UNDERWATER CAVE SURVEYING IN AUSTRALIA

by

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In the last 30 years in Australia cave diving has flourished. Sinkhole diving in the Mount Gambier area is now safely controlled, and highly advanced cave diving is successfully undertaken in a variety of other areas. During these years many thousands of sinkhole dives have been conducted, hundreds of sumps negotiated, tunnels penetrated and considerable 'dry' cave discovered by divers. However, even now many of the regularly-dived caves have not yet been mapped beyond sketch level, with some no more than vague recollections in the water-logged memory of old time divers. The reason for this is not that cave divers are bone lazy but due to the technical difficulty of conducting underwater surveys.

This discussion outlines the basic techniques and equipment of cave diving and underwater surveying and includes a brief history of Australian cave diving with examples of detailed exploration and mapping that has been undertaken.

Cave diving has been in Australia since 1952, when its unlikely birth occurred in the demanding river systems of the Jenolan Caves. From these pioneering days of homemade equipment and experimentation this rather maligned activity has flourished despite negative publicity and public ignorance.

During these 30 years, the events which most shaped the development of cave diving, were the tragic deaths which occurred during the 1970's in the Mount Gambier sinkholes. These incidents led to the formation in 1973 of the Cave Divers Association of Australia, which has safely controlled diving in these sink holes preventing further fatalities.

Whilst the CDAA has accomplished more than any other cave diving body in the world in the fields of administration, education and qualification testing, it has unfortunately not had the opportunity to undertake organised research into the caves over which it has some jurisdiction. This is in part due to the make up of the membership, most of whom are ocean divers who have been trained and tested in techniques suitable for sinkhole diving. In general these divers could be classified as recreational sinkhole divers with only a passing interest in these unique formations which they consider simply as large clear deep holes.

Consequently it took from 1960 when diving started in the sinkholes until 1980, before any maps were published, even though many holes were dived very frequently. In terms of dry cave exploration this would be unheard of since the usual practice is for the cave to be mapped as it is discovered. In the case of the Mt. Gambier water holes, however, the initial discoverers were usually local, self taught ocean divers with no caving experience. One can appreciate that they were fully occupied with simply surviving the unknown dangers of this new and eerie environment without being concerned with detailed surveys. Even when divers became better equipped and had some prior knowledge of what they were about to enter they seemed content to accept the holes being 'bottomless' football field size chambers without any desire to understand anything further. Eventually curiosity got the better of a small number of divers, and sketches showing basic dimensions, shape and direction of the holes were published in the book 'Cave Diving in Australia' dispelling much of the argument and fictional fantasy surrounding them. It is, however, interesting to note that the personnel involved in the production of these sketches had dry caving backgrounds and had been involved in advanced cave diving in such places as the Nullarbor, Jenolan and Tasmania. All of these locations required very different techniques from sinkhole diving. The generally horizontal penetration diving undertaken lent itself to similtaneous mapping and exploration using standard dry caving survey equipment. Whilst some extensive caves in the Nullarbor were mapped and detailed mapping of stream way passages in the Jenolan caves was successfully undertaken, it was found that the survey techniques used were not entirely suitable for the larger open voids of the Mt. Gambier sinkholes.

Indeed the logistics of undertaking a detailed survey of a water filled sinkhole is so great that only very few serious attempts have been made. From these experiences we have come to recognise the factors which affect the accuracy of the maps. By breaking these factors down under two major classifications - the Diver and the Environment, the magnitude of the overall difficulty of this type of surveying can be appreciated.

THE DIVER

Any person who ventures below the surface of the water for whatever purpose is acted upon by pressure which increases with depth. At 10m depth water pressure is double that of air at the surface and at 20m triple. This basic physical constant when related to human physiology introduces the diver to a number of potentially dangerous afflictions such as Pulmonary Barotrauma (Burst Lungs), Decompression sickness (Bends), Nitrogen Narcosis, and so the lethal list goes on. In a cave diving situation where a direct ascent to the surface, and hence to that vital substance air, cannot be made in an extreme emergency, then the problems become compounded. Whilst the possibilities of becoming stuck or hit by rock falls are what most cavers face occasionally, these events or simply losing ones way underwater has some very severe short term effects - usually death by drowning. Without wishing to sound either morbid or paranoid the simple facts are that diving, especially cave diving has very real potential dangers so great in number and so different from any other activity that only by specialized methods can it be undertaken with relative safety.

Over the last 10 years, systems, equipment and techniques have been developed to make cave diving safer and more enjoyable. The price paid for much of this safety is very limited time underwater. On an average sinkhole dive, the divers would spend not much more than 30 minutes in the water with about half of that time at the maximum depth of 36m (maximum safe depth determined by the CDAA) and the remainder for decompression stops which are required to prevent the bends, and entry and exit. Two dives per day to these depths can be conducted with relative safety, which gives you a total of 30 minutes per day suspended under the ledge in these large chambers. During this 30 minutes the diver must watch his depth and make adjustments to his buoyancy as required, monitor the time, air pressure of his tank and adjust equipment. Most importantly he must watch his buddy, who is watching him, for signs of nitrogen narcosis which has a similar effect to drunkeness and occurs often without any warning. As a consequence of this continuous demand on concentration and manual operation the ability for a diver to undertake even simple tasks such as taking a bearing or noting a distance is severely hampered even in ideal conditions. In extreme conditions such as greater depth, darkness, poor visibility and other environmental factors the task may become so demanding that it could be expected that any data collected would be so dubious as to not warrant the risk.

There are however some positive factors one of which is the divers ability to swim almost effortlessly from floor to ceiling and hover at any point between. This is a considerable advantage over walking around a cave and spending effort and time in clambering about the floor and having to use vertical climbing techniques to check out roof and wall details. Furthermore it can give a diver the opportunity to get a birds eye view provided he has adequate lighting and good conditions. Unfortunately because of the limited time available, the limited vision a mask allows, and the inability to adjust to night vision until nearly the end of the dive it is usually not possible to take full advantage of these benefits. Because of this, divers tend to gain a rather jig-saw memory of underwater features often with considerable difference from diver to diver.

THE ENVIRONMENT

The main environmental factor is water.

Emptied of water these sinkholes would be very large dome roofed chambers with daylight penetrating to almost all areas. Dry cavers would be able to gain access to the tops of the large natural rock piles 30-40m below the doline mouth using vertical techniques and clamber down the slope to the flatter rock strewn areas under the overhangs. At the extremities of the caverns they would be able to explore the small silty tunnels and gaps between boulders for further cave which could connect with other known features via conduits at greater depth below the surface. Certainly an exciting thought, but as yet we haven't a big enough pump to drain the Otway Basin and hence we are left with the problem of water filled caves.

Probably the first difference between our de-watered sinkhole and a typical water-filled hole is that you can't see much below the water surface, in many of the holes algae and aquatic vegetation grow across the surface sometimes in a complete carpet. As a consequence of this surface layer and of the property of water to deflect and absorb light, nearly all of these caverns are in total darkness and powerful underwater lights are necessary. Towards the rear of the chambers only a faint green glow signifies the position of the entrance and the way out. For safety, guidelines are unreeled by the divers so that should they loose sight of the entrance they can retrace their path. Whilst in many cases the water is crystal clear algae and dirt in the water can reduce visibility to less than 1 metre especially in the upper regions whilst silt which has accumulated for thousands of years on the floor and ledges can change visibility from perfect to zero in seconds when disturbed by a passing diver's fins.

Another major problem with the water is its temperature of 11° to 15°C which is sufficiently cold to cause discomfort after 30 minutes even when protected by professional style wet suits. In Tasmania the water temperature can drop to 6°C. At depth, during longer exposures or under certain other conditions the effect can lead to hypothermia which itself is dangerous but can also increase tendencies to other physiolological disorders such as the bends and narcosis. Probably the most common sympton of even mild hypothermia is the loss of manual dexterity and coordination with out which writing, taking bearings and those other simple survey tasks become painfully difficult.

In review then it can be seen that the cave diver has a number of serious disadvantages when compared to his dry caving counterparts. As an outcome any task he wishes to undertake is constrained by time, depth, vision, equipment, physical ability and experience. Unlike the dry caver an oversight in any of these areas could lead to the diver being suddenly at very real risk.

When surveying underwater all of these points have to be considered and coordination and planning thoroughly conducted to ensure maximum efficiency. It must also be remembered that divers cannot talk underwater, communication has to be simple and to the point. Many many dives to undertake a simple task have been wasted because the parties did not understand or were not correctly prepared to do the job.

UNDERWATER SURVEYING

In any cave survey the basic data required is horizontal distance, vertical distance and the direction (bearing), between known points which can then be related to the features of the cave. Accuracy and precision varies with technique and equipment used and since equipment such as theodelites etc., have not been developed for underwater use we are left with only fairly basic tools.

Generally linear measurements are made either using fibreglass tapes or our polyporpylene guideline which is run out from a known point at the surface and marked by placing knots at the features and then measured against a tape at the surface. No correction is made for sag (or infact float) or tension on these lines since the error would be expected to be minimal, however slope corrections can be made knowing the depths of the points measured. The average depth gauge could be expected to generally have an accuracy of + or - 5%, however those used for detailed surveyings are usually check calibrated to 1%. Consequently both horizontal and vertical distance components can be measured quite accurately, given that the diver has had suitable diving conditions.

Fixed lines are often used between selected points and can even be developed into a grid pattern for detailed small area mapping of areas such as bone deposits. It has been found through experience that a well laid system of fixed lines is vital to the success of surveying.

Direction is measured using underwater compasses which cannot be expected to have better accuracy than + or - 5 ^{0}. They are also subject to greater user error and it has been common for several divers to take the same bearing with 30^{0} discrepency between them. Some of these errors can be eliminated by better technique and minor equipment modifications, however, bearing measurement remains subject to the greater error.

The use of underwater datum points which are directly related to a surface point which can be surveyed using more accurate above water techniques and where there are no time restrictions is also a major method of reducing inaccuracy. This can easily be done with points around a sinkhole mouth where shot line can be dropped directly into the water. In enclosed air chambers Radio Direction Finding equipment has been used. As yet we do not have RDF equipment for use underwater as has been experimented with in Britain. This type of equipment could be developed into an under water survey tool allowing surface personnel to trace the path of divers carrying the transmitter in the cave below and could even be used for communication. Until such time as these dreams are realized underwater sinkhole surveying will not be able to extend itself much beyond at best ASF grade 3 level. Nevertheless it must be realised that this is a considerable gain on the nothing we had 5 years ago, and that the end result is a map of sufficient accuracy to meet the major aims of dive planning, orientation and search and recovery. As scientific interest increases in the water-filled environmental systems, we can expect that more detailed maps will be required and more advanced survey systems perfected.

REFERENCES

Lewis, Stace, 1980, 1982. **'Cave Diving in Australia'**