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SAFETY MEASURES
of the
WARM MINERAL SPRINGS
UNDERWATER ARCHAEOLOGICAL RESEARCH PROJECT

As in any large scale undertaking, hazards were involved in the diving operations of the Warm Mineral Springs project. The extent with which they were overcome is shown by the success of the project, including the fact that not one serious accident occurred during my stay there. However, the hazards were multiple, and since this is an on-going project and other projects of like nature may be undertaken in the future, the problems which occurred and their solutions should be discussed.

There were four main hazards which faced the divers. This is the deepest underwater archaeological project ever undertaken, and as such depth itself is a considerable hazard.[1] And yet several dives were made to approximately two hundred feet. A second hazard was that of the "bends", or decompression sickness as it is now more commonly termed. A very small working crew of divers, usually no more than six on any one day, meant that repeditive decompression dives were necessary to get the work done. A third hazard has to do with equipment problems and malfunctions. Warm Mineral Springs is probably the most extreme environment in the world for diving and related equipment as its water contains approximately 20,000 parts per million of solids, including large numbers of chlorides, sulfates, sodium and potassium ions and calcium carbonates. These not only deposite onto equipment, but also corrode the metals involved and are very good conductors of electricity (which is critical when dealing with underwater vidiotape equipment and photographic strobe lights). The last problem was with the bathers who flocked to the spring, which is a privately owned health spa.

One of the divers named the bathers "dinasours", a name which stuck because of the problems which involved trying to conduct demanding research dives with detailed pre-dive briefings while also trying to cope with some of the most ridiculous questions ever put to a diver. The very number of bathers in the spring kept safety observers from tracking surface bubbles or seeing distress markers and thereby constituted a big safety problem. It was a problem which had to be handled with tact because the State of Florida had contracted with the owners of the spring and spa under the understanding that diving operations wouldn't interfere with the operation of the spa. All but the last of the major safety hazards were completely overcome, and the last was negated to some degree by ingenuity and sophisticated diving techniques.

One of the most basic safety measures taken was the strict enforcement of the buddy system. The buddy system was defined as a pair of divers who maintained visual contact and were physically close enough to render aid when it was warranted. Basic working techniques had to be modified at one point to allow the buddy system to function. A couple of times during the project this system broke down, due to a number of factors. Whenever this happened, the problems were thoroughily discussed and a solution to the problem was found.

For deep dives, a safety diver who could be in the water, fully equipped, within sixty seconds after notification of a problem or an emergency was used. The safety equipment was set up and ready for immediate use. At times the safety diver would rendezvous with the deep divers by diving to the deepest decompression stop (usually 40 feet) at the computed time at which the deep divers should be at the stop. This allowed a visual check of and slate communications with the divers to check their condition and communicate any needs to the surface.

It also provided a link with the surface so that in an emergency the deep divers need not interrupt their decompression schedule.

A timekeeper was provided for all diving operations. It was the timekeeper's duty to log the dive, including the diver's time spent underwater, bottom time, and repeditive dive status. Figuring initial and recalculated decompression was also amoung the timekeeper's responsibilities. The dive log was also filled out by the diver. Any observations about the work, physical or archaeological aspects of the cave, or any other pertainent observations were noted in the log and the log was read by the dive safety officer at least onee a week.

Of the physical and physiological hazards associated with deep, repeditive dives, decompression sickness was probably the greatest hazard. The US Navy decompression tables for air,[2] both standard and exceptional exposure tables, were used exclusively for both planning and the actual carrying out of various decompression schedules. When a dive was conducted using the exceptional exposure tables which had no repeditive group designator listed at the end of the dive, with one exception no further diving was done by these divers for the full twelve hours required to be a non-repeditive dive. The one exception involved the use of computer determined (but untested) repeditive group designators on one of the dives for the US Navy Exceptional Exposure Tables.[3] These tables, designed for use with air decompression, were used with oxygen decompression schedules. Decompression meters were banned from the project as unreliable and unsafe. All dive teams, and usually all divers, were equipped with laminated copies of the dive tables, including exceptional exposure tables plus a watch and a depth gauge. If planned decompression times were exceeded, new decompression schedules could be computed without the hazardous need to surface. A surface decompression stop, lasting $\frac{1}{2}$ of the time spent at the ten foot stop, was also required in chest-deep water as a further safety measure.

Helicopter evacuation in case of a decompression accident was set up using both the US Coast Guard Station at St. Petersburg, Florida and Detachment 14, 48th Aerospace Rescue and Recovery Squadron at McDill AFB, near Tampa. The Air Force would be notified during the week days, and the Coast Guard after hours and on weekends. Air Force response time was five minutes (response time being the time it takes after notifacation of an emergency to get a helicopter flying) using the HH-I helicopter and the Coast Guard response time was about 15 minutes using the large S-61 type helicopter. Proceedures were also set up for the notification of the chamber at Riviera Beach as soon as helicopter support had been confirmed. Driving to the chamber or an airport was not practical in an emergency due to crowded freeway conditions.

Orientation dives were given to each new diver before the diver was allowed to work on the project. This allowed the diver to adjust to the new environment in which much of the diving invloved working on the side of a "cliff" (actually the side of the spring) and not on the bottom which is more familiar to most divers. It also allowed the diver to adjust to the different equipment and techniques used by project divers. Dives usually required the use of twin tanks (either 71.2, 80 or twin 100 cubic foot tanks); a single hose regulator equipped with an octopus regulator, submersible pressure gauge and a "zapper" hose (to manually inflate the buoyancy compensator); a wet suit jacket (even diving in 87°F water, divers chilled slightly during decompression and severely at the surface when exposed to an evening wind); fins; mask; knife; watch; depth gauge; writing slate & pencil; buoyancy compensator & weight belt; primary and secondary lights as basic equipment. Cameras, various tools and lines, sample containers, etc. were also carried as the dive plan indicated. The lights used were extremely good, having been custom built for cave diving, and constituted another safety plus.

The problems involving narcosis were minimized by using highly skilled divers of the Florida Cave Diving Association, and project divers who had been acclimized to deep diving for all deep dives. The acclimization process consisted of several dives to moderately deep (120-160 feet) depths before going to extremely deep dives. This conditioning is said to decrease the effects of nitrogen narcosis. The diet of the deep divers was watched closely to preclude any physiologica interferance with diver performance.[4]

Equipment malfunctions did occure. The author, for instance, recieved several good shocks from a short which developed in the housing connector for a Subsea 150 strobe light, the battery of which is rated at 510 volts. At one point a buoyancy compensating vest was rendered inoperable when the cover of the overinflation relief valve was pulled off as the diver swam over a taut horizontal line upon which it caught. Four regulator malfunctions were noted, one of which resulted in a completely inoperative first stage (this is debated by different members of the team, as turning off the scuba tank valve and turning it back on restored the functioning of the regulator; some feel that the tank valve hadn't been correctly turned on). Another malfunction involved an uncontrolled underwater freeflow of the regulator. These malfunctions occurred to Poseidon's Cyklon Super 300 regulator, a regulator chosen virtually unanimously by the team beacuse of its extreme ease of breathing, and (except as mentioned above) involved sucking water along with the air due probably to a combination of a partially clogged open exhaust port and a high venturi setting on the regulator.[5]

The use of underwater vidio tape equipment and hard line (telephone-type) communication with the surface introduced not only a new method of observing and recording data, but a substantial safety factor as well. The diver's condition is constantly monetored using this equipment via a "hot" mike (one that's never turned off) which allows surface personnel to hear the diver's exhalations and the demand regulator opening upon inhalation. The voice communication with the surface averted what could potentially have been a very serious situation involving a deep dive in which too much time was spent on the bottom and the divers ran low on air during decompression (before the oxygen equipment was available). Dive proceedures required the divers to surface when scuba pressure got down to 750 psi gauge, but in this case this wasn't enough as the divers had to go to an interrupted decompression schedule when one of the divers inadvertently ascended almost to the surface before beginning decompression. The safety diver was notified of the emergency and brought extra scuba cylinders to the divers. In addition, this diver was put on ~~pure~~ 100% O_2 for thirty minutes after surfacing.

The vidio tape equipment itself constitutes a considerable hazard if it is improperly used. Because of the extremely high voltage associated with the camera and its mercury vapor light, if the system isn't properly grounded, the diver could recieve a serious or even fatal shock. The Underwater Archaeological Research Section (UWARS) vidio personnel, perhaps the best in the world for this type of work, did an excellent job of overcoming these problems.

The problem of the bathers was delt with by planning the dive at the diving locker and away from the bathers. However, their overwhelming presence at the spring was still a problem. This problem may have been lessened after my departure as the diving safety officer was thinking of doing most of the diving in the early morning, late afternoon, or at night.

Because of the high emphysis on safety, and constant vigilance on the part of the project director and dive safety officer, most of the major problems involving a deep water research project have been overcome. Other measures, such as saturation diving techniques, the use of semi-closed and closed circuit scuba and the use of a breathing mix which lessens or excludes nitrogen (which is responsible for the narcosis) have been discussed but are, at this time, impractical due to the extreme cost involved. One measure which will probably be used in the future is the use of surface supplied air for the Kirby-Morgan Band Mask, Mark 9 (KMB-9 mask) instead of using the KMB-9 mask with scuba. The mask must be set to free flow at depth when the diver works hard or carbon dioxide (CO_2) will build up inside the mask and compound the problem of narcosis (due to the synergistic, or compounding, of CO_2/nitrogen). This greatly increases air consumption from the scuba and necessitates the use of larger air tanks, twin 100 cubic foot tanks in this case, for KMB-9 mask dives. It would probably be a good idea if all the deep divers could work with the KMB-9 mask and surface supply air with hard line communications both between divers and with the surface personnel. However, there are other problems involving entanglement and training, aside from the cost, associated with this concept and it's still in the discussion stage.

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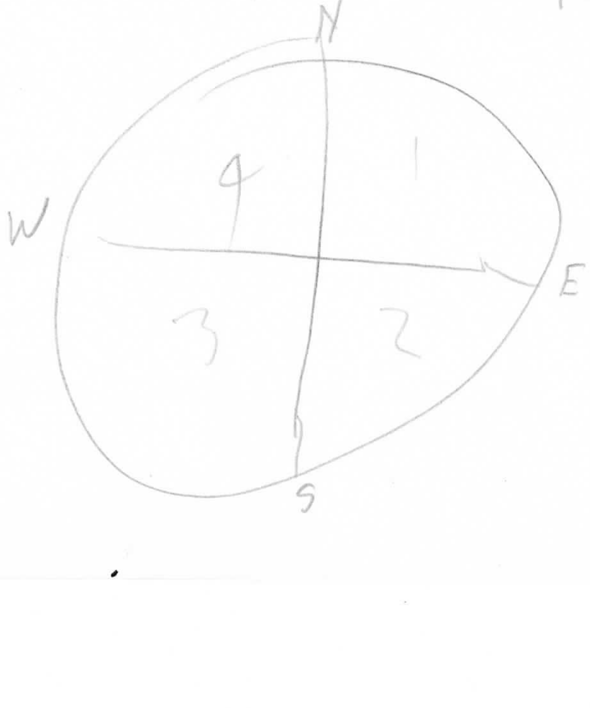
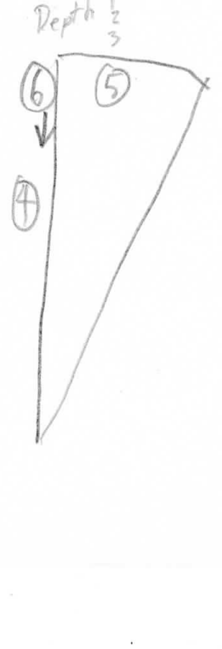
Quad #	3	1	2	3	4	5	6
Depth	1	65'	68	65	65	65	70
	2	65'	68	65	68	65	70
	3	20m	21	20	21	20	21,5
D_m	④.	19,72	19,90	19,88	20,90	20,76	21,40
P_m	⑤	5,20	5,08	5,20	5,52	5,56	5,90
C°	⑥	0°	20°	27°	36°	60°	74°

$P_m - 0.6\ m = P$

Ouad #	4	1	2	3	4	5	6
	1	62	65	65	65	65	65
	2	62	65	65	65	65	65
	3	19,5	20	20	20	20	20
D_m	④	19,52/19,90	21,00	20,40	20,21	19,60	19,40
P_m	⑤	5,40	5.82	7,96	5,50	5,34	5,80
C°	⑥	90°	104°	122°	140°	—	[illegible]





Quad #	1	1	2	3	4	5	6
Depth	1	65'	65'	65'	65'	65'	65'
	2	65'	65'	65'	65'	65'	65'
	3	20m	20m	20m	20m	20m	20m
D_m	④	19,27	19.10	18.73	18,91	19,89	20.54
P_m	⑤	3.67	3,37	5.26	5.82	4,85	6,35
Reverse Compass Bearing	⑥						

$P_m - 0.6m = P$

Quad #	2	1	2	3	4	5	6
Depth	1	65'	65'	65'	65'	65'	65'
	2	65'	65'	65'	65'	65'	65'
	3	20m	20m	20m	20m	20m	20m
D_m	④	20,00	19,38	19,48	17,46	19,40	19,88
P_m	⑤	6,20	6,06	5.68	5,18	2,73	3,45
Reverse Compass Bearing	⑥						

Level line
Pt. distance