Towards the Centre of the Earth Krubera-Voronja 2010

04-25 August 2010

Report of the Irish Members of the International Expedition to Krubera-Voronya Cave 2010

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PROLOGUE

Two expeditions, both alike in dignity,
In fair Voronya, where we lay our scene,
From ancient grudge break to new mutiny,
Where civil mud makes civil hands unclean.
From forth the fatal loins of these two foes
A team of pitch-haggard cavers haul great bags;
Whole misadventured piteous attempted coups
Do with their toil bury their comrades' strife.
The fearful passage of the 'Way to the dream',
And the continuance of their stay at -1800,
Which, but by 4 days there, could be removed,
Is now the twenty minutes or so' traffic of our stage;
The which if you with patient ears attend,
What here shall miss, our toil shall strive to mend.

Niall Tobin

From Left: Niall, Tim, Eoghan, Stephen

Introduction

Our expedition focused on the main branch of the cave (to -2,000 m). The main obstacles in the cave were multiple, large pitches, long meanders, a free-diveable sump at -1,450 m and flooding of a passage between -1,200m and -1,400m.

These obstacles were of course found to be challenging for the expedition members – one of whom had only been caving for approximately 3 years.

Progressing through the cave using SRT is very technical, with large and tiring pitches in the upper half – typical pitch sizes of 100 to 150 metres, interspersed by tight meanders. A minimum of 2 tackle sacks were carried through all of the upper section of the cave – both on the ascent and the descent, in multiple trips.

The lower 1,000-metre section of the cave is very hydrologically active, with multiple cascades, crawls in water, and a free-diveable sump which was passed in order to reach the water loggers and the primary purpose of our 2010 expedition.

Inexperience and perhaps a lack of expectation for the length of time underground caused additional difficulty for some members of the Irish expedition team.

Temperatures in the cave range do not rise above 2 to 6°C, and this, in combination with the water, adds an unforgiving edge to all activities underground.

A day into the big push for the bottom of the cave, the French and Spanish refused to porter the diving equipment needed to push the terminal Dva Kapitana sump. Their argument was that it was too exhausting and hazardous to bring the quantity of diving equipment needed for such an ambitious dive. The divers (Lithuanians all) were frustrated at this, and requested the continued help of the French/Spanish team members. It was agreed that the water level loggers at the far side of the much shorter Kvitochka sump needed to be downloaded, which ended the acrimony. The Irish team members remained focused on retrieving & analysing data from water level loggers at -1,710 and -1,800 m and kept good relations with all cavers in trying circumstances.

It is difficult to describe the scale of the cave. It can begin to seem never-ending, numbing and debilitating. All that being said, the heart-in-mouth beauty of the place, the camaraderie, and the occasional fits of laughter created a unique and unforgettable team experience.

Tim O'Connell

Background

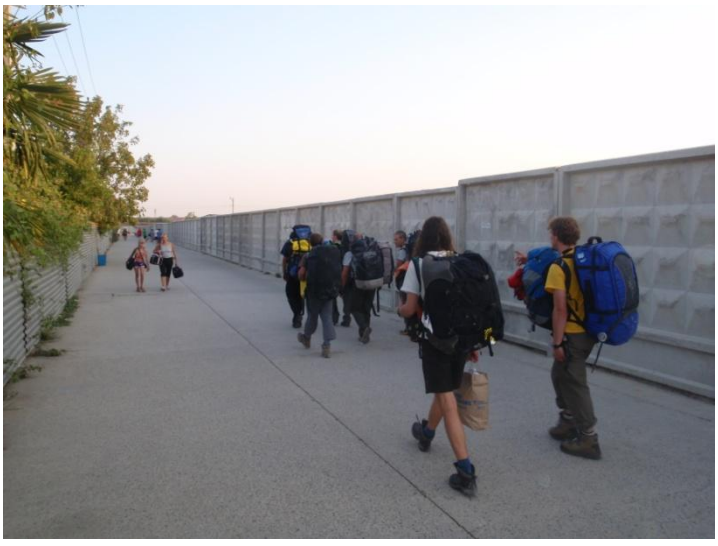
The background to the 2010 expedition to Krubera began in 2007, when Stephen McNamara made contact with "Aenigma" soon after moving to Lithuania. Aenigma is a caving club based in relatively cave-free country; so members are well used to the training and preparation involved with expedition caving. Steve introduced 10 members of the club to the caves of Co. Fermanagh on one expedition and joined another to the Alek karst region of south Russia (near the Black Sea), in 2008.

Aidas Gudaitis (Then Aenigma club leader) make contact with Yuri Kasjan, (Expedition leader of the "Call of the Abyss" project), and so Steve joined with three Lithuanians on the Ukrainian team in August 2008. Their aim was to install water level monitoring devices at depths of -1,710m (Chamber of Soviet Speleologists) and -1,810m in the main branch.

Feedback at the 2008 SUICRO symposium led to Tony Furnell joining with Steve on the expedition in 2009. The 2009 expedition saw Aenigma working more independently while still under the auspices of the Ukrainian "Call of the Abyss". This team, named "Towards the Centre of the Earth", consisted of cavers from four different countries. Using SUI funded equipment, the dataloggers were downloaded, reprogrammed and repositioned. Also, SUI funds allowed a new logger to be installed at -2,145 m which helped identify with more accuracy flooding periods within the Krubera system.

The opportunity for more Irish cavers to join the international "Towards the Centre of the Earth" 2010 expedition arose in June. Six Hungarian cavers decided to not return, leaving vacancies on the team. So joining the now veteran Stephen McNamara were Eoghan Mullan (Shannon Group) and Niall Tobin (UCD Caving / Shannon Group) and Tim O'Connell (Clare Cave Club). A brief training period and one meet up for the team prior to the off was all time allowed for.

Abkhazian Border Crossing – Photo by Niall Tobin (All photos by Niall unless otherwise stated)



Expedition Aims and Objectives

Below are the list of our aims and objectives, as specified in the grant application.

Aims / Objectives	*Comments*
Within cave	
1. Reach -2,145 m and resurface safely 1.1 Rig/rerig cave as necessary 1.2 Transport food and camping gear to establish staged underground camps (at least 3x mobile camps, deepest at -1,810 m) 1.3 Pass free-divable sump at -1,450 m 1.4 Repair cabling and set up telephones to -1,790 m 1.5 Reach -2,080 m (2 teams out of 4, approximately 10 cavers) 1.6 Resurface, removing all camping equipment and rubbish (including from previous expeditions)	**1. Successful** 1.1 Two hundred and fifty metres of rope replaced 1.2 All food transported as intended. 3 Camps established at -1200, -1810 and the permanent camp at 'Sandy beach' -1400 augmented 1.3 All members passed sump 1.4 Cabling repaired as possible/required with some problems 1.5 All members who wished to get to -2080m did so 1.6 Removed rubbish and resurfaced safely
2. *Monitor water levels to determine flooding patterns 2.1 Retrieve & analyse data from water level loggers at -1,710 and -1,800 m (from last year's expedition) 2.2 Clear level logger memory to start logging afresh for 2009/2010 2.3 Install new level logger & ambient pressure logger at -2,000 m	**2. Successful** 2.1 All data collected 2.2 Loggers re-started for 2010 - 2014 2.3 New loggers installed at -52m and -2000m

3. Dive "Kvitochka" sump at -1,900 m 3.1 Support 2 divers in Kvitochka sump (water levels permitting)	**3. Successful** 3.1 Divers bottles and gear ferried to the Kvitochka sump in support of the dive. Water level monitoring devices logged and recalibrated beyond
4. Explore inlet at -1,340 m 4.1 Continue bolting aven from last year's expedition 4.2 Survey new passage found	**4. Partially Successful** 4.1 Spanish Branch bolted to a conclusion by Spanish team members, no possible continuation beyond five metres of the surveyed cave. 4.2 5 Additional five metres of cave remains unsurveyed.
5. Examine insect life 5.1 Sample flying insects found at -1,800 m during last expedition & transport to surface for identification	**5. Unsuccessful** Centipede without pigmentation discovered in Spanish Aven by Jorge and Jesus, believed to be washed into the cave. No other insect discovered, transported out of the cave or reported upon.
6. Photograph cave 6.1 Photograph as much underground as possible	**6. Successful** 6.1 (Special mention to Niall Tobin's consistent photography throughout the expedition, exampled throughout this report)

General Objectives	
7. Personal development 7.1 Develop expedition & planning skills by partaking in a 3-week, large-scale, international expedition to a remote area 7.2 Develop caving skills – in particular underground self-sufficiency & confidence – and attain personal depth record (and Irish depth record)	**7. Successful** 7.1 Developed expedition planning awareness/ skills, partook in all aspects of surface camping, underground logistics, etc. Furthered knowledge for future expedition planning 7.2 Developed skills and confidence in a challenging caving environment through SRT, underground camping, intensive team work. Achieved personal/Irish depth record.
8. Gather information for future Irish expeditions 8.1 Make firm contacts with Lithuanian, Ukrainian, Russian, Hungarian & Spanish cavers 8.2 Search neighbouring valley (relatively unexplored) for cave entrances 8.3 Prepare expedition report (English-language accounts and descriptions are currently limited)	**8. Partially Successful** 8.1There was some friction both between the nationalities/teams in "Towards the Centre of the Earth", and between the "Call of the Abyss" expeditions. Despite this backdrop, Irish team members worked cohesively with all parties/teams/groups, and made solid contacts with cavers of other nationalities (Invites to Montenegro, Ukraine, Russia etc.). All Irish cavers invited to join the 2012 expedition to Krubera 8.2Informal exploration of

	neighbouring dolines/entrances led to the exploration of a short cave. A limited time frame disallowed any other serious prospecting in the area. 8.3 This report, also with scientific research, public talks given at the Irish Student Caving Forum 2011, video footage, online postings, *Underground* article (Autumn 2010)

**The Irish team members' primary involvement is with water level measurement .*

Gintas organising porters for moving equipment to base camp

Caving Region

Arabika Massif, Gagra Range, Western Caucasus Region, Republic of Abkhazia

The Abkhazian Republic is a breakaway republic from the former Soviet State of Georgia. Although not recognised by Western Europe or most of the wider international community, it has strong control within its borders – including separate visa requirements from Georgia or Russia.

The Arabika Massif is one of the largest high-level karst massifs in the western Caucasus, bordered by the Bzyb gorge to the east and the Black Sea to the west. Its valleys lie at 2,000 – 2,300 metres, while peaks rise to 2,500 – 2,700 metres. The only entrance to the Krubera-Voronja cave system is at an elevation of 2,256 metres.

The surface campsite for the 2010 expedition was situated beside the cave entrance, and is reached by a 6-hour drive from the nearest village of Tsandripsh followed by a further two hours' hike on foot.

Political map, Europe

Political Map, Georgia

Abkhazia and Tsandripsh

Abkhazia is a self-proclaimed republic in the Caucasus region. It considers itself an independent state yet is not recognized as such by Georgia and most Western European countries. The state is situated on the eastern bank of the Black Sea, bordered on the northwest by Russia and on the east with Georgia at the Ingur River, with the Caucasian mountain range on the north.

It gained control of the territory after the war of 1992-1993 between Georgian forces and Abkhazi separatists.

It enjoys support from Russia, who in August 2008 officially recognised its independence.

The status of breakaway regions of Abkhazia and South Ossetia have been an ongoing source of tension between Georgia and Russia, contributing to frequent clashes including the most recent military conflict in 2008.

Abkhazia has a subtropical climate, combined with the Caucasian mountains give it strongly seasonal weather extremes - hot summers and cold winters.

Tsandripsh is 5 km from the Russian city of Sochi and amply provides for the tourist trade, mainly Russian day trippers. Typical of many seaside towns, there are amusements, disco-bars, restaurants,

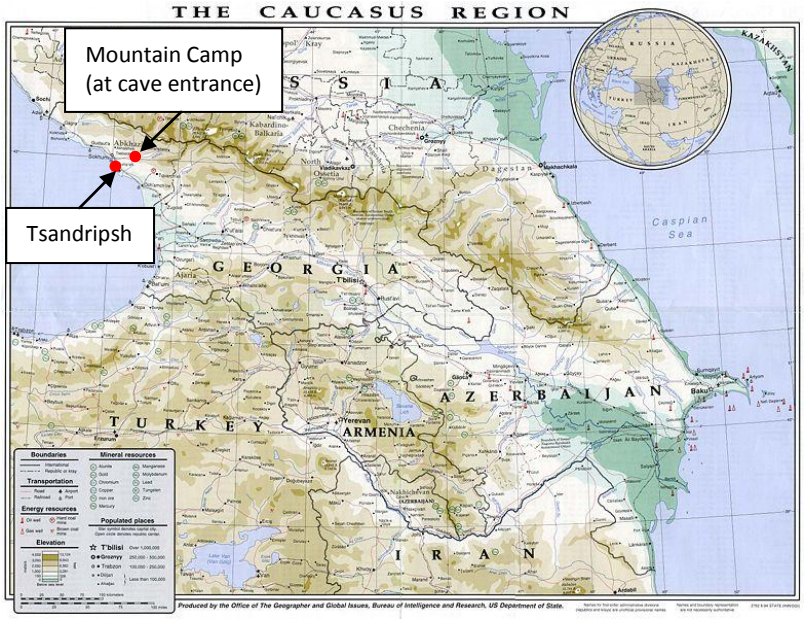
guesthouses to complement the natural beauty of the beach. The Arabika massif is highly visible from the town, making a picturesque view and giving it extremes of weather – hot in summer, heavy snowfall in winter.

Political Overview 2010

Following its recognition of Abkhazia's independence in 2008, Russia significantly has a presence in the territory in 2009/2010. In June 2010, the United Nations Observer Mission in Georgia (UNOMIG) ended its 16-year mission in Abkhazia after an extension was vetoed by Moscow. During an August 2009 visit, Russian prime minister Vladimir Putin pledged funding to reinforce the Abkhaz border and establish a military base in the territory. Abkhazia later announced that it would transfer control of strategic assets to Russia, prompting protests by the Abkhaz opposition. (UNCHR, 2010)

In August 2010, concurrent with the expedition, Russia deployed high-precision air defence missiles in the breakaway Georgian region of Abkhazia, sending a defiant signal to Tbilisi and the West two years after a war with Georgia, which was met with threats of retalliation by Georgia (Irish Times, August 8th, 2010)

The Caucus Region Showing Krubera Cave



The turbulent politics of the region impacts on caving expeditions. Access to the territory is effectively limited to two land-border crossings (No sea or air access for non-residents), and it is necessary to obtain a visa from the Abkhazian Ministry of Foreign Affairs. Political conflict halted caving exploration in the area for a large part of the 1990s, and the 2008 summer expedition was almost prevented due to the Russian/Georgian conflict.

History of Exploration

The first exploration of Krubera-Voronja Cave began in the early 1960s, but it was not until 2004 that the magic 2,000 metre depth had been reached. Exploration is continuing to date, with the focus in 2010 on extending the Dva Kapitana Sump. Equipment problems and difficult diving conditions for both the Russian and Lithuanian diving teams meant that no further gains were made in depth in 2010.

Early 1960s

- Georgian cavers first explore the entrance shaft and name it Krubera Cave after famous Russian karst scientist Alexander Kruber (1871-1941). Stopped by squeeze in meanders at bottom of shaft, -95m

1960s,1970s

- Cave neglected apart from occasional visits from various clubs 1980 Kiev Speleological Club with Alexandar Klimchouk starts systematic exploration/digging in Ortobalagan Valley

1982

- Kiev cavers start working in Krubera with the aim of linking to Kujbyshevskaja Cave (200m distant) and the Arabikskaja System, and adding 60m depth to the Arabikskaja System

1982- 1987

- Slow progress through tight meanders requiring blasting; cave deepened to -340m.
- Two windows at depths of 220-250m is marked on survey but unexplored. Cave is christened "Voronja" (Воронья - Crows') Cave because of crows nesting in entrance.

1988- 1998

- Political instability; war during 1992-1994; caving largely suspended

1999

- Ukrainian Spelaeological Association (Ukr.S.A.) explores two windows at depths of 220-250m. Main branch is pushed to -740m and "Nekujbyshevskaja" branch pushed to -500m.

2000

- August - Ukr.S.A. pushes main branch to -1,200m.
- September - Ukr.S.A. pushes main branch to -1,410m

2001

- January - Ukr.S.A. pushes main branch to -1,710m ("Chamber of Soviet Spelaeologists" - world record)
- "Call of the Abyss" project is established, coordinated by A. Klimchouk, Y. Kasjan, G. Samokhin and K. Markovskoy. Its aim is to find the first 2,000m deep cave, focussing on Turkey and Abkhazia.

2003

- Kiev Spelaeological Club and CAVEX pass Sump 1 at -1,440m and continue to -1,660m

2004

- July – CAVEX continue to -1,775m beyond Sump 1. August – Ukr.S.A. discover "Way to the Dream" passage and push to -1,840m
- October – Ukr.S.A. discover new lead near Big Junction at -1,790m and push to -2,080m ("Game Over") – first achievement of 2km depth

2005

- February – Ukr.S.A. pass "Kvitochka" sump at -1,980m
- July – CAVEX explore beyond "Kvitochka" to -2,140m
- August – Ukr.S.A. extend "Nekujbyshevskaja" to -640m

2006

- Ukr.S.A. dive "Dva Kapitana" sump to -2,158m
- Ukr.S.A. extend NK to -1,004m

2007

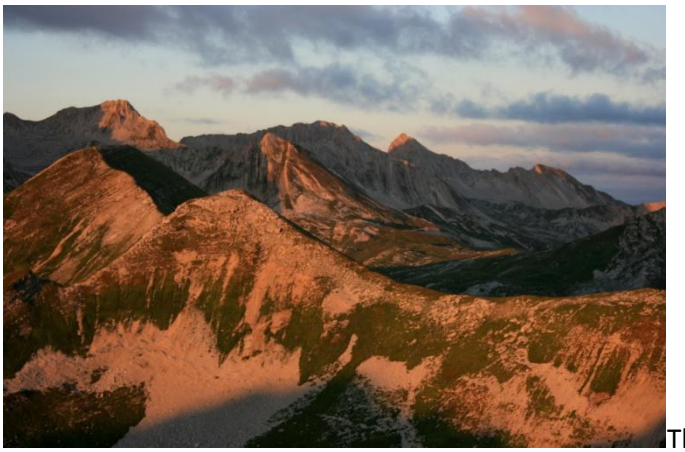
- Ukr.S.A. dive "Dva Kapitana" sump to -2,191m.
- Ukr.S.A. dive "Blue Lake" sump and extend side passage -1,841m
- Ukr.S.A. extend NK to -1,293m

2008

- Ukr.S.A. extend NK to -1,390m
- Lithuanian/Irish commence hydrological monitoring in main branch and bolting "Spanish Branch" at -1,340m

2009

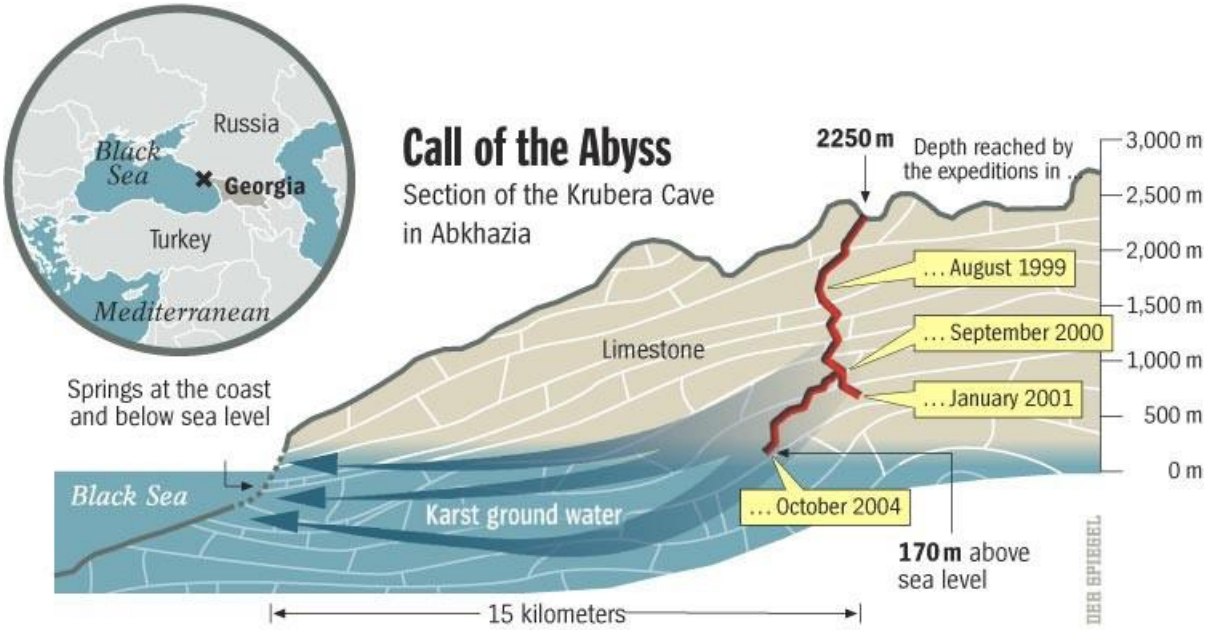
- Ukr.S.A. extend NK to sump at -1,557m "Towards the Centre of the Earth" expedition continues monitoring in main branch and extends "Spanish Branch"


The Arabika Massif from above base camp

Geology and Hydrology

Much work in the area of geological and water tracing surveys have been conducted by Ukrainian spelaeologists, lead mainly by Alexandar Klimchouk and Yuri Kasjan. Papers on the geology and hydrology of the Arabika region and Krubera-Voronja Cave are available online (see References). The following diagrams and summary are drawn directly from these sources.

Section of Krubera Cave



The Arabika Massif is one of the largest high-mountain limestone karst massifs in the Western Caucasus. It is composed of Lower Cretaceous and Upper Jurassic limestones that dip continuously southwest to the Black Sea and plunge below the modern sea level. Among several hundred caves known in the Arabika Massif, fifteen have been explored deeper than 400 m and five deeper than 1,000 m. Krubera Cave is located at 2,256 m altitude in the Ortobalagan Valley. All large caves of the Ortobalagan Valley likely belong to a single hydrological system, connected to large springs at the Black Sea shore. The Ortobalagan Valley extends along the crest of the Berchil'sky anticline, which gently dips northwest. The cave entrances are aligned along the anticlinal crest (see Figure 4.1) but the caves are controlled by longitudinal, transverse, and oblique fractures and faults and comprise complex winding patterns in the plan view, remaining largely within and near the anticlinal crest zone. The caves are predominantly combinations of vadose shafts and steep meandering passages; although in places they cut apparently old fossil passages at different levels.

Hydrological map of Arabika Massif

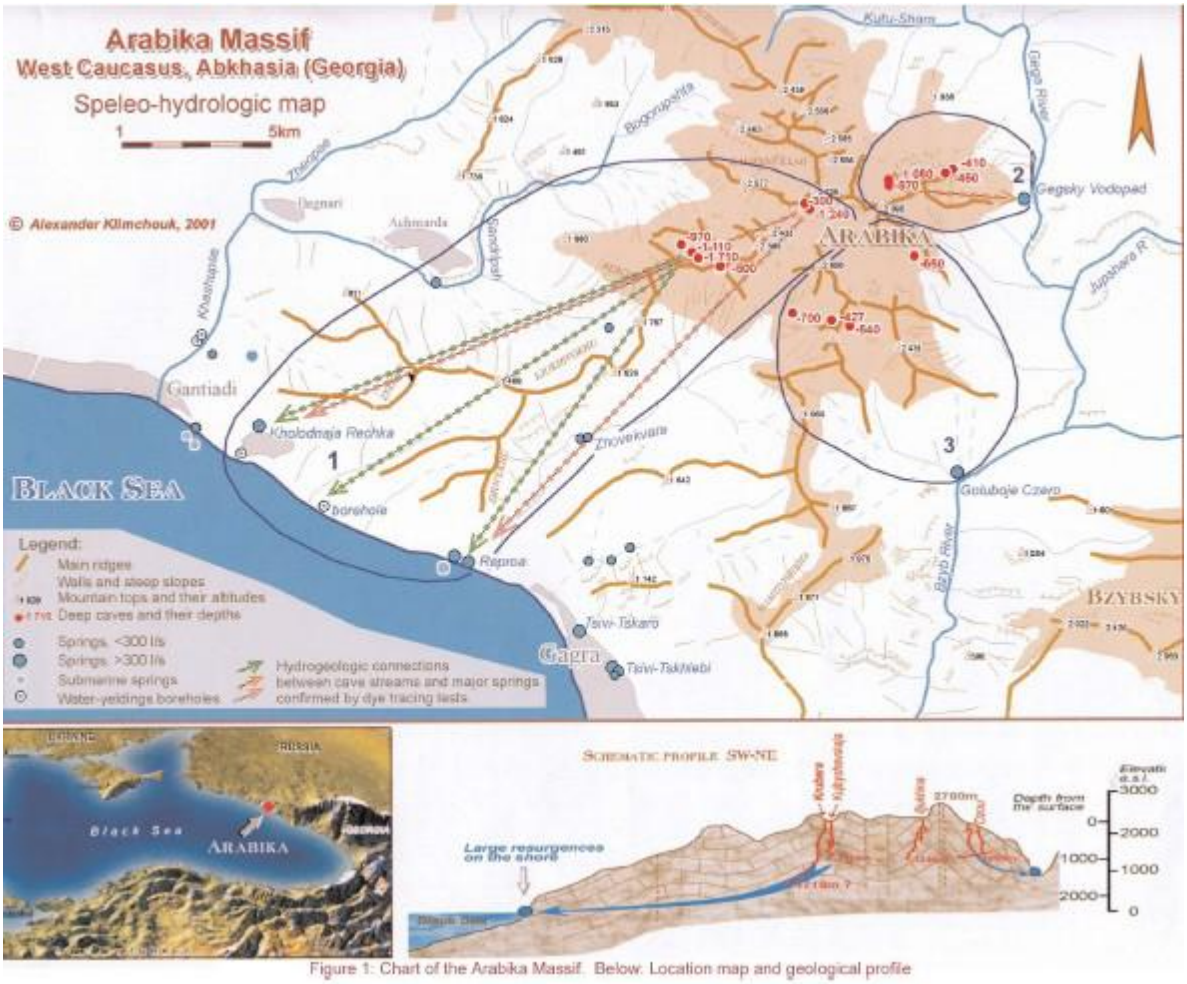
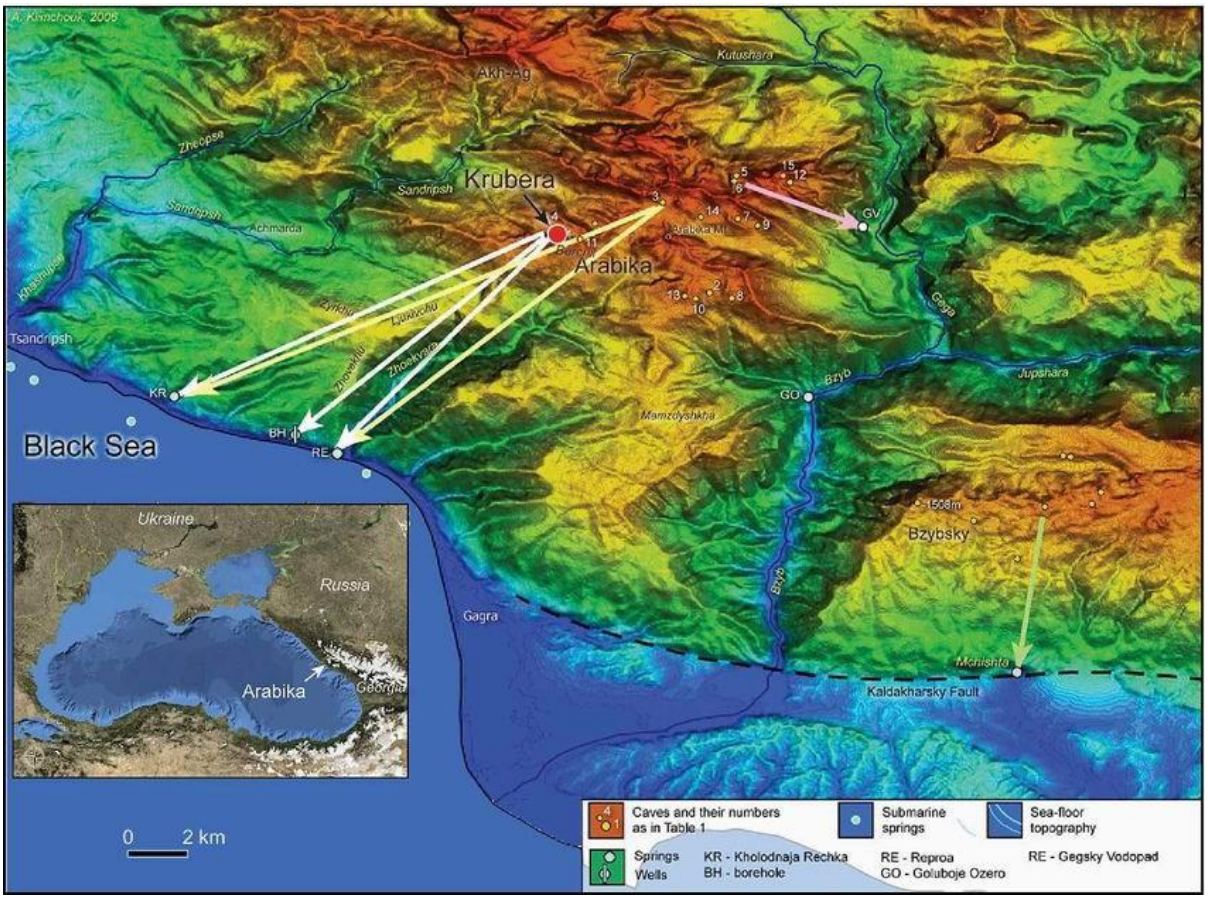


Figure 1: Chart of the Arabika Massif. Below: Location map and geological profile

Krubera Cave has an extremely steep profile and reveals a huge thickness of the vadose zone. The lower boundary of the vadose zone (the top of the phreatic zone) is at an elevation of about 110 m at low flow, which suggests a low overall hydraulic gradient of 0.007-0.008. Low total dissolved solids groundwater is tapped by boreholes in the shore area at depths of 40-280, 500, 1,750, and 2,250 m below sea level, which suggests the existence of a deep flow system with vigorous flow. Submarine discharge along the Arabika coast is reported at depths up to ~400 m below sea level. It is difficult to interpret these facts in terms of the development of karst systems controlled by contemporary sea level, or within the range of its Pleistocene fluctuations (up to -150 m). In combination with the existence of the Arabika Submarine Depression, all these facts point to the possibility that karst systems in Arabika could have originated in response to the Messinian salinity crisis (5.96-5.33 million years ago) when the Black Sea could have almost dried up, as did the adjacent Mediterranean, where the dramatic sea level drop of ~1,500 m is well established.

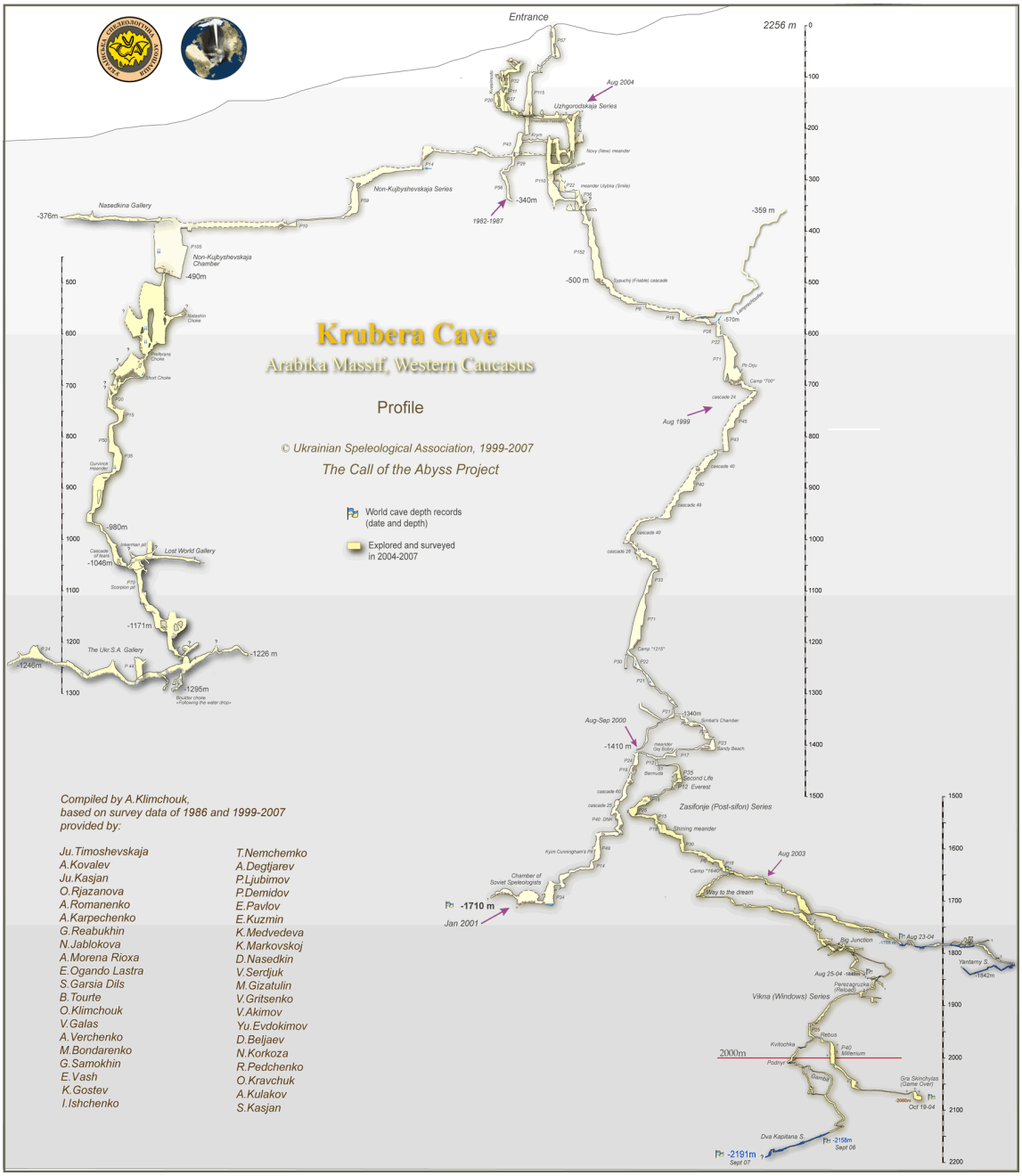
Hydrological Map of Arabika Massif



Cave Survey/Description:

At 2,191 metres' depth, Krubera-Voronja Cave is currently the deepest known cave on earth, followed by Ilyuziya-Mezhonogo-Snezhnaya (1753 m, also in Western Caucasus), and Lamprechtsofen (1,632 m, Austria).

Krubera-Voronja Cave, Elevation



The entrance to Krubera-Voronja is an unassuming, 1-metre-wide, 4-metre-long cleft on the side of a hill in the Ortobalagan Valley. The pitch quickly opens out and after some rebelays reaches the rock-strewn floor 57m below. The rubble is from frost shattering at the entrance, and continues for some distance down the small tube leading off from the foot of the rope.

A couple of short drops bring you to the top of the 115m shaft, which soars down with about 4 rebelays. The pitch like all of the big shafts down to -1,200m, is impressive in its magnitude. You quickly reach the 43m pitch, of which you descend only 7m before swinging into a walking-sized tube in the wall – "Krym". This is the "magic window" that was known about since the mid-eighties but only entered in 1999, and which led to the flurry of exploration that in 2 years transformed a 340m pot into the deepest cave in the world.

Entrance Series of pitches

Continuing further down the 43m pitch the tight meander to the "Nekujbyshevskaja" branch is found (so called because despite speculation, it has not been linked with Kujbyshevskaja Cave).

Krym has a howling gale and quickly opens up to the vast blackness of the 110m pitch. There is spray in normal conditions at the bottom of the pitch. Meander Mozambique is short and easygoing (though annoying with bags). Afterwards, the huge 152m pitch, via a couple of big ledges, takes you to the 500m mark and the start of the Sinusoida Meander. Sinusoida is not very tight, and not all that long for that matter –but again carrying bags makes it a chore. There are some pitches along the way, and most of it is travelled at the base of the meander. A small stream gradually forms as tributaries enter. One of these is Lamprechstofen, which enters from the left just before the end of the meander. A couple of pitches open to the 71m pitch – a beautiful drop which takes you to the homely sight of Camp -700.

-700 to -1,400m 7 hours

The tent is pitched at the back of the chamber, on a large slab with drops on 2 sides. Down a hole behind the tent, a tube leads to a wet section and an awkward takeoff. This part of the cave is much wetter than the upper section, with plenty of active cascades, although the bolting goes a long way to keeping you mostly dry. The rigging standard is excellent in fact throughout the cave – even at the very bottom: textbook rebelays to avoid rub points and hazards.

Camp -1,200 is on a muddy platform at the foot of another 71m shaft and is a respite from the water. We only camped there during the exit from the cave. Beyond, another very wet and active cascade section follows. It includes a tight take-off past a water spout which is difficult to avoid.

However, near the bottom of this pitch, a pendulum brings you into a dry tube. Looking across from the tube through the spray, a passage on the other side carries the water away to -1,410m, and also leads to the "Spanish Branch" where bolting efforts concluded in 2010.

The dry tube takes you into the comfort and relative warmth of a parallel set of dry pitches which are remarkably quiet in comparison. You will probably hear the roar of a Primus stove before you reach the top of the 23m pitch, which would drop you straight through the ceiling of Camp -1,400 were it not for a last-minute deviation. This is an atmospheric place – a mushroom-tunnel type tent on a flat floor with room for ten cavers. Its name is "Sandy Beach".

-1,400 to -1,640m 3 hours

Descending the 12m pitch leads to a tube and a sump (Sump 1). This is about 1.5m long, 1m in diameter, and shallow (ceiling submerged by about 10cm).

It can be free-dived using the in-situ rope. Beyond this, the cave develops into wet cascades in nicely sculpted rock. It's a very sporting bit of cave with ducks. Camp -1,640 is at the bottom of a dry oxbow pitch.

-1,640 to -1,800m 3 hours

Beyond the camp, the stream is soon found again, and the passage can be continued to a sump at -1,785m. However, by entering a window 2m high just downstream of the camp, "Way to the Dream" is found. This small dry passage continues past several little pitches to reach the "Yellow Tube", a flat-out 130m crawl. While not hugely constricted, with bags it is a torture. The floor is calcite so is easy to slide along. In this section, you really will feel that you are in the bowels of the earth. At the end, a hole through the calcite floor pops out to the head of a pitch, and after this the cave suddenly opens up. Passage is very pleasant here with glossy black limestone, walking dimensions and plenty of formations in comparison to other parts of the Camp -1,800 is a small rocky platform just beside the "Big Junction", which is a confusing network of passages.

-1,800 to -2,080m ("Game Over") 2 hours

The way through the Big Junction is to traverse across the drop towards the obvious continuation (traverse line in place). Following the main passage brings you to a 25m pitch and then a hole in the floor which takes the stream.

Down this hole and another pitch is Kvitochka Sump and the divers' route to the cave's deepest point, Dva Kapitana Sump (currently -2,191m). Stepping over the hole towards the ongoing horizontal passage leads to Camp -1,900. The passage can be followed past more pitches – including the "Millenium" 40m pitch – until it eventually drops into a large, tubular passage which is half filled with mud. The cave character changes abruptly here from its previously vertical nature to being predominantly horizontal. Crawling or crouching along the flat floor leads after 100m to the final chamber, "Game Over", where the world depth record was made in 2004 and held for nine months until it was beaten by exploration beyond Kvitochka Sump.

Sleeping and waking:

With cavers staying underground for anything from 4 to 11 days, the only indicators of day and night were our personal watches. In long trips such as these it is possible (even natural) to extend days further than they would normally be on the surface, and to sleep longer, so that one waking/sleeping cycle underground could last 36-48 hours. For the majority of the trip, we chose to stick close to standard day and night times, to allow us to keep to the planned logistics and to more easily stay in contact with those on the surface.

Camp-1400

Personal kit

Baggage weight had to be taken into account while assembling gear in Ireland to avoid any issues with our flight providers. As a result, everything was cut down to exactly what we could manage with for the four-week period. This meant some very careful planning with regards to clothing, as the weather was to be hot and sunny for the journey and by the coast in Abkhazia, but changeable and potentially very cold and/or wet in the mountains.

Surface kit:

- Tent (2 x 2-man tent between us)
- 2x sets of clothes
- 1x set of thermals
- Sleeping bag
- Sleeping mat
- Sun hat / Buff
- Swimming shorts (for our time at Tsandripsh, Black Sea)
- Pac-Towel
- Toiletries (minimal)
- Sun cream
- Bowl, cup, cutlery
- Camera (optional, but recommended: a good morale boost)
- Knife etc. (optional)

Underground kit:

- Helmet and light (inc. batteries to last 14 days)
- Spare light (inc. batteries to last at least 3 days)
- Undersuit
- Oversuit – PVC or technical suit works best, not Cordura.
- Wellies
- 2x pairs gloves (Gauntlet type, plasticky, not woven material
- Kneepads (optional)
- Sleeping bag (lightweight synthetic)
- 1x set of thermals (or second undersuit) for sleeping
- Socks for sleeping
- Socks for caving
- Balaclava for sleeping / Separate balaclava for caving (optional)
- Drysuit and neoprene hood (for diving sump at -1440) or wetsuit (5mm, as 3mm was a bit too cold.)
- Drybag x 2 (preferably 2-3)
- Wrist watch with alarm
- First aid kit (Between 4.)
- Knife and lighter
- Full SRT kit (MUST inc. foot jammer)
- Spare top bobbin for Stop descender (x2)
- Spare chest jammer
- Spare krabs x 2
- Spare foot-jammer webbing for under boots
- Repair gear for caving suit

Provided by the expedition were AA batteries (as a result many cavers were using Petzl Duo & Myo lights), sleeping mats for the cave, all cooking equipment and fuel, rigging hardware, underground tents and associated ropes.

Specific kit:

In addition to the above, there was some kit required to fulfil the various aims of the trip, namely:

Dataloggers: Solinst Levelogger and Barologger (packaged to be cave-safe)

- Rain Guage
- Cord and PVC tubing for installing data loggers in the cave
- Handheld datalogger computer interface
- Bolting kits (for bolting in Spanish Branch and installation of data loggers)
- Surveying equipment
- 20 screw gate Krabiners each, donated to rigging team.

Most of the ropes in use in the cave had been installed three years previously and had been in place for numerous expeditions already. As a result, many of them were highly gritty and particularly wearing on gear. About 250m of rope from the worst places was replaced, close to the surface. On reaching Camp 1410 all descender bobbins were retired; thankfully the ropes beyond the sump were mostly clean-washed and not so wearing. On the way back out the new 200m rope placed by the Spanish was very frayed looking with the colourful flecks sticking out of the rope, v. disconcerting when initially you think it is the core sticking out (which it wasn't).

Personal Equipment x4 persons

Surface Camping

Location

The surface camp was set-up where we were able to find space. The main camping site was already occupied by the larger Russian Operation (Cave X). We located in a small hollow plateaux reached by walking 80m past the cave entrance to the ridge and back down the other side to the camp site.

We pitched a central mess tent, surrounded by personal tents wherever flat ground could be found. A small petrol generator had been brought along to provide light and charging facilities in the mess tent; seating and table space was provided by rocks retrieved nearby and covered in Carry mats to make a more even surface.

Base Camp

Food

All of our food had been brought up from Tsandripsh on the trucks (the vast majority having come directly from Lithuania). All expedition members were responsible for food preparation, although those less active underground were naturally on food duty more often. The food organisation on the expedition was excellent; ingredients were OK and abundant in supply; each meal was generally a combination of:

- Tinned meat/fish or preserved sausage;
- Fresh root vegetables, salads or tinned vegetables;
- Rice, pasta or instant mashed potato;
- Flavouring provided by packet soups, herbs, salt, mayonnaise and/or ketchup.

Desert was condensed milk crème goo with a sweet bread or two.

Additional supplies included bread and cheeses, and twice expedition members trekked down the valley to the nearest farmer's house (a 3-hour round trip) and bought fresh cheese, kefir and beer.

As a vegetarian however protein was a little limited. There were no nuts, lentils or eggs (powdered eggs). Staples from here like oats were not considered but there was plenty of chocolate. Buckwheat and other cereals would have been a welcome change as would rice.

Dinner, lunch, breakfast and snacks pictured below

Water

There are no surface streams in the valley, and we had only brought a small amount of personal water supply for the journey. For the rest of the expedition we were to rely on melted snow. Snowdrifts lay in some of the nearby depressions, and a daily task was to shovel snow into bags and bringing it back to the camp.

Beside the camp, a snow melting system was set up with two tarps draining into a barrel; snow shovelled between the tarps would slowly melt and trickle into the barrel after a few hours in the sunlight.

After it was melted the Spanish crew filtered the water through a silk handkerchief.

The final step involved adding Iodine drops to the filtrate.

Filtering water

Toilet facilities

There were two regular toilet locations near the expedition surface camp, all within 2 minutes' walk of the communal areas. These were dived into female and male toilet with either sex going to different sides of the camp.

They were generally small dolines that had previously been investigated for cave sites and found to have no prospects. Any paper waste was burned after use, and the toilet areas themselves were also used as bonfire sites at the end of the trip, when any flammable waste was burned to save weight on the return.

Underground Camping and Food

Camp bag

Camp equipment was contained in one 50 litre drybag per group. Within this was the tent, stove, fuel bottle, pots, mugs, spoons etc. (Included in this should be a magnesium flint rather than just cigarette lighters. The contents should also be double dry-bagged as flooding of the bag causes a long delay in warming up a wet tent.)

Tents

The expedition group used square box shaped tents of light 'parachute material,' held up on tensioned nylon cord belayed to flakes and horns of rock. The material is breathable and light while remaining tear resistant. A useful addition to the simple design are the rows of sizeable mesh pockets at the top on three sides. A length of cord was packed with eaach tent to allow it to be guyed out to rock spikes and tensioned ropes as the campsite dictated. The bright green and orange colour of the tent improved visibility when using smaller head torches.

Stoves

The expedition standard was the Primus Optifuel, (The Irish team provided an MSR Whisperlite). The stoves used refined petrol 'white gas' in a pressurised bottle. Once the burner is heated the petrol is vaporised in the fuel line before ignition, giving a clean efficient flame. One drawback of this was that in an area of low air circulation, foul air builds up. In conversation with CaveX personnel we found that they have a policy of only using butane/propane gas stoves after Sump 1, As there was a significant delay in leaving the cave, the Irish team suffered from a prolonged camp at -1800m and subsequent effects of foul air causing lack of sleep, headaches and nausea.

Camp cutlery was a primus folding plastic spoon/fork. These broke easily but were adequate.

Food

The typical food bag contained salami, salted ham, instant mashed potatoes, instant rice flakes, packet soups, chocolate bars, boiled sweets, tea bags, instant coffee sachets, condensed milk packets, dehydrated carrot, cheese, dried rye bread, dried bagels (sweet and savoury), gingerbread, salt - all difficult to distinguish at first

Setting up

Camping in the cave is limited to a few locations due to its vertical and constricted nature. Many of the larger chambers are either very aquatic in flood, or exposed to rockfall. There are established sites for camps now with a limit of spaces at each one;

-700m	4	-1200m,	4
-1400m 'Sandy Beach'	10	-1650m,	4
-1800m 'The Station/Big junction'	4	-1980m.	2 (only used by CaveX during expedition)

From previous years, camps have a good supply of foam rollmats and plastic sheeting for the base of the tent. Camp -700m is well covered with a tarp suspended on ropes over a filled platform in the boulders. It is reasonably flat and has a supply of mats stacked to the side when not in use. There are many points to hang a camp tent on, but some imagination is needed to avoid getting quite wet. It is one of the colder camps, in a large chamber, not far down the system. There is a toilet area nearby that is used quite a lot, as this part of the cave is well travelled.

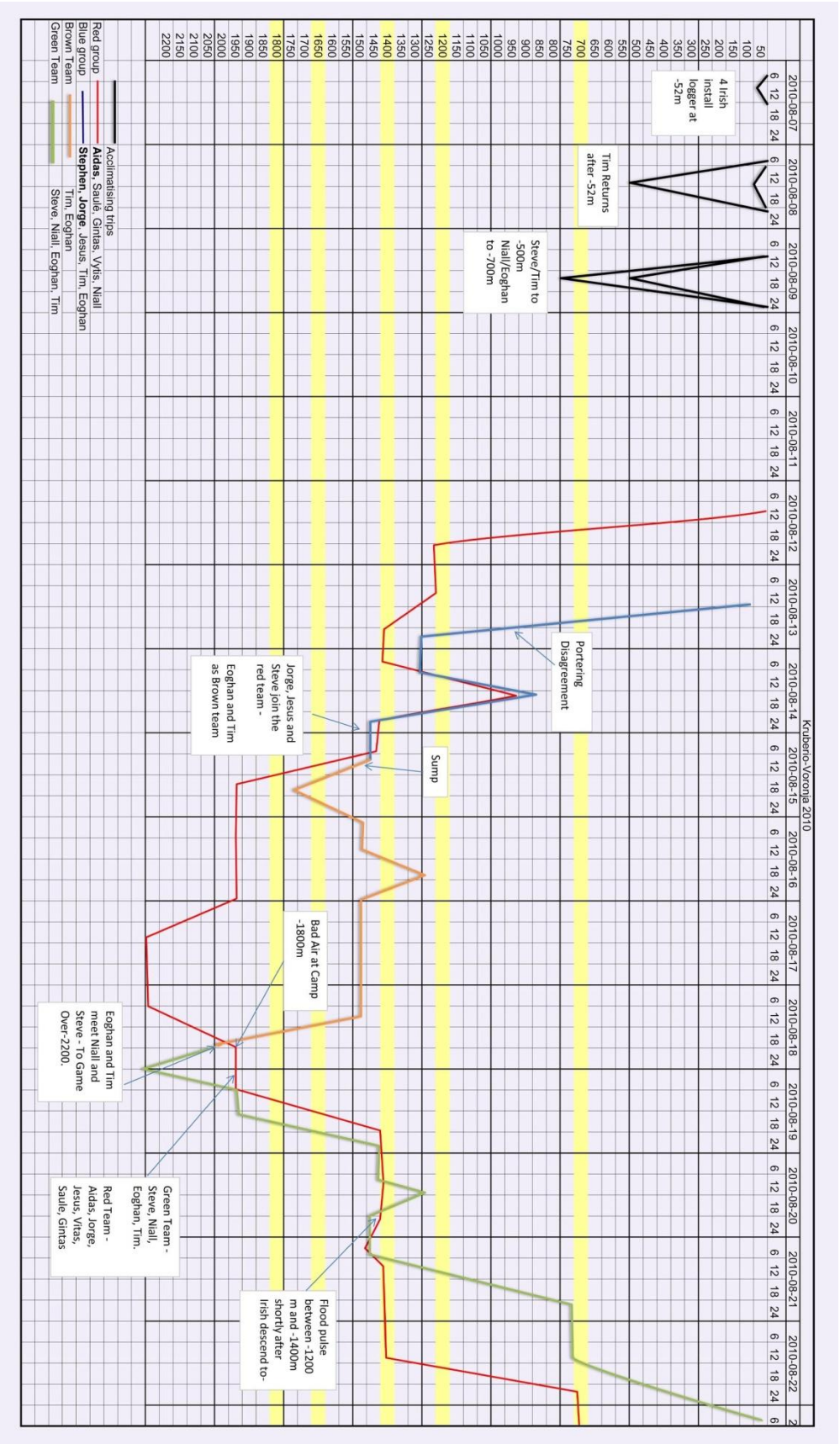
Camp -1200m is on a mud platform at the bottom of a large chamber, but reasonably far away from the waterfall. It has a light tarp hung on ropes and sleeps four comfortably. Water is taken from the waterfall pool and siphoned down in a water pipe to nearby the tent site. It is worth setting this up if there are plans to use the camp for a time, the trip up the scree to the water is time consuming.

Sandy Beach, at -1400m is the most complete and is left intact through the year. Its roof is made of 2.5cm plastic water pipe in arches with a covering of silvered plastic sheeting (Christmas wrapping), it is tensioned in place with cord. The floor is currently about three foam mats thick over sheeting and drops away at the edges to allow condensation from the roof to drip away. Other camps are more rough and ready.

Camp -1600m was not used by the team, apart from 3 brief rest stops to make hot drinks en route to another camp. This was due to the small size of the camp, and it's near continued usage by the Russian expedition team.

Only 'Sandy Beach' at -1400m is capable of coping with a large number (10) of cavers, and with two expeditions running concurrently in the cave, this lead to serious disruption to the expedition timetable.

Underground Logistics



Spanish Branch Exploration

Only Jesús and Jorgé were involved in the further exploration of the Spanish Branch. They used different equipment to the previous year, favouring the Raumer bar method in progression. As points of aid, they chose to use a mix of DBZ anchors with Lucky keyhole hangers and Hilti 8mm concrete screws. The Hilti screws offer good sheer resistance and also protection from an outward pull, though this is dependant on the quality of the rock. As a bonus, when climbing is completed, these are simply removed, leaving minimal damage to the rock.

The cavers picked up from their high point the previous year and continued a further five metres vertically, before the ceiling closed in and halted progress. They are satisfied that there is no possible progress from this point.

Insect life

As they were there they collected a troglodyte millipede that had lost its pigmentation. In their report back to the expedition group they remarked that it was unlikely to be a new species or even a cavernicole species, having most likely been brought in with flooding.

Communications

A fixed telephone line is in place in the cave down to camp -1980, at the Kvitochka sump. When not in use it is disconnected at the surface and coiled away, out of risk from snow damaging it but still easily accessible. The radio units that connect to the line were similar to the Franco phone units used by ICRO. The expedition was supplied these by the Ukrainian Speleological Association, developed and built by Leonid Fegin (Israel)

An important difference being that the units only connect to one strand of wire and use an earth cable supplied with the unit to complete the circuit. At some camps, where the earth was placed in sandy mud, some salt from the camp food bag was used to improve the conduction. Power was supplied by AA batteries as each team had a large supply of spares. A connection point is established at all camps and if necessary, a section of wire can be exposed of insulation and wrapped around a terminal for emergency connections. This is avoided where possible to maintain the integrity of the cable.

Through the cave the cable is routed close to the most travelled route through the cave and provides a guide to a solo caver unfamiliar with the cave. The anchorage of the cable is excellent and skilfully done, allowing easy passage past and still easy access for repair if needs be. On the pitches there is no point at which the cable interferes with free movement. Generally speaking, the cable is routed

within sight but just out of reach apart from notable sections of the 'Way to the dream' and passing Sump 1. At these points space is extremely limited and much care is required to avoid damaging the line. Sump 1 is the most likely site of damage to the line as cavers are keen to pass quickly. During the 2010 expedition the line was damaged at this point and communications were lost to the three lowest camps, the most remote sections of the cave. Luckily, Sump 1 is within 30 minutes caving from Sandy Beach, the most continuously manned camp.

At the surface, a line is connected and run to the camp. More than one line/extension can be connected to the in-situ cable, but only one radio unit can transmit at any one time. While a radio transmits, all other units receive, this added to the political tensions of having three expedition groups in the cave at the one time and sharing limited resources.

Barnabe, Stephen and Eoghan portering bottles at-250m

Expedition Timetable

Wednesday 4th August

- Steve, Niall, Eoghan and Tim meet at 22.30 in Dublin Airport – final packing of equipment.

Thursday 5th August

- Fly at 1.30 Dublin-Riga, Riga-Moscow, Moscow-Adler/Sochi
- Sochi/Adler-Russian/Abkhazian border transfer by bus
- Rendezvous with other expedition members
- 22.30 Abkhazian border crossing on foot
- Transfer by bus to Tsandripsh
- Rendezvous with most members of the expedition at guesthouse

Friday 6th August

- Final preparations and stocking of consumables and perishables
- Arrival and packing of trucks (x2)
- 6 hour journey climbing from Tsandripsh to Arabika (Arrive 13.00)
- Unpacking and departure of trucks
- 1 hour trek to surface camp, relaying equipment
- Repeated relays from truck dropoff to surface camp (Using donkeys)
- Surface camp setup

Saturday 7th August

- Collect last of the equipment from truck dropoff
- Begin collecting snow to make drinking water
- Roster camp duties, finish making camp
- Arrival of Ukranian team members
- Introduce expedition goals, groups, methodologies and members
- Re-pack foodstuffs for caving
- Survey to -56 metres

Sunday 8th August

- Niall and Eoghan (N and E) acclimatising trip to -500, carrying food in preparation for later descents.
- Steve and Tim (S and T) acclimatising trip to -250m, carrying food. Tim encounters difficulty and returns to surface early.

Monday 9th August

- N and E acclimatising trip to -700, carrying food in preparation for later descents
- S and T acclimatising trip to -500, carrying food in preparation for later descents

Tuesday 10th August

- Rest Day

Wednesday 11th August

- Rest Day

Thursday 12th – Monday 23rd August

- Caving (see underground logistics)

Monday 23rd August

- Rest Day

Tuesday 24th August

- Breaking surface camp
- Porter equipment to truck collection point, 1 hour down the mountain
- Majority of Expedition, Including all Irish contingent leave for Tsandripsh
- Tsandripsh-Abkhazian/Russian border by taxi
- Border crossing by foot
- Border – Adler/Sochi airport by bus

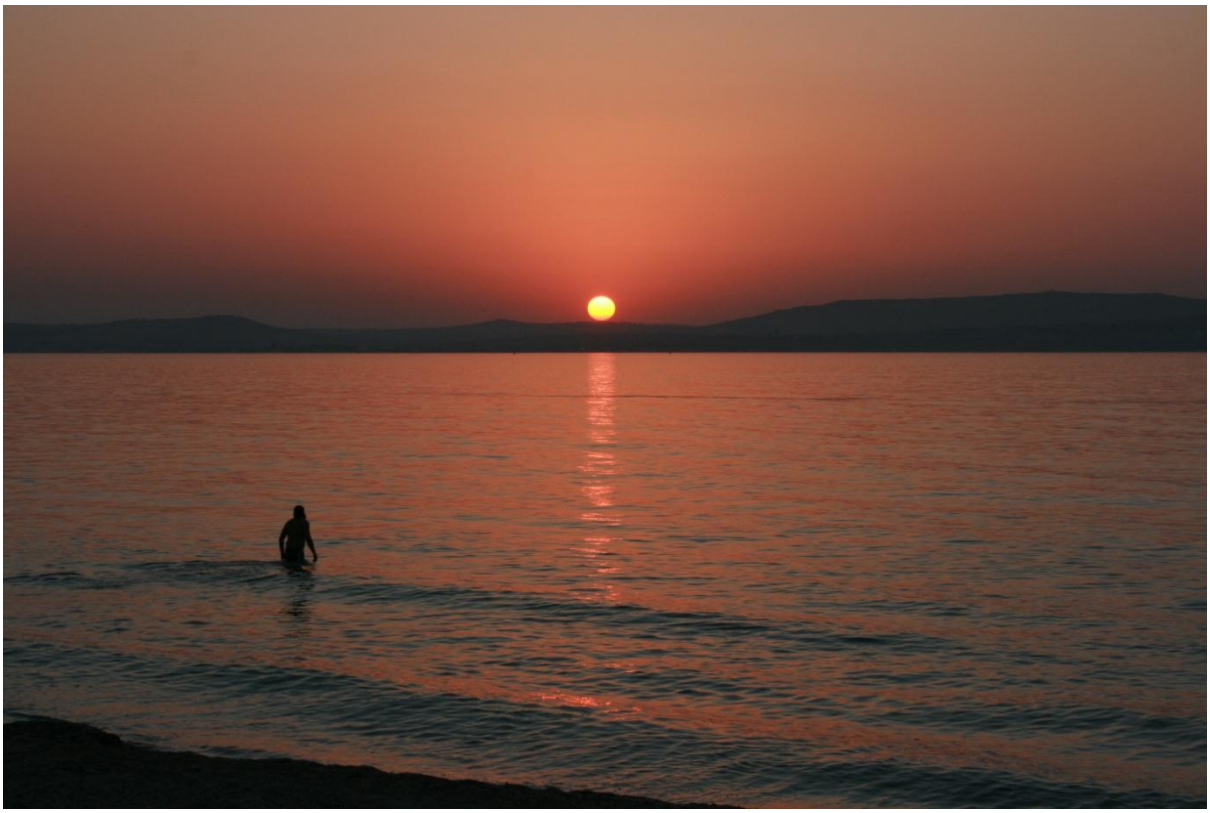
Weds 25th August

- Adler/Sochi – Moscow, Moscow-Riga, (T,S,E) Riga-Dublin

Thursday 26th

- (N) Riga-Dublin

A welcome swim - on return to Tsadripsh, en route home



Hydrological Measurements

Prepared by Stephen Macnamara

Background

The water level monitoring programme in Krubera-Voronja was started in August 2008. Monitoring devices were placed in two locations: the Chamber of Soviet Spelaeologists (~1,710 m) and Big Junction (~1,800 m).

At each location, a "Levelogger" device was placed at the water to measure submerged water level, and a "Barologger" device was placed in a dry location above the water to measure atmospheric pressure. The Barologger reading was used to compensate Levelogger readings for atmospheric pressure variations.

In 2009, the Soviet Spelaeologists devices were relocated to Kvitochka sump (~1,980 m), and a further set of devices, sponsored by the Spelaeological Union of Ireland, was placed at the final, Dva Kapitana sump (~2,141 m).

In the 2010 expedition, support from the Spelaeological Union of Ireland and Les Brown allowed the following additional devices to be installed:

- atmospheric temperature and pressure loggers inside cave entrance and on the surface near the cave entrance;
- rainfall logger on the surface near the cave entrance.

The current logging locations are depicted in Figure 1.

To date, the following data has been downloaded:

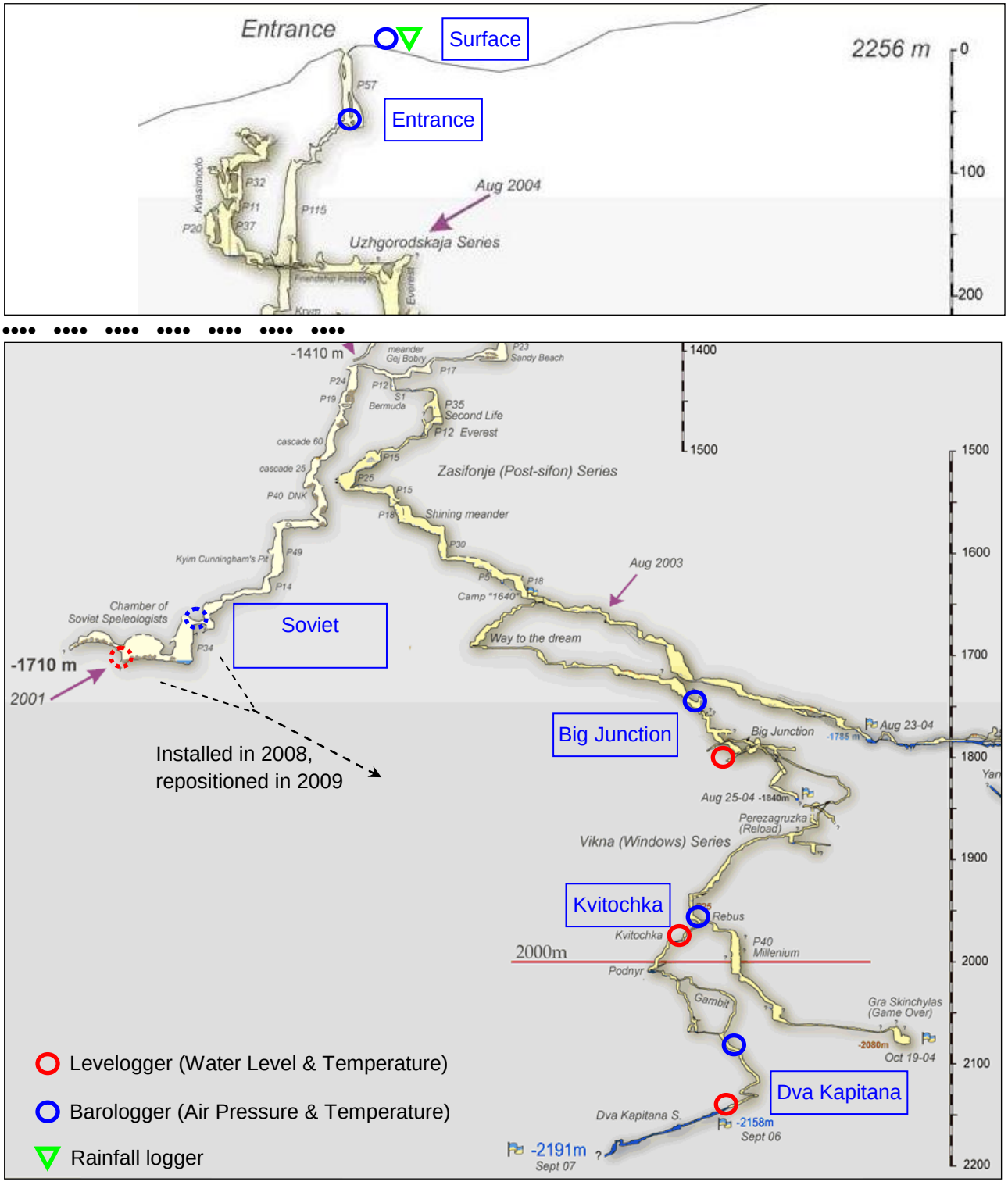
- water levels/temperatures and air pressures/temperatures at Soviet Spelaeologists and Big Junction for period Sep 2008-Aug 2009;
- water levels/temperatures and air pressures/temperatures at Big Junction, Kvitochka and Dva Kapitana for period Sep 2009-Aug 2010;
- air pressures/temperatures at Entrance for period 08 Aug-22 Aug 2010.

In this report, the data is analysed to show the extent and rate of flooding at each water monitoring location, and the temperature ranges throughout the year.

The barometric data is also analysed to give an initial estimate of cave depth (the estimate will be refined after download of further data in the autumn of 2012). This estimate is compared to the official depth of 2,191 m $\pm$ 22 m, which is based on a survey by the Ukrainian Spelaeological Association using conventional magnetic survey techniques and "hydrolevelling"[1].

[1] Hydrolevelling is a technique to determine cave depth. A 50-metre, water-filled tube is hung into the cave from the entrance, and the water pressure at the base is measured to determine the height difference. This is repeated for sequential legs further down the cave. This technique was used in Voronja to verify the convential magnetic survey to a depth of 1,200 m.

Figure 1: Monitoring Locations



Methodology

For the 2010 expedition, the following objectives were set regarding hydrological monitoring.

- Retrieve & analyse data from loggers at 1,710 m, 1,800 m and 2,145m.
- Clear level logger memory to start logging afresh for 2010-2014.
- Install new pressure logger at surface.
- Obtain initial data from surface logger to allow depth estimation.

Install New Loggers

At the start of the 2010 expedition, the Irish team installed an Onset *HOBO* rain gauge on a hillock approximately 300 metres from the cave entrance.

On a small cliff beside this, we anchored an Onset *HOBO* air temperature and pressure gauge. The vertical location was chosen in preference to horizontal ground, which is covered in several metres of snow every winter. It was also chosen to minimise the daily duration of direct sunlight falling on the device. The logger was protected by PVC tubing, closed at the upper end.

The purpose of these surface instruments was to determine rainfall and snowmelt (correlated to temperature), and correlate with flooding underground.

Figure 2: Installing Rain Gauge

Underground, on an early acclimatisation trip, we installed a Solinst air pressure and temperature gauge ("Barologger"). The primary purpose of this gauge was to give an accurate atmospheric pressure datum that could be used in conjuction with the deeper Barologgers to estimate cave depth. The foot of the entrance pitch was chosen as a convenient location close to the entrance, but sheltered from wind effects and temperature fluctuations that a surface location would experience.

Figure 3: Barologger

Once the Barologger was installed, and accurate survey was conducted up to the entrance, to confirm the instrument's depth at 56 metres.

Retrieve Underground Logger Data and Reset Loggers

During the stay at the -1,800 metre camp, the Irish team downloaded data from the Big Junction and Kvitochka sumps, using a handheld "Leveloader" device. Lithuanian divers passed the Kvitochka sump and downloaded the data from the Dva Kapitana sump.

Figure 4: Downloading Instruments

Battery life and internal clocks were checked for each instrument; all were satisfactory.

Each instrument was cleared of data. The logging interval was reprogrammed from 15 minutes to 1 hour, to allow a longer monitoring period (over four years).

Retrieve Initial Data from Entrance Barologger

On the return from the 10-day underground camp, the initial data was downloaded from the entrance Barologger, which had at that stage been logging for 2 weeks.

The Leveloader, now containing data from 3 Leveloggers and 4 Barologgers, was carried to the surface for upload to a computer and data analysis.

Results and Discussion

Quality of Data

All loggers were downloaded successfully, and continuous data was available from September 2009 to August 2010 (over 33,000 timepoints per instrument, 15-minute intervals). There was one exception: for a short period in July 2010 (<1 day), the Dva Kapitana Barologger registered a step change in temperature and pressure. These were clearly not true results (e.g. 5753°C!), and were probably caused by a transient electrical fault. Readings returned to normal after this.

It was evident from the readings that the Dva Kapitana Levelogger was submerged to a depth of over 200 metres during the snowmelt season. The instrument is calibrated for 0-100 metres, and warranted for submersion up to 150 metres. The pressure transducer may have been damaged during this flooding event: analysis of the pre- and post-flooding data suggests that the baseline water level has been offset by approximately 0.3 metres, and the baseline variation ("noise") has increased. The magnitude of this offset is not enough to cause concern in this project, although it does mean that the quoted instrument accuracy of ±5 cm cannot be applied after the flooding event.

Of more concern is submersion of the Barologgers. The Dva Kapitana and Kvitochka Barologgers were submerged to depths of ~180 m and ~55 m respectively.[2] Barologgers are designed to operate in dry conditions, and are calibrated to a maximum pressure equivalent of 1.5 metres water column.

The Kvitochka Barologger data before and after the flooding event were compared, and showed clear signs of degradation. Figure 5 shows the pressure difference between the reliable Big Junction Barologger and the suspect Kvitochka Barologger.

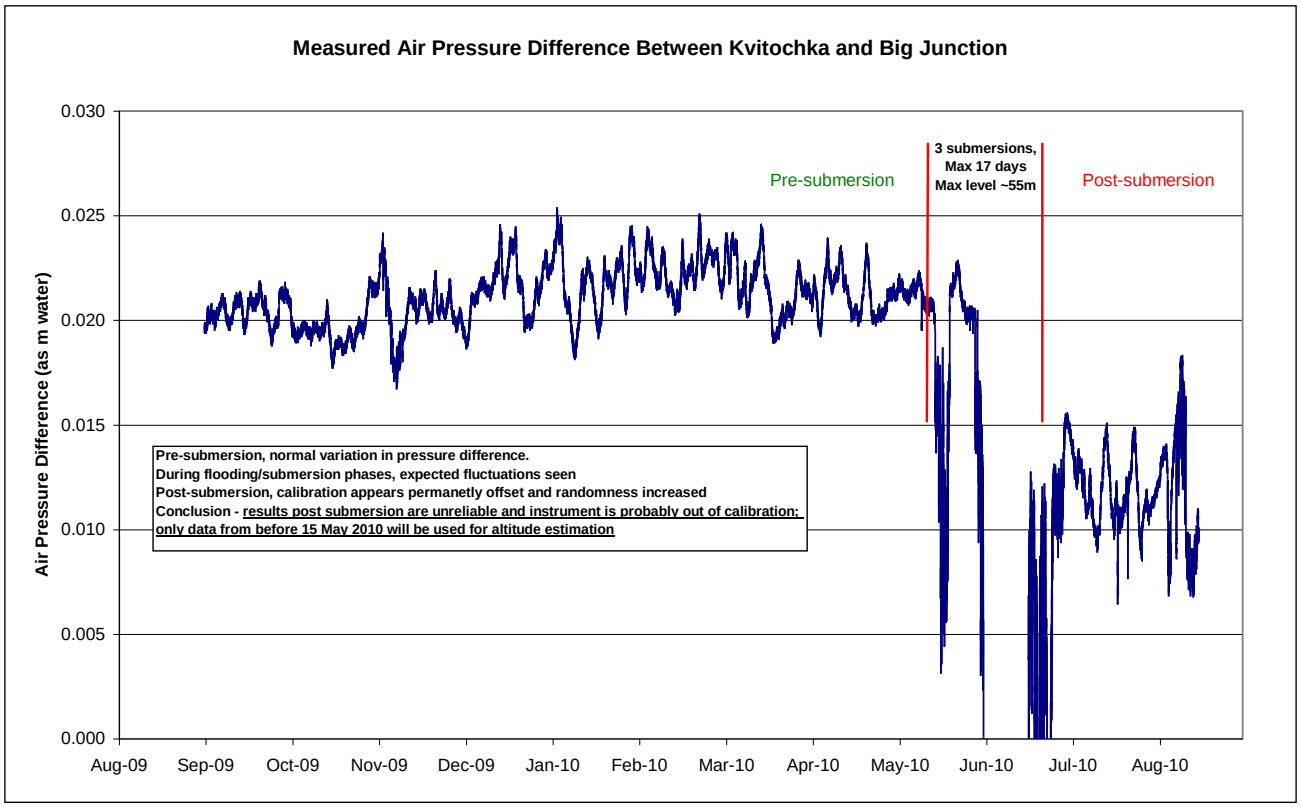
Post-submersion data is permanently offset and more variable. The offset is only 1 cm, so does not have a significant impact when used for barometric compensation of Levelogger readings. (The barometric compensation calculations have nonetheless been corrected by this offset.)

[2] The Big Junction Barologger showed no evidence of flooding. It is located approximately 50 metres above its corresponding Levelogger, which registered a maximum submersion of 13 metres. It can therefore be accepted as remaining reliable and within calibration. This is supported by the data over 2 years from 2008 to 2010, which are consistent and show no signs of degradation.

However, the offset *is* significant when the pressure data is used to estimate altitude or cave depth. A one-centimetre error in the Kvitochka Barologger reading gives rise to an eight-metre error in the estimated altitude for this instrument. For this reason, only the clean, pre-submersion data is used in calculations to estimate cave depth.

The Dva Kapitana data was also analysed to demonstrate an offset of 5.5 cm. This has been treated in the same way, and only pre-submersion data will be used for depth estimations.

Figure 5: Kvitochka Barologger - Flooding Damage



Water Level Monitoring

Figure 7 shows the water monitoring results for Big Junction, Kvitochka and Dva Kapitana sumps during September 2009 to August 2010. The water levels have been compensated for fluctuations in barometric pressure, as read by the corresponding Barologger. Barometric compensation calculations also include corrections for flooding damage to the Barologgers, as discussed previously.

Big Junction experiences a maximum flood depth of **11.58 metres**, on 04 June 2010. This corresponds to the summer snowmelt. It is slightly less that the previous year's maximum (~13.5 metres).

Another notable difference is that the October rain flood peak, visible in 2008 as a sharp 6-metre peak in Big Junction and an 11-metre peak in Soviet Spelaeologists, is completely absent from Big Junction in October 2009. Nor is any significant corresponding peak evident in the Kvitochka or Dva Kapitana 2009 data. This is probably attributable to a lower rainfall in October 2009, although no surface rainfall data is available for this time.

On 05 June 2010, during summer snowmelt, Dva Kapitana floods to its annual maximum of **229 metres**. At this stage, the entire cave below the high water mark is submerged. This can be seen in the Kvitochka data, which has an exactly coinciding maximal peak of **71 metres** (Kvitochka is approximately 160 m above Dva Kapitana).

Figure 6: Maximum Flood Levels During 2010 Summer Melt

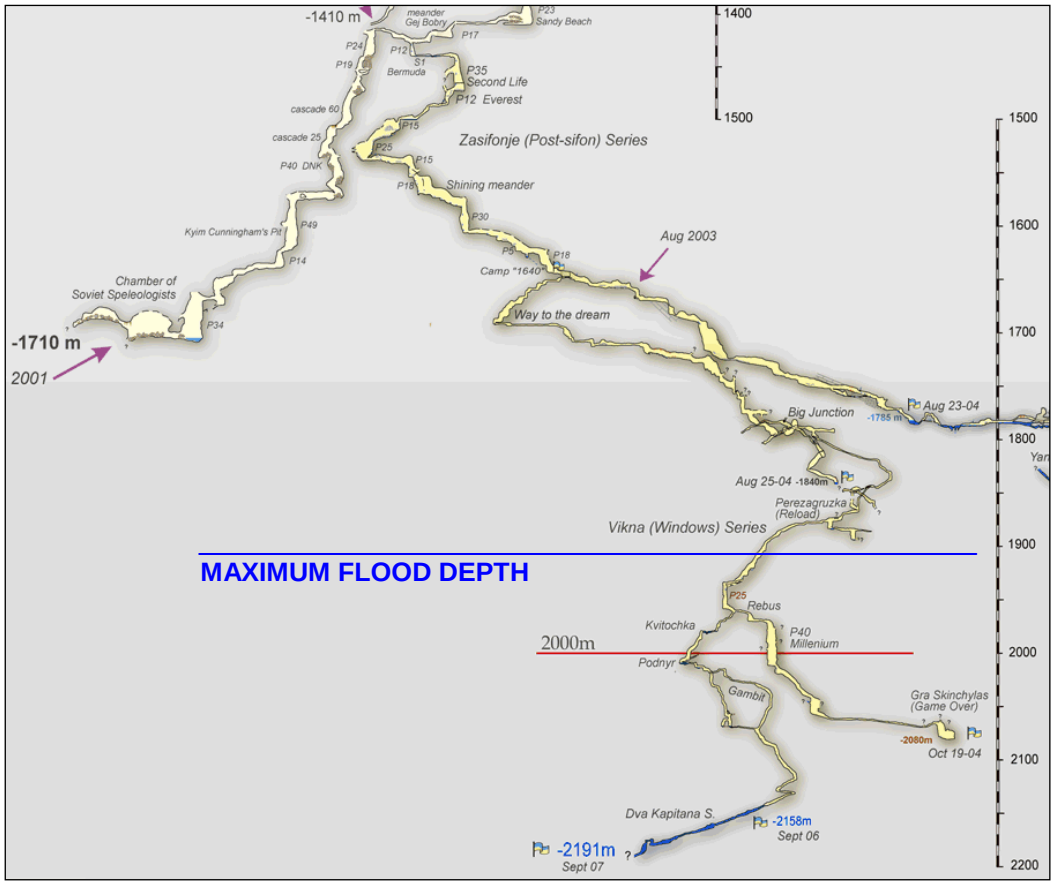
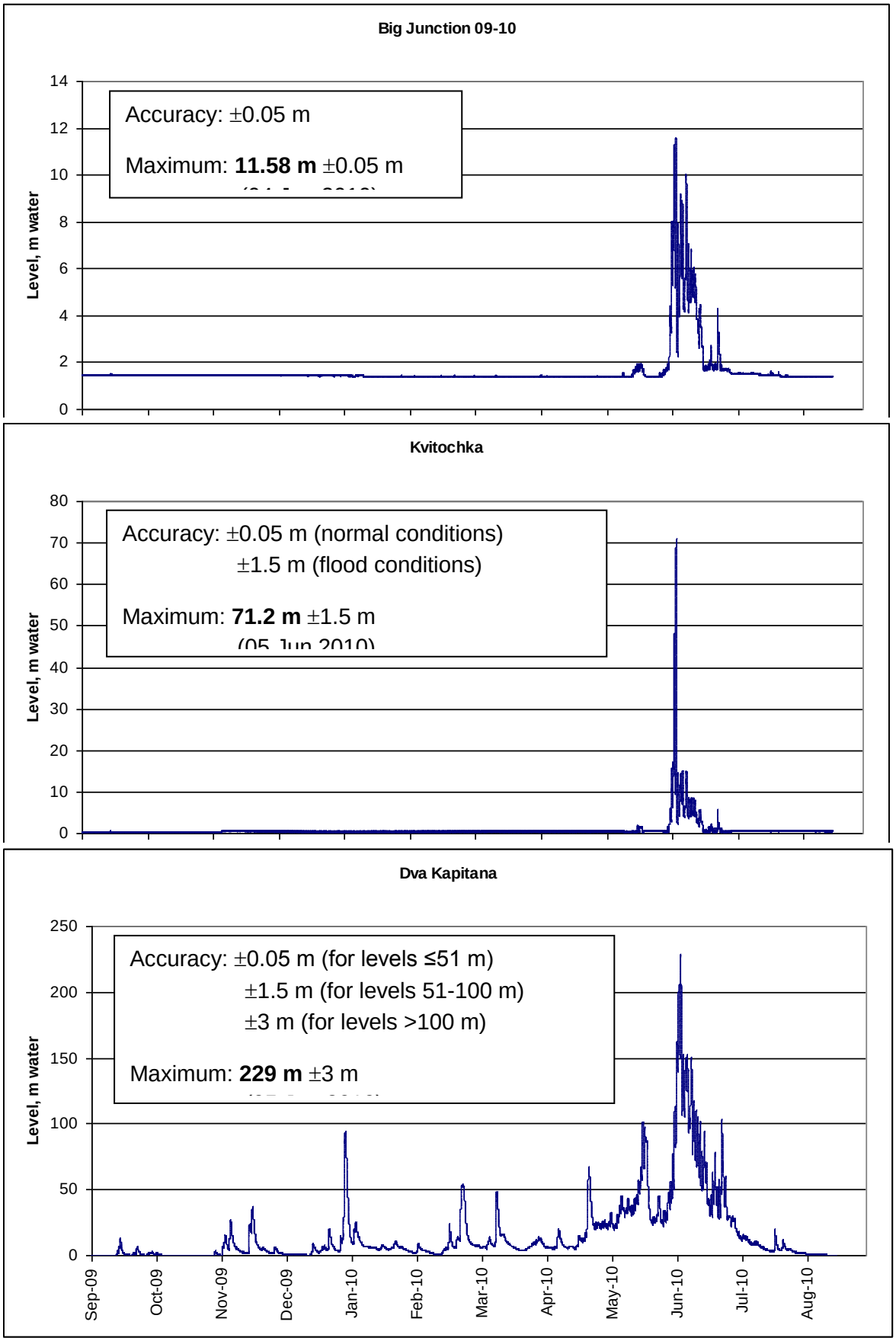


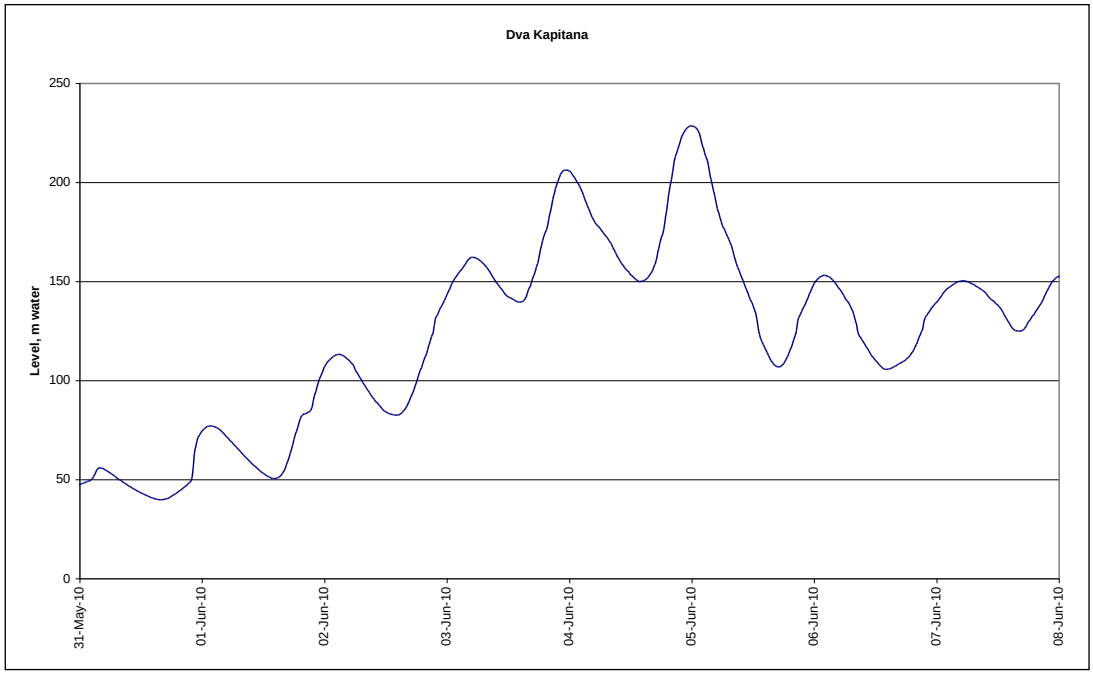
Figure 7: Water Levels in Big Junction, Kvitochka and Dva Kapitana, September 2009-August 2010



The data suggest that it takes 1-2 hours for a flood pulse to propagate from Big Junction to Dva Kapitana.

All sumps show a large daily fluctuation in water level, probably corresponding to fluctuations in air temperature and hence snowmelt rate on the surface. A "zoomed" example is shown in Figure 8.

Figure 8: Daily Level Fluctuations, Dva Kapitana



The maximum flooding rate in each location is shown below.

Location	**Maximum Flood Rate (depth increase)**	**Date**	**Comment**
Big Junction	2.3 m/hour	10 Jun 2010	Compares with 2.4 m/hour in 2009
Kvitochka	20 m/hour	04 Jun 2010	This rate occurs at a flooded depth of ~26 m, or cave depth of 1,954 m – i.e. the pitch above the point where the cave branches between Game Over and Dva Kapitana arms
Dva	27 m/hour	31 May 2010	This rate occurs at a flooded

Kapitana			depth of ~60 m, or cave depth of 2,080 m – i.e. the narrow tubes below Kvitochka

A correlation between snowmelt and flood rate will be available when data is retrieved in autumn 2012. It will hopefully be possible to factor out the "noise" of daily temperature fluctuations, to examine how the flooding rate corresponds with the geometry and branching of the cave.

Temperature Monitoring

Air and water temperatures over the year are shown in Figure 9.

All temperatures are affected by passing cavers: November 2009 and August 2010 expeditions are clearly evident in the temperature profiles. Temperature irregularities are particularly pronounced at Kvitochka, because the Barologger is located at the underground camp. The effect of divers' body heat is also visible in Kvitochka and Dva Kapitana sumps.

Flood pulses are clear in the data. The summer thaw starts in May, and temperatures are unstable through May, June and July as cold meltwater surges through the cave. Water and air temperatures drop significantly.

Note: when a Barologger is submerged, its measured temperature reflects the water temperature rather than air. This is the case for Kvitochka and Dva Kapitana during the summer thaw. It also occurs on three occasions at Dva Kapitana, in December, February and April.

It is interesting that on these three occasions, there is no significant drop in the water temperature as seen during the main summer thaw. This may be because these are smaller flood pulses where the water has time to warm up on its transit through the cave – as opposed to the major volume of summer flooding which is sufficient to cool the entire cave. Alternatively, it may suggest that these lesser floods are *not* caused by direct meltwater from the surface, but water enters by an alternative route. More will be known when surface melt rate is correlated in Autumn 2012.

An annual cycle is apparent at each location. Water and air temperatures rise very gradually from September to May (by 0.1°C everywhere except Dva Kapitana sump, which rises by 0.5°C). The summer thaw causes a shock cooling of up to 1.2°C. The system begins to recover after the floods subside in late June, settling in August/September back to gradually rising again, and the start of the cycle.

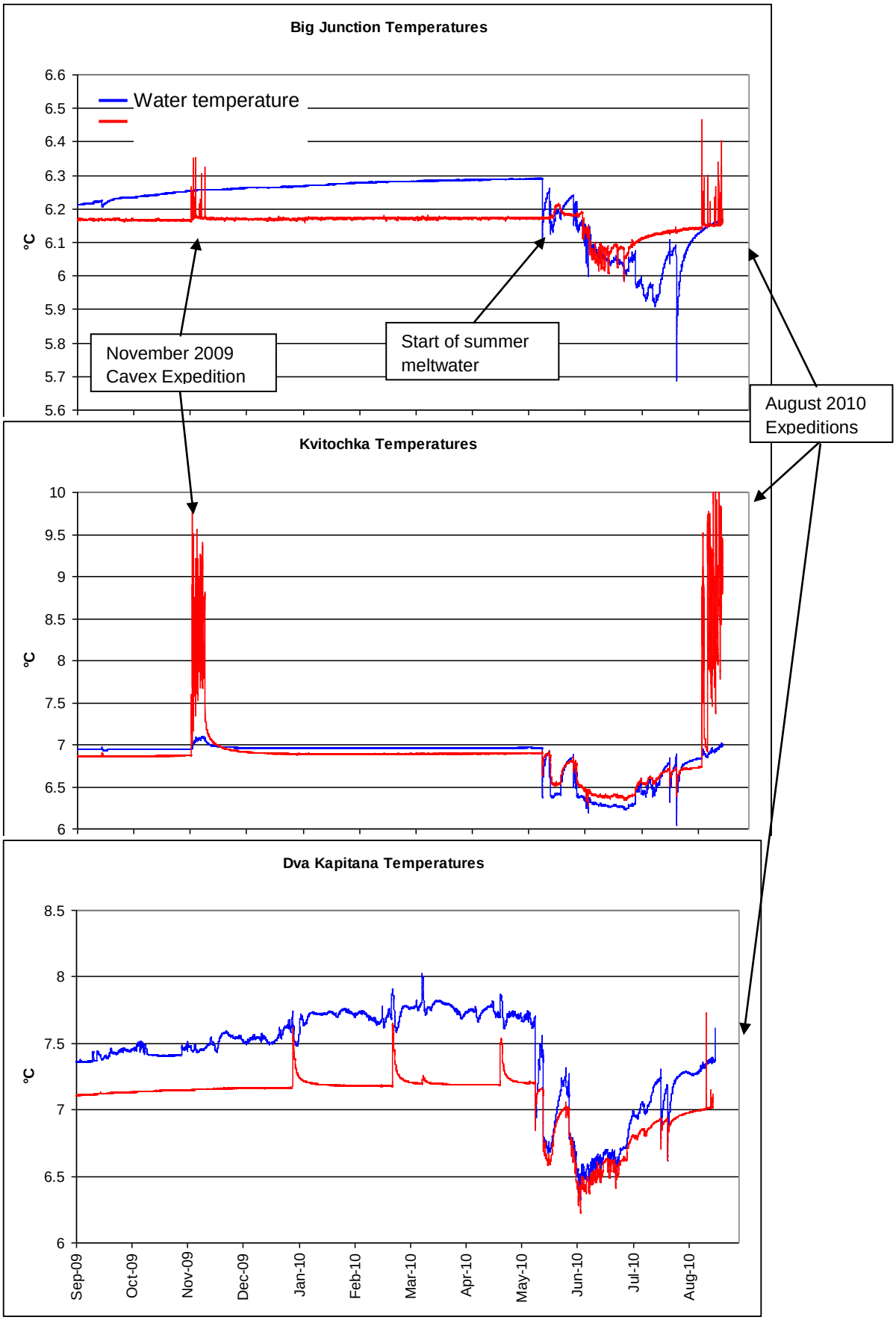
Excluding human disturbances and Barologger flooding, the temperature ranges are shown below.

Location		Temperature, °C (Accuracy ±0.05°C)		
		Minimum	Typical[3]	Maximum
Big Junction	Water	5.69	**6.28**	6.29
	Air	5.99	**6.17**	6.22
Kvitochka	Water	6.04	**6.96**	6.97
	Air	6.34	**6.89**	6.93
Dva Kapitana	Water	6.32	**7.72**	8.03
	Air	6.62	**7.18**	7.23

Initial temperature measurements at the base of the entrance pitch showed an average temperature of **2.10°C**.

[3] Temperatures at 00:00 on 01 Feb 2010

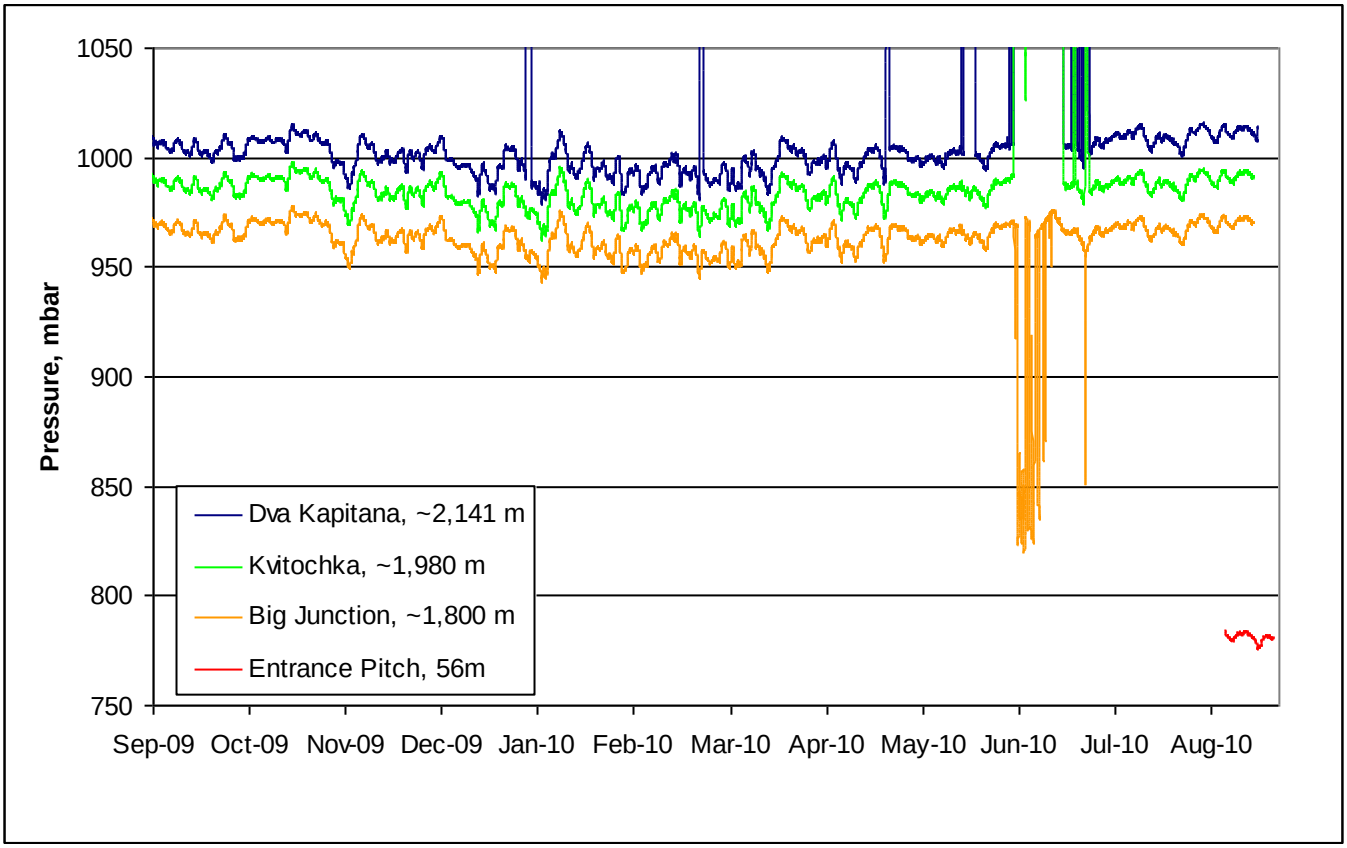
Figure 9: Air and Water Temperatures, September 2009-August 2010



Pressure Monitoring

The Barologgers record air pressure above or below the expected "normal" pressure for their altitude, expressed as metres of water column. This measurement can be converted back to absolute pressure by reversing the conversion algorithm in the instrument firmware. Results are shown in Figure 10.

Figure 10: Air Pressures, September 2009-August 2010



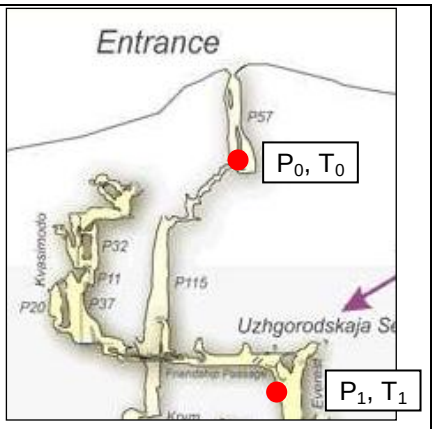
It is clear that outside flooding events, which register significant pressure excursions from the norm, the pressures read by the four independent instruments are aligned closely. There is a constant pressure difference between any two given instruments, in direct proportion to their difference in altitude.

All of the four pressure traces are in phase – i.e. peaks and troughs align exactly (at least to within 15 minutes, the recording frequency). This means that there is no significant lag in pressure propagation throughout the cave, despite the presence of sumps between the instruments.

This constant pressure difference can be used to estimate the relative altitudes of the instruments and hence the depth of the cave. Only limited data is available from the Entrance Pitch Barologger, so the estimates in this report are only preliminary: a more refined estimate will be possible later in 2012 when a year of surface data is available.

Depth estimates are based on the ideal gas law, which is adapted to express cave depth in terms of ambient pressure change.

The final formula is shown below.

$\Delta d = \frac{T_0}{\alpha}\left[\left(\frac{P_1}{P_0}\right)^{R\alpha/g} - 1\right]$		
where:		
Δd =	difference in height	m
α =	temperature lapse rate	$K.m^{-1}$
α =	$(T_1 - T_0) / \Delta d$	$K.m^{-1}$
T_0, T_1 =	temperature at upper, lower levels	K
P_0, P_1 =	pressure at upper, lower levels	Pa
R =	specific gas constant for humid air	$J.kg^{-1}.K^{-1}$
R =	$\frac{R_a + R_w x}{1 + x}$	$J.kg^{-1}.K^{-1}$
R_a =	specific gas constant for dry air (287.05)	$J.kg^{-1}.K^{-1}$
R_w =	specific gas constant for steam (461.51)	$J.kg^{-1}.K^{-1}$
x =	humidity ratio of cave air	kg water / kg dry air
g =	gravitational acceleration (9.80665)	$m.s^{-2}$

The temperature lapse rate, α, is the change in temperature per metre gain in cave depth. It is estimated for each section of the cave using the Barologger temperature gauges and their estimated approximate depths.

The formula is applied to three sections of the cave to estimate the depth for each:

- Bottom of Entrance Pitch Barologger to Big Junction Barologger
- Big Junction Barologger to Kvitochka Barologger
- Kvitochka Barologger to Dva Kapitana Barologger
-

This gives a total depth to the Dva Kapitana sump of **2,179 metres**. This is the estimated depth *at the water surface of the sump* during our expedition in August 2009. The position of the UkrSA's last survey point relative to the Barologger's position has not yet been established for a direct comparison; however, it is believed that the above estimate puts the cave at 30 to 40 metres deeper than the UkrSA survey suggests.

There are a number of factors that may contribute to the discrepancy.

1. Non-linear Temperature Profile

   The formula assumes a constant temperature lapse rate over the section of cave in question – i.e. a linear temperature profile. The real temperature profile is curved rather than linear, but can be approximated by separating the cave into sections and assuming linearity within those sections.

   There were three sections used in the estimate. The availability of more temperature data for the first and largest section (Entrance Pitch to Big Junction) would improve the estimate, which at present could be affected by up to $\pm$10 m by this non-linearity.

2. Variations in Humidity

   The estimate used an assumption of 100% relative humidity in all parts of the cave. The actual humidity was not measured.

   Making an assumption of 70% relative humidity would reduce the depth estimate from 2,179 metres to 2,176 metres.

3. Lack of Data for Entrance Pitch

   Only a limited set of data (2 weeks) is available for the Barologger at the entrance pitch, and this data will have been affected to some extent by the passage of cavers. The availability of a year's data when the instruments are retrieved in 2012 will give a much sounder statistical base for calculations.

4. Calibration of Instruments

   All Barologgers were calibrated by the supplier before dispatch, and have a claimed accuracy of $\pm$0.1 cm water column. This corresponds approximately to $\pm$1 m in the depth estimate. However, given the harsh cave environment, it would be advisable to validate instrument calibration after removal from the cave.

The 2012 expedition will allow some of these factors to be assessed and addressed. If time permits, a Barologger may be temporarily relocated to a known depth in the upper half of the cave, so that pressure depth estimates can be compared with the highly accurate data from previous hydrolevelling work.

The full data will be analysed statistically. It is intended to publish the findings in spelaeological journals.

Sponsors

We would like to thank the Speleological Union of Ireland as our primary financial support for this expedition. Their generous continued sponsorship further develops understanding of the hydrology of the Krubera cave system, and aids future expeditions in planning and safety.

Speleological Union of Ireland

Irish Sponsors			
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Total Cost with Breakdown (In Euro):

Item	*Cost Per Person*	*Cost for Irish team*	*Funding Request*
Travel & insurance			
Return flight Dubin-Moscow	400	1600	1600
Return flight Moscow-Sochi	330	1320	1320
Transit visa Russia (tourist double-entry) – inc. postage	125	500	500
Tourist invitation (for Russian visa)	25	100	100
Insurance	50	200	200
Shared Expedition Costs			
Abkhasian visa Transport from Sochi to mountain Ropes & rigging equipment Communal equipment, fuel, food, medicine, etc.	400	1600	1600
Further karabiners (10 each)	50	200	200
Personal Equipment			
Wetsuit (some members require new)	150	300	-
General caving kit replacement (new & spare kit needed for week's stay underground)	200	800	-
Water Logging Equipment – Irish team			
1x barometric logger + p.& p.	92	368	368
TOTAL	**1822**	**6988**	**5888**

Lessons Learned/General Recommendations

The following is a brainstorm of ideas collected soon after returning from the trip on what was effective, what was vital, what caused difficulty, what equipment changes we would make if returning, etc. Some are obvious and vital, and so worth repeating. Some points were an issue for part of the team, and not others. Some may seem small details/changes, but the repercussions of these seemingly small issues had significant influence on the effectiveness and enjoyment of the trip.

- Dependence on a team - recognition of the importance of clear communication within a group, the necessity for camaraderie, and maintaining courteous relations in times of difficult going.
- Psychological element – Difficult to prepare for the debilitating effect of prolonged periods in a remote environment, in darkness and occasional solitude on a rope.
- Training specifically for moving heavy bags, on and off rope. This would lessen the risk of injury if started well in advance of the trip. Care would have to be taken to plan this in a way that slowly builds up strength and stamina.
- Gear should be thoroughly tested before use, especially drybags, to ensure the proper function of gear further down the cave. Extended camping trips underground by the group was useful in this.
- Altimeter watches are useful to aid navigation in the cave and inform of flood risk.
- Practise of treating water for consumption during a journey caving could be done at home, as the team strategy was to travel without drinking water or food apart from a small package of boiled sweets.
- New (but broken in) caving suits are a must.

Photo of team yellow showing bag carrying – from left, Tristan, Bernabe, Ivan

- Sponsorship takes far more time than you have.
- Methodical diary or journal keeping is helpful in writing reports later.
- Learn to use a PETZL simple (French way).
- Pack light if you can too many spare batteries causes excess weight.
- When you get bad days just keep going.
- Always stay in touch with the last man on a rope - as being on your own & last, can really REALLY get to you after a few hours.
- Bring some magic food that will really help you when you're done in (spirulina, macadamia nuts, etc.).
- Consult on food with a professional nutritionist before leaving.
- Practice SRT till you can do it with one hand after little food and no water and no sleep for hours and hours on end.
- Strangely, a camera with pictures of surface are a huge boost.
- Waterproof pack of cards.

- More information on Surface regarding goals etc. - a white board and a few maps as a 'hub' point.
- Learn to function without recourse to drinking water much – chewing gum keeps the mouth moist.
- Don't pee in wetsuit when you're wearing it for 14 hours in a harness (rashy).
- When carrying heavy bags get a 'nappy strap'.
- Plan trips the way CAVEX cave. Instead of a 10 day push for bottom better 5 day push and 2/3 day putting dumps in & get stuff out. This is because of the grinding of carrying heavy bags wears you down days on end.
- Don't give away part of your kit (be self sufficient). Pre-shrink ropes before you go.
- When tying cowstails don't wet them in the sun (as core will dry slower and the ends will get messy).
- Cowstails stretch dramatically when you add the weight of 2 or 3 loaded bags.
- Always pack a mixture of food, as only choc bars, sausage meat & cheese do nothing for a teams morale, or an individual's energy levels.
- Sleeping packs were bang on, the better quality you bring, the better you sleep.
- Bivvy bags work excellently and are vital.
- Decent gloves made of plastic and tested on both wet rope/dry rope for a good few days prior to a big push, - NOT material or neoprene gloves as they fall apart with friction and dampness after a few hours of big pitches.

Expedition team 2012 (Photo by Gintautas Svedas)

Appendices

Preparation

The team had little time to prepare between the end of June and the start of August. One weekend trip to Shannon Cave was organised to sleep underground for two nights, test gear, do some exploring and practice carrying bags for prolonged periods of time. A vital part of this exercise was for individuals to meet up and work as a team.

Travel Arrangements, Notes

Flight	Ireland to Moscow	From Dublin usually via Riga in Lithunia
Flight	Moscow to Sochi (Adler airport, near Black Sea)	2½ hours
Public Minibus	Sochi to Russian/Abkhazi border	30 minutes – buses in airport carpark look for "Psou" (Псоу)
Walk	Across border	30-60 minutes – Footbridge crossing with Russian and then Abkhazian border control
Taxi	border to Tsandripsh	30 minutes – buses action "Gagra" direction (Гагра)

Visa arrangements were tedious, pernickety and took a substantial amount of time - We went to Russian consulate in Dublin with all necessary documents; we found that 2 people made it easier to Deal with the old style soviet Bureaucracy.

At the Abkhazian side there was a 30 euro 'insurance' charge for tourists which now seem to be unavoidable requirement to pay, despite no mention of this on any paperwork prior to departure. Some officials confiscated the team's passports until this was paid out.

Insect Life

Although our part of the expedition did not succeed in capturing any data on the fauna of the cave system, the world's deepest land animal was discovered in 2010, in Krubera. The insects were collected during the Ibero-Russian CAVEX team expedition to Krubera -Voronja during the summer of 2010 at a depth of 7,188 feet (2,191 meters) below the surface.

More information here - http://www.livescience.com/18586-deepest-land-animal-cave-springtail.html

And a scientific paper here - http://booksandjournals.brillonline.com/content/10.1163/187498312x622430

Role Play

Eoghan prepared this (very slightly) dramatised example of a typical underground interaction. It reflects the absurd, scatalogical and unanticipated side to an Expedition with a capital 'E', which they don't tell you about in 'The Boy's Own Paper'.

Characters:

Lithunian - Aidas (*eye-das*) - Commander, Gintas (*gen-tas*) Second in command, logical explainer

Irish - Eoghan (*owen*)-Surplus porter, Tim - strong porter, only caving 3 years/AKA weakest link
Steve (*Muh*) Veteran, skinny strong, blue team leader

Spanish - Jesus (*hey-zeus*) kid but hard as nails, Jorge (*Yor-Ye*) Quiet hard man who wants to be first down the deepest caves & up the highest mountains on each continent

Camp -1400 biggest camp. Team blue and red are together and they have just finished breakfast.

Aidas: 'OK, gut morning. So today we go down to -1800. Steve, Serge and Jaysus you come down, got to bottom and then come up. Eoghan and Tim you stay here'.

Eoghan and Tim are shocked and surprised

Jorge, Steve and Jesus: 'OK'

Eoghan: 'Uh Ok' feeling *shattered.*

Tim: 'Ok' *surprised*

They busy themselves getting dressed & packed up

Aidas: 'You will stay here tonight, you must go up to -1200 tomorrow night' *to Tim & eoghan.*

The others are packed and they are outside ready to leave, Gintas comes in.

Gintas: 'Eoghan you fix the Toilet'

Eoghan goes 'what de fuk' in his mind.

Eoghan: 'Ok, why not'

Gintas: 'Iss messy, you tidy up, yes**!**'

Gintas leaves - Tim and Eoghan turn to each other

Tim: 'I'll help you'

Eoghan: 'What are we now Team Brown?'

Tim: 'Yep! Team brown ain't goin down'