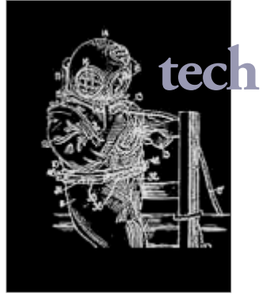
*The fine art of conducting*

# Extreme Exploration Dives





## How to master the complexities of extensive explorations of underwater caves and other overhead environments

Our case story will be a recent actual exploration where the dive profile posed a few challenges:

- Distance of 700 meters from the entrance to the end point.
- The depth of 164 meters at the beginning of the actual exploration and 186 m at the end.
- Duration of the dive which including deco stops required a run time 9 hours and 46 minutes submersed.

However, even if this specific dive profile presented us with some exceptional challenges, it wasn't fundamentally different from other technical dives in terms of safety and logistic considerations. We do our preparations and make plans in which we try to reduce the number of unknown factors as much as possible.

In technical diving "what if.." and "plan your dive and dive your plan" are all basic mantras. It is only the magnitude of the undertaking that changes as well as the levels of complexity. Even for a practiced tech diver who routinely dives his twin 12-liters tanks and use ready made table dives like this are much more complicated.

### Preparations

1. Defining objectives and means.

In this case the objective was to explore an underwater cave that would take divers beyond the depth of 164 meters before the made it to the end. In this case we planned as if we were diving to a depth of 200 meter and ranging more than 700 meters from the entrance. On the actual dive date we may then find that these preset definitions of depth and time do not match up with the actual diving profile, mental and physical fitness and the equipment at hand. This leads to postponements and delays which may run into a year, or at least several month of waiting, which is often the case. It is thus necessary to stay fit and keep practicing all the relevant technical skills. In this case I kept up a regular schedule doing many speleological/cave dives where I could rehearse practice stage and travel procedures as often as possible, as well as practicing deep and rebreather dive profiles.

In the beginning of May we found ourselves in Egypt. After one week of diving between 50 and 100 meters deep with stage and trimix, I've also made five dives to depths between 65 and 180 meters on rebreather in order to some build routine with real deep dive profiles and to test the 150 meter barrier.

Physical fitness training was not an issue as I practice every year around 4-5 times a week by running, swimming and bicycling so I simply took a nice break the week before the actual dive.

### Knowing the location

This cave is quite the labyrinth and has several levels. So it is a good thing I knew it rather well. A year ago I first dived it to a depth of 60 to 90 meters before going down to 150 meters. And the week before the dive I've returned with a rebreather,

going to the 70 meter mark, just to memorize the route, using a scooter, to avoid wasting time when we were going to do our exploration. Needless to say I had also gone over the available topographic information and reports from previous dives in order to get a clearer picture of equipment load during the dive, restricted passages, currents (what of if it rains the preceeding days?),visibility and necessary permits. In nature it is not any different from when you check the weather forecast, prevailing currents and swell before you go on a dive in the ocean.

2. Choice of equipment

The choice of gear must reflect the depths and environmental hazards. For example when I did my 330 meter dive it was obvious to go with an open circuit system since I had never been beyond 150m on a rebreather. And no one has ever gone deeper than 270 meter on a closed circuit rebreather. On the other hand, the closed circuit system (or semi-closed circuit) is the latest trend amid serious underground exploration dives for a number of good reasons:

- greater autonomy
- greater gas economy
- breathing a much less colder gas
- less tanks to manage
- Possibility for using helium – in the form of heliox - for the entire dive, significantly improving the decompression profiles.

My Voyager dive computer has a battery life of at least 7 hours, making it possible to complete the entire dive, starting from the entrance until the bell-area. My other technical option was to stick with the usual open circuit system with complete redundancy.

We had to bring a few 20 liter tanks inside the cave, between the depth of 110 meters which was 600 meters inside the cave and the dive bell at 12 meters. It was a bit heavy, but in case of a complete failure of the closed circuit, it would have allowed me to make it back to the bell area from the deep end. This also permitted the team to familiarize themselves with the cave.

The scooter or, as it appropriately termed, the Diver Propulsion Vehicle, was also a requirement because of the distance to be traveled. Several trips starting from the deep end which was 500 meters from the entrance helped me to select a model that can really tow, rather than a lighter one. The former, although a little less speedy, seemed to me to be more maneuverable inside that particular cave.

The deco stations: the possibility of mounting a deco station was extensively used. The choice was between a mobile deco station – suspended between 11 and 9 meters deep and then again at 6 meters. Or a fixed

deco station at 6 meters which is much simpler. The mobile option was then chosen as it was capable of staying dry and hot twice as long which in this case meant almost 4 hours instead of the 2 hours offered by the fixed option.

## Decompression strategy

The dive profiles were simplified as much as possible so we opted for a short one and a long one, for a depth of 180/200 meters at the bottom which was already very complex with its several levels and a great end depth. As an additional option we could use a set of a set of more conventional tables and 2 multi-gas computers, one connected to the rebreather to deal with all the intermediary situations.

Simplicity is preferred even if it demands hours of calculations for different profiles and using different software.

With the calculations for depth and time completed, we opted to go with the "full helium" option which only had 6% Nitrogen without a second thought.

Even the bailout plan an open circuit system had a maximum level of 30% Nitrogen

We had full sets of tanks with standard deco mixes 02/He 20/50, 40/30 and 60% $O_2$ which were thoroughly analyzed, marked twice and pressure verified. Also clips sets, and speleological cable keepers for the ropes were checked.

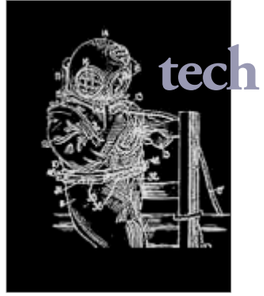
For the sake of safety we also had to consider the situation where we had to perform the dive on open circuit systems and not rebreather. Did we have enough of each mix? For each depth we had to calculate what was needed with an acceptable level of security

Thermal insulation was taken of by a drysuit with Thinsulate 300 undergarment

The diving bell was mounted at 11 meters and since the ambient temperature was 18 ° C it wasn't required to heat the habitat.

## Provisions

Dealing with dehydration is paramount to ensure proper decompression - we can never drink too much. Lots of water with a bit of fructose and a isotonic salt mixture is ideal. Fruit juices or energy drinks can also be used but with moderation as the last thing you would want is nausea. Hot drinks such as light sweet teas or soups are alsi suitable During long dives it is also important to eat to keep up the energy. Energy bars are fine also nut paste or cocoa but go easy on sweets. Put pastes and creams into tubes or syringes. And don't bring ham or other meat products into the dive bell



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## Team

Stay with the same team if possible. It is important to know each other well and how you act under water. In our team we are all multitaskers but each one of us is also a specialist on some area. For this specific dive, I had part of the team who assisted me at my record dive to 330 meters. Each member dove both according to their qualification levels and their role in providing assistance during the dive such as:

- placement of safety and decompression tanks
- helping the deep divers get in the water
- assembly and handling of the diving bell
- deep diver assistance during decompression until the end of the dive (comfort/information assessment, food/re-hydration, photography, etc.)

During planning we delegate roles and responsibilities and some will be tasked with very special roles which he will focus entirely on throughout the dive.

The person in charge of surface management has a lot of particular responsibilities;

- Make decisions.
- Manage the chain of support divers while keeping tabs of the deep diver. Each support dive will be planed according to each particular deco planning.
- Manage safety and possible variables, in case a problem should occur such as longer dive time than planned, evacuation, decompression, drifting in open sea drifts as well of having prepared or evaluated the weather forecast, communications, medical assistance and an evacuation plan.
- Manage the boats if the dive occurs at sea (crew, available anchorage, different types of vessels, etc?)

For that purpose we used a list of participants and material, as well as the deep diver's runtime as planned. Managing it all is no mean task.

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## During the dive

On the big day having everything properly planned and rehearse will pay off, help ease the stress, and aid the visualization during which we review all stages to be followed during the exploration.

Once the process has begun, people are usually less stressed and always very focused on the different technical tasks ahead: All equipment is checked one last time and after performing bubble checks at the surface we commence our descent.

We leave the diving bell and its reassuring shape behind us, the safety tanks, pilot the scooter. After 500 meters, drop the scooter and let yourself glide along successive of wells between 60 and 114 meters deep. Take advantage to descend slightly the 2 remaining safety stations, at 60 meters, at 75 meters and 114 meters respectively. I can appreciate Stéphane's re-equipment handwork as I appreciate my companions'

work at storing the safety tanks. After some 40 meters

It is then a great pleasure and one that makes all the preceeding months of tedious preparations worth all the whole to go beyond the 164m and enter the "terra incognita" as we go into the uncharted gallery. We frequently check the rebreather's oxygen partial pressure, dive time and depth. As we carefully reel out our lines we keep an open eye out for the next opening. We pass 170 meters and go along a long ledge. We reach 180m and another flat surface that gradually leads us up to a dead end at 168 meters. The next area will probably be at a much higher level. Next time perhaps

Facing more than 8 hours of deco time we turned around and went back at a slow pace, taking the opportunity to scrutinize the fault with the powerful 21 watts HID Green Force torch, making it all as bright as daylight. Since we were still on the first stage of the return, we reduced our ascent rate even further to just 3 meters per minute when we reached 132 meters. Still being 600 meters from the entrance we felt being well at home. Our return was very slow being sectioned into short deep stops and by us being busy going into thenooks and crannies.

At 54 meters we recovered the scooter and the third relay, then recompression ahead. A while afterwards, Fred – the first to return and followed by David, Patrick, François and his equipment – 12 meters and its already time to re-enter the diving bell. It was Marc, Josep, Henri and Michel who manned the relay, along with François and Tono, as always.

After 4 hours inside the diving bell, I've surfaced as an extremely happy man. The whole team was eagerly awaiting our accounts from the depths, my opinions and the perspectives of going there themselves. Because is their dive as well.

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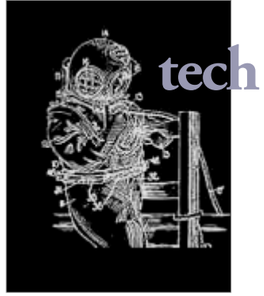
## After the dive

It is important to acknowledge and savor the accomplishment and never forget that it is the result of good teamwork. At this stage we usually already drift into planning the next dive even in the cases where we had a disastrous dive and have just be swearing to ourselves never again. In any case it is important to learn a lesson from each dive. In this case, for example, we felt afterwards that we could have done with a lighter load of equipment in the cave, in particular the safety tanks.

## The downside

We didn't use the rebreather to its fullest. Too many equipment pre-carryover dives, over the entry area, very easy to reach. We should have left some safety/deco tanks between 30 and 6 meters, very easily installable while setting up the diving bell,



the why burden the team.

The use of a dorsal redundant rebreather (2 totally independent closed circuits ) and a third side rebreather left safely, for example, with the scooter at 54 meters would have prevented long/deep and tiresome carryover dives, while allowing for a triple safety measure. And even more, at every moment of the way while we approached the exit.

The re-equipment dives are left in place, which – when needed, would be eventually used as an added safety measure.

## The positive

- We used only 60 bars of trimix during almost 6 hours of dive time, outside the diving bell (wings included). The rebreather option allowed for cutting down to half the number of carryover trips and tank load inside the cave.
- The option of using a mix close to heliox (only 6% Nitrogen to counter the onset of High Pressure Neurological Syndrome) without having to pay a small fortune, and without the fear of helium freeze, since the gas breathed in the rebreather is warm. Also, at 186 m, we could enjoy having completely clear minds and the total absence of narcosis as well as exiting the water in refreshed state after a dive lasting 9 hours and 46 minutes.

Going with the "full helium" option must therefore be considered for validated.

The usage of the mobile diving bell enabled is to stay warm, for being able to talk during decompression and being able to eat proper food rather than having a second stage stuck in your mouth for four long hours. The equipment was chosen for its performance characteristics and reliability. It was a key point for the success of this undertaking.

This equipment included high performance Apeks XTX 50, 100 and 200 regulators, and the Aqualung Legend on the rebreather (oxygen, air and trimix diluent feed) and on the open circuit for the safety trimix. This setup is used by the majority of the British cave divers and and for my dive to 330 meters with no problems whatsoever.

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It also included a very warm Arctic 330 Thinsulate undergarment. Credits also to the Green Force Tri star LED torch with its long lasting power, 21 watts HID over the hand mount and safety torches. The whole set was developed for a 500 meter beam and tested in a hyperbaric chamber at 350 meters.

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- D9 Suunto wristwatch, making our depth up to 200 meters and ideal for a very precise runtime.
- Aquatek Voyager manual close circuit rebreather which was unmodified. For the planning, I've enquired with the manufacturer regarding the model's limitations not only theoretical ones, but those tested in hyperbaric chambers and/or during assembly. At least 240 meters for the O2 feed and 300 meters for the triple PPO2 electronic control.

Setting the limit for this dive to 200 meters left me a large margin.
I have tested the equipment at progressively greater depths, 111 meters (wreck), 177 meters (reef), 150 meters (cave), 180 meters (at sea at Dahab), 186 meters (cave).

Thus, the next step will be using dorsally mounted redundant equipment with totally independent circuits giving 10 hour of autonomous operation. Another laterally carried set that will be carried clipped on so it can be left behind as a safety set for the return trip.

## Acknowledgements

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