

In a search for the route to 2000 meters depth: The Deepest Cave in the World in the Arabika Massif, Western Caucasus

by Alexander Klimchouk and Yury Kasjan--Ukrainian Speleological Association

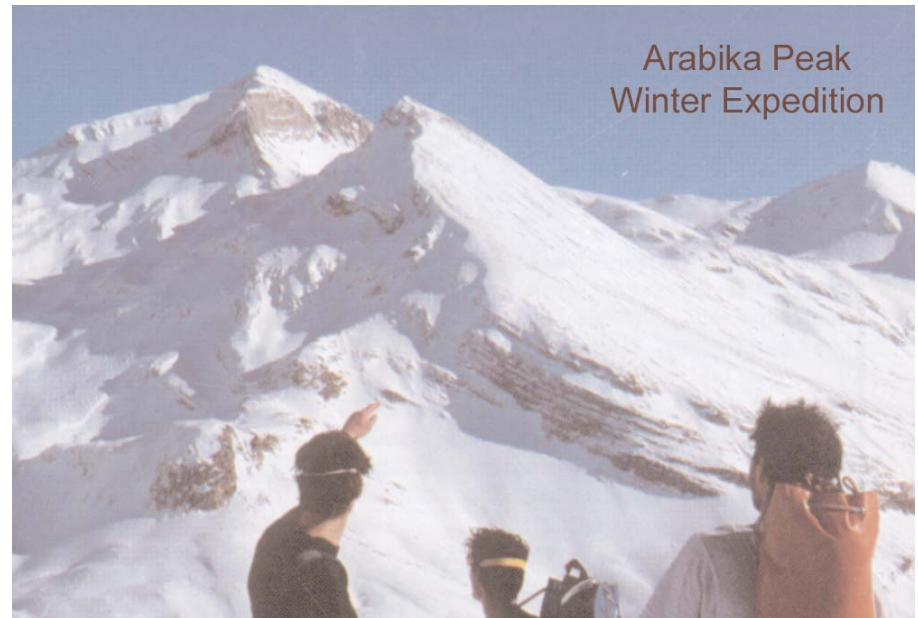
Photographs by Oleg Klimchouk, Denis Provalov, Yury Kasjan, Vladimir Kisseljov, and Alexander Klimchouk

In January 2001, the expedition of the Ukrainian Speleological Association explored Krubera (Voronja) cave in Arabika to a record-breaking depth of 1710m. For the first time in the history of speleology, the world's deepest cave has been explored outside of Central/Western Europe. It stands alone as the most remarkable achievement in super-deep exploration of the recent decades, the largest single breakthrough in depth since 1975. Overcoming of the previous depth record of Lamprechtsofen-Vogelschacht in Austria by 80m is particularly impressive compared to the three previous records, each of which raised the bar no more than 20 meters (to -1602m in 1989, -1610m in 1998, -1632m in 1998). This article briefly describes speleological potential of the Arabika massif and history of its exploration and gives some details of the Krubera cave and the recent record-breaking exploration.

ARABIKA MASSIF: SPELEOLOGICAL, GEOLOGICAL, AND HYDROLOGICAL FEATURES

The Arabika Massif is one of the largest limestone massifs of the Western Caucasus. It is located in Abkhazia, the republic that officially belongs to Georgia although claims itself as an independent state. The latter is the matter of still unresolved political contradictions between Abkhazia and Georgia that caused the major conflict in 1993-1994.

The massif has strongly pronounced glaciokarstic surfaces at elevations ranging between 1900 to 2500m, and is composed of Lower Cretaceous and Upper Jurassic limestones. In the central part of Arabika the formations of Cretaceous age remained only in some ridges and peaks, as well as in patches within trough valleys. The core part of the massif is composed of Upper Jurassic strata that dip continuously to the Black Sea shore and submerge below the modern sea level (Figure 1, profile). Geologically, Arabika corresponds to the large anticline of the sub-Caucasian (NW-SE) direction with the gentle dipping south-western megafank (complicated by several low-order folds of the same direction) and steeply dipping north-eastern flank. The massif is severely tectonised, with the fault-block structure strongly controlling both cave development and groundwater flow sys-



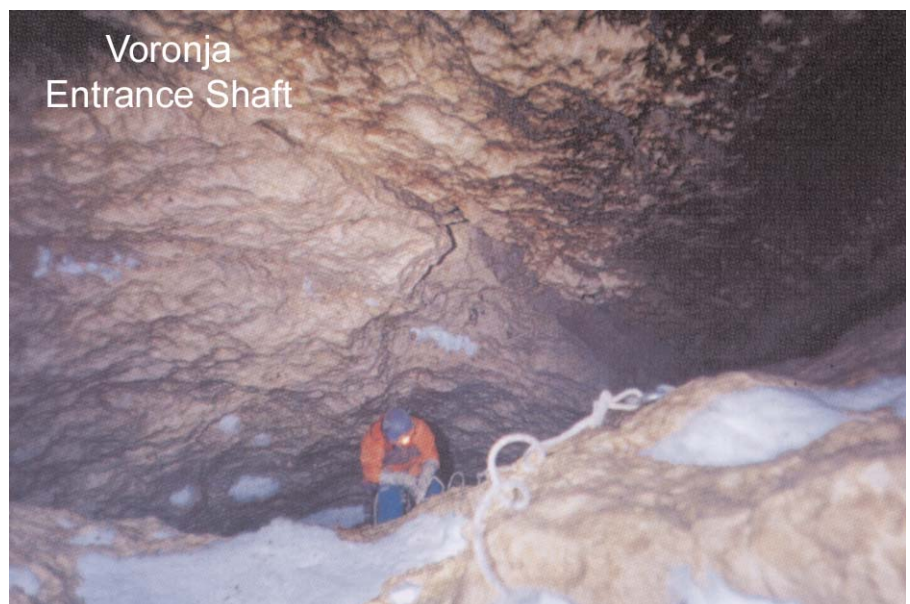
Arabika Peak
Winter Expedition

tems (Klimchouk, 1990). On the north-west, northeast, and east, Arabika is bordered by the deeply incised canyons of the Sandripsh, Gega and Bzyb rivers. The latter separates Arabika from the adjacent Bzyb sky Massif, another area of major speleological significance in the Western Caucasus with Snezhnaja Mezhonogo (-1370m), Pantjukhina (-1508m) caves and many other considerable caves.

Glacial trough valleys formed during the late Pleistocene glaciations are the main features of the central part of the Arabika massif (Klimchouk, 1984), with ridges and peaks in-between them. The

central part is shown in beige tint in Figure 1 and indicates the area above the tree line at approximately 1800-1900m. The highest peak (the Peak of Speleologists) rises to an altitude of 2705m. Some low-altitude ridges covered with forest stretch from the central part towards the Black Sea.

Among several hundred caves known in the Arabika massif, some deep caves were explored during the 1980s (indicated by red dots in the Figure 1), including Ijukhina system (-1240m), Arabikskaja system (Kujbyshevskaja-Genrikhova Bezdna; -1110m), Dzou Cave (-1080m), Moskovskaja Cave (-970m), Sarma Cave



(-700m) and Cherepash'ja Cave (-650m). The deepest cave, Krubera, is located in the Ortobalagan trough valley, some 300m to the southeast of, and 60m above the Kujbyshevskaja Cave, the main entrance to the Arabikskaja system (Figures 2 and 3). Although Krubera Cave is not connected directly to the Arabikskaja system, it most probably forms a single hydrologic system with the latter.

Figure 2 depicts quite strong tectonic control of cave development in the plan view. Some segments of the major caves stretch along faults, other parts twist within major tectonic blocks and reflect back inside blocks when reaching a fault. The main branch of the Krubera Cave slew many times and goes steeply in depth by vertical pits separated by short meanders. The cave remains within a small tectonic block and does not extend beyond the limits of the trough valley.

Major karst springs with individual average discharges of 1 to 4 m are located at altitudes ranging from 1m (Reproa Spring) to 540m (Gegsky Vodopad) above the sea. Submarine springs are also known here, emerging from the Black Sea floor at depths of 20 to 40m and probably below. Some boreholes located along the Black Sea shore yield karstic groundwater from depths of 40 to 280m below sea level. An outline of the hydrogeological structure of the massif and its true speleological potential were revealed in the 1980s, when spectacular progress was made in deep cave explorations and two large-scale dye tracing tests (in 1984 and 1985) proved connections between the major caves and springs (Klimchouk, 1990; see Figure 1). Tracers injected in the Kujbyshevskaja and Iljukhina caves were detected in Kholodnaja Rechka (1.5m³/s; 50m a.s.l.) and Reproa (2.5m³/s; 1m a.s.l.) springs on the seashore. The tracer from Kujbyshevskaja has also been detected in a borehole that yields groundwater from the depth of 40m below sea level, located between these two springs. This gave a reason to distinguish the large Central karst circulation system (number 1 on Figure 1), the deepest in the world at that time with the vertical amplitude being over 2300m. It corresponds to the most of the southeastern flank of the major Arabika anticline. The tracer injected in the Moskovskaja Cave (-970m) have been detected at the Gegsky Vodopad spring, indicating the presence of the karst circulation system comprising the northeastern flank of the Arabika anticline (the Northern system, number 2 on Figure 1). No connections were revealed with yet another major spring, Goluboje Ozero in the Bzyb River

canyon, although it apparently drains a large area in the southeast of the massif (the hypothetical Eastern karst circulation system, number 3 on Figure 1). This outline remains rough, and catchment areas of some other considerable springs (in particular those located in Gagra town) are not yet clarified. Increase of the number of deep caves with shaft flows and further tracing experiments will clarify the picture in the future.

HISTORY OF KARST STUDIES AND CAVE EXPLORATION IN ARABIKA

Of the rather rich history of karst and speleological investigations in Arabika we shall mention below only some names, events and circumstances which seem to be the most important in the context of the modern state-of-the-art in cave exploration.

In the beginning of the 20th century, Arabika was visited by famous French speleologist Edward Alfred Martel, who published several works about the massif (i.e. Martel, 1909). In 1909-1910 well-known Russian karstologist Alexander Kruber, a founder of karst science in Russia, performed some field studies in Arabika. He published his observations in a series of specific papers (Kruber, 1911, 1912a, 1912b) and in his major monographs. During the following 50 years no special studies of karst and caves of the massif had been done, although the karst of Arabika was referred to in many works dealing with regional geology and hydrogeology.

In the beginning of the 1960s, specific speleological investigations were started by Georgian researchers (Maruashvili, Tintilozov and Changashvili, 1961, 1962; Maruashvili and Tintilozov, 1963). They recognised an important role of the Quaternary glaciations in karst development in Arabika and began to explore caves in the high altitude part of the massif. Despite obvious limitations imposed by poor equipment and technique and the general "infant" state of Soviet speleology then, Georgian researchers explored several vertical caves (up to -250m) and pointed out the considerable depth potential of the massif. In particular, they made a first exploration of an open-air 60m shaft in the Ortobalagan trough valley and named it after A. Kruber, the cave that in the very beginning of the 21st century became the deepest in the world. Forty years ago, however, Georgian speleologists were stopped by an impassable squeeze in a meandering passage that stretched from the bottom of the entrance shaft.

The Georgian researcher Tamaz

Kiknadze made some additional investigations in Arabika, analysed available data on geology and hydrogeology of the massif, and published its monographic description (Kiknadze, 1972). Although his ideas on the structure of karst circulation systems were not confirmed by later dye tracing experiments, this book was an important summary of karst and caves of Arabika.

During the late 60s and 70s the caving clubs of Moscow, Crimea and Krasnojarsk made several expeditions to the massif. Major discoveries were the Genrikhova Bezdna cave in the Ortobalagan trough valley (the 120m deep entrance shaft ended with a squeeze) and the Jubilejnaja, Karrovaja, and Akhtiarskaja caves in the northern part, explored respectively to -260, -200 and -160m. With only six 100m+ deep caves, two 200m+ and no 300m+ deep caves explored before the late 70s, Arabika had acquired somewhat contradictory reputation among cavers ("Good potential but no



deep caves"). Discouragement about Arabika was strengthening by contrast with the adjacent Bzyb sky massif where many 100 to 300m deep caves and several 500m+ caves were under active exploration, including Snezhnaja Cave with its -1380m. By the late 70s, Arabika had been virtually abandoned by cavers. In 1980 the Kiev Speleological club led by Alexander Klimchouk chose Arabika as the main focus for its exploration efforts and implemented a strategy of thorough and systematic search on an area-by-area basis. This appeared to be particularly successful in this formerly glaciated karst massif, in contrast to the previous "quick-search" practice, because of glacial debris blockage of most open-mouth shafts. In

Arabika Massif West Caucasus, Abkhazia (Georgian)

Speleo-hydrologic map

1 5km

© Alexander Klimchouk, 2001

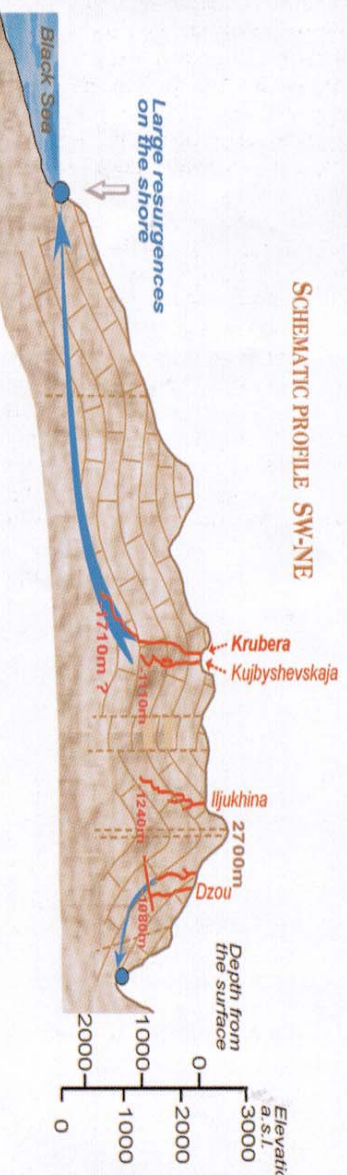
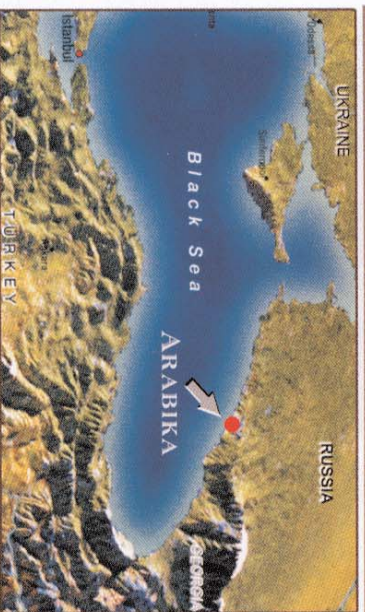
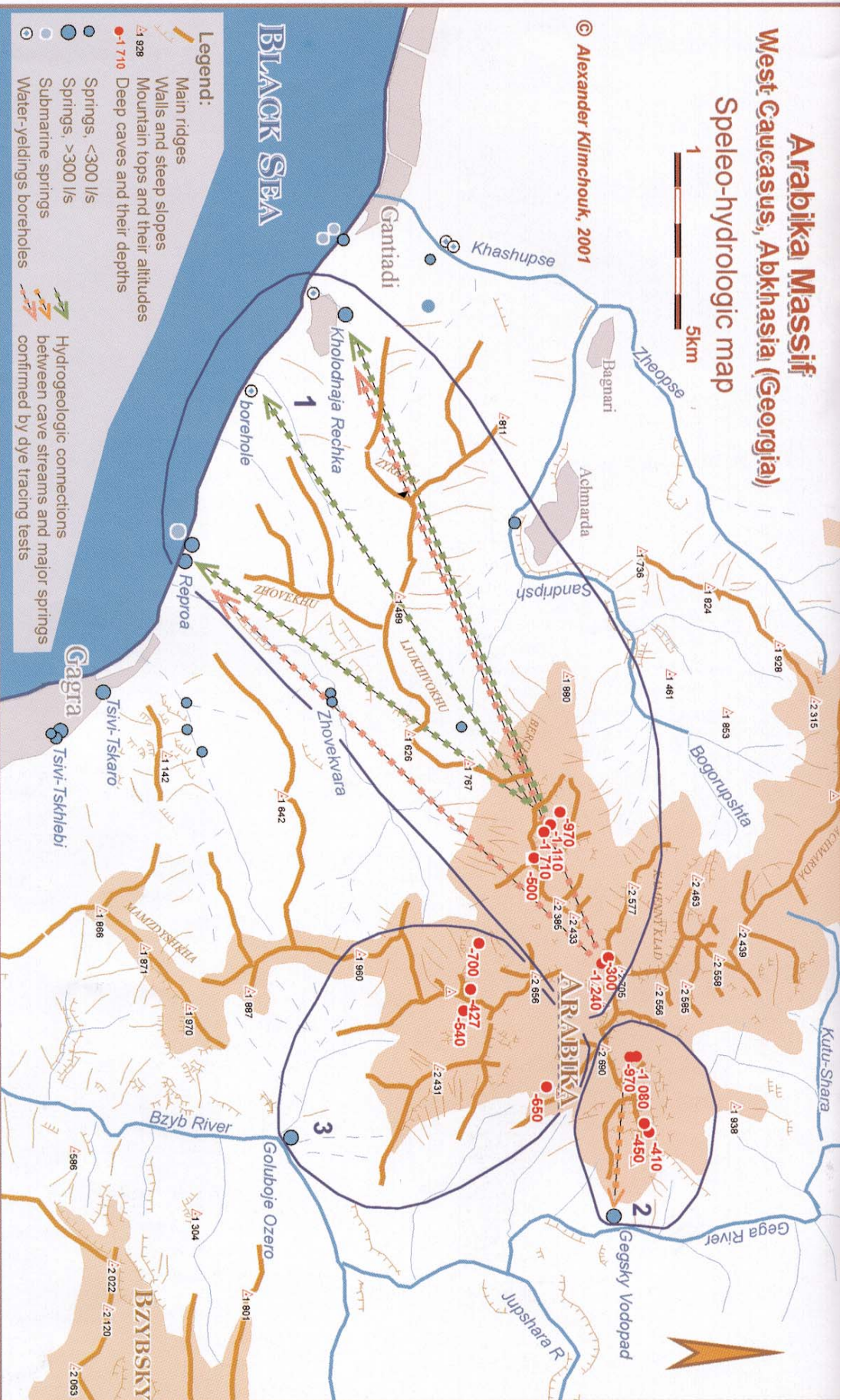


Figure 1: Chart of the Arabika Massif. Below: Location map and geological profile

addition, a "no dead ends" concept was adopted that implied re-inspection of all known caves and systematically challenging such common obstacles as boulder chokes and squeezes that previously blocked exploration. The Perovsky Speleological Club of Moscow, led by Vladimir Iljukhin, joined our exploration activity in Arabika in the same year. This approach quickly led to important discoveries. Kiev cavers concentrated their efforts in the Ortobalagan trough valley where, among other caves, they pushed Kujbyshevskaja Cave through a series of expeditions (-450m in 1981, -700m in 1982, -900m in 1985, -1110m in 1986). The main obstacles in this cave were boulder chokes, penetration through just one of which (Ugrjum-Zaval at -700m) took three years of arduous work. Meantime, exploration progressed in the nearby Genrikhova Bezdna cave, eventually connected to Kujbyshevskaja at -965m in 1989. The resultant system was named Arabikskaja. In the Krubera Cave, which was supposed to connect the Arabikskaja system and increase its total depth by 60m, exploration progressed slowly because of critically tight meanders between pits that required some widening to get through. The cave was pushed to -340m during 1982-1987 and then exploration was suspended. Two "windows" in the P43 in the depth range of 220-250m, indicated on the cave survey, remained unexplored. During this period the cave received its second name Voronja (Crow's cave) due to a number of crows which nested in the entrance shaft. Another cave in this valley, the Berchil'skaja Cave, (located 150m higher than Krubera and 210m higher than Kujbyshevskaja) was pushed by Kiev and Moldavian cavers down through a vertical boulder choke that extended almost continuously from the bottom of the upper 60m deep shaft to the current end at -500m.

Cavers of the Perovsky Club, based mainly in the upstream part of the Central trough valley, invested most of their efforts



in pushing the Perovskaja Cave. The cave was renamed after an outstanding Soviet speleologist, Vladimir Iljukhin, was accidentally killed by a car after the 1992 Arabika expedition. They reached the first sump at -950m in 1984 and spent huge efforts in the subsequent years negotiating through a series of three sumps and "dry" sections in-between them (including a 230m deep section between the 2nd and 3rd sumps). The forth sump, at -1240m, explored for about 100m in length in 1987, remains the end of the system till now. In this extreme exploration one of the leading roles had been played by another outstanding Soviet speleologist, Vladimir Kissel'ov.

Important discoveries made in Arabika by Kiev and Moscow cavers in the early 80s attracted many caving clubs of the former Soviet Union. Cavers from Leningrad, Sverdlovsk, Krasnojarsk, Minsk, Kishinev, Poltava, and also foreign cavers from Belgium, Britain, Hungary, Italy and France got involved in Arabika in various years. All explorations during the 80s were closely coordinated, by planning work ahead for each coming year and assigning certain areas for involved groups.

Results were reported on the regular Arabika conferences held in Kiev after each field season. By the end of that decade, 36 caves exceeding 100m deep had been

explored in the massif, including seven exceeding 500m+ deep.

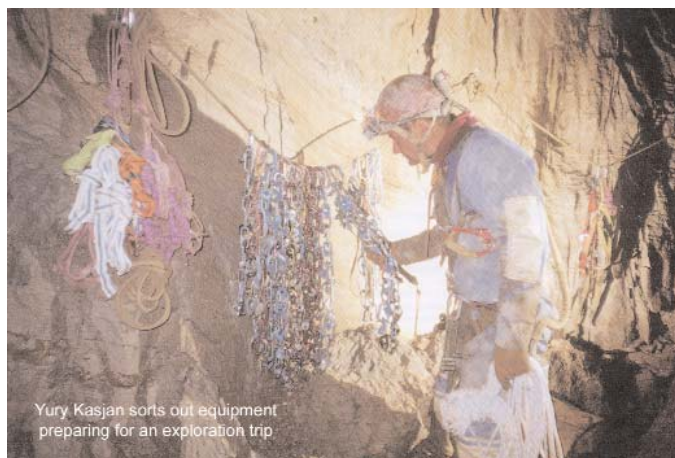
In 1984-1985 two large-scale dye tracing experiments were conducted in Arabika, in which three different tracers were used to trace shaft flows in Kujbyshevskaja, Iljukhina, and Moskovskaja caves. All known springs and boreholes were monitored around the massif. These experiments have proven hydrologic links from Kujbyshevskaja and Iljukhina caves with the major springs at the seashore over a direct lateral distance of 14-20km and vertical amplitude of over 2300m. Obviously, the decade of the 1980s resulted in dramatic progress in speleological exploration in Arabika and in revealing its true depth potential (Klimchouk, 1990, 1991).

The political and ethnical conflict in Abkhazia in 1992-1994 and instability and border problems, which continued throughout the subsequent years, suspended speleological explorations in Arabika. Although some small groups of cavers occasionally visited the massif during this period, planning and realisation of large and serious expeditions was not feasible. Stabilization of the situation in Abkhazia since 1997 has allowed us to re-activate exploration efforts in Arabika.

RECENT EXPLORATIONS IN ARABIKA:

BREAKTHROUGH IN KRUBERA CAVE

In 1998 the CAVEX team, consisting mainly of Kiev and Moscow cavers, made a breakthrough in the Dzou Cave in the northern part of Arabika, previously explored by French Villefontaine and Moscow Perovo Speleoclub teams



to -493m and after Vladimir Kisseljov team to -750m in another part of the cave. The expeditions of 1998 and 1999 resulted in discovery of a laterally extensive major river passage at the bottom area and in pushing the cave to -1080m. In August 1999 the expedition of the Ukrainian Speleological Association (that included cavers from Poltava, Kharkov, Uzhghorod and Dnepropetrovsk) led by Yury Kasjan, re-started the work in the Ortobalagan trough valley, in the Arabikskaia system, and in Krubera. In fact, the main target was to find a connection between the Krubera and Kujbyshevskaja caves that would increase the total depth of the system by 60m. In Krubera, the team checked the two "windows" in the walls of the P43 in the depth range of 220-250m, which remained unexplored since the 1980s, and found continuations in both. The lower window led to a new branch that seemingly headed toward Kujbyshevskaja, but eventually missed it and ended up with a chamber (Non Kujbyshevskaja) at -490m. The upper window opened to another branch that was explored to -750m during the 1999 expedition. Alexey Zhdanovich from Uzhghorod was instrumental in this breakthrough and exploration. The Ukr.S.A. expedition in 2000 ran in two stages, both led by Yury Kasjan. During the first stage (August), in which cavers from Poltava, Uzhghorod, Kiev, Kotel'va and Novaja Kakhovka participated, the main branch was explored and surveyed to

-1215m. On the second stage the MTDE team, composed of six cavers from Spain (Sergio Garsia Dils de la Vega, Vilafranca Javier la Pera, Enrico Ogando Lastra, Juan Alberto Martin Otero, Aifredo Morena Rioxa, Ramos Ignacio de Rafael) and two cavers from France (Bernard Tourte and Olivier Ubiergo) joined Yury Kasjan and Denis Provalov to continue exploration. They reached a depth of 1410m in a branch piece that seemed to lose airflow and ended with a squeeze. When ascending after the very last trip to the "bottom," Yury Kasjan found a "window" in the wall of a pit at -1340m, which promised to give a continuation. There are many aspects, some of which lie beyond the scope of rational thinking, which experienced cavers evaluate when assessing the prospects for further exploration. In the fall of 2000 we clearly heard "The Call of an Abyss" and felt a smell of the super depth. It was a mixture of knowledge of general prospects of Arabika, historical aspects, impetus of the recent explorations, excellent team resources at our disposal and other, sometimes mysterious, feelings. Even the coming turn of the centuries took its role. We could not wait until the next summer and decided to organise the next expedition to the Krubera cave in the winter, a severe period in Arabika in terms of access and conditions at the surface. Among rational reasons for such decision was a fear of sudden flooding at great depths that could be expected in summer if the cave entered a hypothetical major river passage collector.

A core of the winter expedition, organised under the banner of the Ukrainian Speleological Association, was composed from the members of CAVEX (Cave Exploration) Association, a strong group of dedicated Kiev and Moscow cavers which have extensive experience of deep caving expeditions in winter conditions.

THE WINTER EXPEDITION 2000-2001

The expedition began on December 25 and consisted of eleven members: Yury Kasjan (the leader), Julja Timoshevskaja and Anatolij Povjakalo (all from Poltava, Ukraine); Oleg Klimchouk, Nikolai Solovjov, Sergey Zubkov (Kiev, Ukraine); Vitalij Galas (Uzhghorod); Konstantin Moukhin, Denis Provalov, Dmitry Skljarenko (Moscow, Russia) and Iljua Zharkov, for-

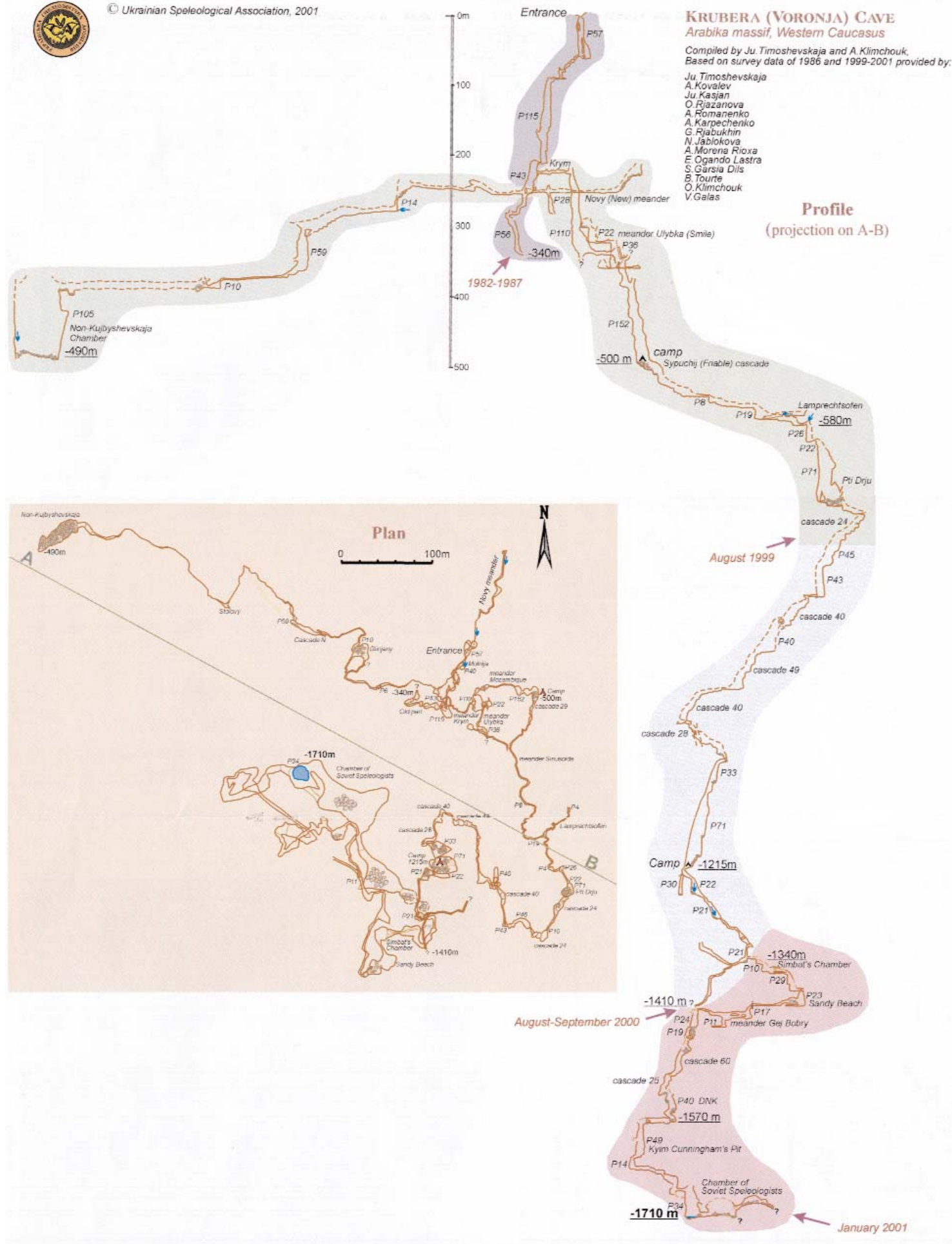


mer Sverdlovsk caver, currently based in Pennsylvania, USA.

On December 27 the expedition arrived in Sochi, the main city on the Russian side, and crossed the Abkhasian border. On December 28 a helicopter from Sukhumi, the Abkhasian capital, brought all members and expedition material to the Ortobalagan trough valley in Arabika. Work in the cave started on December 29 and in the same day the route was rigged to the first camp at -500m. Such a quick start was possible due to preparations made during previous expeditions and ropes conserved at the tops of main pits. By December 31 the route was rigged down to -850m and many bags transported to that point. Meantime, a special team widened three squeezes in the upper section of the cave (begun back in the 80s by Kiev cavers but still being hardly passable) to a degree that allowed easy travel of many people and bags back and forth through them.

On midnight of December 31 all the expedition members gathered on the surface, in a small cave near the camp, converted into a kitchen and dining room, to celebrate the New Year and the beginning of the new century and the millennium. Everything and everyone were prepared to achieve the new world's depth record. On January 1 the work in the cave continued. On the next day an advanced group set up the main camp at -1215m and now no one remained at the surface. All the expedition members carried out various tasks of this assault. On January 3rd the advanced group reached the "window" at -1340m and began new exploration. The right to descend the first new pit in this expedition was granted to the youngest member, Anatolij Povjakalo, who'd had his 18th birthday. By the end of the day a

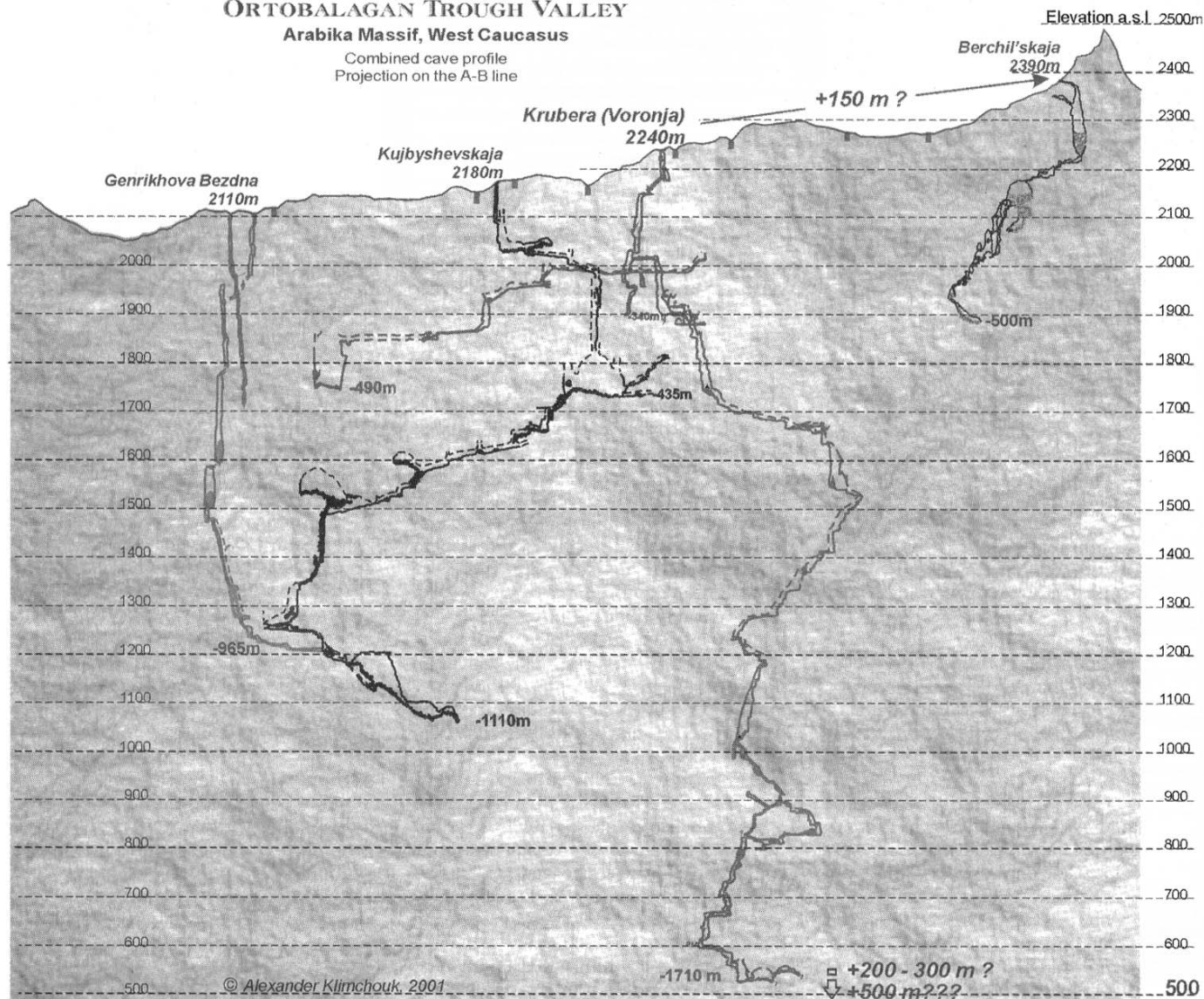




ORTOBALAGAN TROUGH VALLEY

Arabika Massif, West Caucasus

Combined cave profile
Projection on the A-B line



depth of about 1450m was reached. The previous depth record of Lamprechtsofen-Vogelschacht was broken during the night of January 4-5 by the pair of Moukhin-Zharkov. They descended a few new pits, including impressive P49 that went through almost black limestones, reached the depth of about -1680m, and stopped at the mouth of the next pit. This news, delivered to the camp at -1215 on the morning of January 5th, brought all its population into a great excitement. Next, two pairs of explorers went to push the cave further and Denis Provalov went to the surface to bring this news to the rest of the world via mobile phone. On January 6th the news was reported to civilization.

The pit at -1680m turned out to be the last one in this expedition. It led to a big chamber with a boulder choke in the far end, the deepest point reached so far (-1710m). A "window" above the boulder choke led to a series of smaller breakdown chambers but gave no apparent continuation. Four other expedition mem-

bers visited the bottom area for additional inspection, survey, and de rigging. The big chamber was named the Chamber of Soviet Speleologists, to appreciate the long and hard work of many generations of cave explorers of the former Soviet Union leading to this remarkable achievement.

By the night of January 9th all the expedition members and equipment were already on the surface. The next day was spent for recovery and on January 11th everything was prepared for evacuation by helicopter ordered for this date. However, the helicopter had not arrived due to weather conditions in Sukhumi. The time had come to pay for such smooth work in the cave. During the night the weather deteriorated dramatically in Arabika and on January 12th they bid farewell to their hope for a helicopter: a strong wind, heavy snowfall and low visibility. This continued through the next night and the weather forecast for the coming few days, received via phone, was unfavorable. Eventually, the team

decided to leave all the equipment but light camping stuff and force their way down by foot. It was a risky venture due to the apparent avalanche hazard on the way to the tree line, some 5km distance with a considerable traverse. The team, split in two groups, was making a trail through heavy snow with great difficulties when a big avalanche crossed the course just before the first group. It caught and buried a front man, Anatolij Povjakalo. He was immediately dug out, frightened but safe. The night was spent in a forest and in the afternoon of the next day, January 14, the team met a track in the Sandripsh canyon, led by local supporting person Vatik Vartanjan and a caver from Brest, Sergey Krasko. Sergey had arrived by air a day before to coordinate an expected rescue operation. This was a happy end of the active part of the expedition.

On January 16 the weather improved to a degree that allowed making a quick helicopter fly to Arabika to take away the conserved equipment. In Kiev and Moscow the expedition members were greeted by

Glaciokarstic landscape of the Arabika massif: the Zhovekvara trough valley

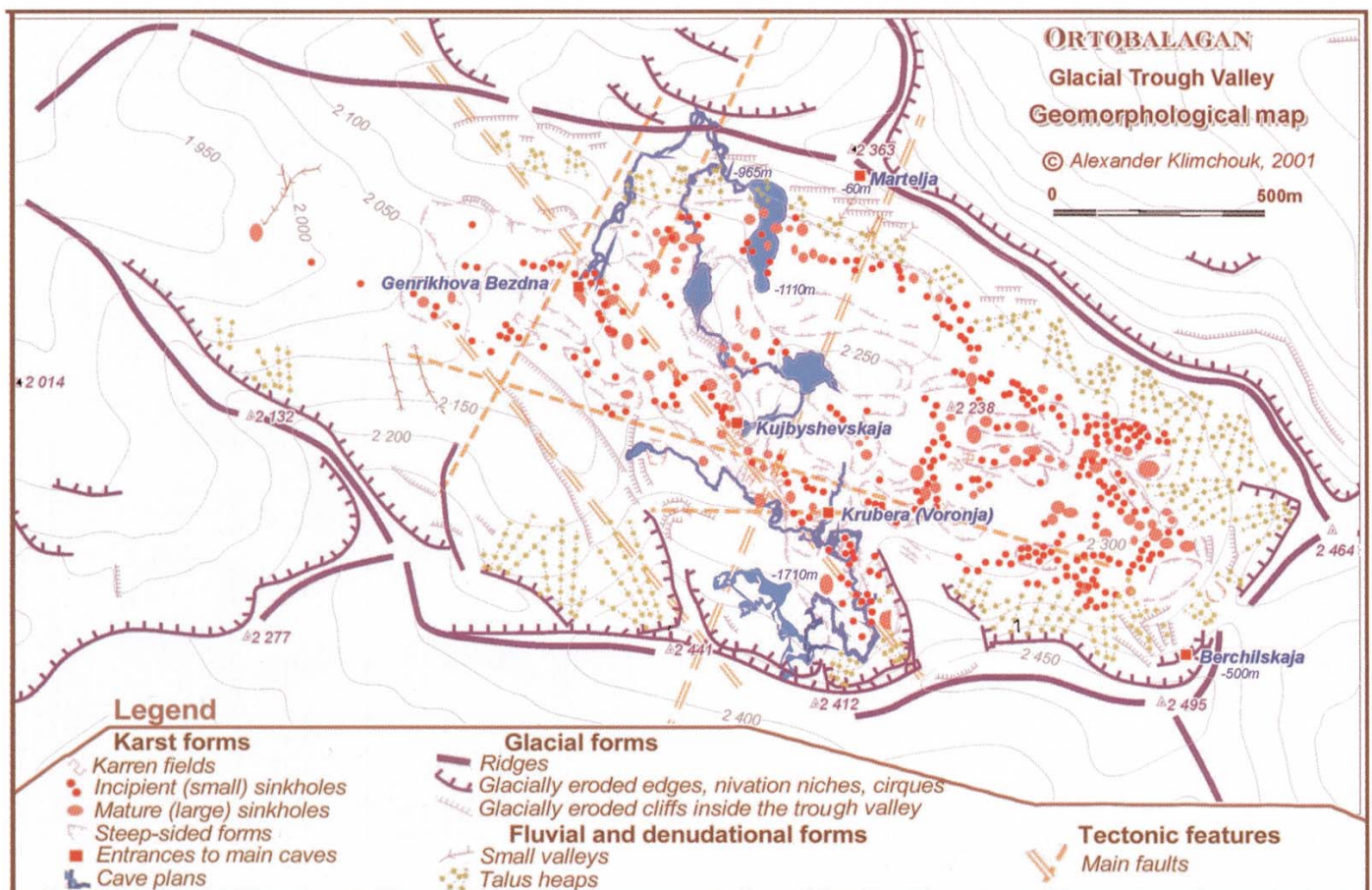


Figure 2: Geomorphological map of the OrtoBALAGAN trough valley



Glaciokarstic landscape of the Arabika massif: the Gelgeluk trough valley

orchestras, champagne, flowers, caving friends, reporters and television crews.

TECHNIQUE AND EQUIPMENT

The exploration was made using standard European single-rope technique and equipment. The total rigging required over 2000m of ropes and about 300 anchors. Almost everywhere ropes were rigged away from water flows and intense drips so that no dry suits were required to work in the cave.

During the winter expedition two underground camps were used, at -500m and at -1215m respectively. The former camp, located at the bottom of P152, is subject to rock fall hazard. For further works in the bottom area a camp can be set up in the Chamber of Soviet Speleologists at -1710m although a possibility of local flooding due to boulder choke constriction should be additionally evaluated.

The camp at -1215m could accommodate eight cavers. Exploration of the lower part of the cave proceeded continuously in two shifts, through the work of four pairs of cavers. All the expedition members had a chance to work in the bottom area below -1600m and nine of them were at the very bottom.

SURVEY AND DEPTH ESTIMATES

The survey of the cave was performed using Suunto and Soviet "geological" compasses and clinometers. In addition, two Casio watch altimeters were used to control the depth by repeated incremental measurements. The depth of the lowest point in the cave was 1720m according to altimeters, but 1710m according to the clinometer measurements; the latter figure was eventually taken as an "official" one. In general, the resultant map and profile (Figure 4) correspond to the BCRA Grade 4.

In September 2000 the MRDE team made independent depth measurements up to the -1410m point with two precise altimeters and found a coincidence within five meters with the depth estimates for various points previously made on the basis of clinometer survey.

BRIEF NOTES ON THE CAVE AND FURTHER PERSPECTIVES

The cave is developed in the thick-bedded and massive Upper Jurassic limestones, in the vault zone of the Berchil'sky anticline. The limestones become increasingly sandy starting from the depth of about 300m, with maximum sand content in the depth interval

of 400-600m, the feature previously noted for the adjacent Kujbyshevskaja Cave.

The main branch of the Krubera Cave develops steeply in depth by vertical pits separated by short meanders and shifts a little to the southern slope of the anticline. Apart from the "Non-Kujbyshevskaja" branch, which stretches for almost 500m to the north west, the cave is looping within a quite small area (400 by 400m), remains within a small tectonic block, and does not extend beyond the southern ridge of the trough valley.

By both the degree of morphological development and hydrologically, the cave cedes to the adjacent Kujbyshevskaja Cave. Small water flow (up to 1 l/sec) appears in the cave at the depth of about 340m. It disappears and reappears on various levels but never increases considerably. At its present bottom at -1710m (530m above sea level) the cave neither enters a main collector river passage nor shows any signs of considerable flooding that would indicate close proximity to its base level collector. These features, together with the previously proven connection of the Arabikskaja system to large springs at the Black Sea shore, suggests clear potential to deepen the cave by at least 150-200m (estimated conservatively) or up to 300-350m with more optimistic estimation.

Equally realistic is the attempt to connect caves with entrances that are at higher elevations into the Krubera Cave main system. The best prospects are the nearby Berchil'skaja Cave (-500m) entered 150m above, and Martel's Cave located some 80m above. Hence, the possibilities of gaining a 2000m + system in this area in the near future are exceptionally good. The Ukrainian Speleological Association and CAVEX Association will continue strong and regular efforts during next several years, both in summer and winter periods, in order to fully explore Krubera and other caves of the Ortobalagan trough valleys with an ultimate goal to explore the first 2000m + cave on the Earth.

ACKNOWLEDGEMENTS

The BASK and Alpinindustria companies based in Moscow donated some equipment to the winter expedition. The Canon representative office in Moscow sponsored us with video and photo cameras. We sincerely thank them for this help.

REFERENCES

- Kiknadze, T.Z. 1972. Karst of the Arabika massif. Tbilisi: Metzniereba. 245 pp. (in russian).
- Klimchouk, A.B. 1984. On impact of the late Quaternary glaciations on the karst development of the Arabika massif (Caucasus). Izvestia VGO (Leningrad), 116 (2). 165-170. (in russian).
- Klimchouk, A.B. 1990. Karst circulation systems of the Arabika massif. Peschery (Caves), inter- university scientific transactions, Perm: Perm University. 6-16. (in russian).
- Klimchouk, A. 1991. Le grotte del massiccio di Arabika. La Rivista del CAI, 112 (1). 37-47.
- Kruber, A. A. 1911. Karabi-Yuajla and the Arabika massif. Zemlevedenie (Moscow), 18 (3). (in russian).
- Kruber, A.A. 1912a. The voyage to Arabika. Estestviznanie i geografia. (in russian).
- Kruber, A.A. 1912b. From observations of karst in the vicinity of Gagra and Karabi-Yuajla. Zemlevedenie (Moscow), 19 (1-2). (in russian).
- Martel, E.A. 1909. La Cote d'Azur Russe (Riviera du Caucase). Ch. XVI: La massif de l'Arabika. Paris.
- Maruashvili, L.I., Tintilozov, Z.K. and Changashvili, G.Z. 1961. The results of speleological explorations carried out in 1960 on the Arabika limestone massif. Izvestia AN GSSR (Tbilisi), XXVI (5). (in russian).
- Maruashvili, L.I., Tintilozov, Z.K. and Changashvili, G.Z. 1962. Karst and ancient glaciation in Arabika. Abstracts of papers of the 2nd scientific session of speleologists. Tbilisi: AN GSSR. (in russian).
- Maruashvili, L.I. and Tintilozov, Z.K. 1963. The results of the recent speleological explorations in the karstic belt of the Western Georgia in 1957- 1960. Zemlevedenie (Moscow), nov. ser. VI. (in russian).