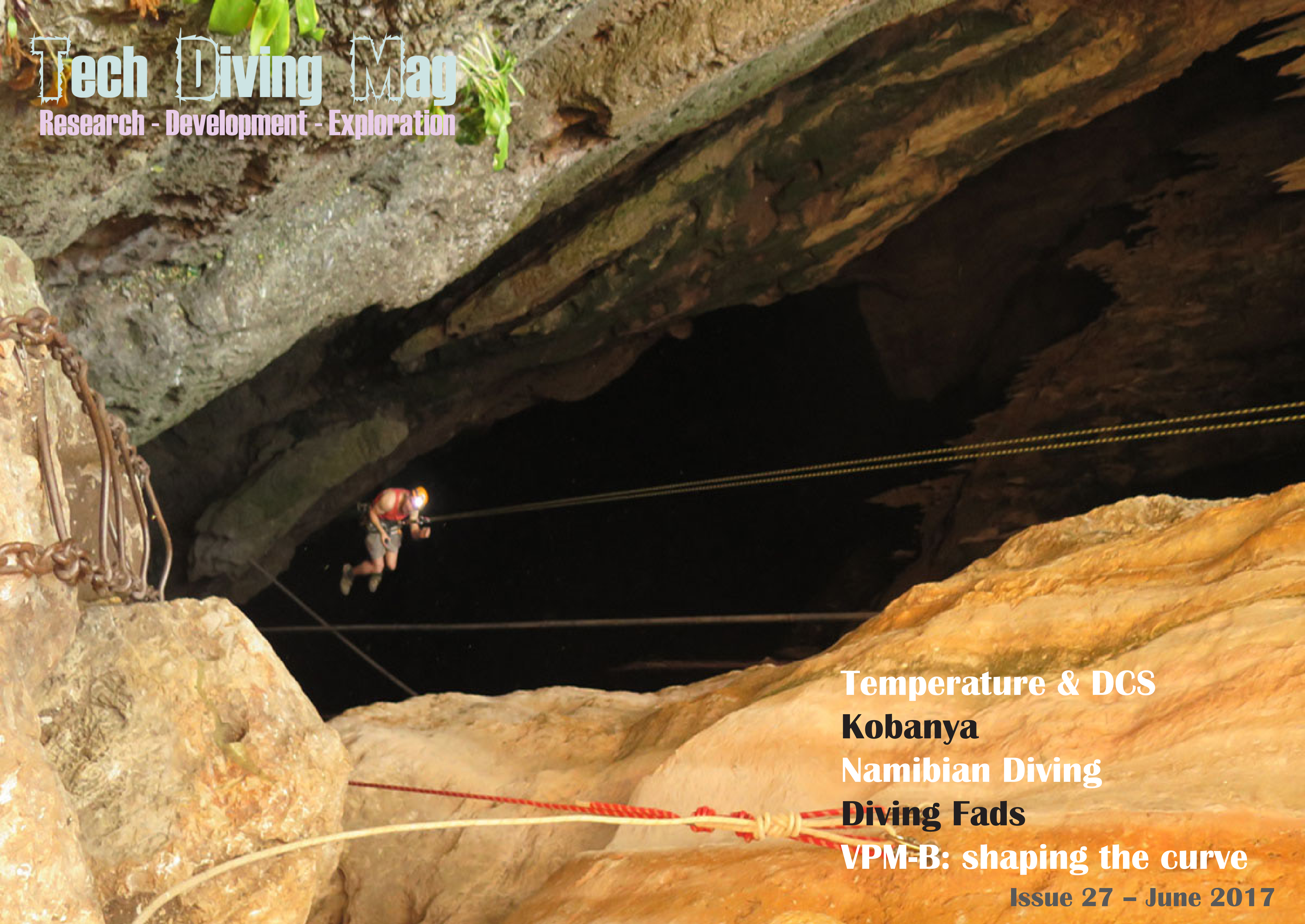

Tech Diving Mag

Research - Development - Exploration

Temperature & DCS

Kobanya

Namibian Diving

Diving Fads

VPM-B: shaping the curve

Issue 27 – June 2017

Contents

Editorial

Welcome to the 27th issue of Tech Diving Mag.

A quick reminder: as an endeavor to share knowledge and experience, Tech Diving Mag finds it inevitable to bring up controversial issues. Information published by Tech Diving Mag are always obtained from sources believed to be reliable. However, Tech Diving Mag can not guarantee neither the accuracy nor the completeness of any information published in its issues.

There's some good news! Due to the global demand and to avoid the sky-rocketing shipping costs, Best Publishing has made *Deep Into Deco* available through Ingram. Dive shops and bookstores throughout the globe can now order the book at Ingram.

If you've ever wanted to get an article you've authored published to an audience of thousands of technical -and wanna-be technical- divers, it's about time to make this happen. You're always welcome to contribute a piece and/or some photos. The guidelines could be found at www.techdivingmag.com/guidelines.html.

This is very much your magazine. If you want to share some views, drop a line to asser@techdivingmag.com. And please subscribe to the newsletter at www.techdivingmag.com/communicate.html to receive a brief email reminder when new issues are available for download.

Asser Salama
Editor, Tech Diving Mag

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Temperature & DCS

By Asser Salama

Anything that increases on-gassing or decreases off-gassing can contribute toward getting hit. As the body cools down, the peripheral blood vessels shut down, thereby reducing the inert gas uptake and release rates. This means that gas-exchange kinetics in tissues involved in DCS are slowed by vasoconstriction during cold exposure. Similarly, the same gas-exchange kinetics are accelerated by vasodilation during warm exposure.[1] Thus, the diver's thermal status during different phases of the dive can greatly influence the susceptibility to DCS. This means that cold conditions during the bottom time and warm conditions during decompression would be optimal for minimizing DCS risk.

In 2007 a study at NEDU concluded that divers should be kept cool during the bottom time and warm during subsequent decompression.[2] The same study found that the beneficial effects of warm conditions during decompression were more pronounced than the deleterious effects of warm conditions during the bottom time. A previous study concluded that divers who are warm at depth face an increased risk of DCS, because vasodilation in warm divers may result in more rapid on-gassing of some tissues. It suggested that a full evaluation of DCS risk should consider physiological and physical effects of ambient temperature.

The bottom-time phase of the dive usually involves some work, so it is comparably warmer than the decompression phase, where the diver is often at rest. The warmer conditions at depth may accelerate gas uptake, whereas the colder conditions during decompression would reduce gas elimination. Of course this is not good for decompression, and that is why some models compensate for this situation by generating a more conservative profile for colder dives. These models are frequently referred to as adaptive models. Ultimate Planner's /U model variation deals with colder dives. Also the ZH-L16D model variation that was implemented in 2013 is addressing the same situation.

In 2008 an interesting study was conducted to investigate the influence on bubble formation of exposure to heat before diving.[3] One hour after concluding a 30-minute far infrared-ray dry sauna-induced heat session at 65°C (149°F), 16 divers were compressed in a hyperbaric chamber to 30 meters (100 feet) for 25 minutes. The same dive was performed five days earlier without the sauna session. Precordial Doppler monitoring detected circulating venous bubbles. Bodyweight measurements were taken before and after the sauna session. The results suggested that the sauna session led to an extracellular dehydration, resulting in 0.6 percent bodyweight loss along with a significant reduction in bubble formation. The study concluded that a single predive sauna session significantly decreases circulating bubbles (probably due to sweat dehydration, among other factors) and that this course of action may reduce the risk of DCS.

The solubility of inert gas is inversely proportional to the temperature. This means that the tissues will hold less gas in solution as they get warmer, which in turn could promote bubble formation or growth. This fact may explain the anecdotal observations that hot showers after diving or during surface intervals precipitate DCS.

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Excerpted from *Deep Into Deco: The Diver's Decompression Textbook*. The title is available at:

https://www.bestpub.com/books/scientific-diving/product/428-deep-into-deco-the-diver-s-decompression-textbook/category_pathway-42.html

http://www.amazon.com/Deep-Into-Deco-Decompression-Textbook/dp/1930536798

Kobanya

By Alpentekkies Dive Club

In the beginning of March 2016 the team of Alpentekkies Tirol along with Triton Diving Croatia went to Budapest to dive the mysterious Kobanya mine.

The mine is located in the Kobanya (X) district of Budapest, which means stone quarry. This district is an industrial area with several quarries. Here the limestone was used for building the famous monuments of the city. In WWII the location was used as a bunker to protect the population. Later the mines were first converted into breweries using the sources as brewing water. In the course of decades, no groundwater has been pumped so four different dive sites were created.

In order to gain access to the mine you just contact with the operator Jozsef Spanyol at jozsef.spanyol@cavetech.hu and make an appointment. Meanwhile, Jozsef has built a building at the entrance to the mine and equipped it with a modern compressor, so visitors can get fills directly on site. There you can also warm up, a toilet is available. Equipment can also be borrowed on request, training is also offered and at all Jozsef is an incredibly experienced diver and a particularly heartfelt person whose stories you just do not get enough.

There are four different main dive sites with different levels of difficulty. All dive sites are well lined and there are no jumps. The dives themselves are accompanied by Jozsef or a local guide, since even in the dry area of the mine is a serious danger of confusion. For the untrained eye, one course resembles the other in this 25 kilometer long underground network. The maximum dive depth is 36 meters and the water temperature is between 10 and 14 degrees Celsius.

Dive 1 „The cold room“
This place is just behind the entrance of the main building and is also the coldest dive. Water temperature here is 10 degrees all year. The access is via a small stair to a platform in approximately a 5 * 7 meter room in which the dive starts.

Here you follow the stairs through two ceilings to the deepest point at about 32 meters. This is the pumping sump of the old brewery. All the installations are still available, such as winches, cables, lamps, tools, etc.

From there it goes up again to the second ceiling. At this point it goes into a corridor of about 100 meters with pipes and cables guiding you to another small room at the end.

On the way back there is a small turn-off, here you can see very well how the stone was dismantled. After about one hour dive time you are back at the entrance.

Dive 2 „The well“
This dive site is through a stair which is already filled with water. It leads into a large room about 6 * 10 meter. In this room you’re going to find a circular shaft at 18 meter depth. Although it looks like a well, it was probably to transport heavy loads with a winch to the top. This „well“ has a diameter of about 1.8 meter and ends at about 32 meter depth. The deepest point is at about 36 meters with many tools and all sorts of leftovers from the time of the dismantling.

From there you can dive up a staircase slowly upwards again to the large room. The water temperature here is about 13-14 degrees.

Dive 3 „Small place“

Also here the water temperature is about 13-14 degrees. The entrance also here is via a staircase. Diving starts right in the stair room. One arrives over two corners in a room of about 5 * 5 meter. From here split two narrows through the wall. The stone is dismantled. Enterance is wide enough for no more than two divers, otherwise the turn around would be a little complicated. Back in the small room you reach a deep hole in the ceiling to a depth of about 30 meters. Here, too, there are still many things to be found. From there one is back again over the upper room through the ceiling towards the entrance.

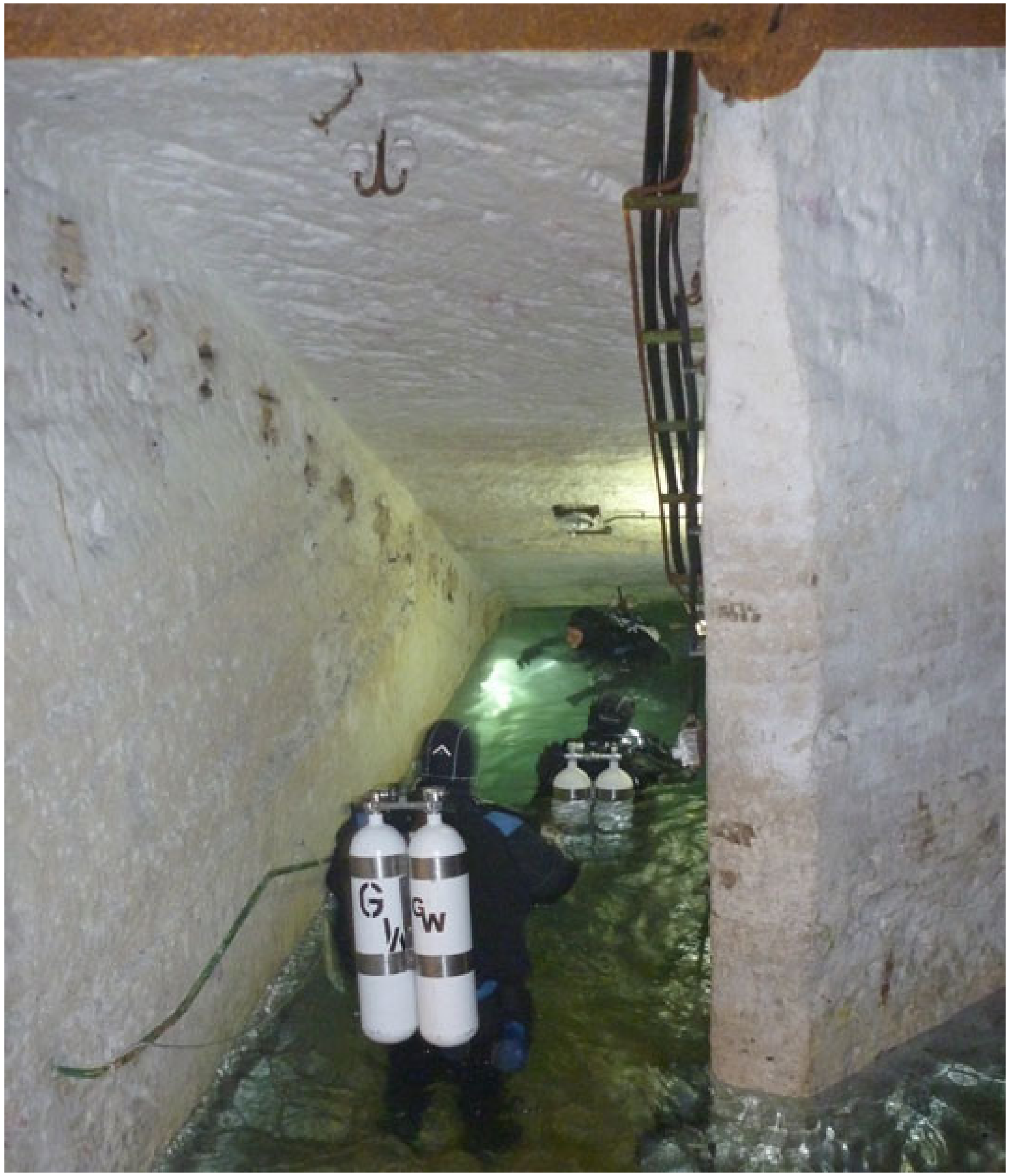
Dive 4 „The great room“

Probably the most beautiful dive of all, the temperature here is 13-14 degrees and the owner of the mine has made this place gorgeous. In the large space about 6 * 20 meter 4 HID lamps are installed, which makes the dive site more of a museum. Here you can find many work equipment wonderfully set with the HID lamps. From this space one goes in a corridor of about 200 meter long at a depth of 13 meters with two levels to a room of a maximum depth of 28 meters. The room is divided with a ceiling. Here, too, we are accompanied by many pipes and all sorts of personal belongings.

Back in the large room you reach the deepest point of 30 meters over a spectacularly decorated spiral staircase. The view along the spiral staircase is a wonderful experience. Here you can take wonderful photos and there are many things to discover. From here, there is also a smaller room with many pipes branching where you can see on the surface hundreds of shoes. The dive time here is about 70 minutes.

The feeling when Jozsef opens the huge entrance gate and you enter the mine for the first time is indescribable. The mine is a mysterious place with a colorful and interesting history, which should be told.

The dives are just fantastic, the dive sites could not be more different, especially the large hall, which extends over several floors and is wonderfully illuminated. We ourselves regularly go there and are always enthusiastic. The city of Budapest has a lot to offer and is always worth a visit.



Namibian Diving

By Chris Serfontein

It was an autumn morning in Gauteng when my cell phone rang, and I noticed that it is a Namibian +264 number phoning me. It was Chris Steenkamp, owner of Dantica Diving Adventures in Windhoek on the line. "There is a French film crew from One Planet Productions coming to visit Namibia, and they want to film some of the lakes in Northern Namibia. Would you be interested in coming to assist?" he asked.

My first thought was; this is better than having the winning lottery ticket – it better not be a joke! "Absolutely" was my answer without delay "When should I start packing?"

The trip was planned for the 16th to 22nd of May, and with my plane ticket booked that same day, I was counting down the days until my departure.

Upon arrival at Hosea Kutako International Airport in Windhoek on the 15th, I was greeted by Chris. After pleasantries were exchanged, we headed off to Dantica Diving, where the final preparations were made for our departure the next morning.

Multiple cylinders, regulators, ropes, climbing and caving equipment, rebreathers and various other pieces of hardware were all neatly laid out in the shop, ready to be packed the next morning.

Early that Monday morning, we met Dr Johan le Roux at Dantica. Johan has a doctorate in natural sciences, and also an excellent diver and rope rigger. He would give the documentary that One Planet was making some credibility, and would frequently be interviewed by the film's director over the course of the next week regarding the underground water, etc. Our 3 man team quickly packed the Isuzu double cab and box trailer – all eager to get on the road and start our adventure.

The caves the film director was interested in documenting were Aigamas, Harasib and Guinas; they are situated approximately 500km north of Windhoek in the Tsumeb/Otavi/Grootfonteinregion.

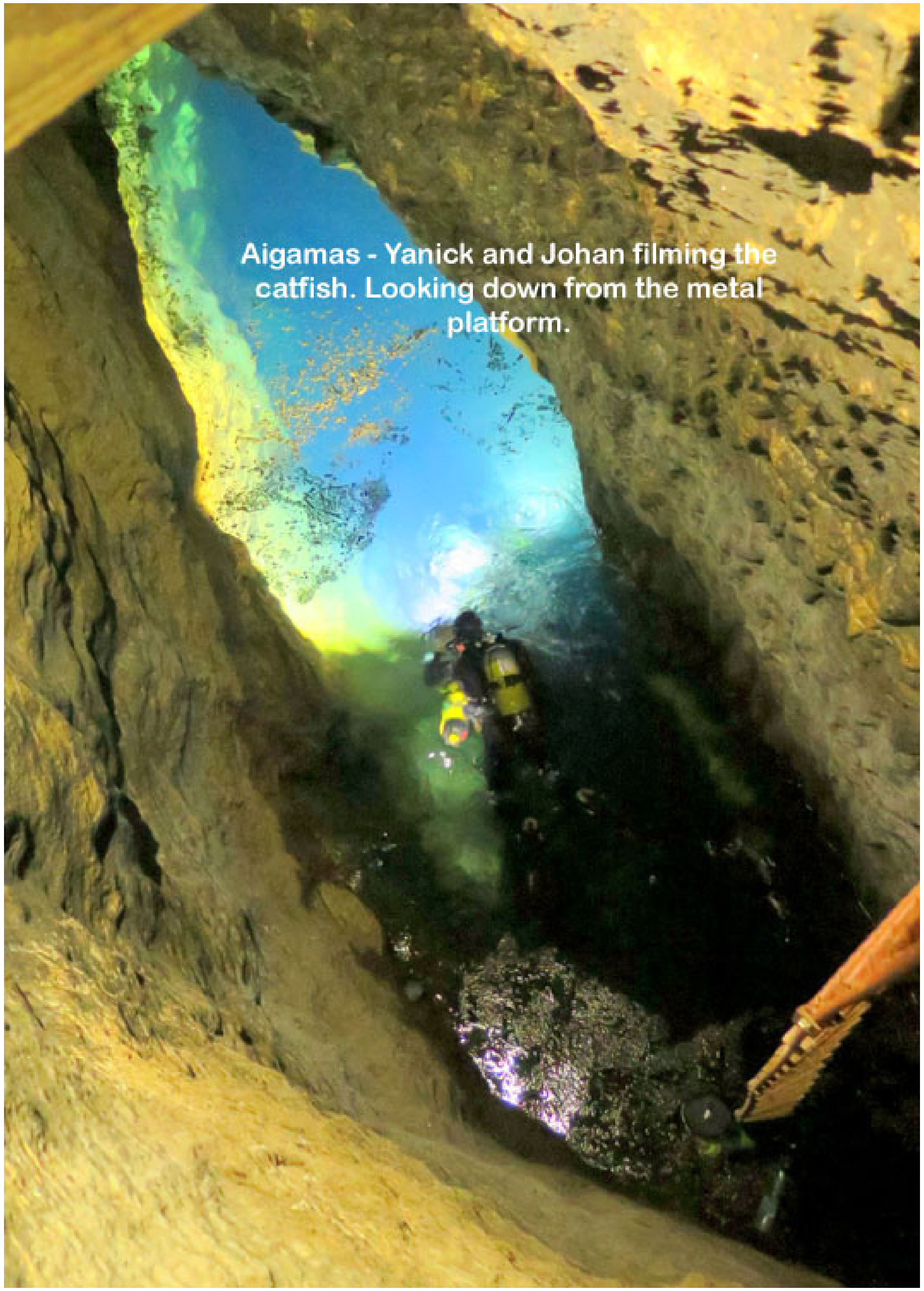
This area receives on average 550mm of rainfall a year, but with no major rivers to lead the water away, it simply disappears into the earth. The area is rich in karst, a type of landscape made up of limestone, dolomite, and gypsum rocks. Rain mixes with carbon dioxide in the atmosphere as it falls to the ground and then picks up more CO2 as it seeps into the soil. This gives the water a slightly acidic tinge that slowly dissolves calcite, the main mineral of karst rocks. This acidic water percolates down into the earth through cracks and fractures and creates a network of passages like an underground plumbing system. The passages widen as more water seeps down, allowing even more water to flow through them. Eventually, some of the passages become large enough to earn the distinction of a cave. Most of these solution caves require more than 100,000 years to widen large enough to hold a human. The size of some of the water filled chambers found in the Tsumeb area is an indication of how old this particular landscape is!

We arrived at Axel and Silke Bauer's farm Aigamas on the Monday afternoon. Aigamas is a private, family owned hunting ranch in Namibia run by Axel Bauer, a licensed master hunting guide. According to Axel, the word Aigamas means "place of big water". The reason for the visit to Aigamas is to find and film the Golden Catfish. Wikipedia states that: "The golden cave catfish (*Clariascavernicola*) is a critically endangered species of air-breathing catfish. They are only known to live in the Aigamas cave. They appear similar to white eels, up to a length of 16.1 cm. They have very small eyes, and are probably effectively blind. They feed on detritus that falls into the lake in which they live. The population is estimated at or 200-400 individuals. Little is known about its reproduction, and attempts to breed it in captivity have failed. The population is threatened by chance events and aquifer depletion that threatens to drain the lake."

After unpacking our gear on the lush green lawn in front of the farmhouse where we also pitched our tents, we loaded the gear required to dive this lake back into the Isuzu, and drove the 4km to get to the entrance of the cave.

The entrance is on the side of a cliff, and an easy walk leads to a 45 degree slope where you have to scramble down approximately 100m to reach the metal platform from which we could lower all the gear down to the water's surface. According to Axel, the Germans installed all the original metal supports pre WWI, to pump water from the lake to irrigate citrus plantations they planned to establish in the valley below the cave. After Germany lost the war, all construction stopped as the land was seized from the Germans. From the platform, a steel ladder drops another 8m down to the surface of the lake, and continues another 10m below the water surface to accommodate the fluctuations in the water level. The surface area of the lake is not very big, maybe 3m by 15m, but drops down to unknown depths. Nuno Gomes dived it a few years back to a depth of over 90m with no bottom in sight yet, but exceeding this was not on the cards for this trip.

After getting the majority of the gear onto the platform below, and after enjoying the spectacular Namibian sunset we headed back to the farmhouse where a delicious dinner of kudu steaks, lamb chops and milk tart for desert was waiting for us.


Aigamas - Yanick and Johan filming the catfish. Looking down from the metal platform.


Aigamas - Golden Catfish

Early the next morning, we headed off to the cave with the film crew closely behind us. The plan was to do two dives, and assist the cameraman Yanick Gentil to capture images of the elusive catfish. Upon lowering his equipment, and Johan assisting him with the lighting, it was evident that we did not have to search long and far to find them as dozens of them were swimming right underneath us on the water's surface and could be clearly seen from the platform above. They were swimming freely among us all the way down to 10m depth, with one was even found as deep as 30m. Another interesting discovery we made, was a skeleton of an adult kudu bull at a depth of 60m. The bones were eaten clean, probably by the many shrimps we found against the walls of the cave, as well as the catfish which I'm sure feasted on its flesh for many months. Two dives later, with a maximum depth of 60m Yanick was satisfied that he had enough footage of the catfish and we started to clear the cave from all our equipment.

The next morning, after packing the vehicles, we headed in an easterly direction to the farm Harasib which will be home for the next two nights.


Aigamas - Looking back up from the platform


Guinas
Oshikoto
Tsumeb
C42
Aigamas
Harasib
Dragon's Breath
Grootfontein
B8
B1
C39

Aigamas - Packing out and pitching tents on Axil Bauer's front lawn

On this farm, owned by Sarel Lacante and his wife Leonie Pretorius, two significant water filled caves are situated. Dragon's Breath, which was only discovered in 1986 and then surveyed by SASA (South African Speleology Association) soon after its discovery and at that stage established to be the world's largest underground lake (Just over two hectare surface area). Lately though, due not only to the good rainfall, but also to the flooding and subsequent cessation of mining/pumping activities at Tsumeb and Kombat, the water level has risen substantially, with the surface of the lake significantly reduced, thus losing this title. The plus side of the water level being so high is that you can now swim among the millions of stalactites hanging from the ceiling that in the past could only have been viewed from the cave floor or water surface below. Multiple diving expeditions have been undertaken here, with a maximum depth reached at 130m and reportedly still extending beyond this point. The true extent of this water-filled cavity is still to be explored.

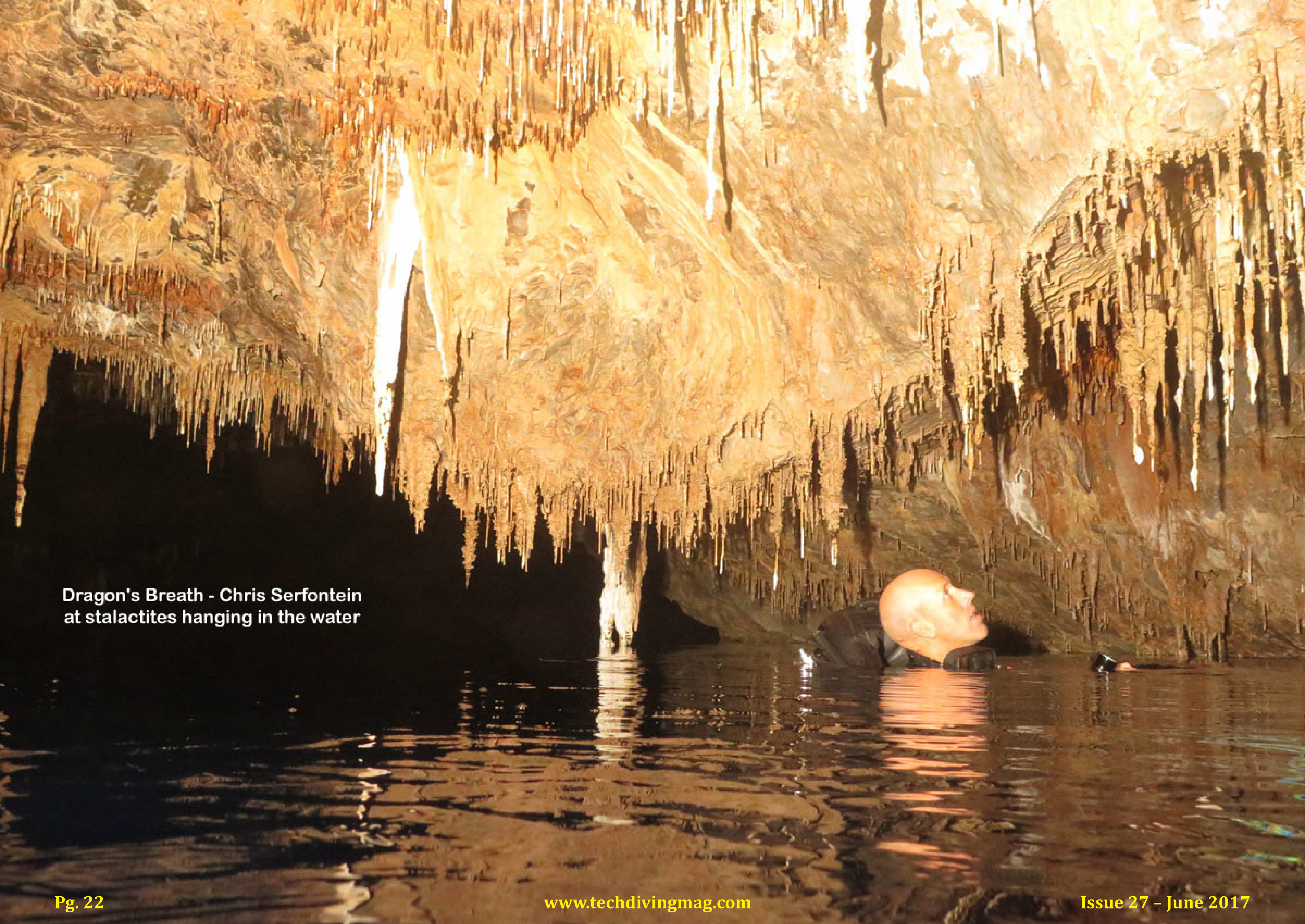
The cave we were visiting on this trip however is a lot less known and seldom dived. The two caves are situated a mere 2km apart, and speculations circulate that they could be linked to each other deep underground – a very daunting but exciting prospect!

The majority of the equipment we brought along was destined to be used on this cave – especially to get ourselves along with all the equipment required, in and out of the cave. The opening of the cave is situated on the side of the hill, 50m up from the valley floor. A steep and rocky Jeep track leads up to the rim of this sinkhole. As with Aigamas, the Germans installed infrastructure to pump water out of the lake for cattle etc. Among the items they left behind, is a cable ladder that leads all the way down into the cave. We opted to rather rig our own ropes for getting into and out of the cave as there was no safe platform to rest once you find yourself halfway up the ladder. From the edge of the sinkhole it's a 100m straight drop to the cave floor. To get to the edge of the water, you first need to climb 10 metres down the side of the sinkhole to get to where the first rope is anchored. Then, after attaching a descending device to this rope, abseil 30m down onto a ledge. A changeover is required to get onto the other rope where you then walk down and along this ledge to the last changeover to attach yourself on the final rope that will take you 70m straight down to the cave floor. On your way down this rope and with your eyes still adjusting to the light, the lake with its blue hue can already be seen. To simply get to the water's edge is definitely not for the faint hearted and is probably the biggest reason why this cave has not been visited that often.

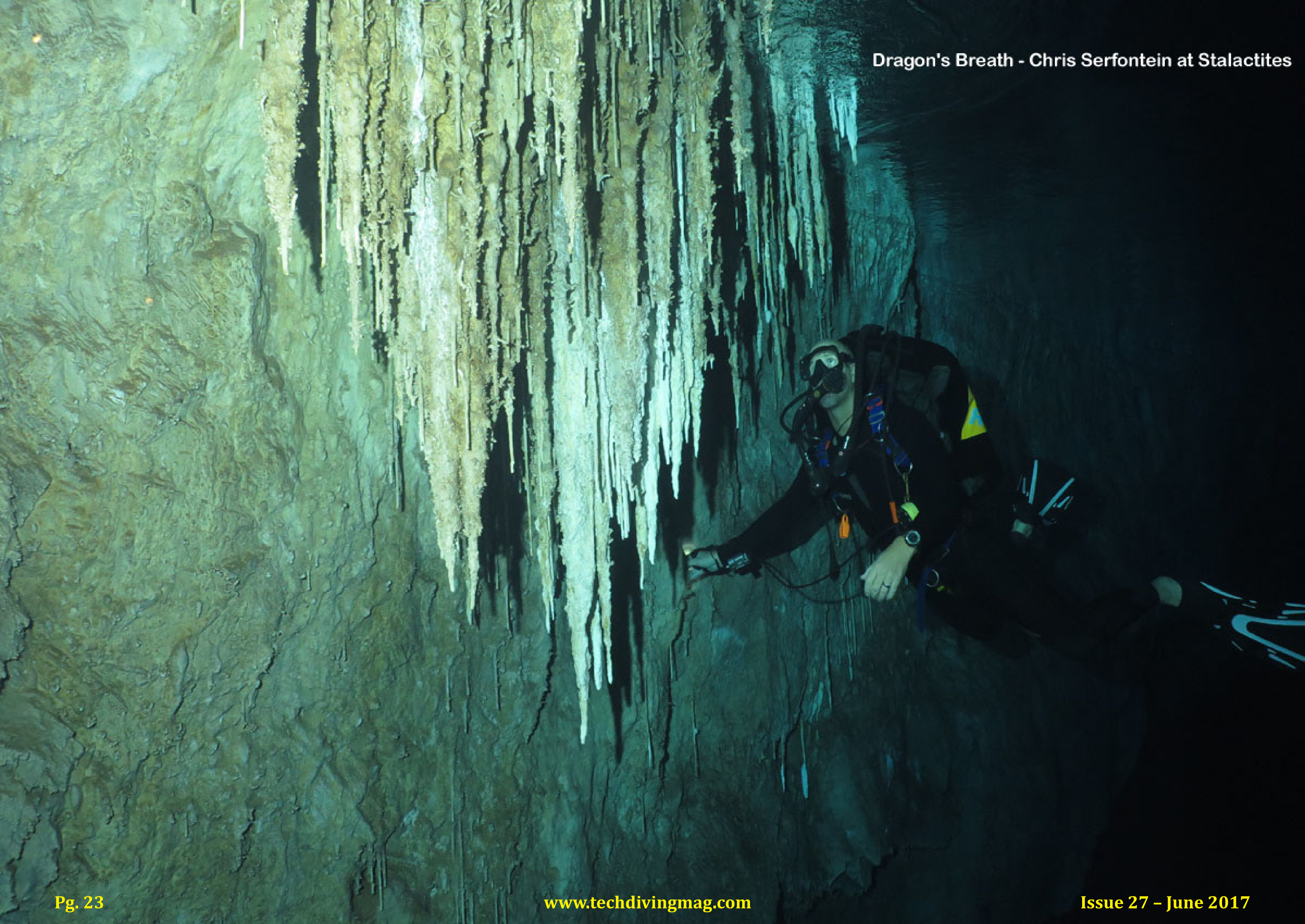
Abseiling into Harasib reminded me of entering a big European catholic cathedral; the massive stalactites hanging down from the dome shaped roof representing chandeliers, and the light from the entrance of the cave above, simulating lead windows with their light streaming into the void.

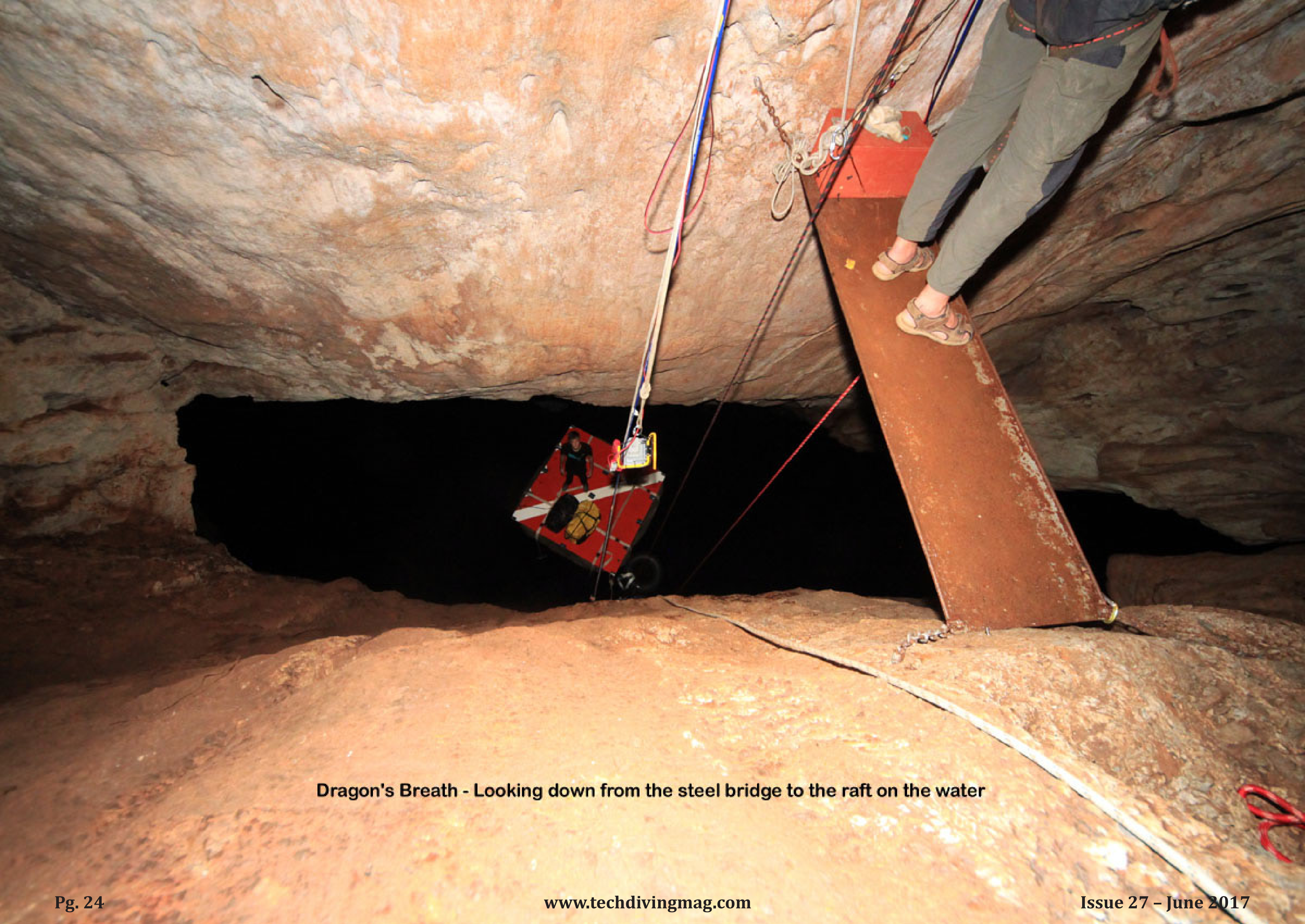
The size of the lake is roughly the length of a football field, but the width of around 30m, on the one side and is reduced to just a narrow sliver from halfway along its length. Divers previously dived it to 147m with still no bottom in sight. Water temperature was a "chilly" 22° and not the pleasant 26° Celsius we got used to in Aigamas!

From the bottom of the rope on the cave floor, you need to scramble down a rocky slope for another 15m to get to the water's edge. Once in the water, it was the first time that I've ever experienced "unlimited visibility"! With Yanick's two 10,000 Lumen video lights and the additional massive 25,000 Lumen video light that Chris Steenkamp had to manoeuvre for him, the crystal clear water could truly be observed and appreciated. If you look at your dive buddy, it gives you



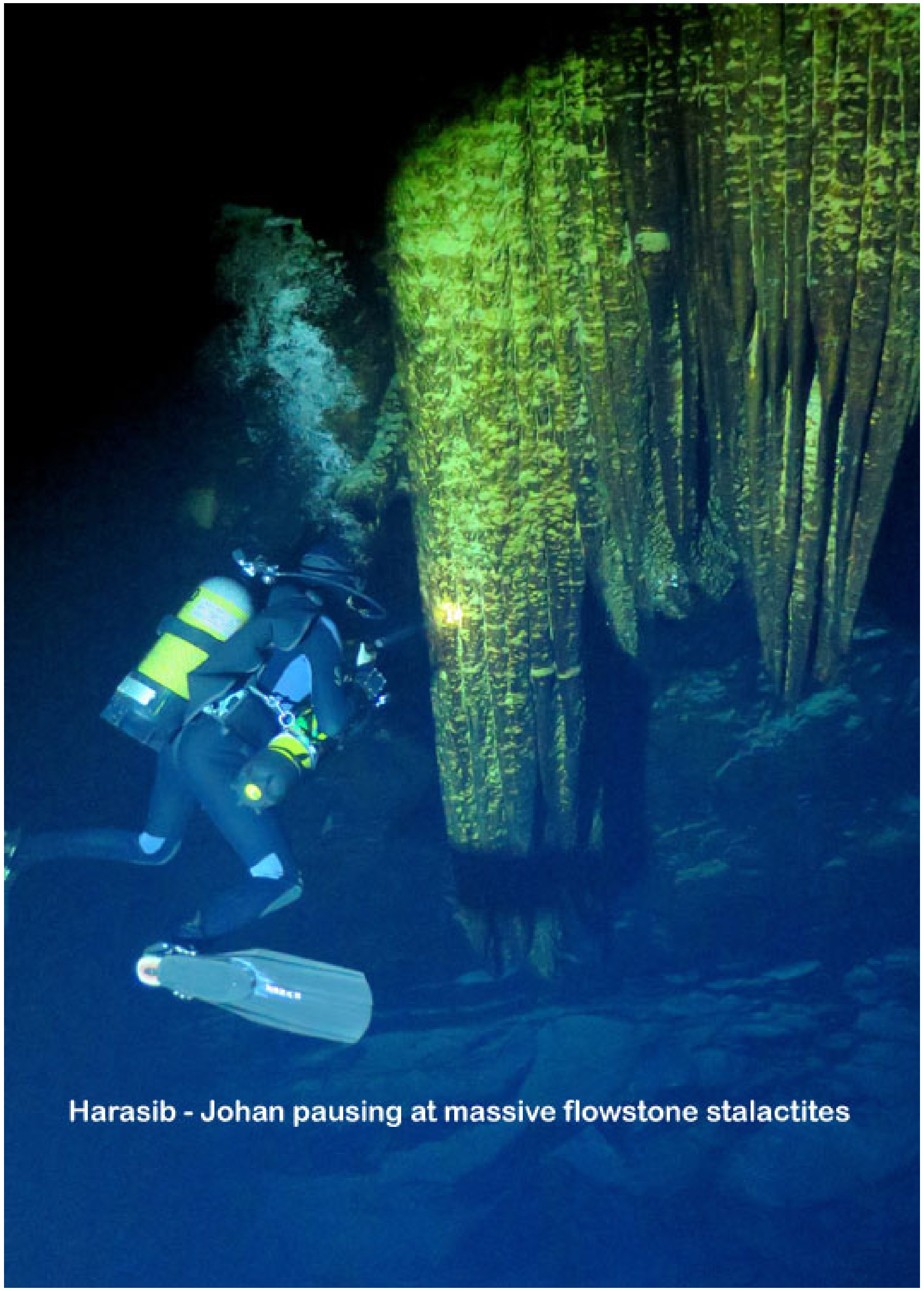
Dragon's Breath - Chris Serfontein at stalactites hanging in the water


Dragon's Breath - Chris Serfontein at Stalactites



Dragon's Breath - Looking down from the steel bridge to the raft on the water the impression that he is floating in mid-air, with only the occasional exhaust bubbles bringing you back to reality that you are both actually underwater! The maximum depth we planned for our dives here was reduced to30m to give Yanick more time to film. All the way down to this level, the walls were decorated with thousands of stalactites, flowstone and even stalagmites on the ledges. The first dive here to me was somewhat of a surreal experience; it seemed that time went much faster than what it normally does; what felt like 10 minutes into the dive, an hour has already passed! Looking up from 30m I could clearly see the slot in the roof we abseiled through and even the tree's branches partly covering it. This little bit of light entering the cave was just sufficient to give the whole pool an electric blue colour when we switched all our lights off. After completing our decompression stops we got out of the water to for our surface interval and to enjoy our lunch consisting of biltong, dried fruit and cold drinks. On the second dive we decided to explore the other side of the cave. Here the bottom is around 12m deep, before plunging into the abyss. The bottom was covered in fine white silt, but protruding from the silt is massive stalactites, some 3-4m high and as thick as a tree trunk. Harasib is truly a remarkable destination and had the most memorable dives here I think I have ever had, even though we didn't get a chance to explore its depths. This is definitely one to add on any cave diver's bucket list and absolutely worth another visit!

The next day was left open to get all our equipment back out of the cave, and head to the last lake on our schedule. Hauling all the heavy equipment out of the cave would have been a mammoth task, if not for the winch, powered by a little petrol motor that Chris Steenkamp brought along specifically for this task. This little device pulled bucket-load after bucket-load heavily laden with our diving gear out of the cave in only 8 minutes per trip! Seven loads later, and with all our gear packed again, we headed to our last destination – Lake Guinas.

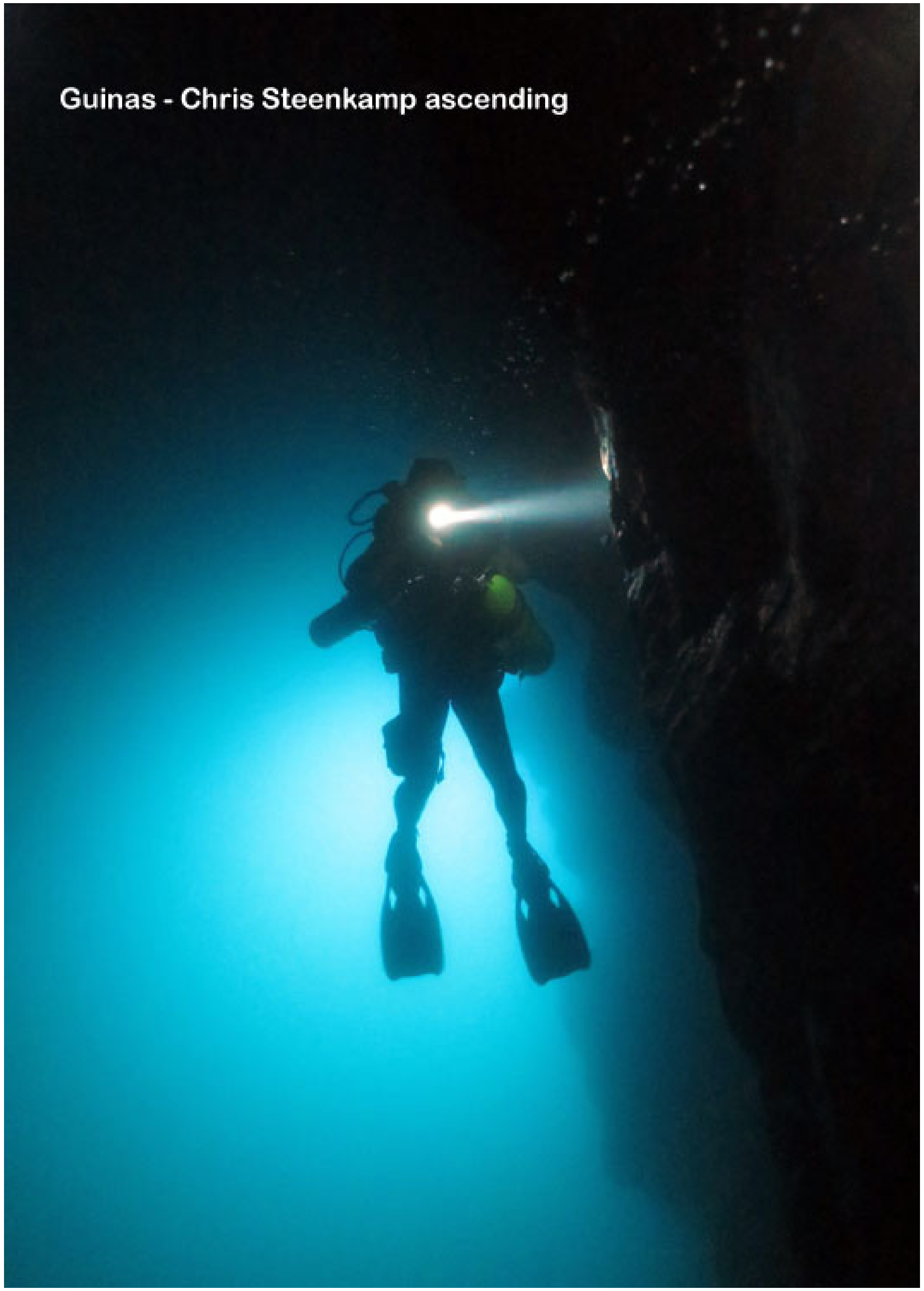


Harasib - Johan pausing at massive flowstone stalactites

Harasib - Chris Steenkamp using the winch to haul the gear out of the cave

Lake Guinas is a massive sinkhole with a surface area measuring 60m x 120m, and as with the previous 2 lakes, the bottom of Guinas has still to be found.

Usual characteristics of sinkholes are that they develop dome shaped ceilings, and when this dome collapses, it leaves a pile of rocks on the bottom of the hole, but with the bottom sloping down and away from this pile of rubble. The problem of determining the exact depth, is that the lake tapers off into a lateral cave system making it impossible to determine its exact depth. The rubble slope has been bottomed at a depth of 105m, and the diver reporting that he could see the steep slope heading down and under the sides of the lake. Weighted lines have also been lowered, and depths of around 100m have been plumbed. Off course, how deep and far these slopes extend is not yet known. Water temperature is a very pleasant 26° Celsius year round, with no thermoclines reported even to the 100m depth! With its fantastic visibility (around 40m), blue water and the resident Tilapia, one could easily mistake it for a tropical coastal lagoon. Also remarkable, are the stalactites hanging from overhangs, further confirming that water levels in all these lakes were much lower in the distant past as stalactites and stalagmites cannot develop and grow underwater. One could only imagine what lies at the bottom of this beautiful lake, and what future discoveries would be made here!


Guinas - Chris Steenkamp ascending


Guinas - Filming and lighting

Another 20km almost due east lies another significant lake – Lake Otjikoto.

Lake Otjikoto is also a sinkhole and the lake is almost perfectly circular with a 100m diameter with vertical dolomite cliffs. What makes this lake extra special, is that in 1915 when the German Schutztruppe were about to surrender, they threw all their ammunition and a total of 19 field cannons into this lake. Many years later, a few were retrieved and are currently on exhibit in the Tsumeb museum. According to legend, and even witnesses, the Germans also dumped a sealed safe into the lake. The search for it and the 6 million gold marks it is said to contain has yet not been successful. Today, Otjikoto, together with its contents are part of the Namibian natural and cultural heritage. It is a national monument and is protected by law. Diving and swimming in this lake is strictly forbidden, however, Chris Steenkamp from Dantica Diving is one of the special permits holders and has permission to lead dives in this lake. Diving into history to the depths of this lake, and to view the cannons and crates of ammunition as they were dumped here over 100 years ago at depths ranging from 52 and 57m deep is an incredible privilege!

With all Namibia already has to offer the eco tourists, the diving there is truly remarkable. I definitely recommend a diving trip to Namibia especially if you enjoy diving and exploring locations off the beaten track. Combining a diving trip there to even include a visit to the Skeleton Coast, Etosha, Caprivi, Sussusvlei or Fish River Canyon would make it a holiday package that the whole family will enjoy!


Otjikoto - Cannon

Diving Fads

By Bruce Konefe

Over the years, the diving industry has taken us through many different diving fads. I have been lucky enough to have seen and experienced the industry taking us through nitrox, deep stops, side mount diving and a few others. Through all of these so called "fads" the diving industry has learned many of the good and bad points and has grown from there. One of the most recent topics that I have noticed is the use of trimix and PN2's that should be used during the student's course and upon completion of their course.

Back in the 1980's before most of the technical training agencies had started, it was not unheard of to hear of divers doing 100m+ bounce air dives. Trimix diving to the general public was just getting started but not totally unheard of within the military. The uncountable stories of barely remembering of what had taken place on the dive or the near mishaps due to the narcosis levels were being told by dive buddies. Divers had dove so deep on air that they would just fall asleep and slip away into the blue. Some of the early technical diving training agencies offered training on air down to 90m and even to this day there is some training available to the 70m range.

Later in the 1980's some of the very first technical diving agencies started to open up. Nitrox, decompression, extended range and trimix courses where starting to be made available to the general public. Proper cave and wreck training courses were also written to help increase the safety of the technical divers. Some of the very first available trimix courses started at a depth of 60m being the normoxic trimix course. Deep air diving was even still being taught down to those depths. Over the years the PN2 of the mixes have gone from 5.0 down to the 3.2 area.

As we know there's always a good side and a bad side of whatever gases we choose to breathe. The nitrogen we have to deal with the high narcosis levels the deeper we go, the oxygen can cause toxicity at a very shallow depth. Trimix is not a gas without its downsides also. When you are breathing helium mixtures the ascent rate and decompression times are more critical. On deeper trimix dives you can also encounter inert gas counter diffusion and also HPNS (High Pressure Nervous System). As each year passes, divers are venturing down deeper pushing the limits every time. Some of these dives have been successful and then again some have ended very badly and we have to learn from all of these dives.

Technical agencies are offering trimix training down to 100m and some agencies train to a depth of 120m. Divers are doing sub 200m more often than you would believe. HPNS starts at about 180 meters; one way to decrease the HPNS is by lowering the amount of helium in the breathing mixture. Normally at that depth you cannot replace the helium with oxygen, so you would have to add nitrogen back into the mix. When more nitrogen is placed back in the loop the PN2 is going to increase and so is the nitrogen narcosis. Another way to decrease the HPNS is to slow down the descent speed, the problem with this at those depths is that the increase of decompression is not as manageable. At those depths that divers are diving more and more they do need to be able to handle a certain level of narcosis.

I am a firm believer of choosing the "optimal" breathing gas; I was first trained this way and still believe and plan my dives with this in mind. Diving with helium requires a higher control of buoyancy and trim than what a diver would need on an air/nitrox dives. A diver's mindset has to be more focused on the dive plan and runtimes. I believe divers will receive a great benefit of having some experience with dealing with narcosis within safe limits and depths. Once the diver has that experience, the great benefits that helium has to offer will be obvious. Some technical divers have the skill level of doing technical air/nitrox dives but do they have the skill and mindset to take it to the next level of trimix diving?

I am not the type of diver who wakes up every day and plans to do a deep air dive. The thought has never even crossed my mine. Is there some level of narcosis training still needed in air technical training courses? Should all of the higher PN2 courses be eliminated all together? No matter what dives we do and what gases we breather whether it be trimix, nitrox, air and heliox there is always a certain risk that we are going to take. What is your thought on the subject?

These are my own personal thoughts and opinions and not related or joined with any training agency. I always keep an open mind and continue to learn as I go along. I am interested in hearing your comments on the subject. For those willing to share their thoughts, please contact me at sidemountdiver@hotmail.com.

VPM-B: shaping the curve

By Jurij Zelic

Despite the fact that we are diving VPM-B for more than a decade now, we still do not have sufficient data proving that the profiles generated by modern VPM-B based tools are any good.

Additionally, limited number of experimental studies indicate that profiles generated by bubble models might be too deep and have inadequate shallow stops in long dives.[1] One can argue that using correct GF settings can always result in optimal (or at least good enough) profile. There is no argue about that, but the goal should be setting an algorithm which can be used at a wide range of bounce dive plans, from short shallow nitrox dives to long deep trimix dives.

The main problem of VPM-B; not generating adequate shallow stops for long deep dives, was observed a few years ago. The problem was addressed by introducing VPM-B model variants. For example, the VPM-B/GFS variant calculates the deco stop criteria by VPM-B and compares it to the calculated deco stop of the ZHL. The more conservative one is then used.[2] This resulted in longer shallow stops for long and deep dives, but as presented in the following discussion, only one part of the problem is solved.

Let's first look at the experimental data available now.

The two most relevant researches are the NEDU study and the University of Split research.[3, 4]

The NEDU study conducted two 170ft/30min air dive profiles in a decompression chamber. One profile was calculated using VVL-18 decompression model (dissolved gas model) and the second using BVM3 model (bubble model). Each profile was performed by little less than 200 divers. The outcome measure for each profile was actual DCS occurrence after each profile.

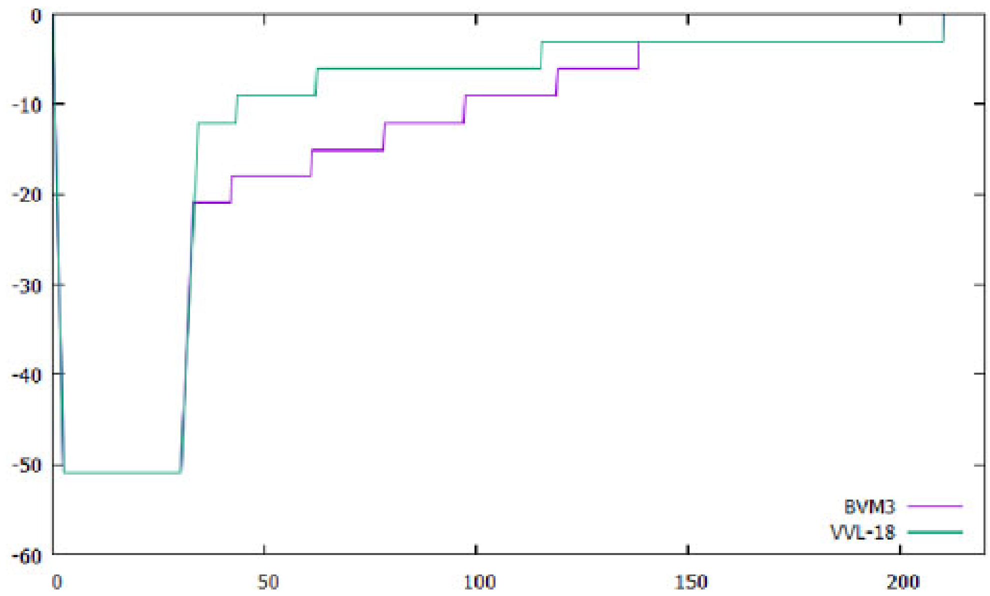


Fig1: The NEDU study dives

Contrary to expectations the VVL-18 gave much lower DCS incidence that BVM3. The DCS incidence on shallow-stops profile was 3 out of 192 dives and the DCS incidence on deep-stops profile was 10 out of 198 dives (more than three folds). Since none of the two profiles is similar to what technical divers follow, that does not prove anything, except that one profile is better than the other on that particular dive. However it gives us an insight that more is not necessarily better when it comes to deep stops.

The University of Split research was based on a series of 60-70 meters trimix/nitrox50 dives, pretty much like the dives we normally do. The research resulted in no DCS on divers performing the dives, but the presence of venous gas emboli 90 minutes after final ascend occurred on 9 out of 21 dives.

Results of the research do not provide any additional information regarding the quality of the dive profiles generated using VPM-B or that any other decompression model would compliment on that kind of dives. However it provides a clue that different profile might be better.

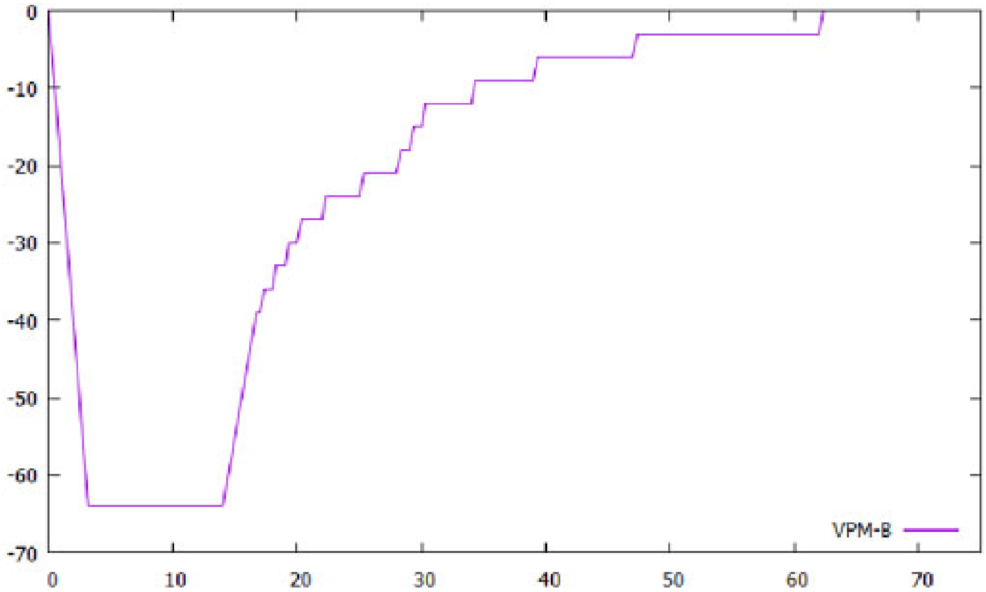


Fig2: Typical “University of Split” dive

Dr. Mitchell summarized some of the researches in his lecture.[5] Although I do not agree on comparing different models based on tissue load as Dr. Mitchell did (of course dissolved gas models will do better on that), but I still think that he made a valid point that ZHL algorithms, unlike VPM-B, are more conservative on slower tissues.

If we would like to reshape our deco profiles, it seems that we would want to shorten the deep deco stops a bit and prolong shallow stops, especially for long deep dives. That would reduce load on slow tissues on the cost of higher load on fast tissues, which are more tolerant to higher gas loads.

The million dollar question is: how to incorporate higher conservatism on slower tissues on VPM-B? As we know, VPM-B has a single configuration parameter for nitrogen and a single for helium (other than physical constants). As a consequence, manipulating with the two parameters will not change the shape of the curve. It will only extend the whole profile. Well it turns out that this is only true for the current implementation of the model and not for the model itself. If we set different critical radii for each tissue differently, we achieve just that.

So instead of using single critical radii of 0.6μm for nitrogen and single critical radii of 0.5μm for helium, I used a set of 16 different pairs of critical radii, one for each compartment. The critical radii ranged from 0.35μm for fastest tissue (0.25μm for helium) up to 2.0μm (1.9μm for helium) for the slowest tissue.

The result is not surprising. It is the profile with shorter deep and longer shallow stops (marked as VPM-BS). Even better, the total dive time is shorter than standard VPM-B on short dives and longer on long dives.

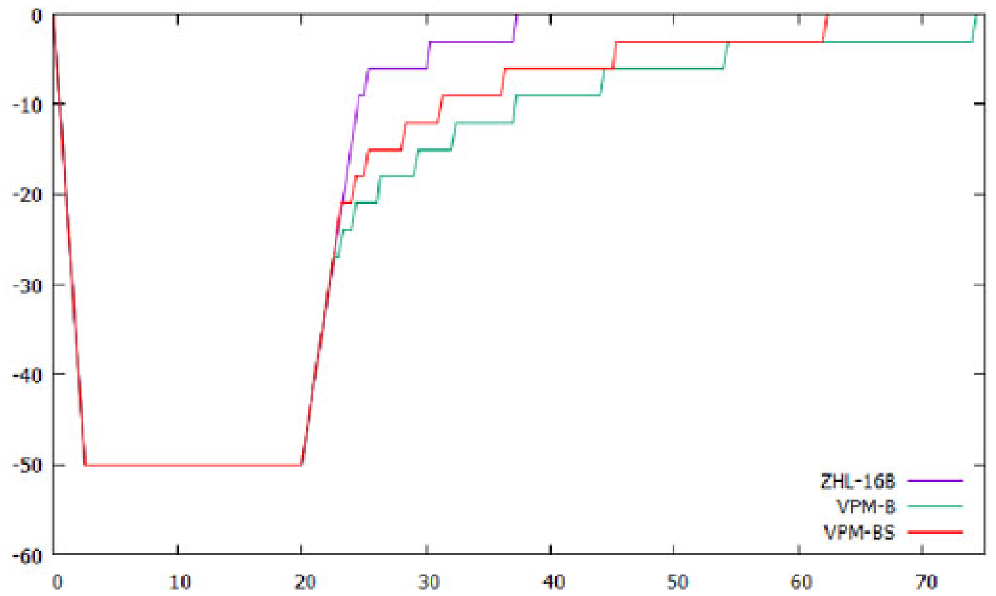


Fig3: Buhlmann ZHL-16B vs. VPM-B vs. VPM-BS profile on 20 min dive

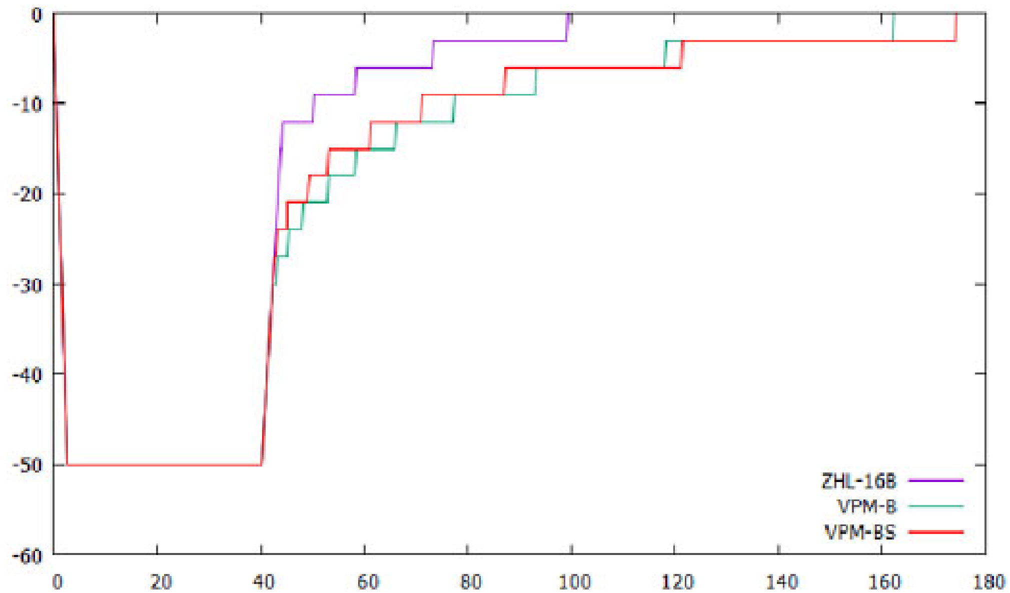


Fig4: Buhlmann ZHL-16B vs. VPM-B vs. VPM-BS profile on 40 min dive

Conclusion

The quality of a deco model is partly about physical model and partly about setting the parameters just right. Prof. Buhlmann spent a lifetime setting those 32 numbers. I believe that meticulously trimmed parameters are more important than the physical model itself. Unfortunately Prof. Buhlmann only gave us a set of M-values for nitrogen, but not for helium. Scaling the half times for helium and using nitrogen M-values simply does not do the trick. Maybe we can finally get the perfect mixed-gas deco model by setting 32 numbers of VPM-BS just right. I do not have the means to do it, so I have only demonstrated that they could be set differently that in current VPM-B implementations.

References

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4. Marko Ljubkovic, Jasna Marinovic, Ante Obad, Toni Breskovic, Svein E. Gaustad and Zeljko Dujic. *High incidence of venous and arterial gas emboli at rest after trimix diving without protocol violations*. J Appl Physiol 109: 1670–1674, 2010. First published September 2, 2010; doi:10.1152/japplphysiol.01369.2009.

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