RONILAČKA ISTRAŽIVANJA U KRŠU

DIVING INVESTIGATIONS IN KARST AREAS

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Ispitivači krša često naiđu na potočne objekte kao što su pritočni i odtočni sifoni, sifonske provalije, izvori, vrulje i jezera.

Ispitivanja u karstnim objektima moguća su samo ako se raspolaže sa uvježbanim roniocima i to sa upotrebom moderne, opreme za jamska ronilačka ispitivanja. Ta oprema mora biti popuna i bez greške. Jamski ronilac mora da vlada sa jamskom i ronilačkom tehnikom. Mora biti psihofizički zdrav i pod stalnom liječničkom kontrolom.

1. Poteškoće

Kod jamsko-ronilačkih objekata susrećemo više poteškoća kao što su:
— niske temperature vode (4-12°C),
— dubina vode (do 80 m),
— dužina sifona (više od 100 m),
— plafon podvodnog rova je zaliven, pa radi toga nije moguć izlazak ako dođe do kvara na opremi,
— tama (mrak) (plivanje je moguće samo uz umjetnu rasvjetu),
— podvodna uska mjesta, stjenoviti noževi,
— tokovi — promjena vodostaja,
— slaba vidljivost radi podizanja mulja ili industrijskih otpadaka,
— jako ograničeno vrijeme ispitivanja.

Karst areas investigators often encounter flooded karst structures such as inlet and outlet siphons, siphon rifts, springs, submarine springs and lakes.

Investigations in karst structures are possible only with experienced divers and modern equipment for speleological and diving researches. The equipment has to be complete and in perfect order. Divers-speleologists must be experienced in speleological and diving techniques. They have to be healthy both physically and psychologically and under constant medical control.

1. Some Difficulties

In speleological structures filled-in with water there are quite a number of difficulties to face, such as:
— low water temperature (4-12°C),
— depth of water (up to 80 m),
— length of siphon (more than 100m)
— the ceiling of the underwater rift is flooded which prevents the exit in case of damaged equipment,
— darkness (swimming is possible only by means of artificial lighting equipment),
— underwater narrow passages, knife-edged rocks,

Svi ovi uzroci prouzrokuju kod neiskusnog ronioca strah, koji lako može da preraste u paniku. Radi toga je pravilo da se svaki jamski ronilac pridržava u granicama svojih sposobnosti i izvježbanosti.

2. Jamsko-ronilačka oprema

Pored klasične jamske opreme upotrebljavaju jamski ronioci još i slijedeću opremu:

— ronilačke boce sa odvojenim sistemom za disanje, kapaciteta boca je 500, 1000 i 3000 litara. Boce su međusobno povezane sa posebnim vezovima;

— dvostepeni regulatori disanja sa manometrom (najmanje dva na jednog ronioca);

— peraje, maska, pojas sa utezima i nožem;

— sigurnosna vesta, koja služi za uravnoteženje i kod savlađivanja podzemnih jezera;

— ronilačka odijela: suho neoprensko odijelo za hladne vode i za dulje korištenje, mokra neoprenska odijela (debljina 6-8 mm, rukavice i nogavice iz neoprena, donje rublje debljine 2 mm, koje se obuče ispod ronilačkog odijela,

— dekompresiometar, dubinomjer, podvodni sat i podvodni kompas, vreteno sa najlonskom vrpcom debljine 2-5 mm.

Vrlo važna je rasvjeta. Reflektor je različitih jačina, koji moraju biti pričvršćeni na sigurnosnim šljemovima, rade sa akumulatorima Ni-Cd. Jačina rasvjete je 2-500 W. Svjetla manje jačine upotrebljavaju se kao stalna rasvjeta, a jača svjetla služe za osvjetljavanje većih prostora i za traženje pravog puta pod vodom. Akumulator je pričvršćen na prsa ili na pojas.

— flows — level fluctuations,
— foor visibity due to silting and industrial wastes,
— very limited time of investigation

All the above mentioned difficulties can cause fear or even panic in an inexperienced diver. The rule, therefore, is that each diver-speleologist should be aware of his abilities and knowledge and act accordingly.

2. Caving Equipment

Besides the classical caving equipment, the divers-speleologists must have the following equipment as well:

— diving scuba with separate breathing systems of the capacity of 500, 1000 and 3000 litres. The air tanks are connected by special binders;
— two-stage breathing regulators with manometer (at least two per a diver);
— diving flippers, goggles, belt with weights and a knife;
— a life jacket which helps to keep balance and also in underground lakes swimming;
— diving suit: dry neoprene suit for cold waters and longer use, wet neoprene suit (6-8 mm thick), gloves and leg cuffs made of neoprene, underwear 2 mm thick;
— decompression meter, depth meter, underwater watch and compass, a reel of nylon cord 2-5 mm thick.

Lighting is very important. Lamps of various strength (2-500W) are fitted to helmets and are supplied by Ni-Cd batteries. Less bright light is used as the main lighting and is constantly on, while stonger light is used for lighting larger spaces and for finding the way under the water. Storage battery is fastened to either the breast or the belt.

Pored ove opreme upotrebljavaju se kompresori za punjenje boca sa zrakom, podvodne kamere, podvodni fotoaparati, podvodni bežični telefoni, sonder za mjerenje odstojanja, posebne posude za transport opreme, tablice za zapisivanje podataka, u izradi je još i radiolokator.

3. *Načini jamsko-ronilačkih ispitivanja za hidrološka ispitivanja*

O svakom jamsko-ronilačkom objektu potrebno je sakupiti čim više podataka. Vrlo važan je opis samog pristupa do jamsko-ronilačkog objekta i geološki opis zaleđa. Iza toga je potrebno ugotoviti njihanje vodostaja, temperaturu vode i čistoću. Sa bojadisanjem utvrđujemo vodne veze. Za svako ispitivanje treba izraditi plan.

Obično u sifon plivaju dva ronioca i to tako da prvi odvija sigurnosnu vrpcu, dok drugi ronilac, koji se nalazi iza prvoga oko 3-5 m, vrpcu pričvršćava na (stjenovite izraslihe) stijenu da ne zađe u pukotinu. Ronioci plivaju uz plafon ili uz stijene. Na taj način manje mute vodu a i orijentacija je lakša. Ronioci između sebe komuniciraju telefonom ili ronilačkim znakovima.

U vrlo uskim sifonima sa naslagama mulja obično pliva naprijed jedan ronioc koji si sam pričvršćuje vrpcu. Drugi pliva za njim istom poslije određenog vremena. Cijelo vrijeme moraju ronioci kontrolisati dubinu, vrijeme, smjer i pritisak zraka u bocama.

Zrak upotrebljavaju naizmjenično iz obje boce tako da 1/3 zraka potroše za ispitivanja, 1/3 za povratak, a 1/3 imaju kao rezervu.

The equipment also includes compressors for air tanks filling, underwater cameras, reel cameras, telephone, a sounder for distance measurements, special containers for equipment transportation, special tables for data recording, and the like.

3. *The Speleological and Diving Investigation Methods in Hydrology*

It is necessary to gather as many data as possible on each speleological structure with water in it. Very important is the description of the access to the structure, as well as the geological description of its hinterland. It is also necessary to find out the changes in water levels, water temperature and turbidity. Water connections are defined by the use of tracers. Each investigation should be planned in advance. Two divers usually go into a siphon making thus a team in which the first one undoes the safety rope, while the other diver, being about 3-5 metres behind the first one, fastens the safety rope to rock protuberances. The divers swim along the ceiling or walls. In this way they stir up the water to a lesser extent and make the orientation easier. The divers communicate either by telephone or diving signs.

In very narrow siphons with mud deposits, one diver swims ahead fastening the safety rope by himself. The other diver swims after him after the agreed-upon time. All the time the divers have to check up the depth, time, direction and the air pressure in the tanks of their scubas.

The divers use the air from both tanks alternately, using 1/3 of the air during the investigation, 1/3 for return, while 1/3 remains as a reserve.

Kod dužih i dubljih potapanja puštamo boce za zrak na određenim mjestima. Rezervne boce puštamo i na dubinama koje su potrebne za dekompresiju (12, 9, 6 ili 3 m).

Kada ronioci preplivaju sifonsku zapreku, u prvoj akciji ispituju što više novih dijelova. Saberu samo osnovne podatke (smjer, dužina, dimenzije i oblik rova). U kasnijim ispitivanjima saberemo što više podataka i izvršimo tačna mjerenja. Nove dijelove fotodokumentiramo. Kod mjerenja podvodnih dijelova čitamo dužinu na već prije naznačenoj vrpci. Naklon dobijemo iz podatka o dubini na određenoj tački. Pored pomenutih podataka sa jamsko-ronilačkom metodom možemo doći i do uzoraka dotoka sa strane, lako bojadišemo odtoke u zaleđu vodene zapreke ili u samom jamsko-ronilačkom objektu. Ronioci lako postave pod vodom razne instrumente.

Podaci dobiveni sa jamsko-ronilačkom metodom su dosta tačni i mogu se provjeriti. Taj način ispitivanja je srazmjerno jeftin i dosta brz. Većinu ispitivanja mogu da obave 2-4 ronioca.

4. Važnija jamsko-ronilačka ispitivanja i njihova važnost

U Sloveniji je u zadnjih 15 godina na taj način ispitano oko 80 jamsko-ronilačkih objekata. Među naša najveća otkrića ubrajamo vezu Magdalene i Črne jame preko dva sifona. Postojnski jamski sistem je s tim postao duži za 4 km, i tako je najduži u Jugoslaviji. U tom sistemu je ispitano 7 sifona, a u 4 su potrebna još dalja ispitivanja.

U Tkalci jami kod Rakovog Škocjana je potopljen 150 m dug i 25 m du-

In the case of longer and deeper diving the air tanks are left at certain places. The spare tanks are left at the depths of decompression (12, 9, 6, or 3 m).

When divers first swim across a siphon they try to investigate as many new parts as possible. They gather only the basic data (direction, length, size and the shape of the rift). In further investigations, however, they try to gather as many data as possible and they carry out the accurate measurements. New parts are photographed. When measuring the underwater parts, the lenghts are read by means of a previously marked rope. The inclination is computed from the data on depth and length between certain points. Apart from the above mentioned data, the caving method also provides water samples from the main watercourse and the underground tributaries and it also enables the water tracing in the hinterland of the water barrier or in the very speleological structure. Divers can attach various instruments under the water.

The data obtained by caving and diving investigations are quite accurate and can be checked. This way of investigation is rather cheap and fast. Most investigations can be carried out by 2-4 divers.

4. The Relevance of Some Caving and Diving Investigations

In the last 15 years about 80 speleological structures with water in them have been investigated in this way. The connection of Magdalena and Črna Jama by two siphons can be taken as one of the most important discoveries. In this way the Postojna

bok sifon, a za njim je ispitano 1800m jame, na to je potopljen drugi 60 m dug sifon, a za njim se nalazi još 150 m jame.

Produženje će biti moguće kroz treći sifon. Ispitivanja u ovom sistemu su važna radi utvrđivanja vodnih tokova u zaleđu postojnskog vodovoda.

U Drči jami na Krasu je izmjeren podvodni dio jame te određeno najdublje mjesto. Na podlogi naših mjerenja je bila izvedena 70 m duboka bušotina. U jami je pronađen Proteus, što je dokaz da se u jami nalazi tekuća voda. Kasnija ispitivanja su pokazala da će ta voda zadovoljiti za višegodišnje napajanje većeg dijela Krasa. Vodovod je u izgradnji.

U izvoru Vrelo u Zavidovićima su uzeti uzorci vode iz više otvora na dnu sifonskog bazena. Na te otvore su pričvršćeni instrumenti. Podvodni dio je izmjeren i fotodokumentiran. Naša ispitivanja su pridonijela ka boljem poznavanju hidroloških uslova u izvoru, koji napaja vodovod Zavidovića.

Jamsko ronilačka ispitivanja su izvršena i u Divljem jezeru, koje je duboko preko 50 m, u izvoru Soče i Vipave, gdje smo ronili do dubine 30 m, u izvorima Ljubljanice, koji su ispitani 300 m daleko i 25 m duboko.

Za 15 godina se je u jamsko-ronilačkim objektima u Sloveniji smrtno unesrećio jedan jamar. Uzrok smrti je bilo nepoznavanje tehnike jamskog ronjenja i u nepotpunoj opremi. Pretpostavljamo da je to bio isti uzrok nesreće kao prije nekoliko godina u Čapljini.

Važnost jamsko-ronilačkih ispitivanja je za lakše razumijevanje hidroloških pojava vrlo velika. Nažalost

cave system has become 4 km longer, being so the longest cave system in Yugoslavia. Seven siphons in this system have been investigated, while further investigations have to be carried out in other 4 siphons.

At Tkalci jama near Rakov Škocjan, there is a flooded siphon 150 m long and 25 m deep, followed by 1800 m of the cave system, another siphon 60 m long and by further 150 m of conduits.

Further continuation might ensue through the third siphon. The investigations in this system are important in order to find out the water courses in the hinterland of the Postojna water supply system.

In Drča jama in Kras an underwater part of the cave was measured and the deepest point determined. On the basis of the measurements a 70 m deep borehole was made. Proteus was found in the cave which proves the existence of running water. Further investigations have revealed that this water could satisfy several years' requirements of a larger part of Kras. The water supply system is in the course of construction.

In the spring Vrelo at Zavidovići, water samples have been taken from several openings at the bottom of a siphon. Instruments have been attached to the openings. The underwater part was measured and photographed. Our investigations have contributed to better knowledge of hydrological conditions in the spring which provides the Zavidovići water supply system with water.

Caving and diving investigations have been carried out in Divlje jezero (Wild lake) which is more than 50 m deep; in the springs of Soča and Vipava the diving was carried out up to 30 m in depth and the springs of

taj važan i obiman rad zahtijeva mnogo vremena i finansijskih sredstava što obično prelazi amaterske mogućnosti.

Ljubljanica were investigated 300 m in length and 25 m in depth.

For the 15 year of caving activities in speleological structures with water in Slovenia only one speleologist has lost his life. The cause of death was the inexperience in speleological and diving techniques and inadequate equipment. The assumption is that the same reasons caused the accident at Čapljina a few years ago.

Caving and diving investigations are of special importance for the research in and better understanding of karst phenomena. Unfortunately, this important and comprehensive task requires too much time and money which is beyond the means of an amateur.