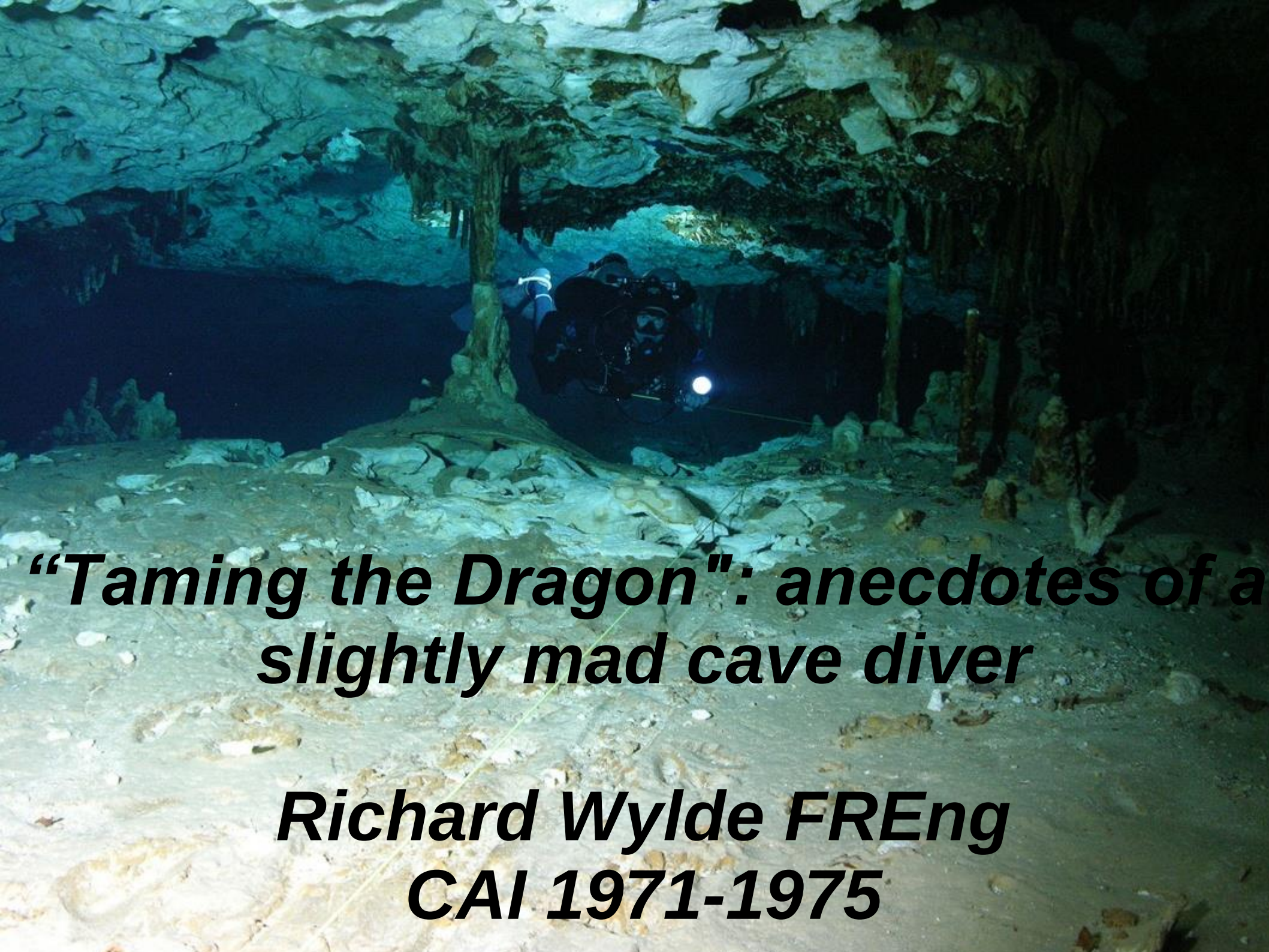


“Taming the Dragon": anecdotes of a slightly mad cave diver

Richard Wylde FREng
CAI 1971-1975

Why do people go into caves under water?

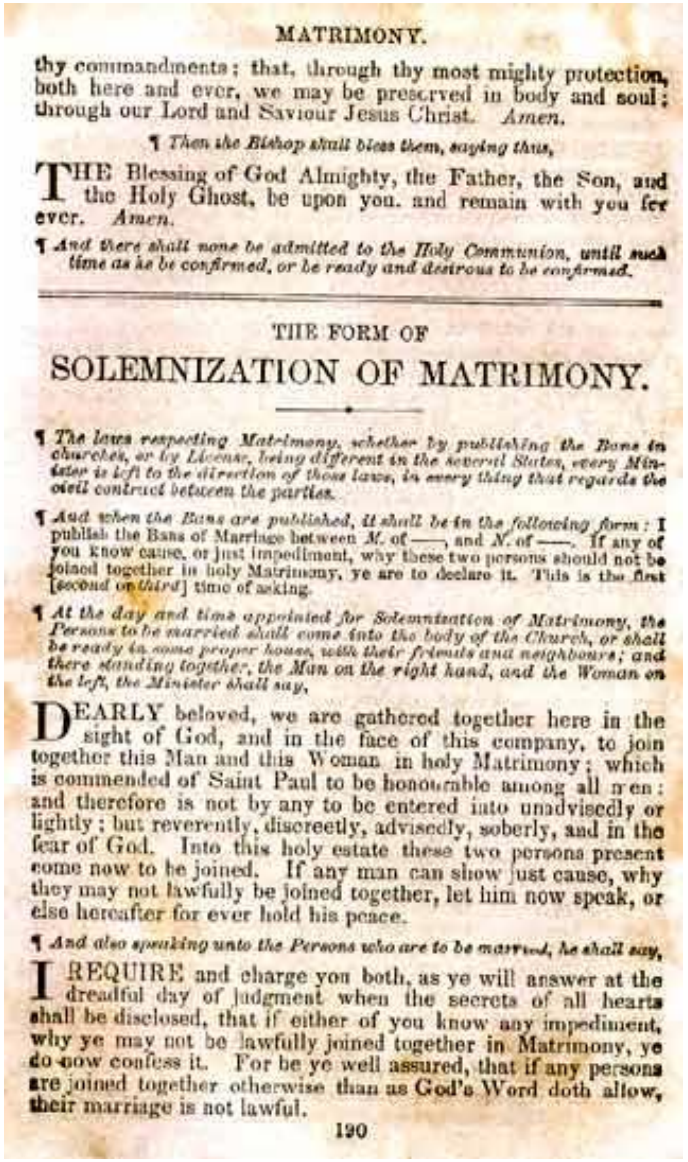
Difficult to explain but basically:

There are very beautiful places

Many of them remain unexplored

The diving is technically challenging

Book of Common Prayer



MATRIMONY.

thy commandments; that, through thy most mighty protection, both here and ever, we may be preserved in body and soul; through our Lord and Saviour Jesus Christ. *Amen.*

¶ *Then the Bishop shall bless them, saying thus,*

THE Blessing of God Almighty, the Father, the Son, and the Holy Ghost, be upon you, and remain with you for ever. *Amen.*

¶ *And there shall none be admitted to the Holy Communion, until such time as he be confirmed, or be ready and desirous to be confirmed.*

THE FORM OF

SOLEMNIZATION OF MATRIMONY.

¶ *The laws respecting Matrimony, whether by publishing the Banns in churches, or by License, being different in the several States, every Minister is left to the direction of those laws, in every thing that regards the civil contract between the parties.*

¶ *And when the Banns are published, it shall be in the following form:* I publish the Banns of Marriage between *M.* of ——, and *N.* of ——. If any of you know cause, or just impediment, why these two persons should not be joined together in holy Matrimony, ye are to declare it. This is the first [*second* or *third*] time of asking.

¶ *At the day and time appointed for Solemnization of Matrimony, the Persons to be married shall come into the body of the Church, or shall be ready in some proper house, with their friends and neighbours; and there standing together, the Man on the right hand, and the Woman on the left, the Minister shall say,*

DEARLY beloved, we are gathered together here in the sight of God, and in the face of this company, to join together this Man and this Woman in holy Matrimony; which is commended of Saint Paul to be honourable among all men: and therefore is not by any to be entered into unadvisedly or lightly; but reverently, discreetly, advisedly, soberly, and in the fear of God. Into this holy estate these two persons present come now to be joined. If any man can show just cause, why they may not lawfully be joined together, let him now speak, or else hereafter for ever hold his peace.

¶ *And also speaking unto the Persons who are to be married, he shall say,*

I REQUIRE and charge you both, as ye will answer at the dreadful day of judgment when the secrets of all hearts shall be disclosed, that if either of you know any impediment, why ye may not be lawfully joined together in Matrimony, ye do now confess it. For be ye well assured, that if any persons are joined together otherwise than as God's Word doth allow, their marriage is not lawful.

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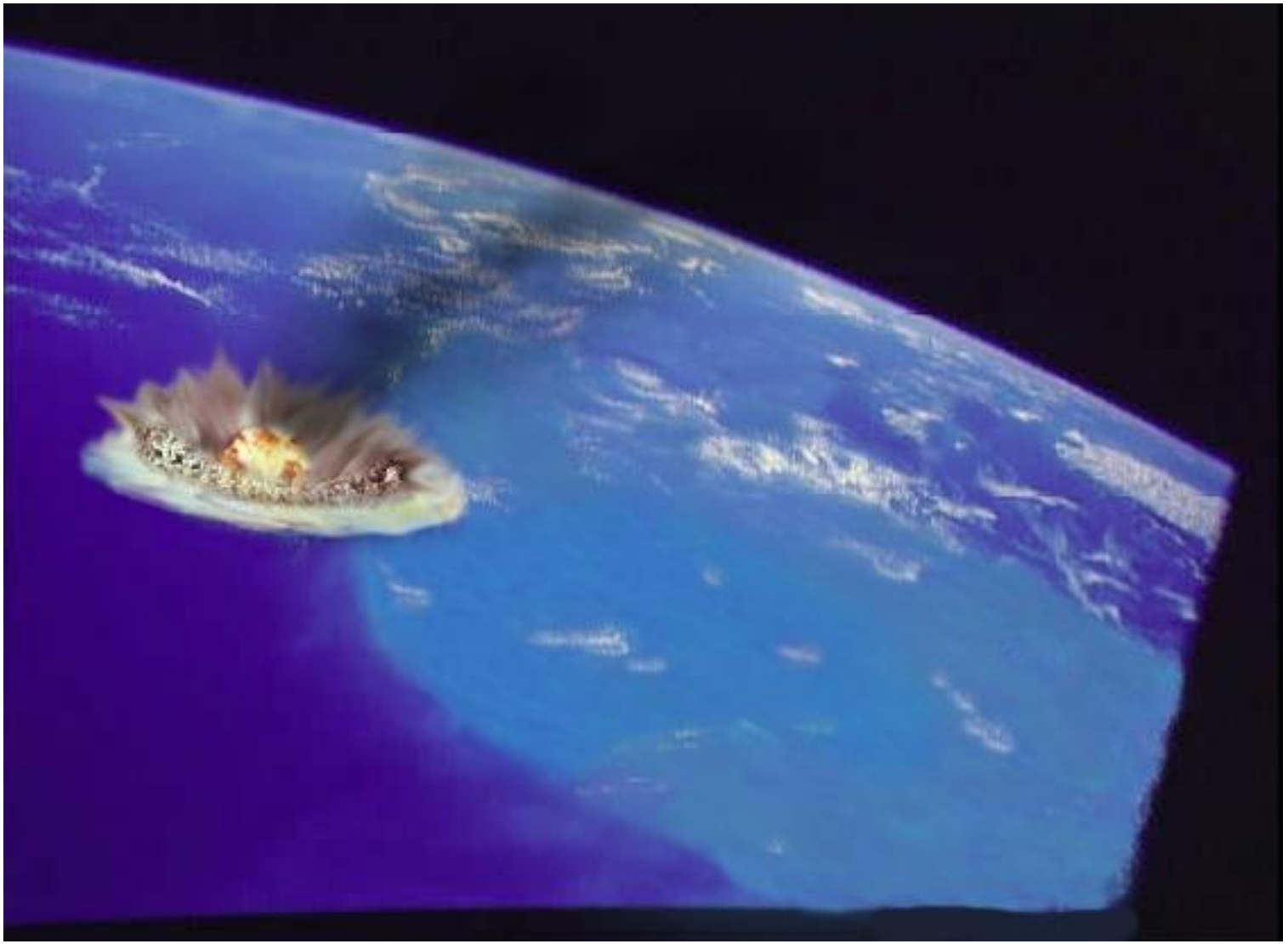
and therefore is not by any to be entered into unadvisedly or lightly; but reverently, discreetly, advisedly, soberly, and in the fear of God.

I will come back to this later

Talk centred on the Yucatan

Why T-Rex?



Mexican site for K/T impact crater?

SIR – A decade ago Penfield and Camargo[1] interpreted gravity and magnetic anomalies from northwestern Yucatan, Mexico, as evidence for a large, buried extraterrestrial impact crater. Research throughout the Caribbean[2–6] suggests that this crater, now named the Chicxulub crater[3], could be the site of the impact purported to have caused mass extinctions at the Cretaceous/Tertiary (K/T) boundary[7]. Using Landsat Thematic Mapper imagery of the Yucatan, we identified[8] a semicircular ring of sink holes, known locally as cenotes, which correlates with the geophysical anomalies noted by Penfield and others[1,3] (Fig. 1). We propose that the origin of the cenote ring is related to post-impact subsidence of the Chicxulub crater rim.

The cenote ring forms a nearly perfect semicircular boundary, 170 km in diameter between unfractured (within the ring) and fractured Tertiary limestones, truncated by the coast and centred 17 km east of Progreso (Fig. 1). This boundary forms a barrier to lateral groundwater migration, causing increased flows, dissolution and collapse along the boundary[9]. Large groundwater flows along the boundary are indicated by a valley-shaped depression in the groundwater surface centred on the ring, and by freshwater springs found where the coastline intersects the ring[8,9]. The cenotes formed by the collapse process are 50–500 m diameter water bodies with depths of 2–120 m. Cenote density and width of the ring vary from about three cenotes per km^2 along a 3-km-wide portion in the southwest (Fig. 2), to a chain of single cenotes 3 km apart in the southeast. This variability is apparently related to differences in the flow of groundwater and fracturing outside the ring.

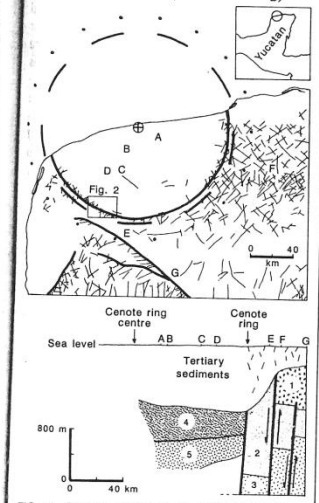


FIG. 1 Structural (upper) and subsurface (lower) geology of the cenote ring, northwestern Yucatan, Mexico (inset). Map fracture traces (thin lines) and faults (thick lines) from ref. 10. Semicircle, cenote ring; dashed circle, approximate location of negative gravity anomaly; dotted circle, approximate outer limit of concentric positive magnetic anomaly. Anomalies from Penfield and others[1,3]. Subsurface data from drill holes are described by Weidie[11] and Lopez Ramos[12], and plotted as a function of the radial distance from the cenote ring centre (hole locations lettered on the map and across the top of the cross-section). Thick lines with arrows show subsidence along possible ring faults; thin lines show fracturing in Tertiary rocks. Key: (1) breccia (ejecta?); (2) Upper Cretaceous marine sediments; (3) Lower Cretaceous marine sediments; (4) breccia (impact?) and crater fill; (5) volcanic rock (impact melt?).

The fracturing that created the cenote ring was almost certainly caused by a circular structure, because no combination of linear stresses would be likely to produce such a nearly perfect circular feature. Except for the fractures, the Tertiary limestones are undeformed, suggesting that the fractures are related to a buried pre-Tertiary structure. A buried impact crater or volcanic caldera could produce a circular structure of this size. We discount the latter possibility because collapse of a caldera would cause fracturing within the ring, and volcanic rocks are found beneath the centre of the ring, not outside as would be expected for a caldera (Fig. 1).

On the other hand, post-impact subsidence induced by slumping and viscous relaxation in the rim of the proposed Chicxulub crater could well have caused the fracturing outside the cenote ring. The magnitude of this subsidence need not have been great to fracture the Tertiary limestones. Viscous relaxation may have been by only metres or tens of metres over the millions of years since the crater was buried. Craters this size have wide or multiple rims, but the fracturing beyond 40 km east and south of the ring is probably related to stresses along adjacent fault systems.

Evidence of subsidence is found in the negative gravity anomaly[3] concentric with and just outside the ring (Fig. 1). Additional evidence of subsidence is the offset of Upper Cretaceous and earlier strata beneath the ring (Fig. 1), which may represent buried ring faults typical of impact crater rims.

FIG. 2 Landsat Thematic Mapper band 5 (infrared) image of a portion of the cenote ring (location shown in Fig. 1). Note chain of cenotes (black dots) across the centre of the image. Width of image, about 31 km. Landsat data from EOSAT Co., Lanham, Maryland, USA.

If there is indeed a crater, the region within the cenote ring corresponds to its floor; the crater rim diameter would then probably be >200 km. If confirmed as a site of impact, the Chicxulub crater would be the largest terrestrial impact crater known, which is consistent with the uniqueness of the Cretaceous/Tertiary global catastrophe.

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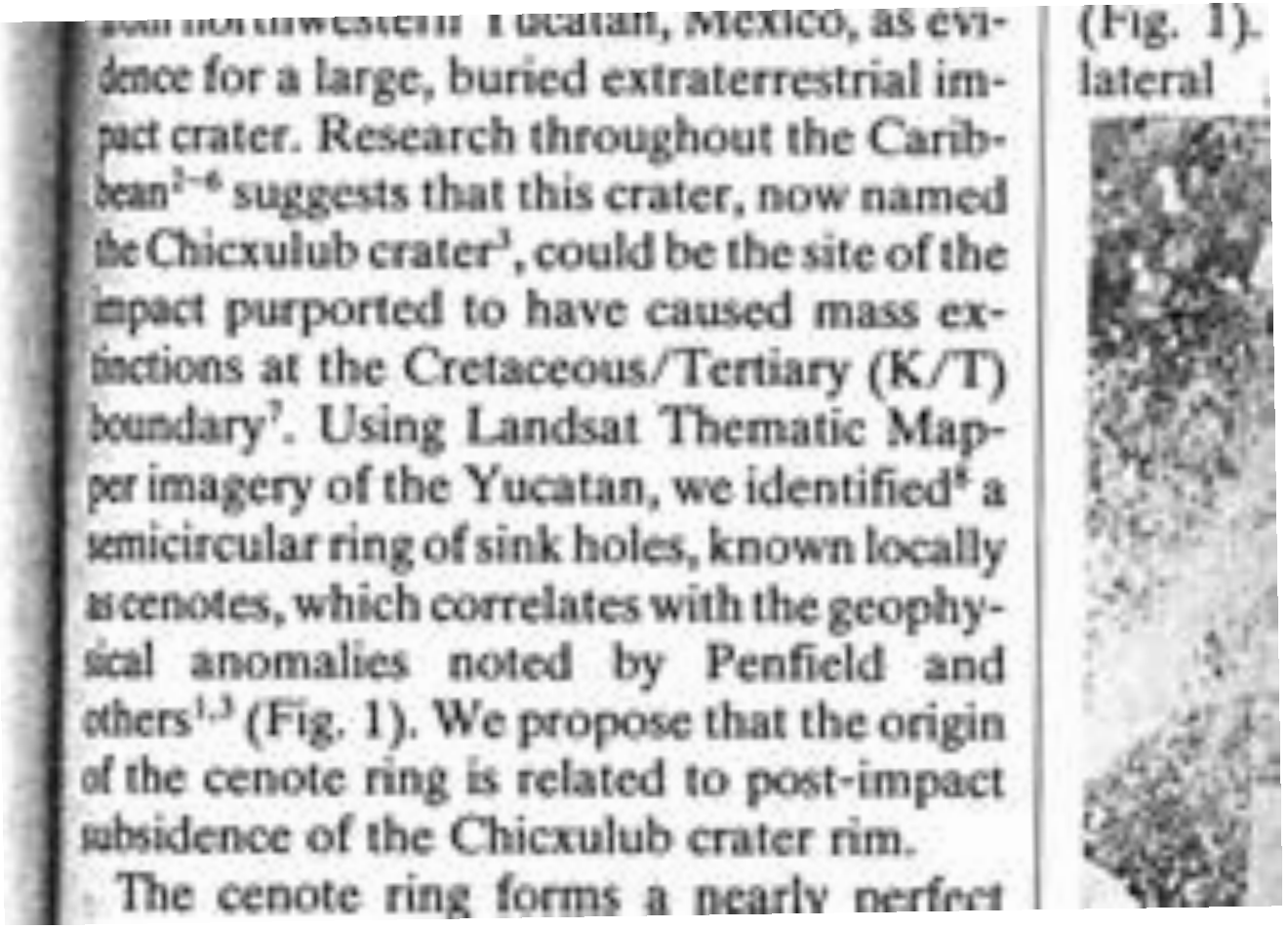
1. Penfield, G. T. & Camargo, Z. A. *A. Mtg Soc. Explor. Geophys. Abstr.* **51,** 37 (1981).
2. Hildebrand, A. R. & Boynton, W. V. *Science* **248,** 843–847 (1990).
3. Hildebrand, A. R. & Penfield, G. T. *Eos* **71,** 1425 (1990).
4. Hildebrand, A. R. & Boynton, W. V. *Eos* **71,** 1424–1425 (1990).
5. Smit, J. *Nature* **349,** 461–462 (1991).
6. Sigurdsson, H. *et al. Nature* **349,** 482–487 (1991).
7. Alvarez, L. W., Alvarez, W., Asaro, F. & Michel, H. V. *Science* **208,** 1095 (1980).
8. Pope, K. O. & C. E. Duller. in *III Simposio Latinamericano Sobre Sensores Remotos, Memoria* (ed. Alvarez, R.) 91–98 (Sociedad de Especialistas Latinamericano en Percepcion Remote and Instituto de Geografia, UNAM, Mexico, 1989).
9. Marin, L. E. *et al.* in *Hydrology Papers from the 28th Int. Geol. Congr.* ed. Simpson, E. S. (Int. Assoc. Hydrol., in the press).
10. *Carta Geologica, 1:250,000* (Secretaria de Programacion y Presupuesto, Mexico, 1983).
11. Weidie, A. E. in *Geology and Hydrology of the Yucatan and Quaternary Geology of Northeastern Yucatan Peninsula* (eds Ward, W. C., Weidie, A. E. & Back, W.) 1–19 (New Orleans Geol. Soc., 1985).
12. Lopez Ramos, E. *Geologia de Mexico, Tomo III* (Mexico, 1979).

Nature

9th May 1991:

Pope, Ocampo & Duller



...northwestern Yucatan, Mexico, as evidence for a large, buried extraterrestrial impact crater. Research throughout the Caribbean[2–6] suggests that this crater, now named the Chicxulub crater[3], could be the site of the impact purported to have caused mass extinctions at the Cretaceous/Tertiary (K/T) boundary[7]. Using Landsat Thematic Mapper imagery of the Yucatan, we identified[8] a semicircular ring of sink holes, known locally as cenotes, which correlates with the geophysical anomalies noted by Penfield and others[1,3] (Fig. 1). We propose that the origin of the cenote ring is related to post-impact subsidence of the Chicxulub crater rim.

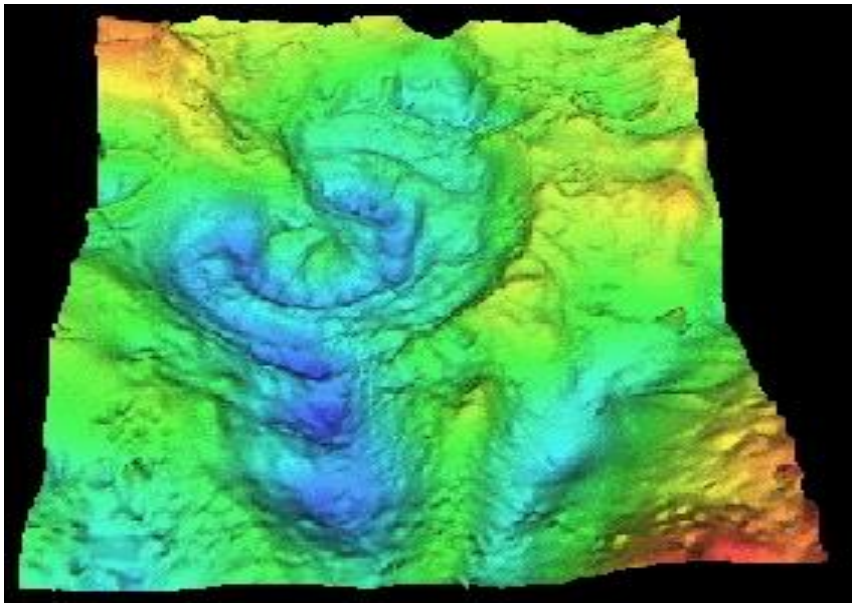
The cenote ring forms a nearly perfect

(Fig. 1).

lateral

Linking K/T impact to the Cenotes

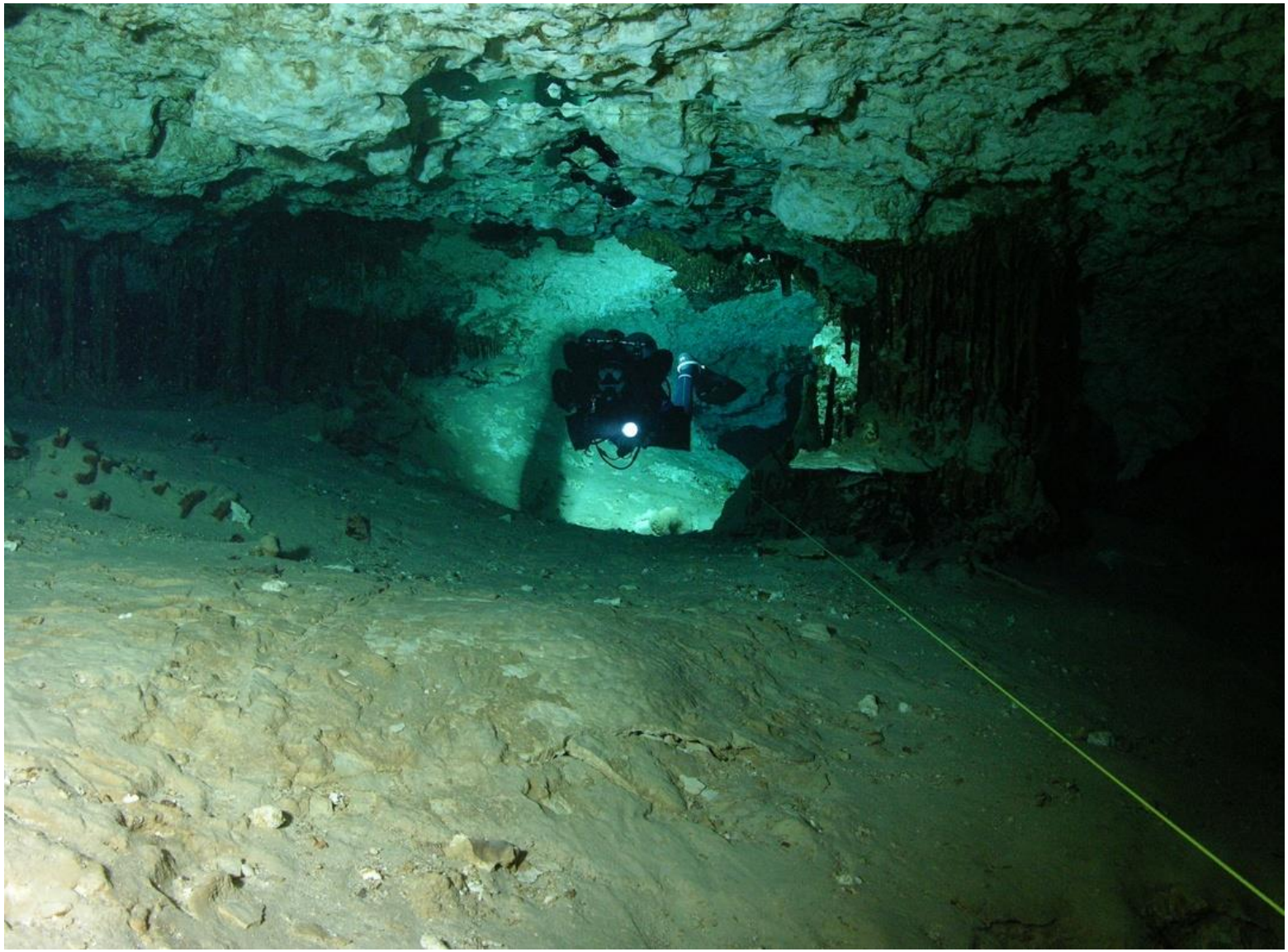
A 180 km wide 1600m deep impact crater is found at the tip of the Yucatán Peninsula, in the Gulf of Mexico. This crater dates back to 65 million years ago.



3-D image of the impact site

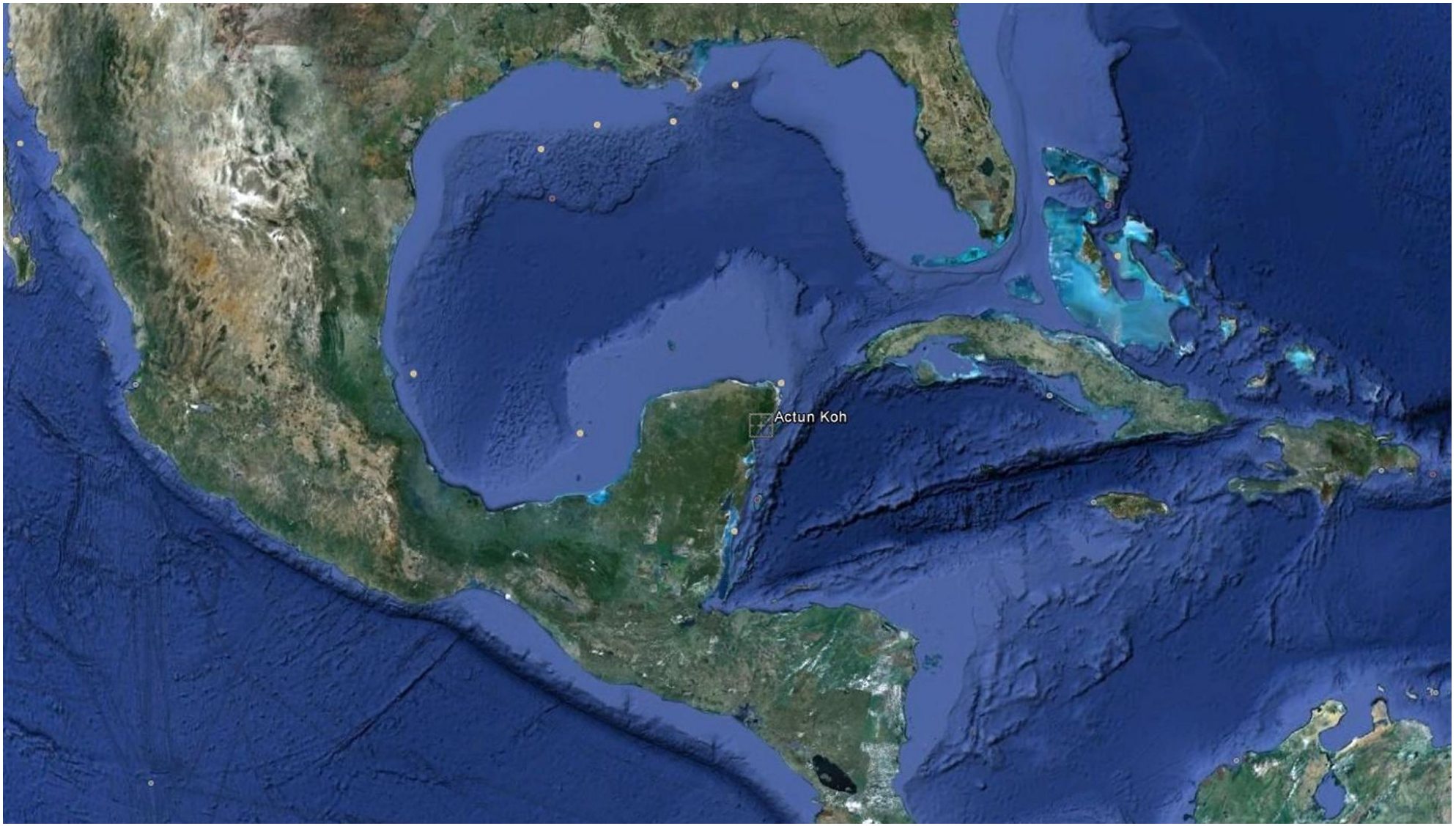
A widely accepted theory – though not the only theory - is that an 4-9 miles (6-15 km) diameter rock hit the Earth, and put up so much dust into the atmosphere that all land animals over about 55 pounds went extinct, as did many smaller organisms

What has formed over this zone – recent in geological time – is a limestone or Karst area. There are no overground rivers in the Yucatan. It is in these – mostly unexplored - rivers that some of the most beautiful cave diving in the world is to be found



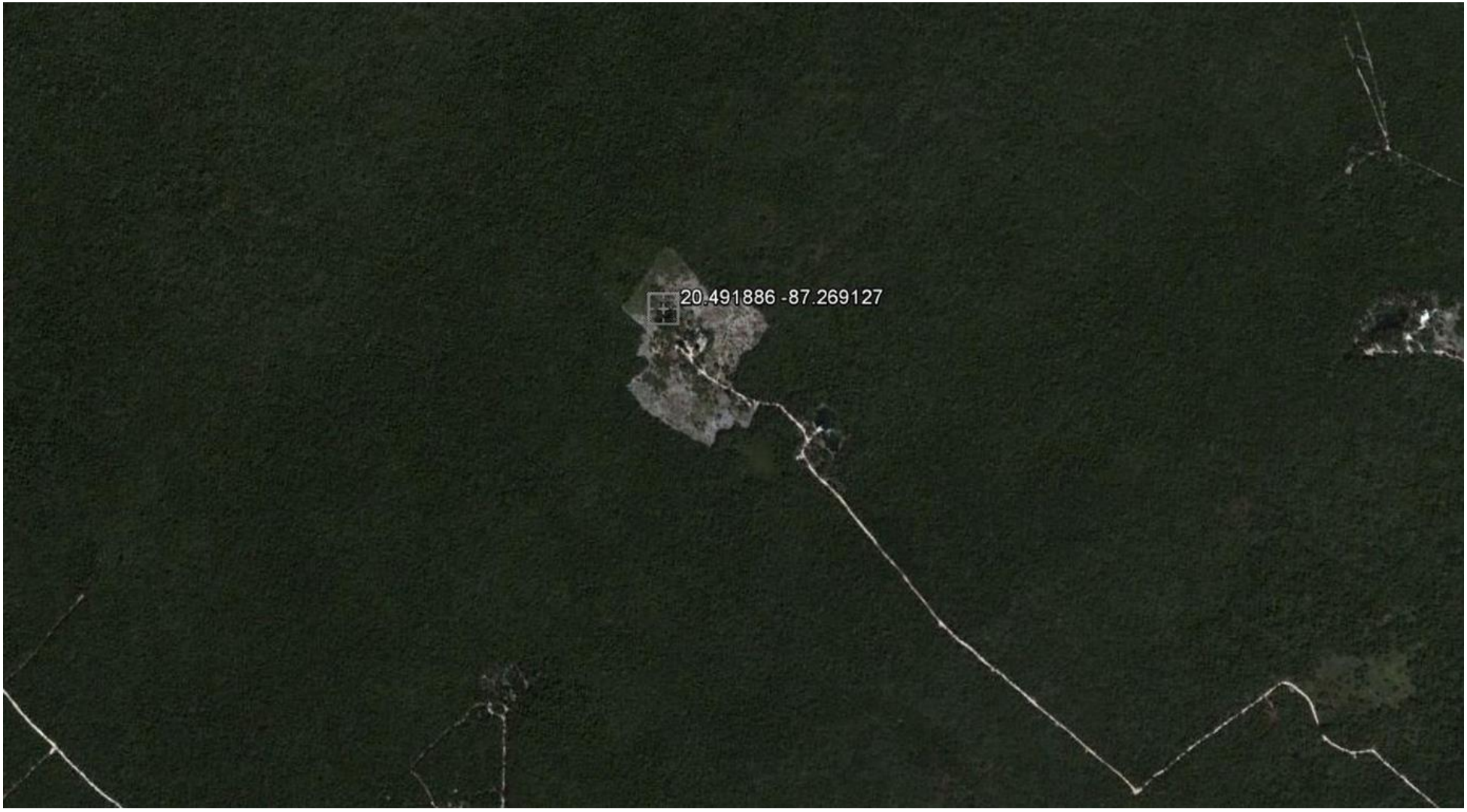
Where is The Yucatan? It is in Mexico

This is the Yucatan – North East Edge of Mexico



Actun Koh - one system I have mapped is here

The Cenotes are in the jungle, often with difficult access roads



How do you stop the dragon on the back of your neck - basically panic - waking up in a dive? You follow some rules:

When I started cave diving I was taught a simple mnemonic:

Thank God All Divers Live

- Training
- Guideline
- Air
- Depth
- Lights

Training: A safe cave diver never exceeds the boundaries of their training. Cave diving is normally taught in segments, each segment enabling more difficult dives.

Many of you may have tried diving in open water – where you can always go up to the surface.

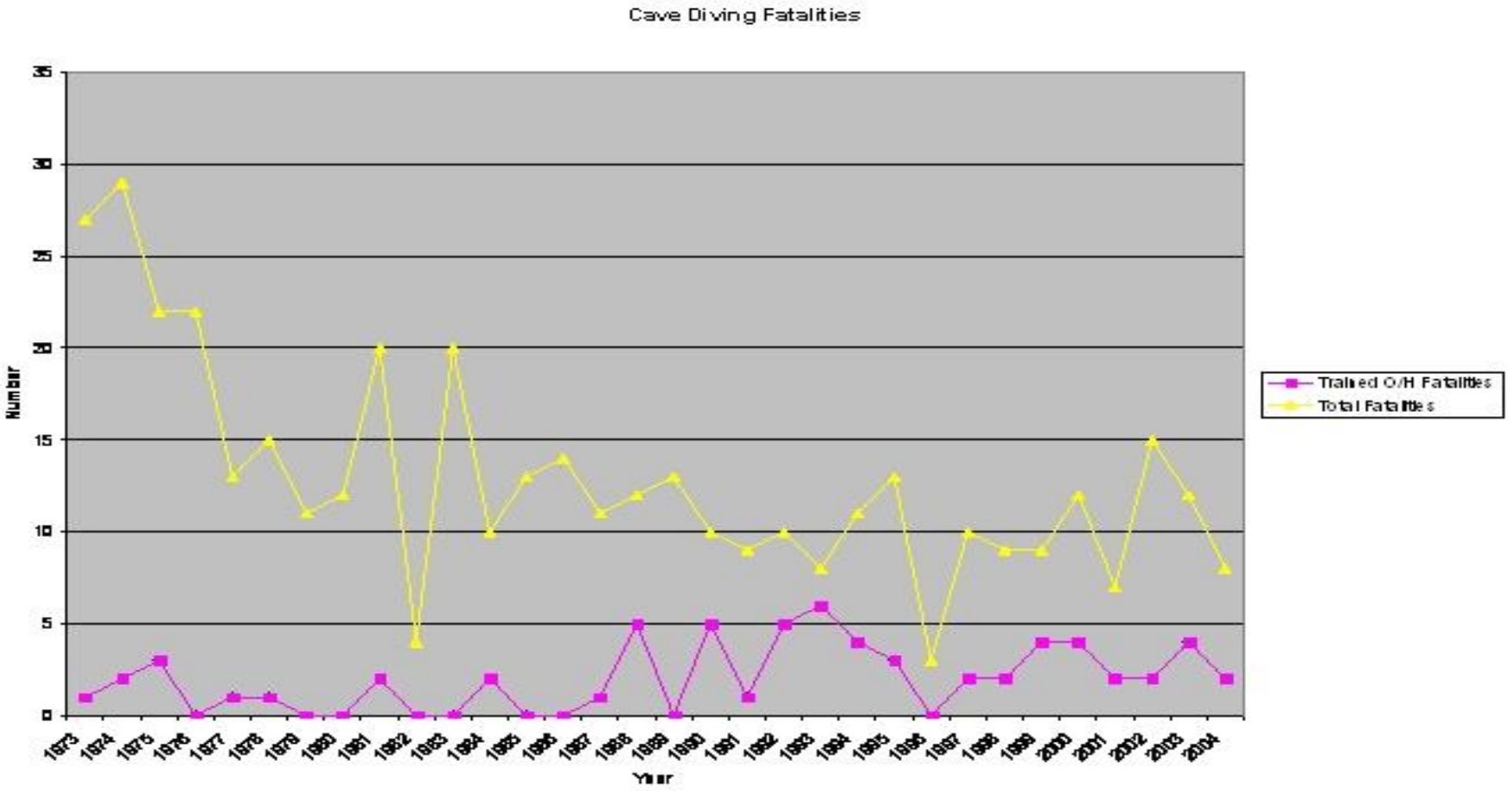
The caves in the Yucatan are often very shallow – no more than 15 or 20M but you can't go straight up – It is an “overhead” environment. (going into wrecks can get you into the same difficulties).

Many have died by just going a little bit further from the safety of one water – and that included Open Water instructors who have not learned how to deal with problems of getting lost or manage air supplies under water.

National Association for Cave Diving

Here's a graph of cave diving Deaths since 1973 – The yellow being total deaths and the pink for trained Cave Divers

So like marriage – it is not to be done lightly or unadvisedly



Indeed my first Cave Instructor – Steve Berman - who turned into a very good friend – died in a cave a decade ago

On the evening of May 7, 2001, Steve Berman died while doing what he had lived for; cave diving.

Steve was one of the CDS's most active instructors and had been involved in a number of exploration cave dives in the US and abroad.. Those of us who knew him and of his respect for the skills and techniques necessary to cave dive are mystified by this tragedy.

Sadly he is not the only one - Rob Palmer (on the right) - perhaps the best of the British cave divers of the ‘80 and ‘90s also died underwater

But what are you taught in the training?

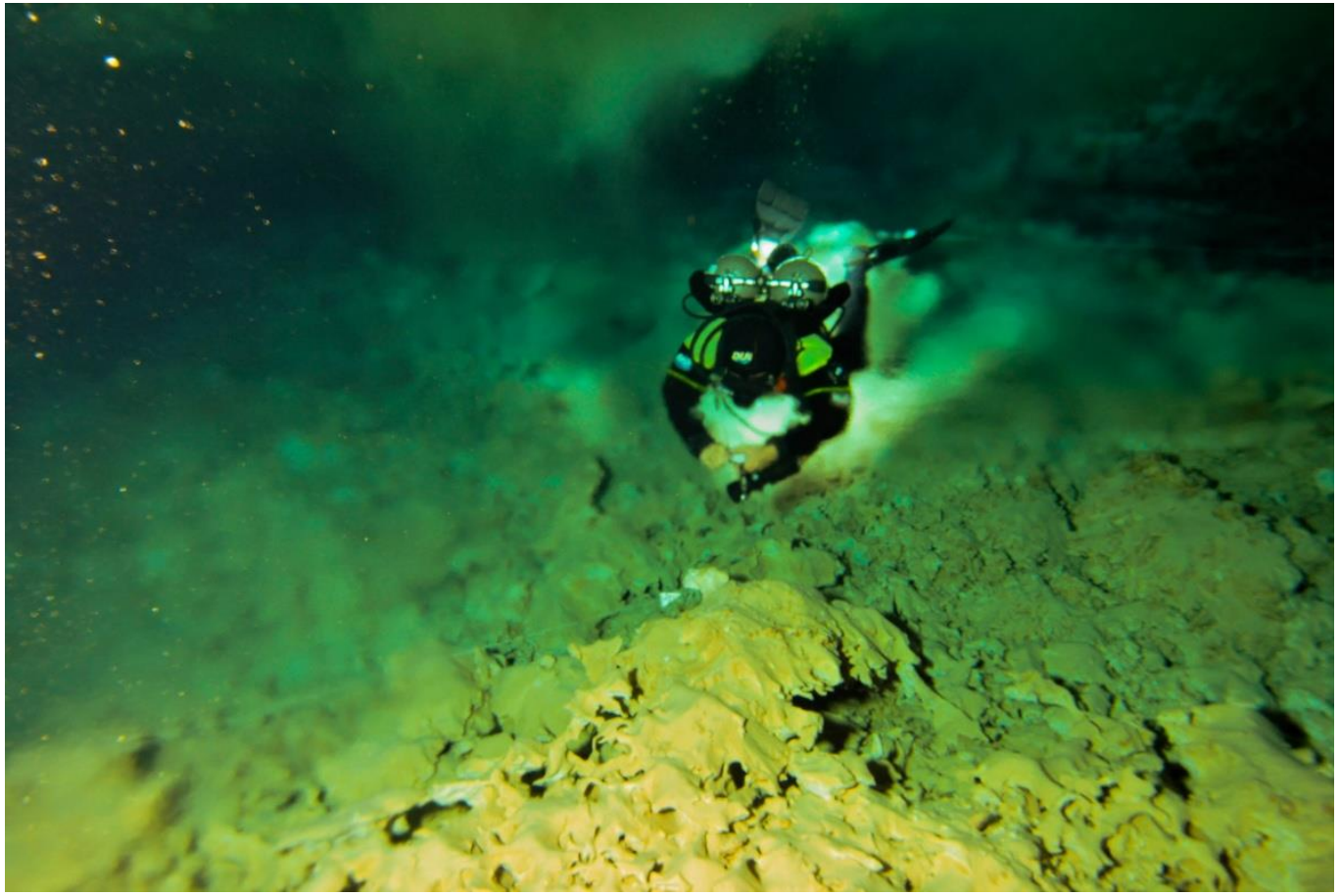
To use a line like Theseus:

Ariadne was the daughter of King Minos of Crete. Minos had Daedalus build a Labyrinth, a house of winding passages, to house the bull-man, the Minotaur. Minos required tribute from Athens in the form of young men and women to be sacrificed to the Minotaur.

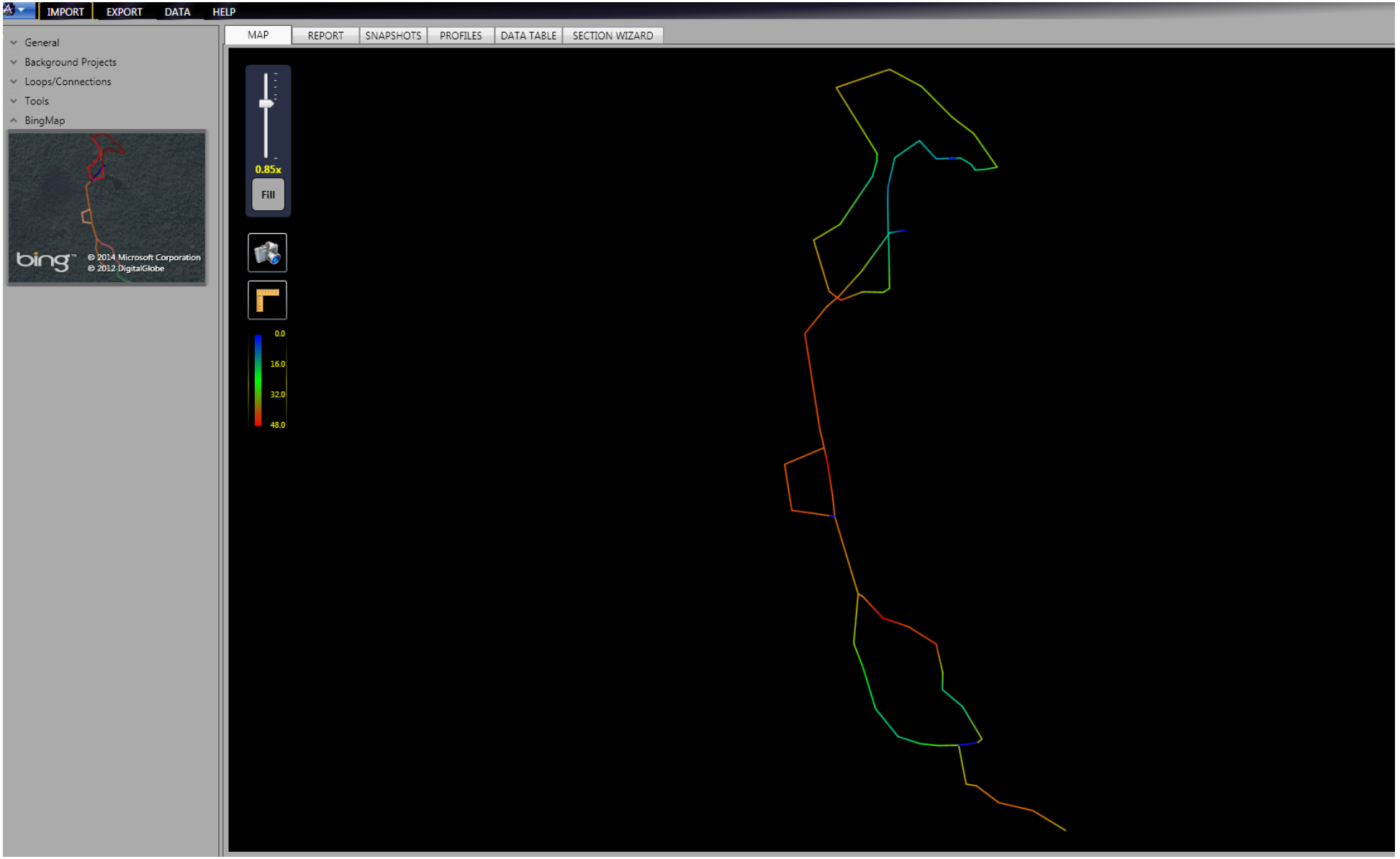
Ovid says that Daedalus built a house in which he confused the usual passages and deceived the eye with a conflicting maze of various wandering paths (in errorem variarum ambage viarum) (Metamorphoses 8.161):

Theseus, an Athenian, volunteered to accompany one of these groups of victims to deliver his country from the tribute to Minos. Ariadne fell in love with Theseus and gave him a thread which he let unwind through the Labyrinth so that he was able to kill the Minotaur and find his way back out again.

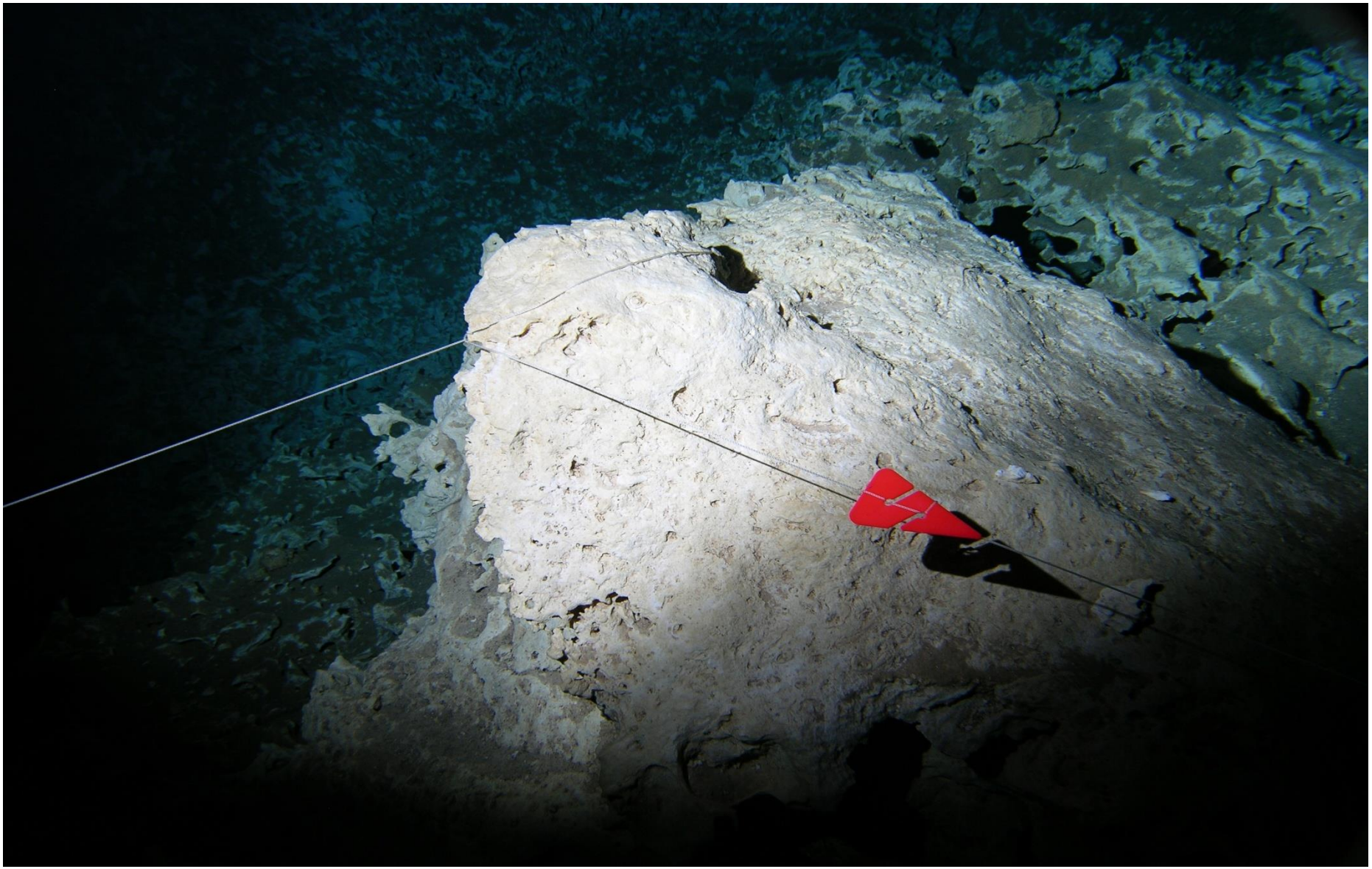
Maintaining a continuous vital to being able to find you way out of the cave – your lights can fail – you had hit the bottom and turn the clear water into something that look just like Milk of Magnesia



Line can break - and then it take effort to stop the Dragon awaking….

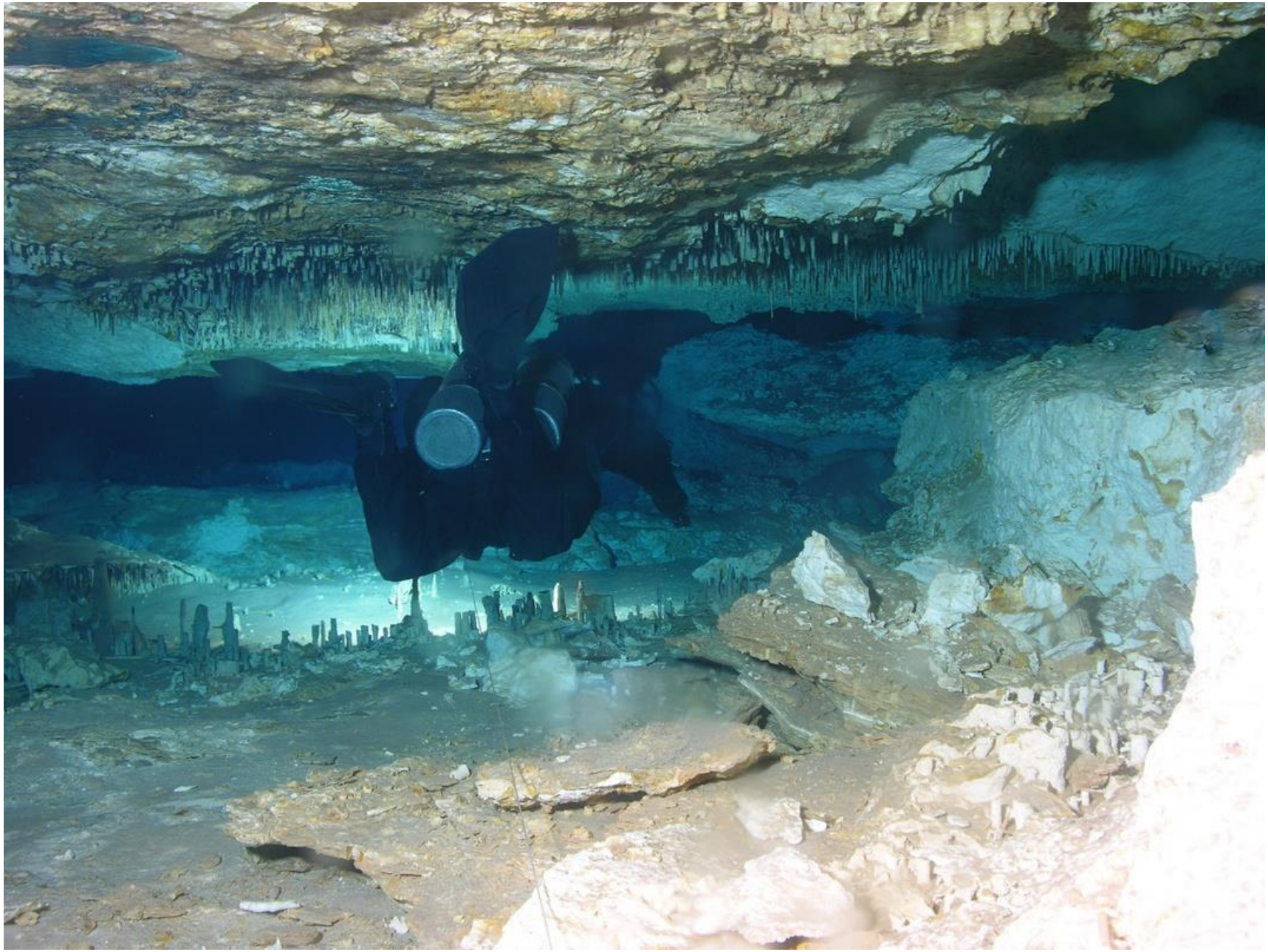


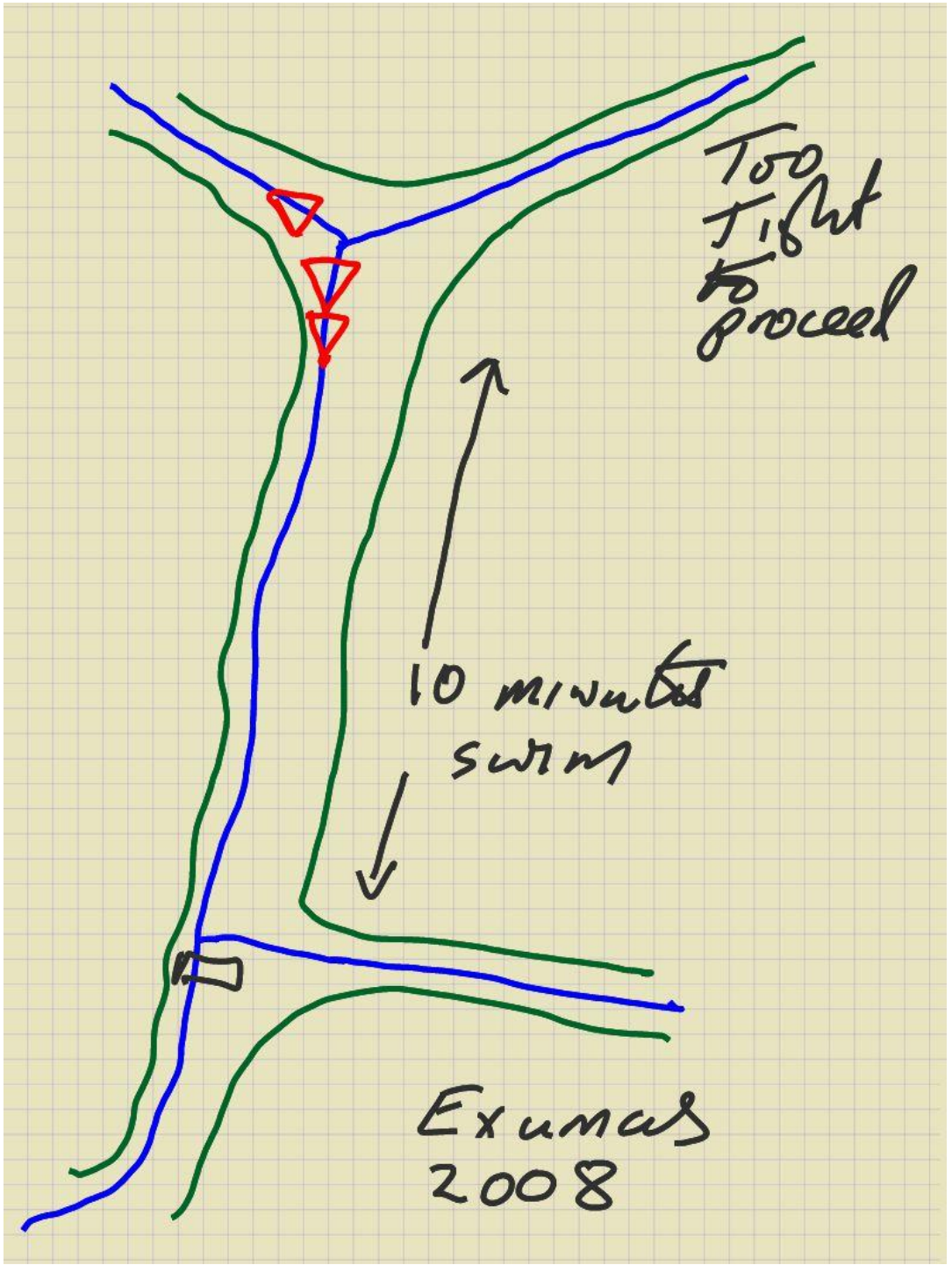
That happened to me last year in the system I am currently mapping called Actun Chen



Arrows are placed upon the line – if you get lost and find the line, you still have to determine which way is out.

Not always easy to see





And if you missed them, you can have a job keeping the Dragon asleep.

This is a dive I did on a Palmer expedition in 1998 - where I missed the Arrows on the “T”

Air (gas) management: The most common protocol is the 'rule of thirds,' in which one third of the initial gas supply is used for going in, one third for egress, and one third to support another team member in the case of an emergency.

To carry extra air – cave divers carry at least two cylinders. These are connected (manifolded) together and are connected to two “regulators” - each of which can be shut off as required. … If a “reg” free-flows, foe example…

Depth rules: The deeper you go, the more air you use. The Yucatan Caves are very shallow which allow long dives without carry very large amounts of air.

Lights: All cave divers must have three independent sources of light, in case two fail during the dive. In a Cavern you are allowed just two.

Even though the water is warm, - 25C - you use a dry suit because of the cooling effect of being in the water for a long time.

How to you get into a cave?

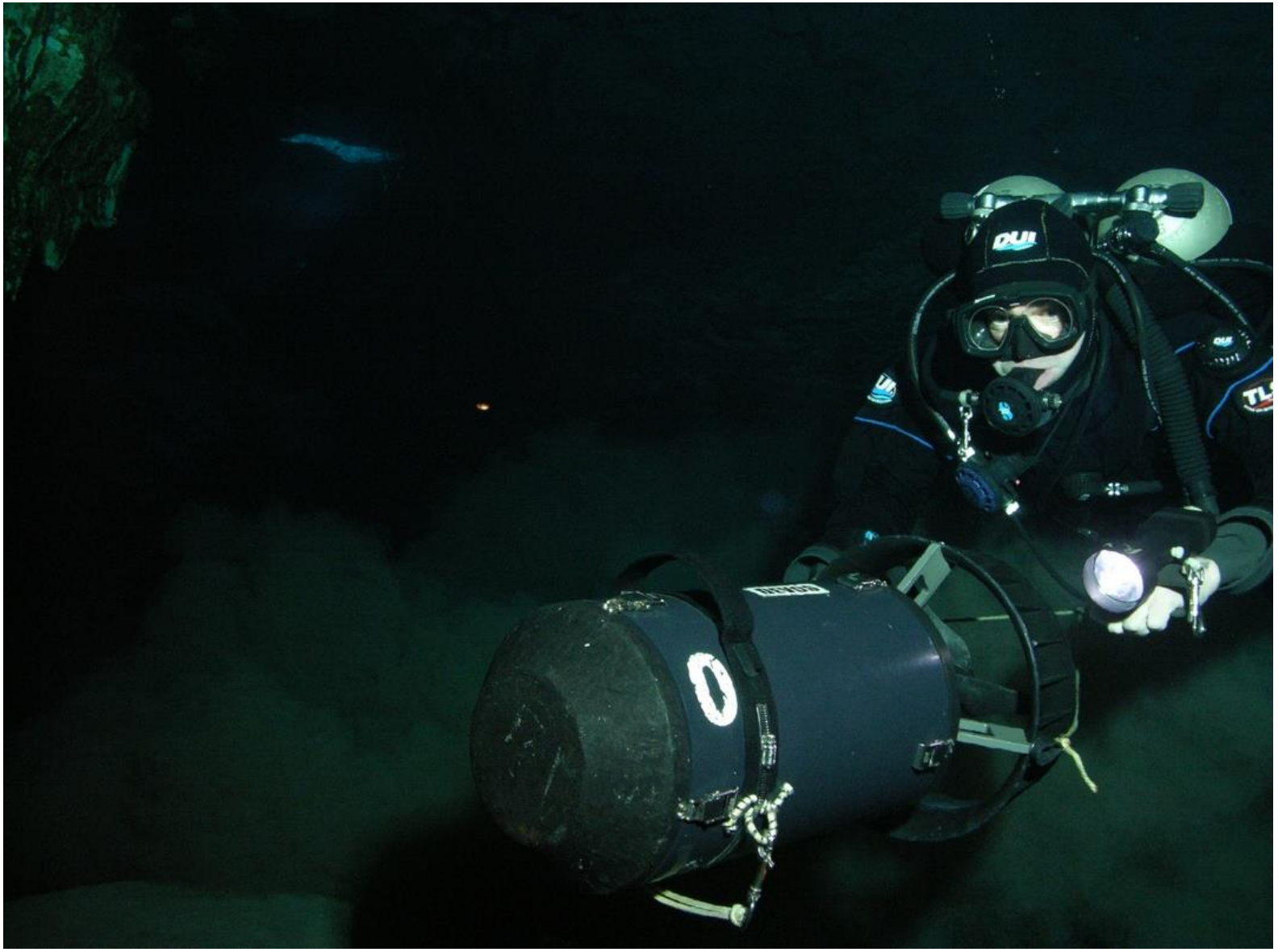
The obvious answer is to swim – and with full cave gear on one's back you can swim at perhaps 20M every minute – that's about to the back of this room.

There is another way – you can use a scooter:

This is to get round a problem that can also appear in badly written software

No. This code uses the *Shlemiel the painter's algorithm*. Who is Shlemiel? He's the guy in this joke:

> Shlemiel gets a job as a street painter, painting the dotted lines down the middle of the road. On the first day he takes a can of paint out to the road and finishes 300 yards of the road. "That's pretty good!" says his boss, "you're a fast worker!" and pays him a kopeck.
>
> The next day Shlemiel only gets 150 yards done. "Well, that's not nearly as good as yesterday, but you're still a fast worker. 150 yards is respectable," and pays him a kopeck.
>
> The next day Shlemiel paints 30 yards of the road. "Only 30!" shouts his boss. "That's unacceptable! On the first day you did ten times that much work! What's going on?"
>
> "I can't help it," says Shlemiel. "Every day I get farther and farther away from the paint can!"



With a scooter one can travel at 60 M a minute and use less air as well

Don't forget to charge your scooters – they only go for 40 minutes (20 Minutes in)….but in that time you can be 1200M – say 3500 ft in – that's a long way.

The scooter is quite heavy – not a trivial exercise carrying down to the water

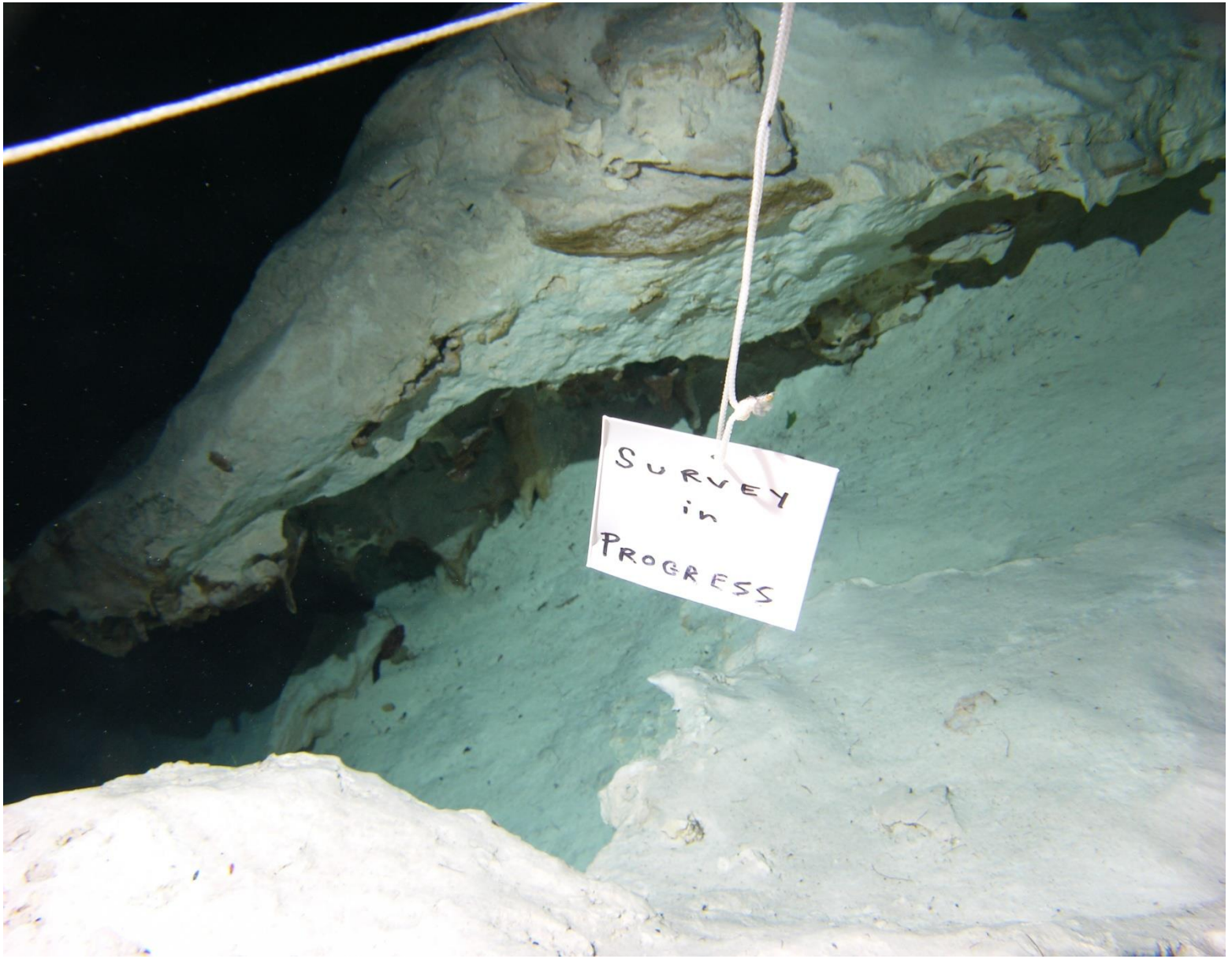
Maintaining good landowner relations -is vital for any mapping project – this is David, the nephew of the Owner

There are other things best avoided - Dry suits are a help

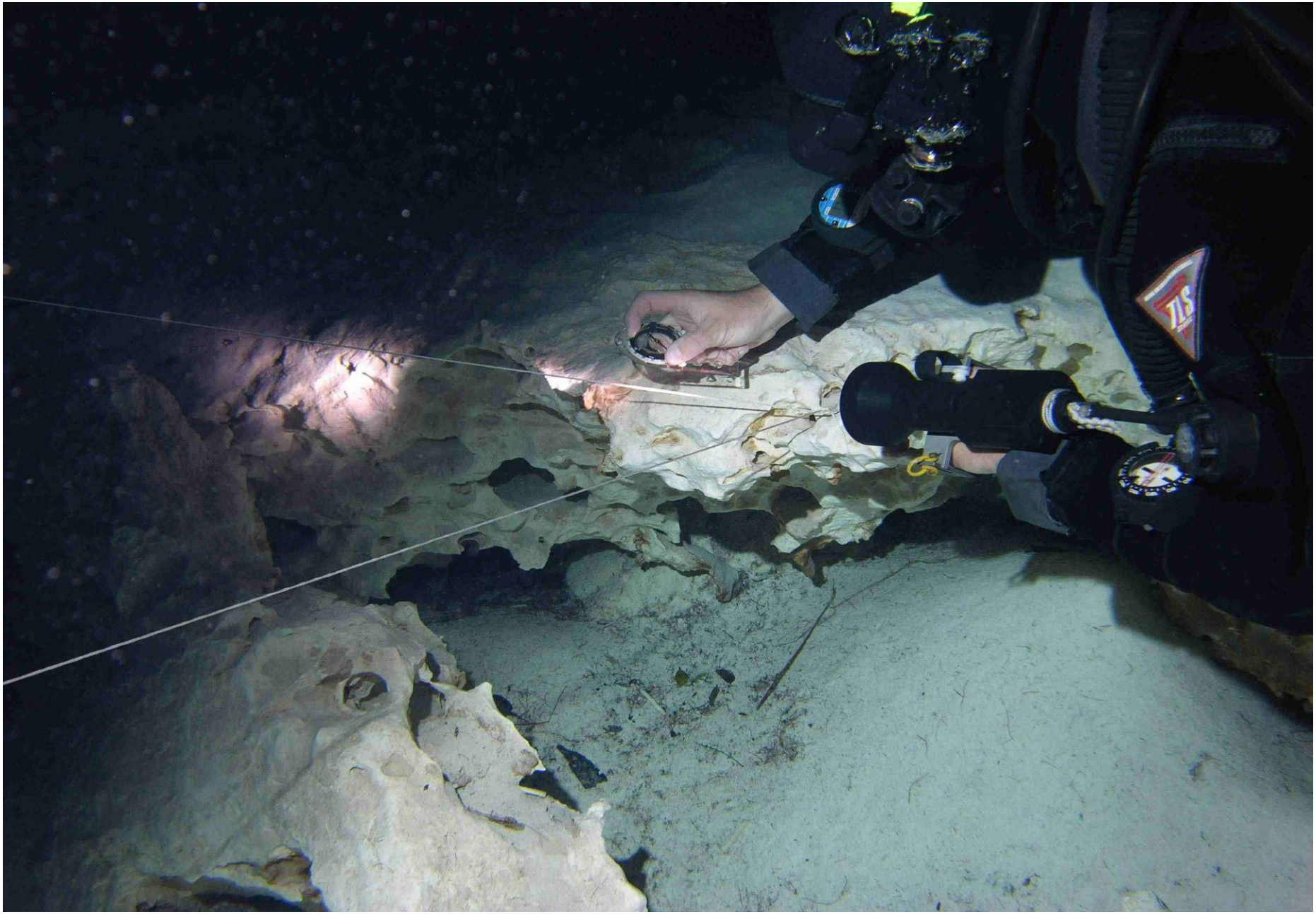
So how do you map a cave: You need a truck to get to the dive site

Setting off:

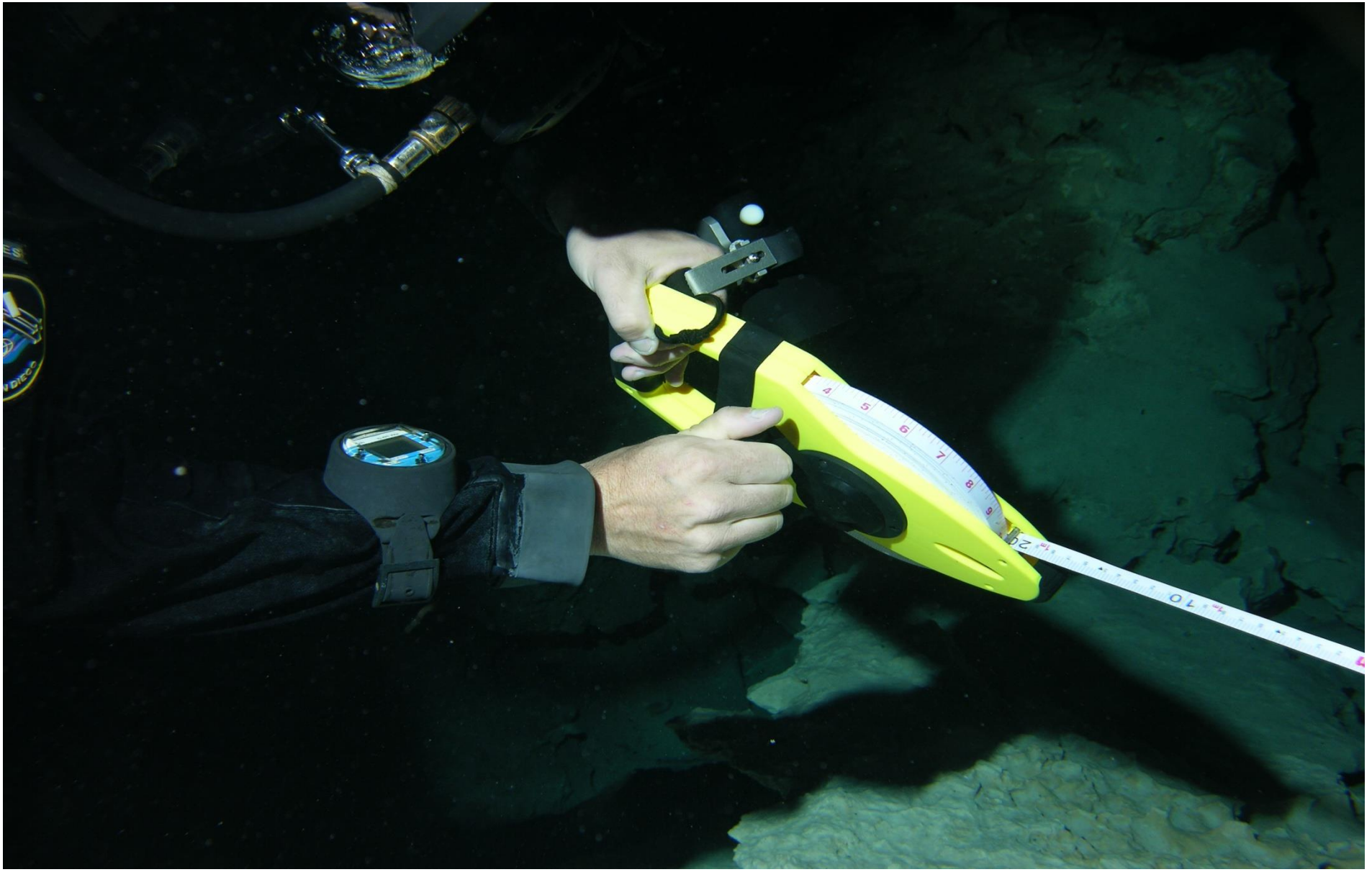
One always dives with at lease one “buddy” - to help you or visa-versa when trouble arrives



The line is marked – to warn any other divers that a survey is under way and there may be other lines in the cave

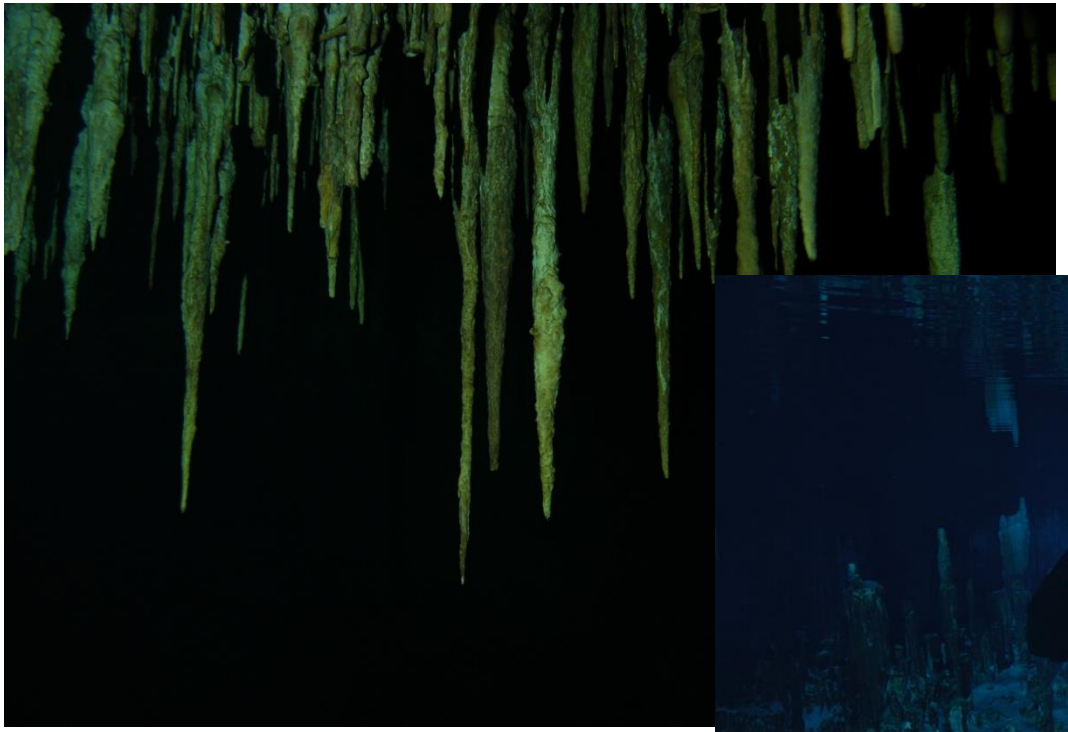


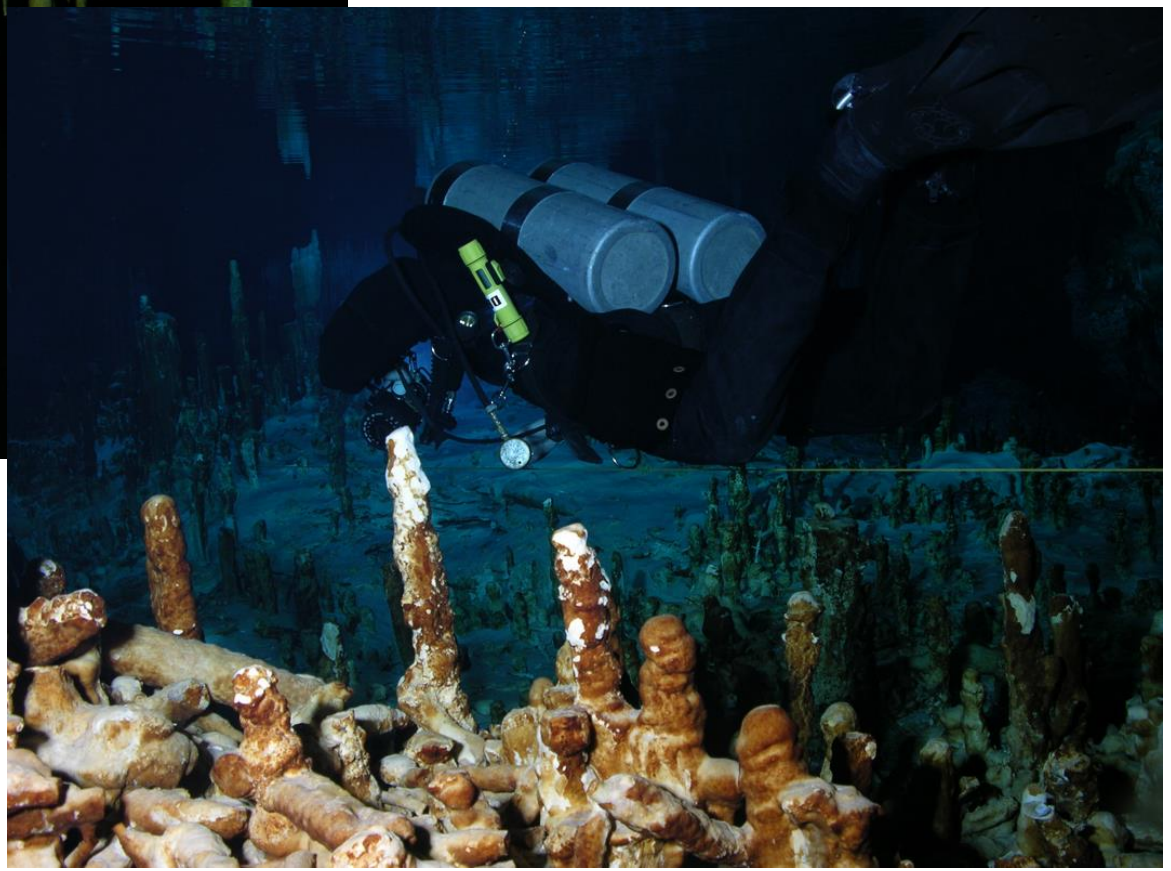
Using a compass to measure the direction of the line in the cave

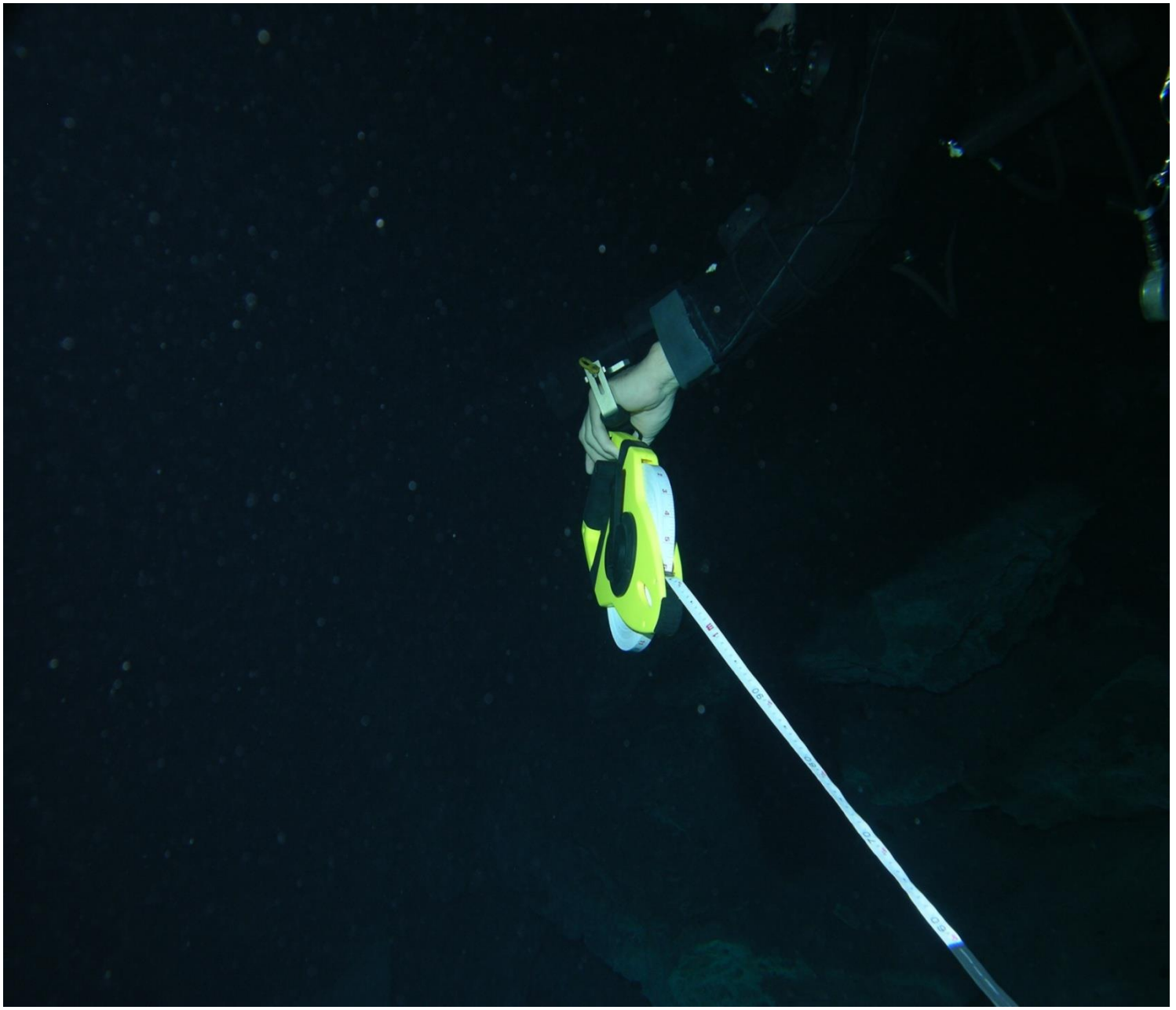


Using a tape measure to measure the length of a line in a cave

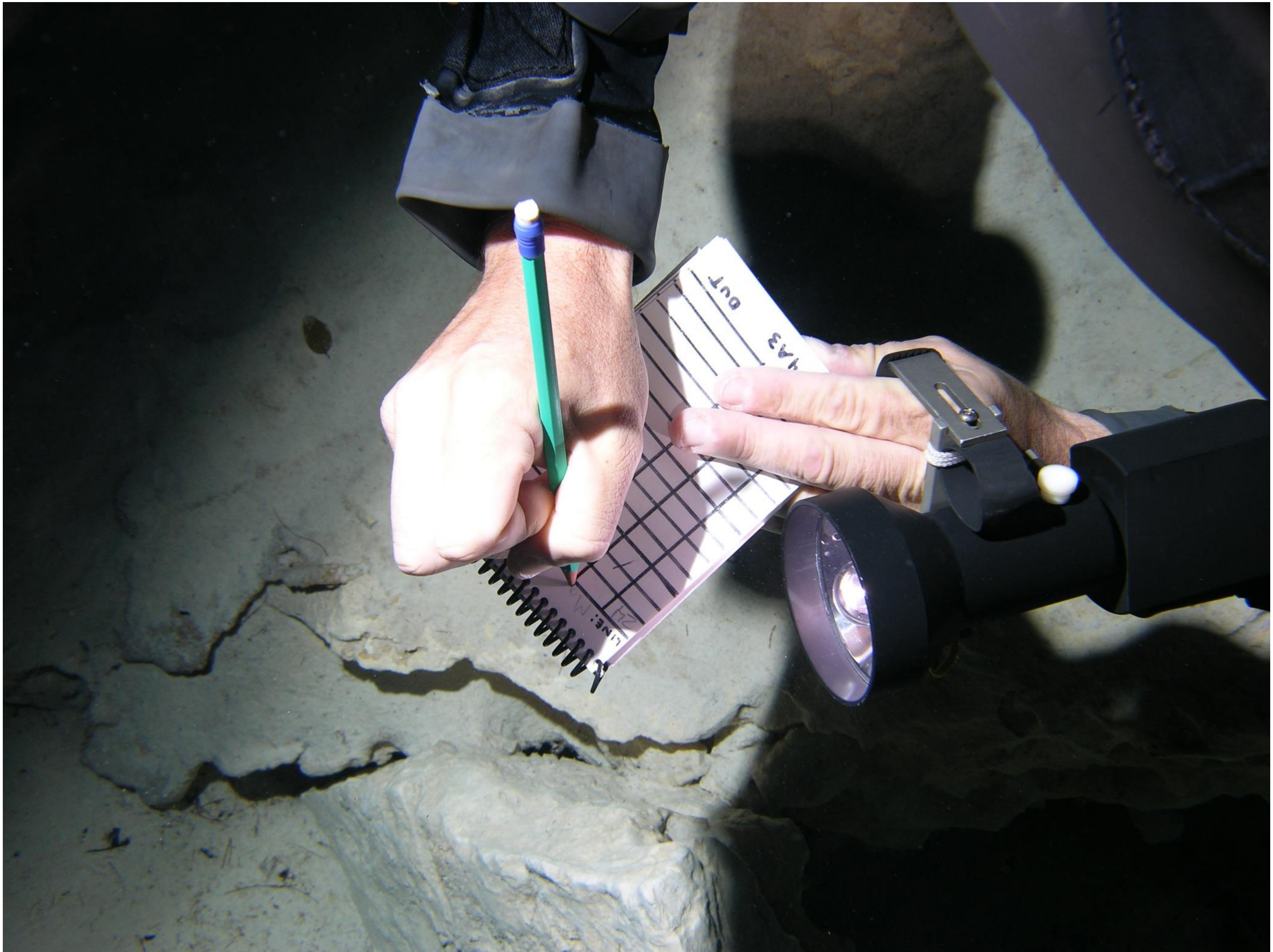
The presence of stalactites proves that the caves were formed in air, when the water table was much lower than it is now – during an Ice Age.







These caves are dark – not a place to be if you suffer from claustrophobia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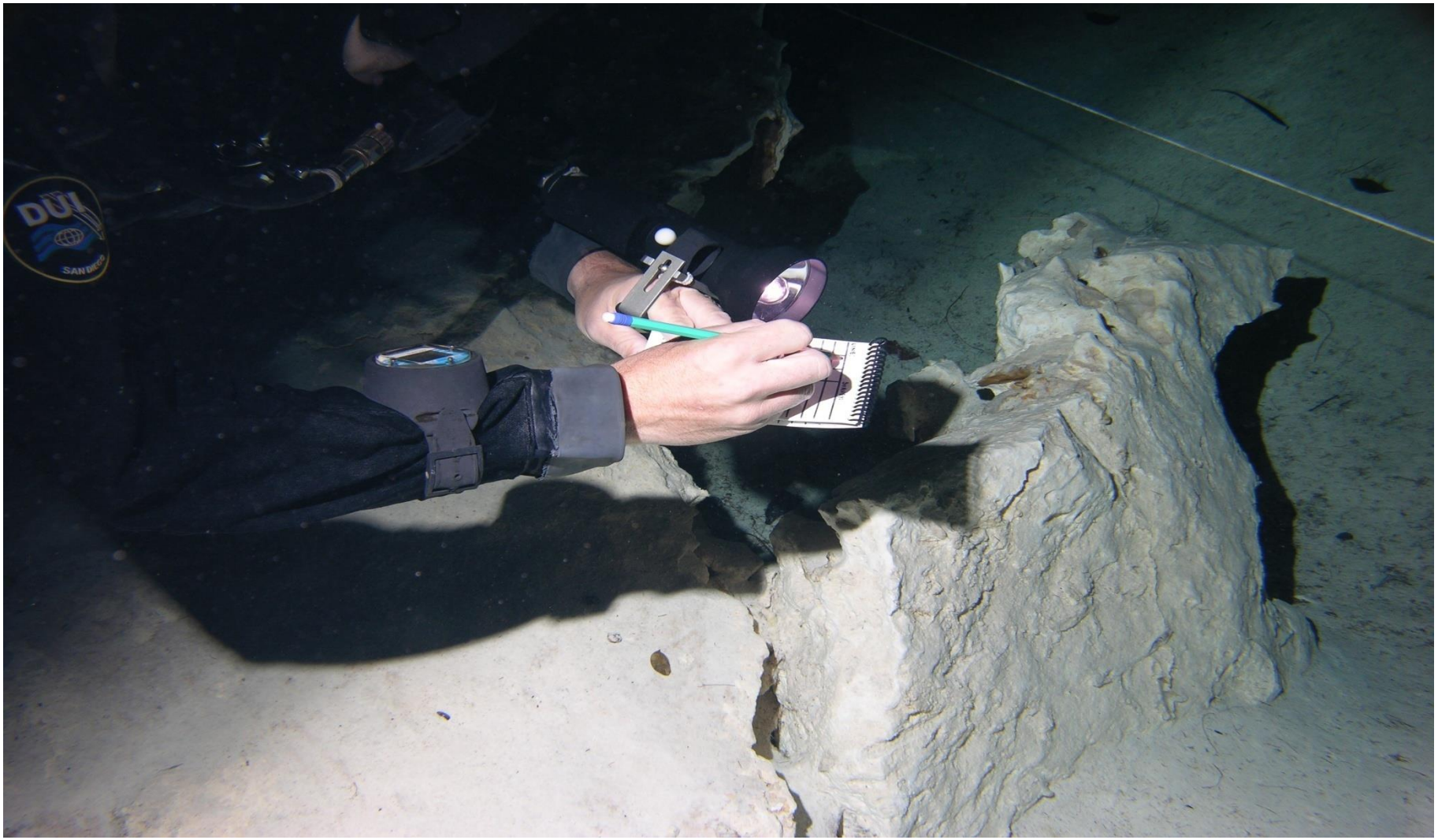
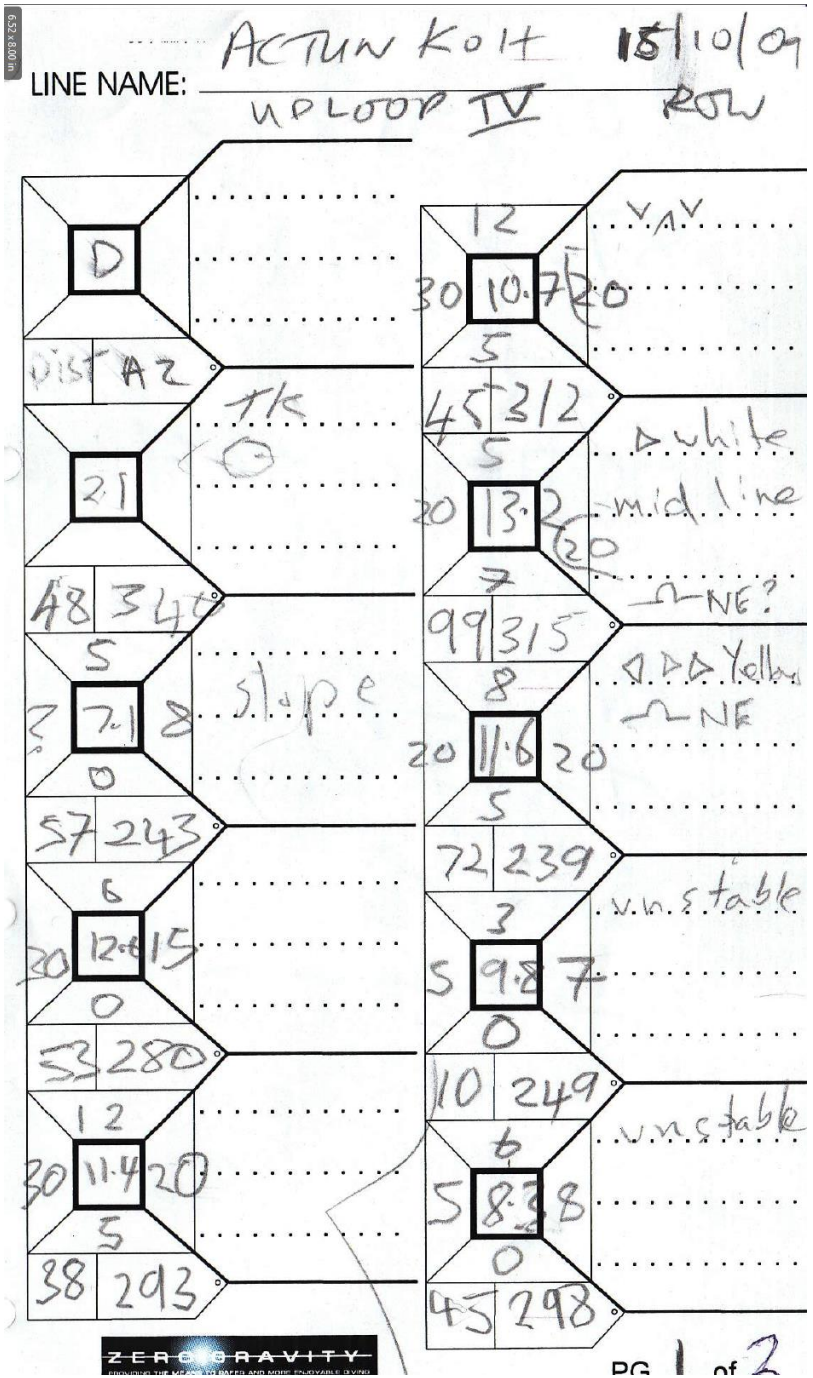
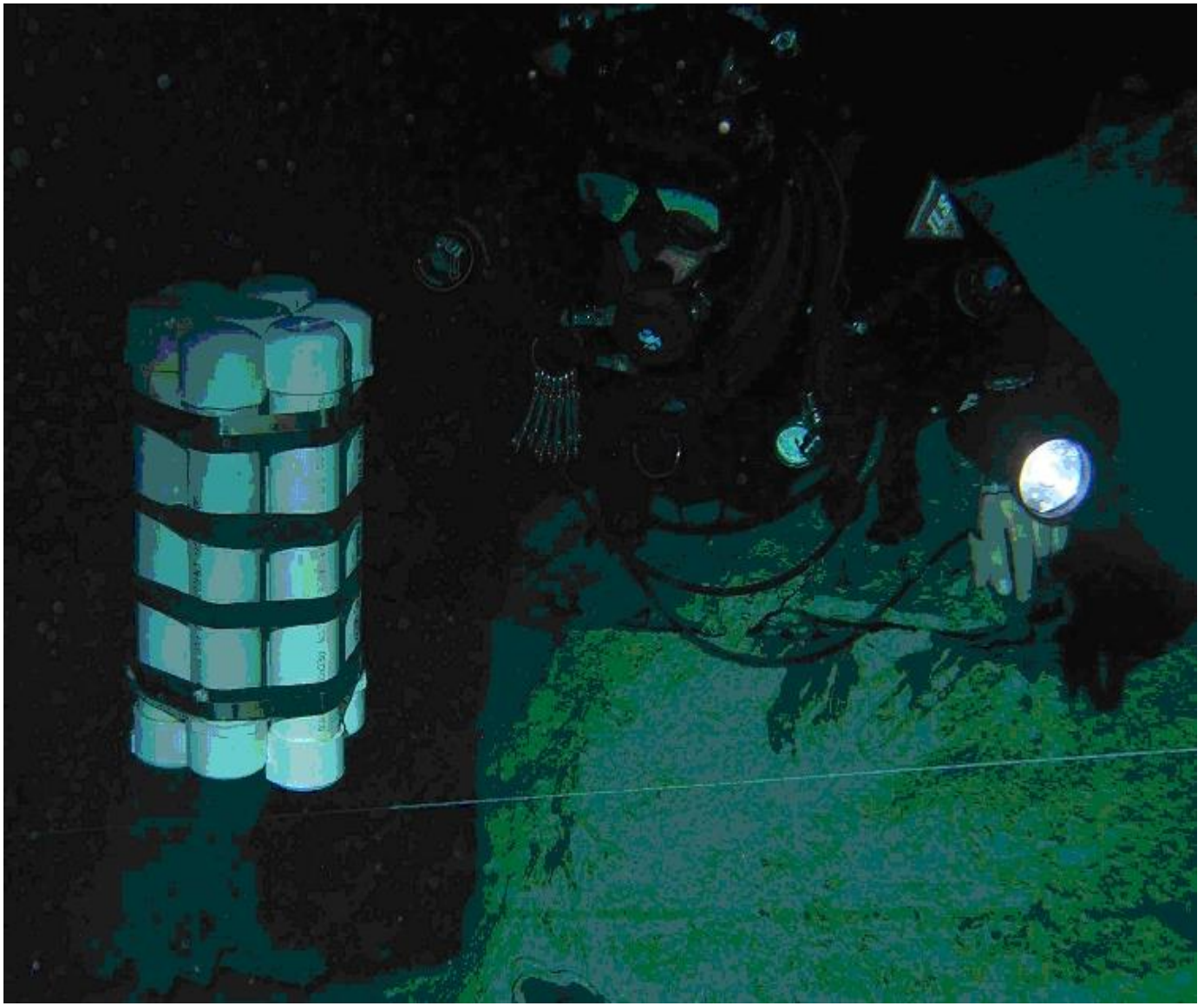


Recording the results – depth, distance, azimuth (compass direction) under water

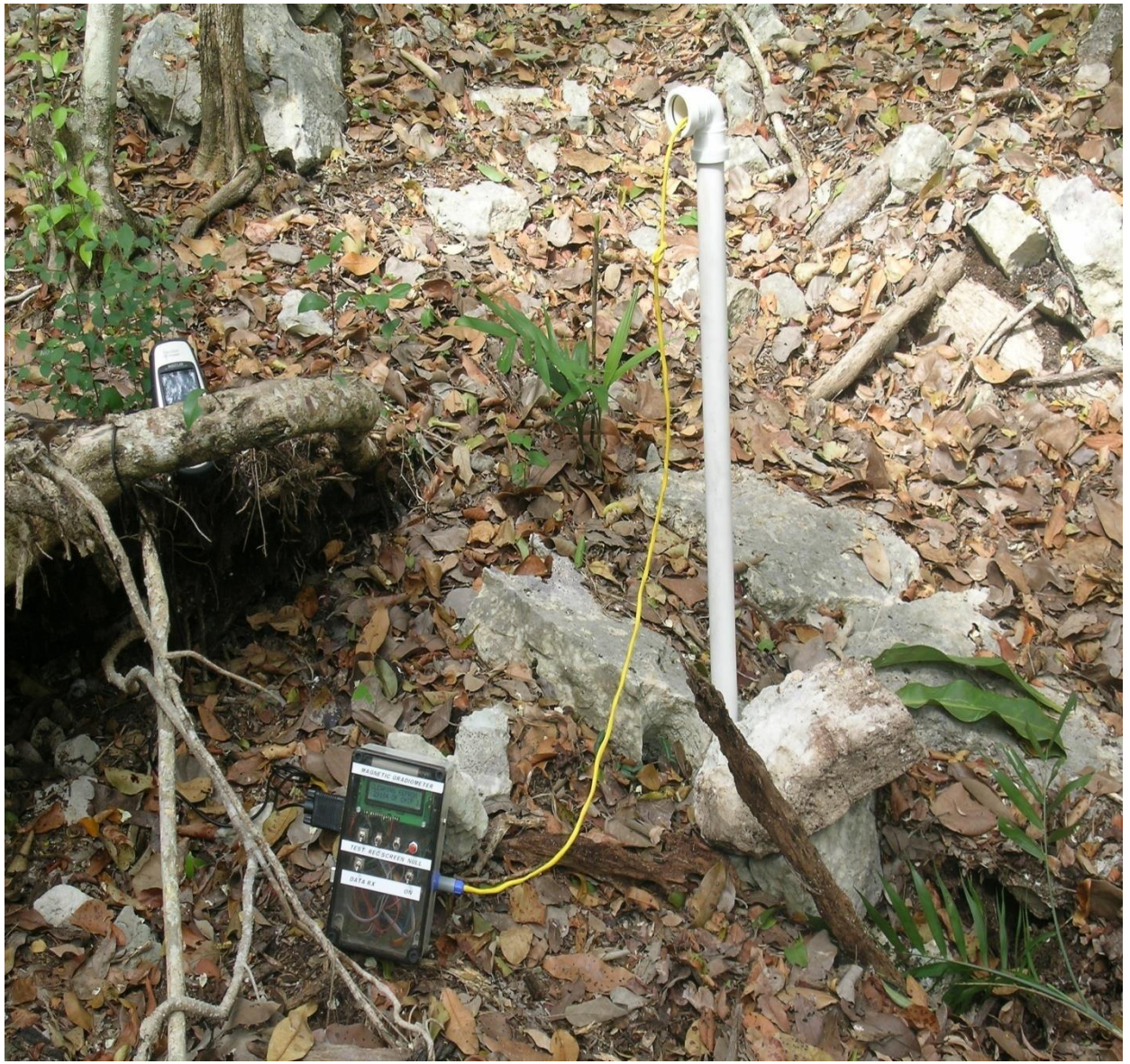


Log book showing

Depth:
Azimuth:
Distance:
Distances to walls
Comments

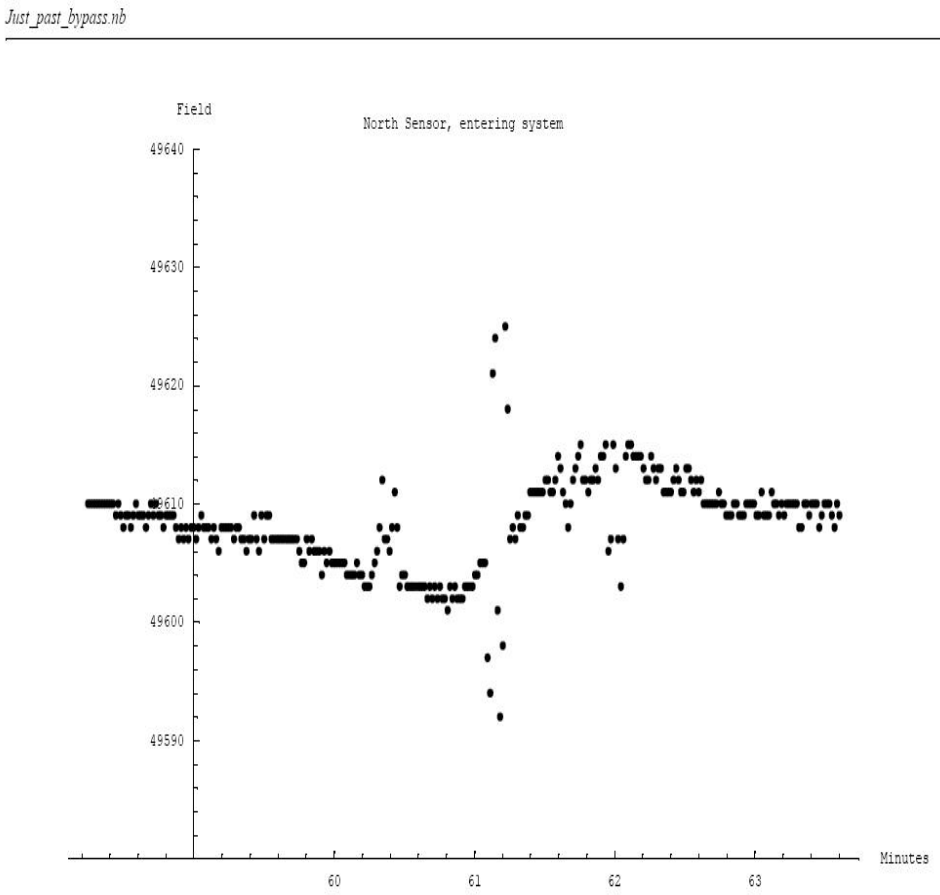


To improved the accuracy of the maps – the errors of line measurements build up over distance, we have been taking magnets into the cave and tracing their movements on the surface with a device called a Magnetometer



This is the Magnetometer – for those interested in how thinks work – this is a Flux gate magnetometer and was developed during the second world war to detect submarines.

You need to know where the magnetometer is – and we use GPS to place the magnetometer in the jungle at the point where we think a known point of the line is.



The magnet is then towed into the cave and the magnetometer detects the magnet when it passes by. By using more than one sensor, you can see which one is nearer the magnet.

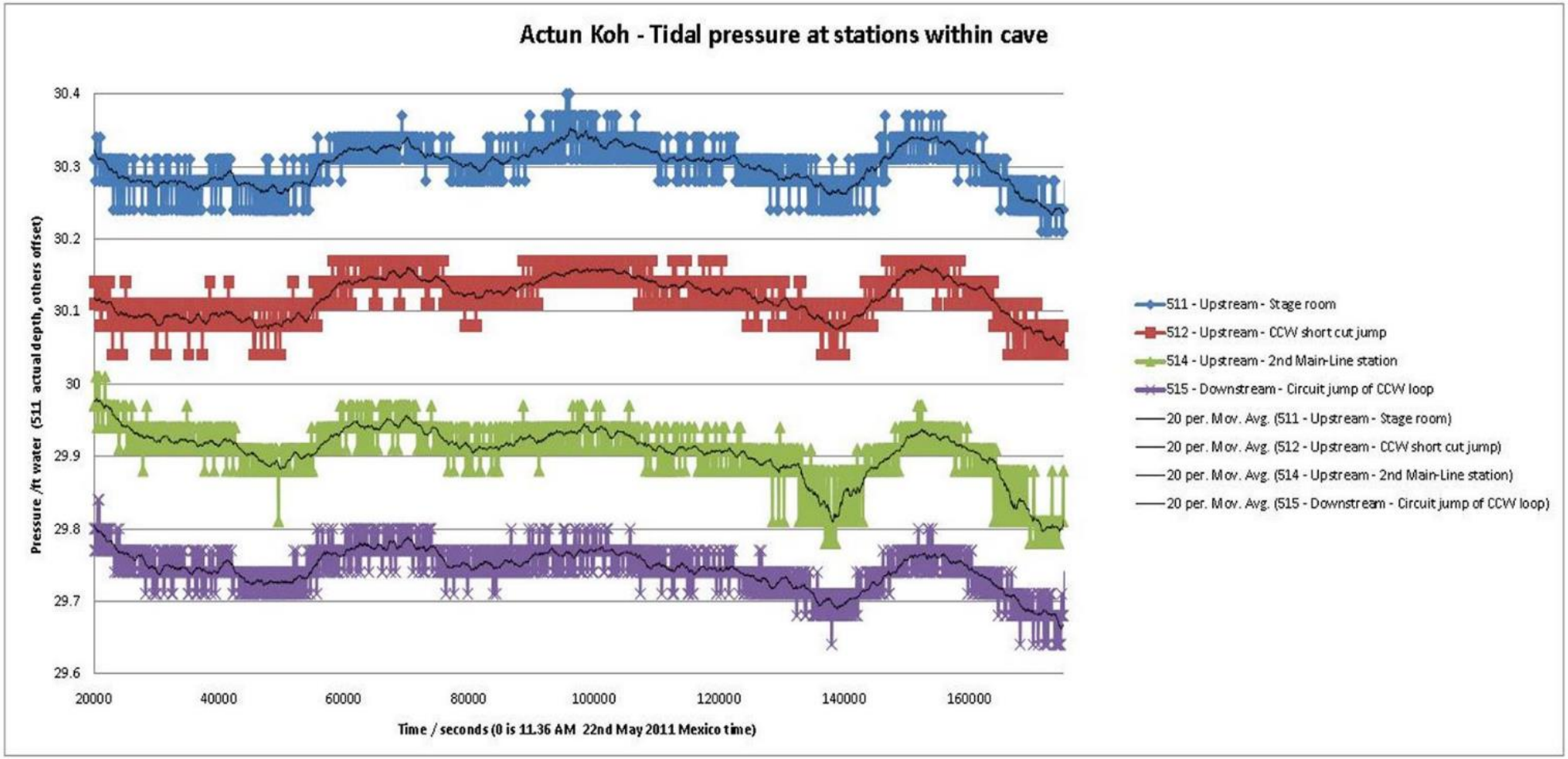
This is the sort of trace that you get on your computer screen (if it has worked) and allows
on to map the passage through the cave to an accuracy of perhaps 3 Metres.

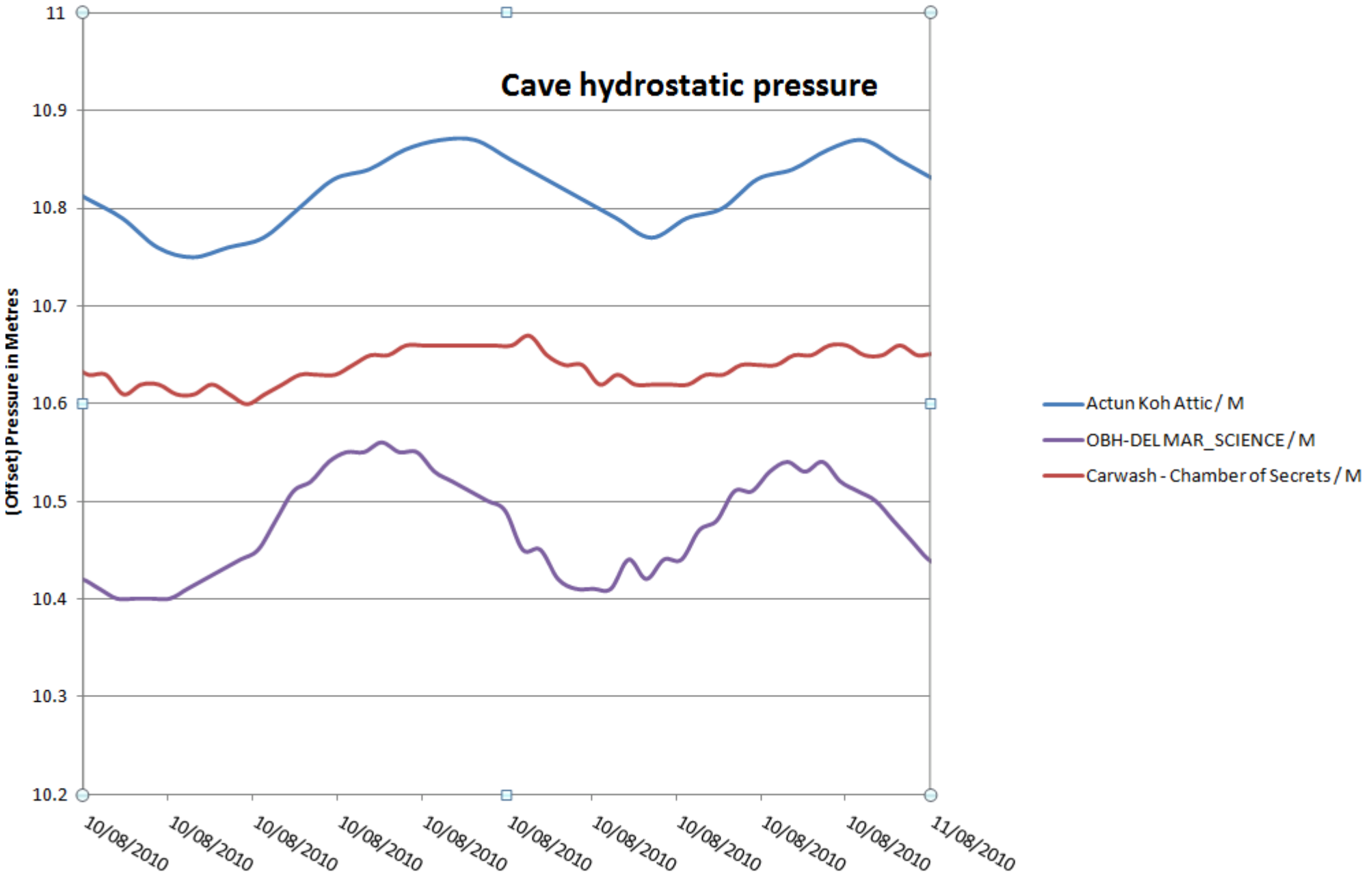
Accurate maps allow explorers to connect different cave systems together

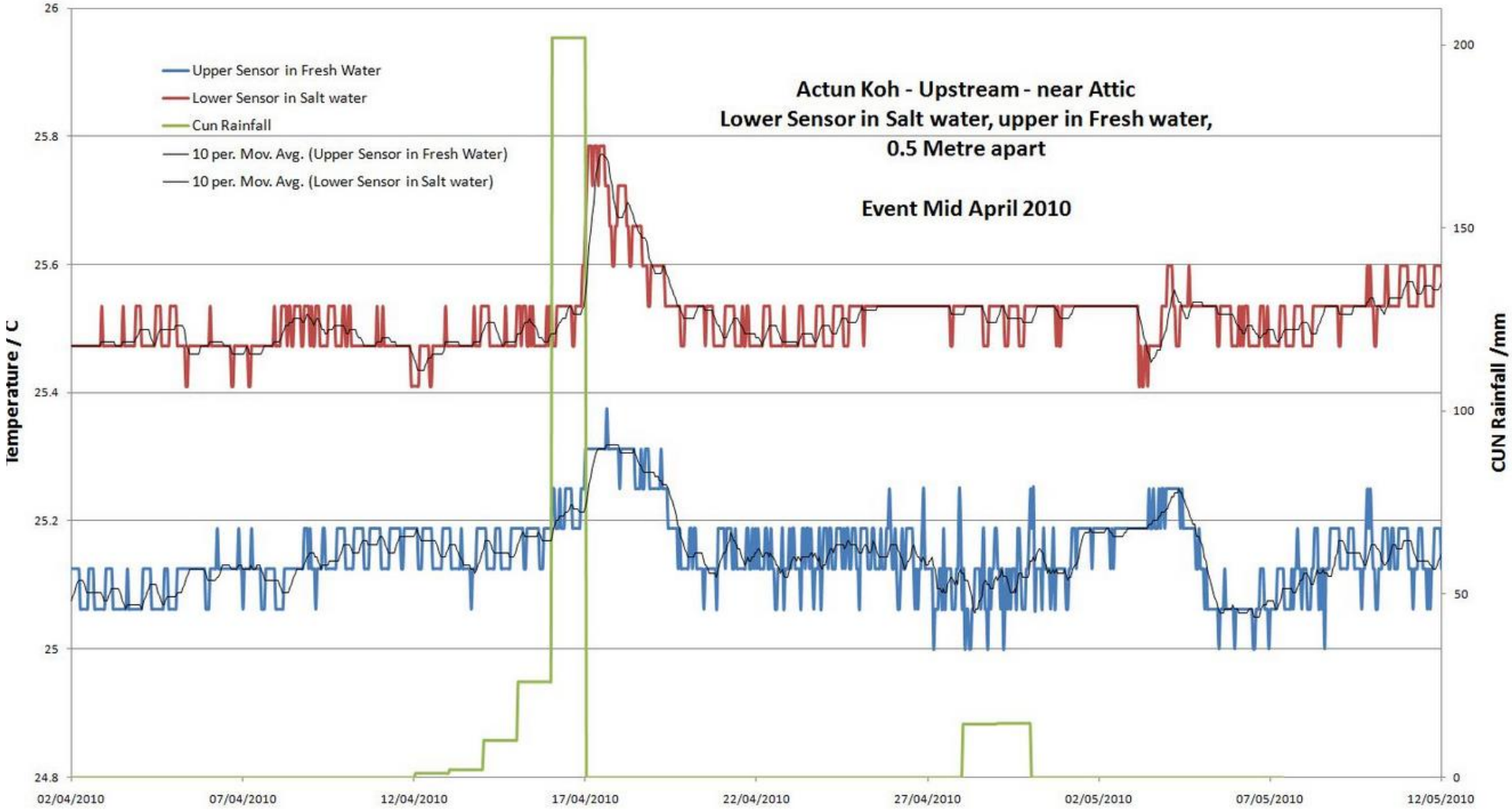
These numbers get plugged into an Excel spreadsheet to work out where the line – and therefore the cave – has gone.

	A	C	D	E	F	G	H	I	J	K	Q	R	S	T	AB	AC	AD
1																	
2		SURVEY BY:											TOTAL LENGTH:	284.49			
3		DATE:											MAX DEPTH:	31.496064			
4		COMMENTS											MIN DEPTH:	17.716536			
5																	
6		SURVEY DATA ENTRY											GRID		UTM		
7	FROM	DEPTH	L	R	U	D	COMMENTS	DIST	AZI	TO		STATION	X	Y	E	N	ALT (M)
9	0	23.95						26.1	14	1		0	-190.6115605	1369.404233	471875.9016	2266353.394	-7.30000023
10	1	17.717	-50	-35	21	0	Air above	40.02	308	2		1	-184.48013	1393.996058	471877.7705	2266360.89	-5.40000017
11	2	18.701	50	40	17	15	> jp SSW mid-line	52.2	308	3		2	-216.0067813	1418.627378	471868.1611	2266368.398	-5.70000018
12	3	24.934	15	15	20	0	jp to Attic >>	44.37	324	4		3	-256.8465916	1450.534934	471855.7132	2266378.123	-7.60000024
13	4	31.496					Cookie Devos 10	121.8	160	5		4	-282.6398599	1486.036323	471847.8514	2266388.944	-9.60000031
14	5									6		5	-240.9818065	1371.581761	471860.5487	2266354.058	
15	6									7		6					
16	7									8		7					
17	8									9		8					
18	9									10		9					
19	10									11		10					
20	11									12		11					

As well as mapping the caves , we also place pressure and temperature sensors in the caves - Here is my colleague Fred Devos with a sensor designed to be hung on the ceiling


Actun Koh - Tidal pressure at stations within cave
Pressure /ft water (511 actual depth, others offset)
30.4
30.3
30.2
30.1
30
29.9
29.8
29.7
29.6
20000
40000
60000
80000
100000
120000
140000
160000
Time / seconds (0 is 11.36 AM 22nd May 2011 Mexico time)
511 - Upstream - Stage room
512 - Upstream - CCW short cut jump
514 - Upstream - 2nd Main-Line station
515 - Downstream - Circuit jump of CCW loop
20 per. Mov. Avg. (511 - Upstream - Stage room)
20 per. Mov. Avg. (512 - Upstream - CCW short cut jump)
20 per. Mov. Avg. (514 - Upstream - 2nd Main-Line station)
20 per. Mov. Avg. (515 - Downstream - Circuit jump of CCW loop)


Cave hydrostatic pressure
(Offset) Pressure in Metres
11
10.9
10.8
10.7
10.6
10.5
10.4
10.3
10.2
10/08/2010
10/08/2010
10/08/2010
10/08/2010
10/08/2010
10/08/2010
10/08/2010
10/08/2010
10/08/2010
10/08/2010
11/08/2010
Actun Koh Attic / M
OBH-DEL MAR_SCIENCE / M
Carwash - Chamber of Secrets / M


Actun Koh - Upstream - near Attic
Lower Sensor in Salt water, upper in Fresh water,
0.5 Metre apart
Event Mid April 2010
Upper Sensor in Fresh Water
Lower Sensor in Salt water
Cun Rainfall
10 per. Mov. Avg. (Upper Sensor in Fresh Water)
10 per. Mov. Avg. (Lower Sensor in Salt water)
Temperature / C
CUN Rainfall /mm
26
25.8
25.6
25.4
25.2
25
24.8
200
150
100
50
0
02/04/2010
07/04/2010
12/04/2010
17/04/2010
22/04/2010
27/04/2010
02/05/2010
07/05/2010
12/05/2010

SISTEMA ACTUN KOH

QUINTANA ROO, MEXICO

16,917 ft

Low area in the Attic

Collapsed Rocks in Bear's Den

Diver in one of many decorated air domes

Fossilized conch shell

Slot in ceiling to upper level

Typical cave wall downstream

CARTOGRAPHY
Richard Wylde
Fred Devos

PRINCIPAL EXPLORERS
German Mendosa
Edsel Rios Del Rios
Christian Thomas
Claude Touloumdjain
Bernd Birnbach
Yair Azubel
Christophe Le Maillot
Fred Devos

All measurements in Feet
BCRA grade 3B

Penetration distances are shortest route from
Cenote Actun Koh
UTM WGS84
16Q 471936 2265938

MAPA MAPS v4
Edition 1.1, AUG 2011

100 ft

LEGEND

- MAINLINE
- LINE SURVEY ONLY
- UNSURVEYED LINE
- SHALLOWER LINE
- AIR DOME
- DRY CAVE
- OPEN WATER
- CEILING ROOTS
- WATER FLOW
- ROCKS ON FLOOR
- FLOOR TO CEILING COLUMN
- GUIDELINE DEPTH
- MINOR RESTRICTIONS
- SIDEMOUNT PASSAGE
- SPELETHEMS

PROFILE SKETCHES
- view from Aktun Koh -
I to V upstream
VI to XII downstream

p. 3,043 ft
p. 2,822 ft
p. 2,311 ft
p. 1,260 ft
p. 2,011 ft

COSA NOSTRA
CORN FLAKES
ATTIC
LOFT
STAGE ROOM
GRAND CENTRAL
RAILWAY
DREAMLAND
WONDERLAND
CATFISH ALLEY
TEENS

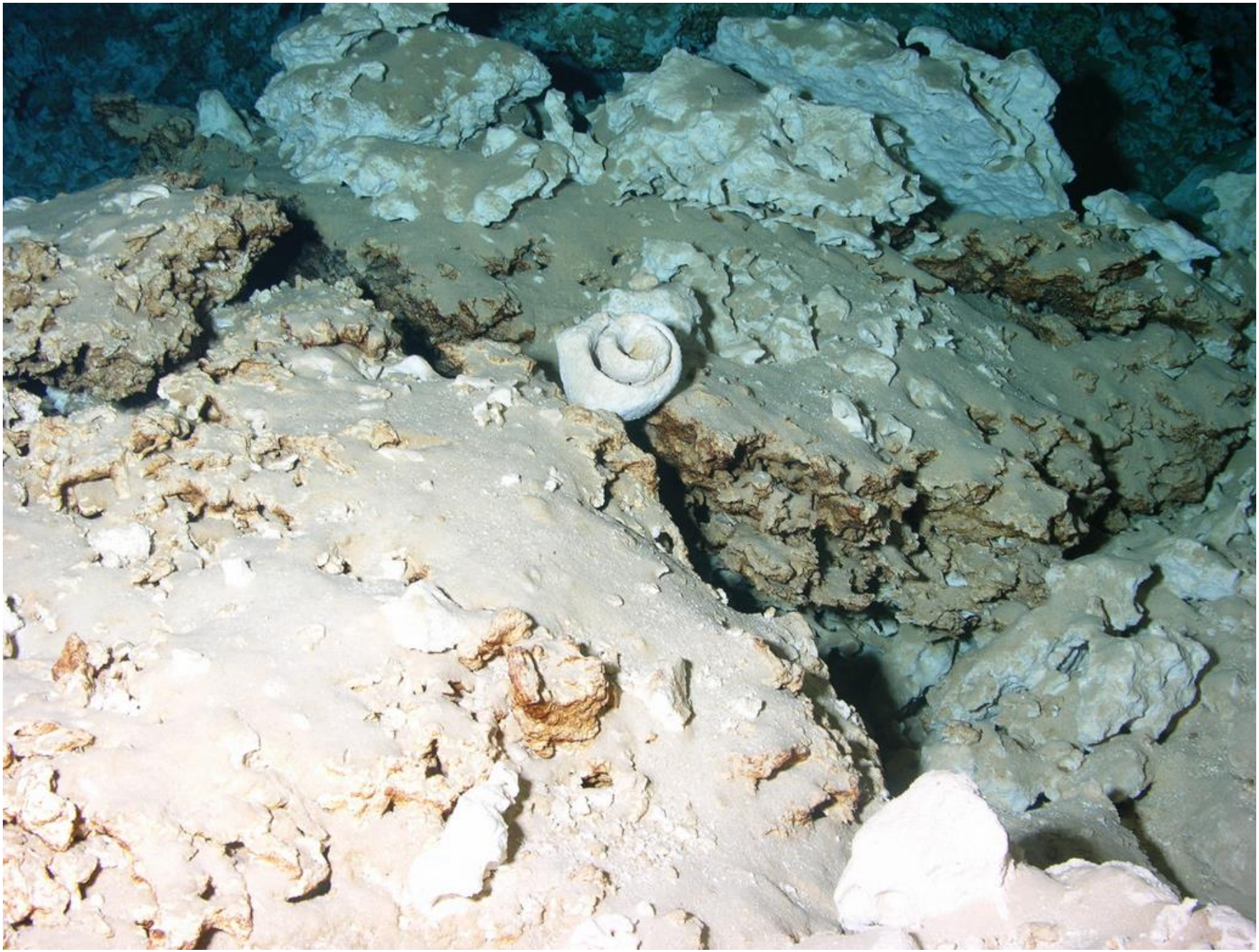
CENOTE BEAR'S DEN

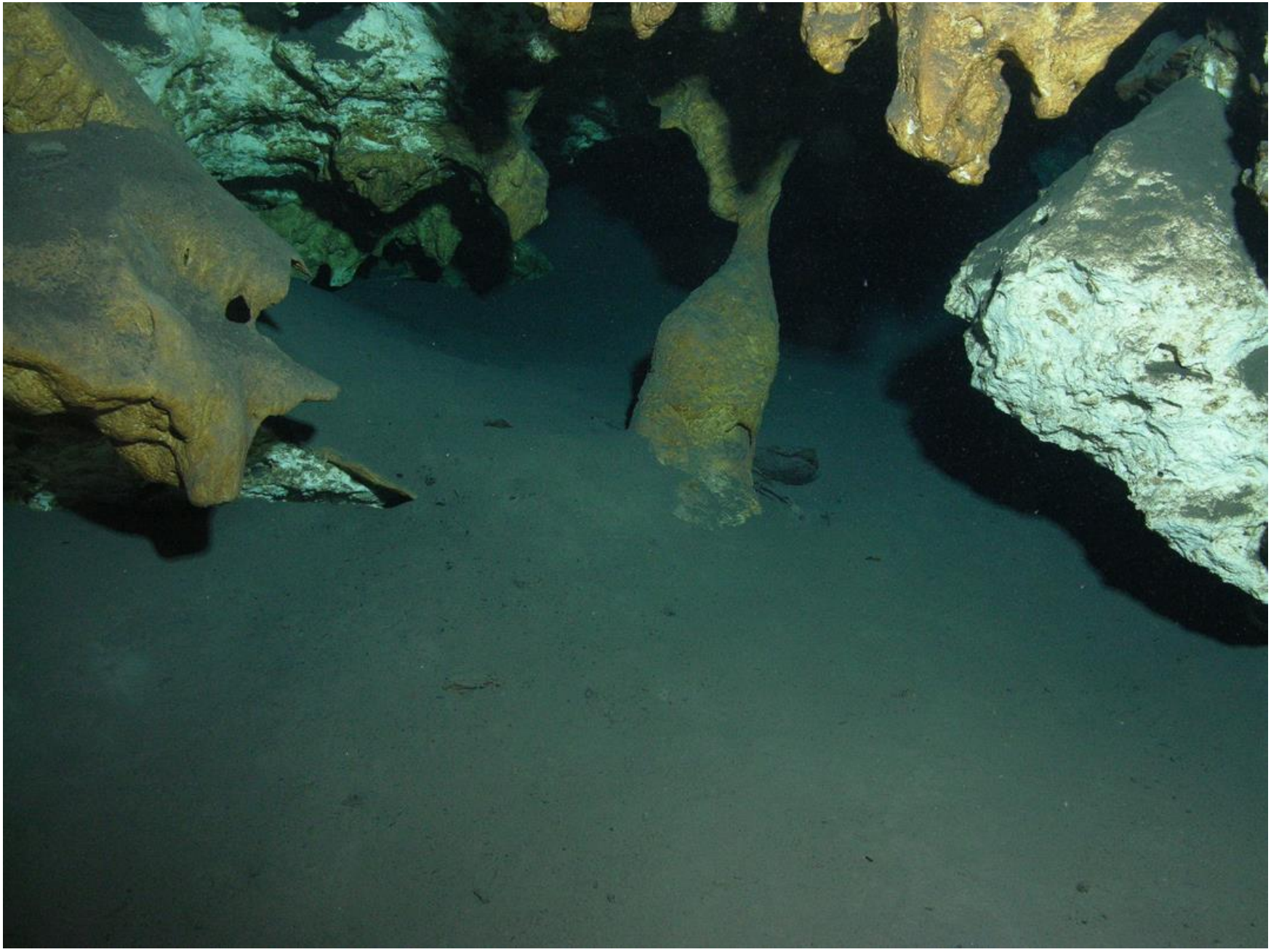
CENOTE ACTUN KOH

CENOTE OVERPASS

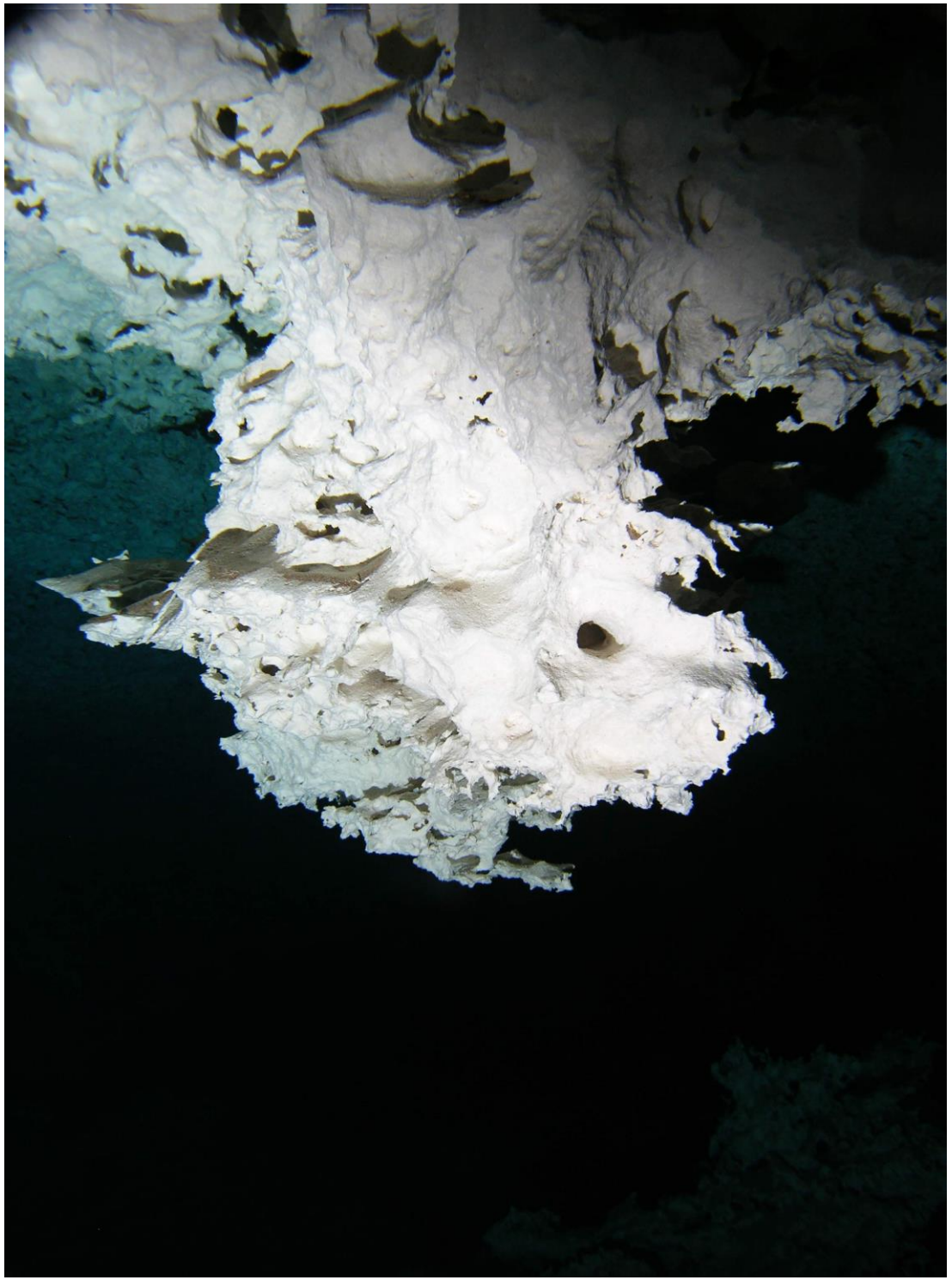
This air filled cave was only discovered by divers arriving from the main Cenote entrance an hour away. The entrance is well defended by wasps

An ancient fireplace - before the cave re-flooded after the last ice age, we suspect…





Downstream Actun Koh - and a lot of silt



An image to leave you with -

Fruiting Body, some 400 Metres into Chiken Ha