cards.
   - Periodically review standards to be met to receive the award.
5. Process nominations.
   - Maintain roster of award recipients.
   - Produce award certificates.
   - Present award to recipients at NSS workshops.
   - Publish list of award recipients in *Underwater Speleology*.

ACCIDENT FILES

Mission: To maintain and update the file of cavern- and cave-diving-related accident reports and provide this information to various groups such as Diver's Alert Network (DAN) and the University of Rhode Island (URI).

Goals:

1. Maintain communication with key people and groups to insure reporting of cave-related accidents.
   - NSS: American Caving Accident Report editor
   - NACD
   - Diver's Alert Network
   - University of Rhode Island (URI)
   - Open-water agencies
   - CDS Rescue/Recovery Team Coordinator
2. Provide only accurate, factual, non-opinionated reports.

CALENDAR COORDINATOR

Mission: Maintain and publish list of activities of interest to NSS/CDS members.

Goals:

1. Develop calendar of events for upcoming 2-year period.
2. Report NSS-CDS activity dates to other organizations for inclusion in their calendars.
3. Publish calendar in *Underwater Speleology*.

Sources for calendar info:

- CDS Board
- Workshops, meetings, special events
- NSS Huntsville office
- NSS Convention
- Regional events: TAG Fall Cave-In, SERA, local grotto meetings
- NSS Grotto newsletters
- NACD BOD
- NACD events
- Diving publications
- Events and activities of interest to CDS members

4. Begin a newsletter-exchange program with the above groups whenever possible.

BIOLOGY

Mission: To increase CDS members' awareness of the unique biological systems found in underwater caves and to provide advice to the CDS BOD in matters regarding cave biology.

Goals:

1. Produce one article per year for publication in *Underwater Speleology* relating to cave biology.
2. Produce a short article for the CDS Member's Manual which is an overview of recent activity relating to cave biology.
3. Advise the Board of Directors about important matters in the field of cave biology.

CARTOGRAPHY

Mission: To stimulate the creation of new underwater cave maps, to provide information and references to those interested in underwater cave maps, and to coordinate CDS-sponsored cartographic projects.

Goals:

1. Produce one article per year for publication in *Underwater Speleology* which promotes creation of new underwater cave maps or enhances members' understanding of cave cartography.
2. Oversee updating any CDS materials relating to cartography.
3. Produce short article for the CDS Member's Manual overviewing recent cartographic activity.
4. Coordinate CDS Workshop Cartographic Salon.
5. Coordinate NSS Annual Convention Cartographic Salon submissions.

CAVE FILES COORDINATOR

Mission: To solicit and compile underwater cave data, serve as a center for information on the location of other cave data repositories, and make the information available to researchers.

Goals:

1. Centralize CDS cave files into one location.
2. Produce and maintain an index to materials on file for publication in the CDS Member's Manual.
3. Produce one short article per year for publication in *Underwater Speleology* which increases members' awareness of the existence of this file and promotes new acquisitions.
4. Communicate with other groups for the purpose of increasing acquisitions.
   - NSS Huntsville Office/ NSS Executive Vice President
   - NSS Cave Files Committee (Chair: Richard Blenz)
5. Study possibilities for computerizing portions of the files.

COMPUTER APPLICATIONS (DOS) (MacIntosh)

Mission: To support the CDS's use of computers, especially relating to the membership database; to promote computer applications for cave surveying and mapping; and to increase members' awareness of computer applications for cave diving.

Goals:

1. Be available to the CDS board for technical support.

2. Produce one article per year for publication in *Underwater Speleology* relating to computers.

3. Produce a short overview of computer applications and electronic bulletin boards for the CDS Member's Manual.

4. Develop a list of software titles and sources of interest to members for publication in the CDS Member's Manual or *Underwater Speleology*.

CONSERVATION

Mission: To stimulate good underwater-cave conservation practices within the cave-diving community, identify areas and issues where the CDS can contribute to cave conservation, and to develop proposed positions which the CDS might take on conservation-related issues.

Goals:

1. Produce one article per year for publication in *Underwater Speleology* relating to underwater-cave conservation, or produce a presentation for a CDS workshop.

2. Produce a short article overviewing recent conservation matters for publication in the CDS Member's Manual.

3. Administer NSS-CDS Conservation Merit Awards.

4. Periodically review and update conservation information in instructor materials.

INTERNATIONAL INFORMATION CONTACT

Mission: To provide information about the CDS and cave-diving training to groups from other countries who are seeking information.

INTERNATIONAL MAILINGS

Mission: To handle *UWS* and Section mailings to foreign addresses.

INTERNATIONAL EDITOR

Mission: Maintain an open, active line of communication to foreign individuals and groups interested in underwater caves, and report on foreign cave-diving activity in *Underwater Speleology*.

Goals:

1. Periodically produce articles for *Underwater Speleology* which summarize or report on foreign cave-diving activities, and consider starting a regular column of excerpts from foreign publications and correspondence.

2. Exchange information and CDS materials with established foreign cave-diving groups.
   - Cave Diving Group of Australia
   - British Cave Research Association
   - British Cave Diving Group

3. Assist with handling of incoming international mail.

4. Help coordinate cave-diver "exchange" programs.

ICDSA (International Cave Diving Safety Award)

Mission: To inform members about this award (recognizes completion of 1000 safe cave dives) and promote self-nomination for qualifying cave divers.

Goals:

1. Publish one article per year informing members about the award. Write or update short description of award for CDS.

2. Develop or update instructor materials regarding administration and (implementation) of the award.
   - Process nominations
   - Maintain roster of award recipients
   - Produce award certificates
   - Present award to recipients at NSS workshops

MAPS

Mission: Maintain the inventory of cave maps for sale

Goals:

1. Increase sales of cave maps.

2. Stimulate donation of maps to the CDS through articles or contact with cave mappers and the Cartography Program Coordinator.

3. Provide suggestions to mapmakers who will donate maps to the CDS.

PHOTOGRAPHY/ VIDEO

Mission: To assist in acquiring photographic images for the CDS to use in training materials and other publications at minimal expense.

Goals:

1. Assist newsletter editor in acquiring photographs for publication.

2. Develop and maintain a file of stock slides, negatives, and video masters which may be used by the CDS.

PROPERTY MANAGER

Mission: To store CDS product inventory, and oversee issuance and return of CDS loaner property.

Goals:

1. Document issuance and return of CDS property.

2. Oversee maintenance and repairs.

RESCUE/ RECOVERY TEAM

Mission: To organize and direct the NSS/CDS Rescue and Recovery Team; communicate with law-enforcement agencies; and revise and produce guidelines, materials, and courses relating to rescue and recovery.

Goals:

1. Produce at least one "Recovery Diver" certification course per year (CDS Winter Workshop).

2. Produce at least one article per year for publication in *Underwater Speleology* relating to the rescue/ recovery team or related topics.

3. Maintain the list of qualified and certified Recovery Divers.

4. Maintain communication with the NCIC/Jacksonville Sheriff's Office and the National Cave Rescue Commission (NCRC).

SAFETY COMMITTEES (North, South and Mexico/Caribbean)

Mission: To promote an attitude and awareness of safe cave-diving practices, be involved in the analysis and review of safety procedures and activities, and to identify potential recipients for the "Safety Award."

Goals:

1. Identify regional safety concerns.

2. Assist with the Warning Sign Project and sign placement.

3. Produce at least two articles or presentation per year relating to general or regional safety issues.

4. Communicate with landowners as needed to promote safety and protect

the landowner.

5. Identify people or organizations who should be recognized for contributions to safety and present "safety award" to them.

SCIENCE COMMITTEE

Mission: To increase CDS members' awareness of the sciences relating to underwater caves and to provide advice to the CDS BOD in matters regarding cave science, to identify areas and issues where the CDS can contribute to cave science, and to develop proposed positions which the CDS might take on science-related issues.

Goals:

1. Produce of articles for publication which relate to cave science.
2. Maintain list of ongoing scientific projects of interest to members.
3. Review requests for financial grants for scientific projects.

ACTIVITIES COORDINATOR

Mission: To create, promote, and manage regular CDS-sponsored activities and events other than workshops.

Goals:

1. Produce 3 - 4 special events per year.
2. Publish events in UWS.

STATE PARKS LIAISON

Mission: To provide a consistent contact person to the state parks which have caverns, caves, and springs, and to maintain and enhance relations and access.

Goals:

1. Create and maintain address and contact list for each state park which has caverns, caves, or springs.
2. Answer questions posed by park staffs.
3. Make suggestions to state parks for safety and management of overhead environments.
4. Assure that parks maintain supply of CDS safety brochures and materials.
5. Periodically produce an article for *Underwater Speleology* which updates members regarding state park rules, policies, and procedures.

LANDOWNER RELATIONS

Mission: To develop, maintain, and coordinate good landowner relations.

Goals:

1. Communicate with owners and managers of established sites, newly opened sites, commercial sites, and possible future sites.
2. Explore the possibility of site acquisition.

SUMP DIVING PROJECT

Mission: Promote information interchange and safety in sump diving.

Goals:

1. Produce one article per year for publication in *Underwater Speleology* relating to sump diving.
2. Maintain a "sump diver registry" of active sump divers, which will be available from the CDS at members' request.
3. Revive and update the *Sump Diving Handbook*.
4. Communicate with international groups and individuals involved in sump diving.

SURVEY

Mission: To coordinate CDS-sponsored cave surveys and to promote active surveying projects.

Goals:

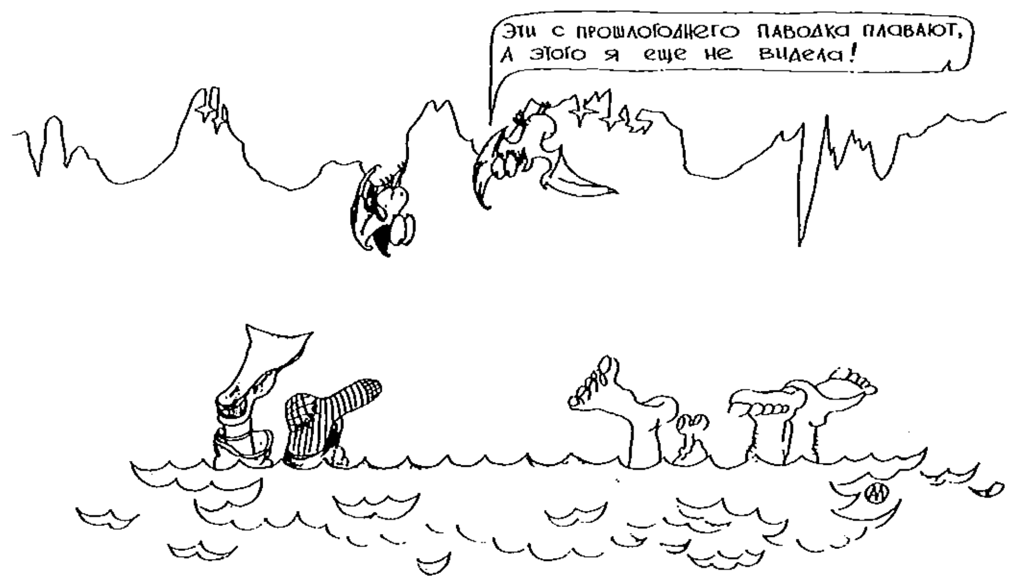
1. Create and revise basic guidelines for CDS-sponsored surveys.
2. Maintain list of active CDS-sponsored surveys, to be published in the CDS Member's Manual.
3. Oversee updating of CDS course materials relating to surveying.

SPECIAL TECHNIQUES

Mission: Develop, document, and present information on new, emerging, or special cavern- and cave-diving techniques.

Goals:

1. Produce one or more articles or presentations per year.
2. Develop and maintain an information package, similar the NSS "Caving Information Series," documenting techniques and ideas gathered from various sources. ■



"The bare feet are from last year's flooding, but this year's are still dressed!" - *Mikhail Aljukov*

CMAS SUBAQUATIC SPELEOLOGY COMMISSION LAUNCHES INTERNATIONAL CERTIFICATION PROGRAM

by Milledge Murphey, Ph.D. (NSS #24433)

CMAS (Confederation Mondiale des Activites Subaquatique) has been a world leader in subaquatic speleology for many years. This was evidenced in 1972, when Rino Gamba, then President of the CMAS Speleology Commission, published the first internationally available comprehensive guide to cave diving, entitled *International Diving Manual: Underwater Speleology*. Earlier, Jacques Cousteau and many other CMAS notables had published accounts of their cave-diving experiences, and had recognized the unique potential risks involved in pursuit of subaquatic speleology.

During 1985, when I became President of the CMAS Speleology Commission, Kai Estrup, then President of the CMAS Technical Commission, and I discussed the worldwide expansion of cave diving, and the need for a world (CMAS) standards training and certification program to aid in counteracting the high number of fatalities occurring in subaquatic dives, primarily involving open-water divers. This topic was of particular importance in view of the more than 400 fatalities which have occurred in subaquatic caves worldwide since 1963 (with more than 350 of these occurring in North Florida, USA). It was these deaths that led to the founding and development of the National Association for Cave Diving during 1968 and the NSS-CDS during 1973 for the purpose of training and certifying cave divers in the USA.

Following the initial discussions with Kai, I presented the program to the CMAS Technical Committee, which approved the project (without funding). Dr. Marcel Bibas, then Secretary General of CMAS, wrote to all CMAS federations requesting national cave-diving standards and I wrote to all known national cave-diving organizations for input. Sixteen countries responded to these requests for information, standards were drafted, and approval was given by the CMAS Technical Commission for speleology standards to be developed in final form by the Speleology Commission. This was accomplished, certification card designs were developed and approved by the CMAS Technical Commission, and the program launched with a letter of invitation to all recognized cave-diving organizations worldwide.

As CMAS could commit no funding to support the program at the time, the United States Underwater Federation, which represents CMAS in the USA, volunteered to sponsor the program.

At present the subaquatic speleology program includes 1, 2, 3 and 4 Star diver certifications, and 1, 2, 3, and 4 Star speleology instructor ratings. Cave divers and instructors who are interested in the CMAS program should write or fax:

Milledge Murphey, Ph.D., President
CMAS Speleology Commission
United States Underwater
Federation
P. O. Box 13754
Gainesville, FL 32604
FAX (904) 392-5262

At present the CMAS SC is soliciting nominations of representatives to the Commission from each national CMAS federation where cave diving is practiced and similar nominations from recognized cave-diving organizations worldwide. The commission will meet during the next CMAS General Assembly to discuss the standards and certification programs. ■

NEW EDITOR SOUGHT FOR UWS

The current Editor of *Underwater Speleogy*, H. V. Grey, has formally confirmed resignation from this position announced at the last CDS Board Meeting. Resignation effective as soon as a suitable replacement can be found.

(To answer the inevitable question on everyone's mind: "Why have I resigned?" ... I'm going to divide that question into two parts. First, "Why?" "Why" is a three-letter word that has plagued mankind since the first caveman went into a cave, got hit on the head by a falling rock and said, "Ugghh??!" [early neanderthal for "Why?"}. As for the second part of the question: "Have I resigned?" Yes.)

Interested individuals should contact Chairman Frank Howard or Grey for further information (see contact information on inside front cover). ■

CDS WINTER WORKSHOP
(Photos from the Pre-Workshop Party at the Steamboat Dive Inn in Branford, Florida)

Joe Dabbs,
Unidentified (sorry!),
Dennis Williams,
and Jack Rensch

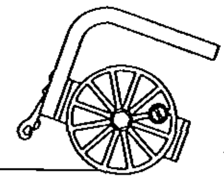
Woody Jasper and
Fred Davis

Dustin Clesi,
Gary Perkins,
and another
Unidentified
Diving Object

Dennis Williams,
John Zumrick,
and UDO
admiring Martyn
Farr's new book

Photos courtesy of Dustin Clesi

THE SAFETY LINE



by Wendy Short (NSS #30802), Safety Coordinator South

In 1977 the Cave Diving Section of the NSS decided to create the Abe Davis Cave Diving Safety Award in honor of America's first known cave diver. This award is presented to any cave diver who has demonstrated a genuine dedication to cave-diving safety as evidenced by the successful completion of at least 100 cave dives.

By making this award available to all cave divers, it is hoped that the award will have a unifying influence on the American cave-diving community. This award will also provide novices with positive motivations to plan and execute their dives as safely as possible while they are in the relatively high-risk area of their experience—the first 100 cave dives. Further, by encouraging the novice to keep records of his activity to apply for the award, he will be indirectly motivated to be more methodical in his dive planning and analytical toward his dive performance, thereby making his cave diving safer.

Hopefully, this is only the beginning to a stronger commitment to cave-diving safety in these recipients.

The CDS proudly announces the 1991 recipients:

DAVE BANKS
GRACE T. BAYS
SCOTT A. BAYS
LAURANCE P. DICKIE
BRADFORD J. GAGNE
MARK W. HAPPE
WAYNE HEAD
QUENTIN JONES
SCOTT MARION
TERRENCE NEAL TYSALL
JAMES ROBINSON
LEGARE ROMIG HOLE, III
CHRISTOPHER ROUSE, JR.
PETER R. SCHULZ
RICHARD TARR
JULIUS TOMSITS
ARTHUR M. WATSON ■

THE SPARE MASK

by Frank R. Lavallee (NSS #27829)

As cave divers, we are all familiar with the need for redundant and backup equipment—dual valves and regulators, air reserve for emergencies, extra lights, backup timers and computers, etc.

If an O-ring blows or a regulator fails, we switch to a backup. If a buddy has an air loss or failure, we keep enough air in reserve to allow both divers to breathe their way back to safety. If a primary light burns out or floods, we switch to a backup light to see the way out. If a timer or computer malfunctions, we have a backup to provide the information required for decompression obligation. This backup and extra equipment we carry on a cave dive is the key to having a successful, safe cave dive and returning unharmed, should a piece of equipment fail.

How many of us really consider and carry a spare mask as part of the backup equipment we carry? To be honest, most of us don't. Think about it. How many cave divers do you know that carry one? For most of us, carrying and storing a spare mask is considered unnecessary and inconvenient. I was one of those pessimistic cave divers for a long time.

Several months ago, I was on a cave dive when my mask developed one of those nuisance leaks—the type in which water continually seeps in and requires the mast to be cleared a couple of times a minute. I found myself devoting more time to keeping my mask cleared than on trying to enjoy the dive. When I finally surfaced and had a chance to examine my mask, I discovered two cracks in the mask frame which had split apart and allowed water to seep past the silicone seal.

This was not what I considered to be a life-threatening or major problem, but it brought out some interesting thoughts. What if the strap had broken? What if the lens had cracked or shattered? Considering that I was soloing at the time, it could have been a major problem.

I decided at that point that I would not cave dive in the future without carrying a spare mask, whether I was soloing or diving with a buddy. Where and how to carry it was not a problem. Most of us wear a zippered pouch or similar piece of equipment for slates, tables, line arrows, etc. A backup mask fits quite easily in one, as long as your backup mask is not large and bulky. If you need it, it is easy and quick to get to.

I have not had to rely on my backup mask as yet, but it is comforting to know it is there, if I need it. Our sight is very precious to us underwater, especially in a dark cave full of obstacles. I would not want to have to exit a cave without a mask.

As cave divers, we should all seriously consider carrying a seemingly unimportant piece of backup equipment—a spare mask. ■

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ZOTTER'S FOLLY CAVE

by Ron Simmons (NSS #16894 Fellow)

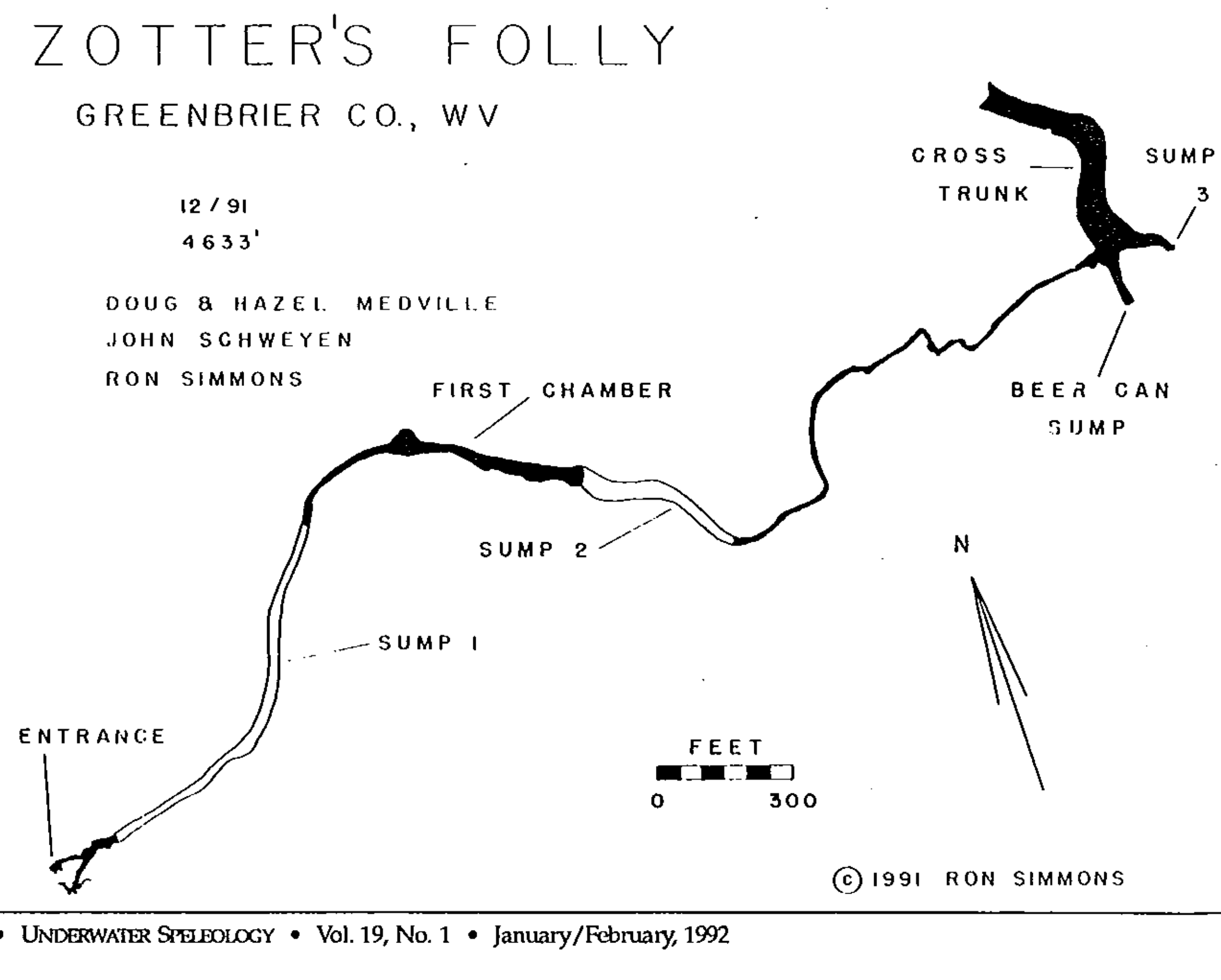
Zotter's Folly is a small cave along Spring Creek in Northern Greenbrier County, West Virginia. It was named after Hermine Zotter, a Pittsburgh caver who did a lot of dye tracing in the area in the mid '60's. The cave was named Zotter's Folly because at one time she thought that it contained the main stream going south out of Friar's Hole Cave. She later found that the water was not the same.

I first looked at the cave a number of years ago with Dick Graham and Patty Mothes. The cave starts as a climb down through breakdown at the base of a headwall. A long mud slope leads to a short section of almost walking passage, which leads to a pool. The cave had a surveyed length of about 350'. The day I saw the cave it looked like as much water was going into the pool as came out. So, looking like just a small pool, I didn't give it much more thought. Recently Doug Medville convinced me that the pool was really a sump and that I ought to check it out. So last February, 1991, I decided to.

Kathryn Haverly, Randy Rumer, and Doug and Hazel Medville helped haul dive gear to the entrance and to the sump. It was an amazingly warm February day, so I changed into my wetsuit and set up my tanks outside the cave. Then we hauled the gear to the sump. On future trips I set up my gear at the sump. All of the gear was covered in mud by the time it got to the water.

Doug was right. The pool had a passage 30' wide and 2-3' high going off at a depth of about 10'. I laid all the line on my reel, about 350'. Visibility was very good, 10' to 15'. So most of the passage could be seen, quite a treat for a sump diver. But it was more than made up for by the very cold water. This was February water and it gave me a splitting headache. The underwater passage averaged 15-25' wide and about 5' high, with the floor at a depth of 15'. It kept on going where I ran out of line. There were no good tie-offs so I just buried the reel in the bottom as a tie-off and surveyed out. I knew that I would be back. The total dive time was about 15 minutes.

It was March before I could get back. On this dive Kathryn Haverly, Charley Plantz, Tony Knaus, and Doug and Hazel Medville helped haul gear. The water had been up since the first dive and all of our footprints in the cave were gone. The high water had also buried sections of the dive line and I had to pull it out of the silt. On the way in I added a few re-belays to the line to keep it out of tight spots. At the end of the line I tied on a new reel and laid another 500'. The passage was still going as a tube 15-20' wide and 4-6' high at a depth of 15'. The dive time this trip was 39 minutes—right at my limit for wetsuit



diving in cold water.

In April John Mylroie, and Doug and Hazel Medville helped haul gear back to the sump. It had rained quite a lot the weekend before and the water in the sump was still turbid. Visibility was down to 5'. The dive line was again buried in silt at spots. I tied on to the end of the line and continued on. In about 100' there was some air space and a little further, walking passage with knee-deep water. Tying the line off and removing my gear, I headed off upstream to see what I had found. The passage soon got up to 50' wide and 20' high. It then reduced to 8' in height, then it was only 4' high, then I came to a sump. The second sump looked like a good dive prospect. The First Chamber turned out to be 500' long after I did a compass and pace survey. The First Sump is about 800-900' long depending on water level.

Memorial Day Weekend saw Doug Medville and me back at Zotter's. I have to hand it to Doug. He really puts in the effort when it comes to the advancement of Speleology or else he's a real glutton for punishment. Before pushing Sump 2 I did a more accurate Suunto and tape survey of the First Chamber. The passage in Sump 2 was a good-sized tube about 20-30' wide and 5-10' high, with the floor at a depth of about 15'. After reeling out over 400' of line, I came up in a canal passage 10' wide and 7' high with 3' of water and calf-deep mud under that.

There was no beach to leave gear on so I used a mud bank. I tied the line to a lead weight and buried it in the mud bank. Then I crammed my fins into the mud and tied my tanks and dive gear to them. Heading off upstream, the canal passage went for about 300' with about the same dimensions. Then the water depth decreased and the passage became floored in cobbles and breakdown. I went probably 600' beyond my gear to make sure it didn't sump right away before heading out. Another diver was now needed to help survey this find.

In August John Schweyen joined me to survey beyond the second sump. Visibility in the sumps was the worst since stating to dive here, only 1-2'. John went in first since he had not seen the dives before. On the upstream side of Sump 2 we started surveying. The passage continued on as an 8-20'-wide and 7-15'-high canyon. We mapped about 1000' until coming to a breakdown pile coming from an upper level. John went up first and called back that he thought we had finally found some real cave.

He was in a passage about 60' wide and 45' high. It was not a continuation of the stream passage but a cross-trunk passage. In one direction the ceiling gradually came down and eventually led to a sump, Beer Can Sump. The main stream had split up under the breakdown and part of the flow was coming out of this sump. The passage leading to the sump was named Beer Can Alley due to the large quantity of fairly new beer cans. This stream probably comes from Brown's Cave.

This is a 1000'-long cave in Renick's Valley that takes a surface stream and ends in a mud-and-debris-choked sump. This stream drains a field just across the road from a local bar. Apparently the clientele throw lots of beer cans into the field across the road. This could be a new way to do water tracing, although it would be hard to get all the locals in one area to drink the same type of beer.

After plotting it was found that the sump in Brown's Cave is only about 300' horizontally from the Beer Can Alley sump in Zotter's, but it is about 180' higher. There must be some nice falls on the other side of this sump.

The main part of the stream comes out of another sump on the far side of the cross-trunk passage, Sump 3. At least some of this water probably comes from Fox Cave but no tracing has been done yet. The end of Fox Cave is about 3500' from the sump in Zotter's.

Back in the cross-trunk passage, the other direction went north and continued just as wide but was not as high due to the floor ascending. At the top of the slope the passage was 60' wide and 15' high. It had some really incredible mud cracks in the floor. A collapse nearly blocked the passage at one point but we were able to get through into the continuation. Unfortunately, this soon ended at another even more massive collapse. There was lots of flowstone and mud covering the breakdown. We could not find any way on and this appears to be the end of this passage. At this point the cave had ascended to 203' above the entrance.

This last survey trip with John had netted 2173'. The surveyed length of the cave is now 4633', which is not bad considering that the original length was 350'. Zotter's Folly is not really such a folly after all. Next summer it will be interesting to see what lies beyond the next sumps.

During most of the dive trips to Zotter's, Doug Medville and a host of others worked on trying to follow the water coming out of the sump. There are two small streams coming out of the sump pool. The one with the most flow ends after a very short distance where it flows into a crack too small to follow on the north side of the entrance passage. The other downstream passage is to the south of the entrance and can be followed for about 100'. The water flows into breakdown at a depth of 59' below the entrance. This is below the level of nearby Spring Creek. ■

CDS Cave Diving Instructor and former Chairman Jeff Bozanic says hello to everyone and sends Wishes for a World of Peace from the Antarctic. Jeff has been at McMurdo Station since Oct. 8 diving under the ice. He writes that "Huge canyons and caves of ice are formed underwater ... extending 40 or more feet in depth. The walls are all covered with large masses of platelet ice, ice crystals up to 5 inches in diameter, but only a fraction of an inch in thickness, ... which look like inverted crystalline castles, with blue skies in the background as the light from above filters into the depths." ■

SEDIMENTS IN UNDERWATER LIMESTONE CAVES

by Harris W. Martin, Ph.D. (NSS #26771)

Introduction. Clastic sediments consist of fragments of rocks or of organic structures that have been moved individually from their places of origin (American Geological Institute, 1976). Clastic sediments in underwater caves vary in size from limestone boulders to colloidal and semi-consolidated fine clays (Jennings, 1985). In underwater caves of the Suwannee River basin, cave floors can be bare limestone rock, clay, sand, gravel, limestone boulders, isolated patches of partially decayed plant matter, or mixtures of these materials. Low-flow conduits and side sections out of the main flow are in some cases "dusted" with a soft, fluffy, semi-colloidal organic-appearing silt which readily goes into suspension when disturbed. "Consolidated" or fluvial-phreatic clay bottom sediments, however, require vigorous disturbance for appreciable quantities to be brought into suspension.

What is the source of clay minerals in phreatic caves? Do they form in situ, i.e., are they autochthonous or endogenic (Kukla and Lozek, 1958; Jennings, 1985)? Are they transported from subsoil entering the phreatic zone from the vadose zone above? Are they derived from residual limestone impurities? Are they imported with flood waters during spring-flow reversals?

Most of what is known of cave-sediment mineralogy is based on study of vadose ("dry") caves. Little is known of the mineralogy of sediments in entirely phreatic (underwater) caves (Horne, 1990), where geochemical and sedimentation processes may differ from those in vadose caves. Only since the advent of safe cave-diving equipment and procedures, and recognized cave-diver certification programs has it been prudent to sample interior facies of phreatic caves (sediments in portions of underwater caves far from cave openings).

The Literature. There is some controversy regarding the origin of fine-grained cave sediments. According to Jennings (1985), red or "ochreous" clays are found widely in karst caves especially in phreatic sections. Kaolinite is the most common clay mineral in such deposits. These deposits can be massive or occur in fine laminations where a silt-sized component is present. The coloring is thought to be caused by ferric oxide (Jennings, 1985). Bretz (1942) referred to this as "red unctuous" clay, which he believed to have eluviated below the water table into phreatic-cave conduits through small fractures and solution pipes from subsoil layers above the limestone bedrock (White, 1988). Data of Reams (1968) collected from Missouri vadose-cave sediments apparently contradicted Bretz's eluviation hypothesis.

Originally thought to be insoluble residues of limestone dissolution (Jennings, 1985), these red kaolinite and other cave clay deposits were later considered to be derived from surface soils and to have entered the cave by one of several vertical eluviation (Bretz, 1942) or transitional vadose/phreatic fluvial mechanisms (B?gli, 1961; Reams, 1968). Other studies have documented the external origin of cave sediment material (Wolfe, 1972; Gospodaria, 1974). White (1988) and others, however, still attribute the origin of much cave clay to insoluble residues (detritus) of limestone dissolution. The proportion of phreatic cave sediments derived from limestone detritus may depend on the concentration of clay and sand impurities in the limestone. The dynamics of sediment transport within phreatic caves may also influence the proportion of sediments derived from limestone detritus.

In much Florida karst, the interface between limestone and overlying subsoil is extremely irregular (Puckett et al., 1990; Puri et al., 1967) due to a process called subsoil solutional sculpture (Jennings, 1985). In the well-developed karst west of the Central Florida Ridge, limestone bedrock is so close to the surface in some places that normal subsoil layers (horizons) are truncated and drained into subterranean air- or water-filled cavities through choked solution pipes. White (1988) refers to this type of clastic sediment as "infiltrates" transported vertically into vadose cavities by the action of gravity. He describes infiltrates as surface soils washed, piped, or slumped into open air-filled crevices or down dry sinkholes. This would provide a mechanism for the vertical transport of subsoil clay and sand into vadose caves. The mechanism for such transport into phreatic caves, however, is not well understood and is the subject of some controversy as previously mentioned.

Sediment is transported vertically into phreatic conduits as indicated by the commonly observed debris cones in these caves. The author has observed an apparently recent debris cone in the Peacock III section of the Peacock Springs cave system. This debris cone was composed of clumped (peds) and loose subsoil clay and sand containing largely un-decomposed plant roots. The author has observed the formation of a debris cone in Thunder Hole cave system (Madison Co., FL). Sandy debris was seen falling from the ceiling through the water column and piling up in a cone on the cave floor. Both of these observations were made during extended periods of drought with associated lowered water-table levels. Debris cones are common in the flooded caves of the Yucatán karst in Mexico.

A poorly understood and only recently examined possible source of clays and other minerals in phreatic caves is the vertical transport of suspended colloidal mineral particles to the aquifer. This type of colloidal transport may possibly be responsible for some of the easily disturbed, apparently recent, and only partially settled sediments observed in the crevices of underwater caves. Such colloidal transport may be differential with respect to clay mineralogy (Kaplan et al., unpublished data).

As water erodes, dissolves, and otherwise weathers the limestone in the cave, the $CaCO_3$ matrix is dissolved away, leaving behind the less soluble impurities. These remaining limestone impurities are referred to as weathering detritus. Silt- and clay-sized weathering detritus composition varies but commonly consists of fined-grained quartz, sericite (mica), and clay minerals (White, 1988). Analysis of red clays from three vadose Missouri caves (Deike, 1960) showed they were composed of quartz, illite, and kaolinite, with traces of hematite—almost exactly the same composition found for the insoluble fraction of the limestone.

Silica in its various forms and the clay minerals make up the bulk of the insoluble fraction of most carbonate rocks (White, 1988). In his review of the literature, White (1988) stated that in most calcitic limestones, insoluble impurities include primarily SiO_2 (silicon dioxide), Al_2O_3 (aluminum oxide), and Fe_2O_3 (ferric iron oxide). The silica may occur as chert, silicified fossil fragments, detrital or authigenic quartz sand grains, or as a component of other silicate minerals. Aluminum and iron may be present in clay minerals or as hydrated oxides, hydroxides, and oxyhydroxides.

Other minor noncarbonate mineral impurities include phosphates (glaucophane), sulfides (primarily pyrite), feldspars, organic matter (White, 1988), anhydrite, and gypsum (Ceryak et al., 1983). Of the layer silicate minerals commonly found in carbonate rocks, kaolinite and illite (weathered mica) are the most common (White, 1988). Other clay minerals commonly found in limestones include smectite (montmorillonite), chlorite, and vermiculite (Robbins and Keller, 1952; Peterson, 1962). Kaolinite is a principle clay mineral impurity in most limestones (White, 1988), but is almost absent from some limestones (Peterson, 1962).

Some sediments entering caves are limited to cave entrances (caverns). Surface materials fall, roll, slide, creep, and flow into caverns at their entrances and become interbeded or mingled with autochthonous (originating from within the cave) materials (Jennings, 1985). These sediments are referred to as entrance talus (White, 1988) or entrance facies (Kukla and Lozek, 1958). These sediments are generally more complex than interior facies (sediments found far inside the cave) (Jennings, 1985).

Sediment cores were collected from the spring bowl and cave system of Wakulla Spring in the Woodville Karst area of the panhandle of Florida during the 1987 Wakulla Springs Project (Rupert, 1991; Rupert and Wilson, 1989). These cores contained remains of fresh-water diatoms and pollen of salt-flat plants (Rupert, 1991). Results of X-ray diffraction of the clay-sized (2μ in diameter) material in these cores indicated the clay was composed almost entirely of calcium carbonate.

Almost no phyllosilicate clay minerals were found (Rupert, 1988). Such a calcium carbonate slime is commonly found on the floor of abyssal areas of the ocean (Arrhenius, 1959). In a cave environment, such a slime would likely be a product of weathering (corrosion and corrasion) and re-precipitation of calcium carbonate ($CaCO_3$). Cores taken in Wakulla were from 130-140' of depth at locations very close to the cave entrance. Because of this and evidence of active entrance facies processes, it is not certain whether the material in the Wakulla cores was of autochthonous, allochthonous, or mixed origin.

White (1988) reports that clay minerals are surprisingly sparse in most [vadose] cave sediments and that some of the muddiest cave fills from south central Kentucky and the Appalachians consist mainly of fine-grained quartz with only small amounts of clay minerals. Wilson (personal communication) proposed that Wakulla system sediments are not typical of Florida caves. He referred to the Wakulla system and its sediment as an "end member" on a continuum of geologic types. Preliminary analysis of sediments from three Florida caves indicate a clay fraction that is predominantly kaolinite but high in quartz (Martin and Harris, in review).

Bill Wilson is a certified cave diver and karst geologist. When I shared this literature review with him, his response included: "Geologically, there is no question that most cave sediments are exogenic [having come in from outside the cave]. Sediments are derived principally from outside the cave and are transported into the cave by flowing water and/or gravity. This is true because caves generally serve as stormwater drainage systems having connections to the surface (such as sinkholes and swallow-holes), and because most limestone is very pure (95-100%) calcium carbonate, so there is not much residual material to be derived from the bedrock itself."

Wilson related this to results of mineralogical analysis of sediments from three Suwannee River basin phreatic caves (Martin and Harris, in review): "Consequently, I would emphasize that, as expected, the cave sediments have mineralogies that correspond to the overlying materials—soil, Pleistocene sand, and the Alachua Formation or Hawthorn Group. That is, the mineralogy of the sediment indicates that the sediment is principally exogenic. This is not geologically astounding, but it conveniently sets the stage for future research."

Commenting further, Wilson said, "The key value of sediments is that they record changes in the velocity and chemical character of the ground water that flows through the cave. These changes indicate variability in the hydrology function and performance of the cave, and give insight to the geomorphic history of the cavernous drainage network.

"It may be helpful to compare the grain size of the sediments to the current water velocities in the caves. Are the currents strong enough to transport sand or are they too strong for clay to settle out of suspension? Changes in the velocity required to either transport or deposit sediment indicates that gradients and/or water table (potentiometric surface) elevations have changed during the history of the cave. These changes could be directly linked to sea level changes during the Pleistocene" (W. Wilson, personal communication).

Clay and sand sediments may enter some phreatic caves when spring flows are reversed during floods of nearby rivers. Bull (1981) described this type of process as "weather events injecting pulses of sediment-rich water by a translatory flow (shunting) mechanism into standing water in the caves" (Jennings, 1985). Clays brought into caves by this mechanism are likely to consist primarily of the predominant clay minerals found in soils of the drainage basin. Some clay minerals, however, may be transported more readily than others. It is also possible that during the last ice age, water-table elevations in the vicinity of many phreatic caves were much lower. At that time, present-day springs may not have been springs, but rather may have been swallow-holes receiving sinking streams. Such streams could have transported significant amounts of sediment into the caves. Once inside phreatic conduits, clay sediments can be re-distributed, sorted, and weathered. They can also be chemically altered by changes in water chemistry.

Some phreatic-cave clay sediment beds have been observed to have been exposed to cross section by post-depositional erosion. Such exposed cross sections often exhibit distinct layering of rust-red and grey, or dark grey and light grey. In most cases, such layering is likely related to fluctuating differences in the redox (oxidation-reduction) potential of the water present when these sediments were deposited. Redox potential is a function of water oxygen content and biological and chemical oxygen demand. Redox potential effects the color of iron and manganese coatings which pigment many soils and sediments. It is likely, therefore, that color bands in clay sediment deposits are caused by fluctuating differences in the redox potential of iron and manganese impurities in the clays at the time of deposition.

Clay sediments of underwater caves have only begun to be examined (Martin and Harris, 1992). Information on these sediments could contribute to a better understanding of the hydrologic history and karst processes of karst regions where most caves are under water.

Future Research. Ideal caves for future sediment studies should be accessible, of reasonably safe depth, well known to cave divers, and already accurately mapped. Some should be cave systems with no upstream sinkholes while others should be systems with upstream sinkholes. Sediments should be sampled from low- and high-water flow areas, from erosion-exposed stratified clay banks, and from debris cones.

Caves exhibit unusual sedimentation mechanisms rarely (or even never) seen in non-cave environments (Bull, 1981, Jennings, 1985). Interesting work could be done on carbonate, silicon, aluminum, iron, manganese, and sulfur geochemistry in cave sediments. Little is known of the microbiology of cave sediments (Peck, 1986), thus much useful work could be done in this area. Results from these types of studies could be complementary to research in groundwater hydrology and chemistry, and karst geomorphology.

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SPEED CONTROLLERS FOR SCOOTERS

Lt. Bob McGuire (NSS #23415)

Speed controllers offer the scooter operator many benefits. Two significant benefits are smooth speed control, from zero to full speed, and an increase in range per battery charge.

There are several different types of speed controllers available. SCR (silicon-controlled rectifier), resistor/contactor, battery switching, and transistorized. Based on the following factors, I have selected, tested, and am presently using a transistorized controller board.

First, transistorized controllers utilize transistors to modulate power to a motor. Pulse-width modulation is the technique of varying the transistor duty cycle (on time) as a means of controlling current to the motor, resulting in smooth, quiet operation, and most importantly, increased range per battery charge.

In selecting a controller, I considered several factors:

1. **Transistors.** Provide high reliability and are not prone to lock-on. Full-on capabilities of transistors allow the controller to go to 100% duty cycle without the added cost of additional components required in SCR controllers.

2. **Switching Speed.** Fast switching capabilities of transistors permit high frequencies, no harmful overheating, lower ripple currents, and nearly 100% efficiency in all modes of operation.

High ripple currents keep average current levels unnecessarily far below the peak current; torque is reduced. With low ripple currents the motor stall current is kept close to the controller limit to provide higher stall torque and optimal efficiency.

3. **Smooth Speed Control.** Transistors allow speed to be varied smoothly from zero to full, resulting in precise motor control of motor speed and torque. No hard starts on motor of drive assemblies.

4. **Current Multiplication.** During acceleration or reduced speed operation, a controller can act as a DC transformer. More current flows to the motor than flows out of the battery. Range per charge is increased.

The controller operates by switching from state 1 to state 2 at a rapid rate. The ratio of the time spent in state 1 to the total time is the duty cycle. When the duty cycle is less than the unity, the current in the motor is always greater than the current out of the battery. Where the duty cycle is equal to 50%, the motor current is twice the battery current.

5. **Current Limiting.** The controller should have a preset maximum value to protect the components of the controller and the motor windings.

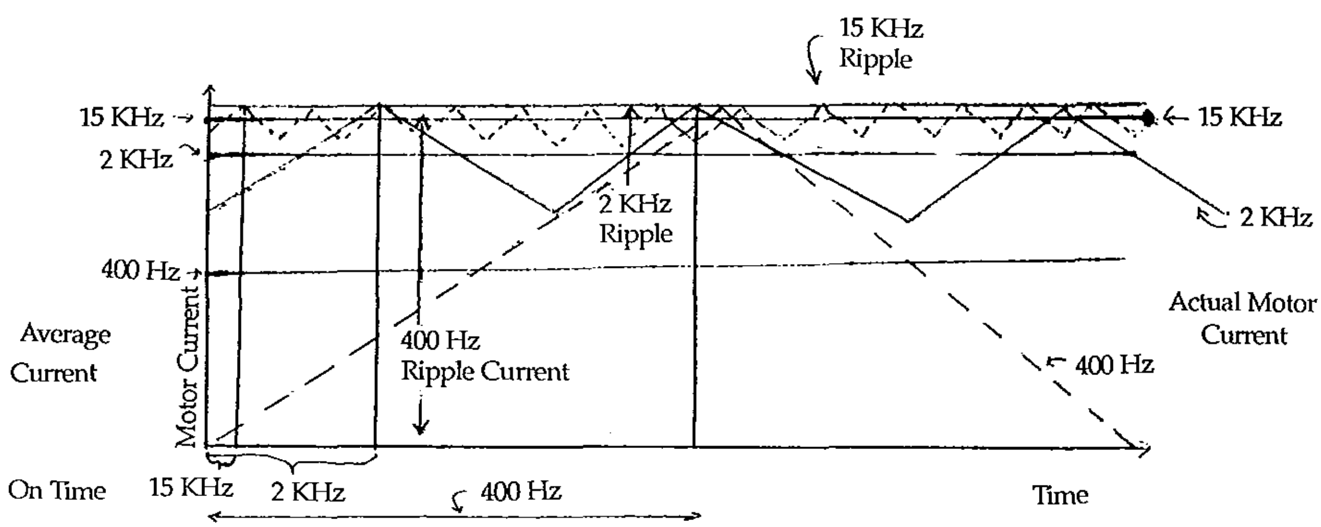
6. **Input Power Filtration.** An input power filter creates higher efficiency operation. This allows the battery to deliver DC power to the controller without on/off pulses typical of unfiltered controllers. Lower losses from the battery, input cables, and contactors are the benefits of high-frequency power filtration.

Some of the safety and design features a controller should possess are:

1. **Slow Speed Control.** The response of the controller to the throttle should have a reduced sensitivity at the beginning of its range. In other words, less than 50% of the total speed is available in the first 50% of the throttle throw. Control and maneuverability are maximized. This allows the scooter operator to run at extremely slow speeds. Even vertical ascents can be made with the scooter powered up (ask Jerrod Jablonski at Ginnie Springs about speed control).

2. **High Pedal Protection.** To protect against the danger of sudden takeoff when the on/off switch is turned on and the throttle is not in the off position, the controller should contain a detection circuit that disables the controller until the throttle is returned to the off position.

3. **Runaway Protection.** If an electrical fault occurs in the throttle, the controller should be automatically dis-



abled by a detection circuit. A simple full on/off system could be wired in parallel with the controller using a relay to provide redundancy.

4. **Polarity Protection.** To protect against accidental reverse-polarity battery hookup, the controller should contain circuitry to protect the main contactor. Normal operation would continue when polarity is corrected with no damage to any components.

5. **Thermal Protection.** Active and passive minimization of heat is required to maintain peak efficiency of the controller and motor. When conditions cause overheating, a thermal switch would reduce current levels, but still allow power to the motor until the controller cools to normal operating conditions. A test dive was conducted with the following parameters: 4000′ run, medium flow, two stage bottles, drysuit at an average depth of 160′; note buoyancy considerations. No heating of the board was evident.

6. **Ramp Circuit.** Provides for smooth acceleration and deceleration and prevents a current spike during initial motor activation.

7. **Trim Pots.** Independently adjustable acceleration that can be set by an on-board trimpot allowing the user to set desired accel/decel times. The time from zero to full power and from full to zero power can be set using trimpots. A good range for these times is from 0.5 seconds to 3.5 seconds. These times could be adjusted not only according to the user's desires, but also to the cave configuration. In some cases the scooter would be set at 0.5 seconds for use in large caves where a fast start is desired and 3.5 seconds in smaller, silty tunnels, allowing the operator a smooth start/stop and the ability to adjust trim and attitude of the scooter before the full power setting of the throttle is reached.

8. **Externally Programmable Top Speed.** Top speed of the scooter could be set by a potentiometer or a switch and resistor.

9. **Under-Voltage Protection.** This reduces motor current when the batteries discharge to about 2/3 of nominal voltage, allowing the controller to continue operation, with reduced performance, on low batteries; at the same time protecting the batteries from extreme discharge. This is important considering how battery-cycle life diminishes as the depth of discharge increases. [NOTE: Lead-acid batteries' cycle life has a curve in which the depth of discharge is directly proportional to the number of cycles. For example: depth of discharge is 95% resulting in approximately 200 cycles and a 50% discharge allows for approximately 400 cycles.]

FUNCTIONAL DESCRIPTION OF DC MOTOR SPEED CONTROLLER

Synopsis. High-frequency, pulse-width-modulated, power FET DC-motor speed controller. A half-bridge FET configuration plus two directional relays result in four-quadrant motor operation. Motor current is always positively controlled. During normal operation, motor current goes through the lower drive FET when both FET's are off. When the regen FET turns on, its internal diode gets shunted by the FET turn-on, further reducing voltage drop and power dissipation. Motor speed is adjusted by varying the duty cycle of the Power FET half-bridge output stage according to the throttle control input signal.

Testing and Results. With limited testing at this time, I conservatively estimate a 25-30% increase in range. The ability to control speed with a mere twist of an external knob has increased the functionality of the scooter by twofold. Instead of swimming the scooter through low areas it is possible to quickly lower speed, but still maintain forward progress.

Future. I am preparing to install a system in a Tekna scooter; by installing the potentiometer near the handle it will be possible to control the speed of the scooter easily in response to the dive configuration and adjust to slower scooters. No more waiting for the slower scooter or clumsy attempts to set the blade pitch. At the same time this may allow for replacement of the mechanical speed adjustment in the scooter eliminating unreliable components.

Cost. At this time the cost of the setup is in the low $200 range. This is based on a 10-49-piece purchase price. Considering the extended range and battery life, this makes the controller viable economically. Any comments, corrections, and suggestions are greatly appreciated.

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Bob McGuire has been cave diving for ten years and has made over 700 cave dives. He dabbles in cave video and has recently extended the line in Madison Blue 2000′. ■

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