Geophysical Research Abstracts
Vol. 16, EGU2014-5279, 2014
EGU General Assembly 2014

Some deep caves in Biokovo Mountain (Croatia)

Mladen Garasic (1) and Davor Garasic (2)

(1) Faculty of Civil Engineering, University of Zagreb, Geotechnical, Zagreb, Croatia (mgarasic@public.carnet.hr), (2) , Society for the Research, Surveying and Filming on Karst Phenomena (DISKF)"Zagreb" (dgarasic@lycos.com)

The investigation of 3 caves explored more than 1000 meters in depth in the Dinaric karst area in Croatia, has been in progress for a considerable period of time. These are complex speleological features situated in the longest mountain range of the Dinaric karst, i.e. at the Northern Velebit mountain range. In fact, these caves have been studied for over two decades now. The first one is a cave system of Lukina jama (Luke's Cave) – Trojama cave, which has been investigated until the depth of 1421 meters (Jalžić, 2007; Šmida, 1993). Its total length is 3731 meters and a new expedition will soon continue to investigate this pit through speleodiving in siphons. The second greatest cave by depth is Slovačka jama (Slovak Cave), 1320 meters in depth, with cave chanals measuring 5677 meters in total length. The third greatest cave by depth is the Cave system of Velebita, reaching down to 1026 m in depth, with the chanal length of 3176 meters (Bakšić, 2006a; 2006b). However, another 3 speleological sites, which can rightly be added to those deeper than 1000 m, have recently been discovered. These are three caverns that were discovered during construction of the Sveti Ilija Tunnel that passes through Mt. Biokovo, in the Dinaric karst area. These caverns undoubtedly point to the link with the ground surface, while the rock overburden above the tunnel in the zone where the caverns were discovered ranges from 1250 and 1350 meters. Bats from the ground surface were found in the caverns and, according to measurements, they are situated in the depth from 200 and 300 meters below the tunnel level. This would mean that the depth of these newly found caves ranges from 1450 and 1650 m, when observed from the ground surface. There are several hundreds of known caves in Biokovo, and the deepest ones discovered so far are Jama Mokre noge (Wet Feet Cave) 831 m in depth, and Jama Amfora (Amphora Cave) 788 m in depth (Bockovac, 1999; Bakšić & all, 2002; Lacković & all, 2001),. The investigations and measurements are still in progress.

State of the art speleological methods were used for measuring vertical distances and geological parameters. A special attention was paid to the radon concentration measurement, and to chemical analyses of ground water.

According to current speleological site classifications (Garašić, M. 1986, 1991), the caves discovered at KM 1+415, KM 1+193, and KM 1+637, are large-size vertical speleological sites (caves) of an elbow shaped morphological type, characterized by the occurrence of the so called "false bottoms", with heigh differences of about 297 m, 268 m and 203.5 m, respectively. This is the zone of the highest tunnel overburden (from 1300 to 1380 m). This means that the deepest parts of these caverns (accessed by bats from the ground surface rather than from the tunnel) sometimes extend to 200-250 m below the tunnel line. Therefore, from the standpoint of geology, these sites can be classified among the deepest speleological sites discovered so far in Dinara karst in Croatia (Garašić, 1986; 1989; 1991; 1995). The depths from the ground surface range from 1350 meters to possible 1650 meters.

Some speleologists will rightfully argue that no one has as yet descended into these caverns from the ground surface, and that their relative depth is smaller. Nevertheless, the objective geological depth established in this karst complex is certainly one of the greatest in Croatia. This has also been revealed by measurement of ground water properties and temperature, Rn-222 and Po-218. It was established that these properties are comparable to those measured at other deepest speleological sites in Croatia. This will however be demonstrated during subsequent investigations.

From the hydrogeological standpoint, it can be stated that intermittent and maybe continuously active underground streams run through these speleological sites. The presence of dripping water has also been established. This dripping water exerts an intensive chemical action on the surrounding rocks (corrosion), which results in formation of underground karrens. Smaller parts of these caverns are covered with speleothems (dripstone formations). The palaeo-hydrogeological function of these caves is characterized by sinkholes on the ground surface (although their entrances are most probably now caved-in or yet undiscovered), and perhaps by a part of cave canals of a swallow hole (ponor) in the Biokovo hinterland (which is less probable because of intensive neotectonic uplift of this mountainous mass).

Inaccessible bottom, northern and eastern parts of the cavern might be linked with the speleological system of caverns passing through Biokovo and participating in formation of submarine springs in the sea below Biokovo. In

fact, the ground water found in these speleological sites has to pass either below or through the Sveti Ilija Tunnel, as it re-emerges from numerous submarine springs in the coastal area of Makarska (from Dubac to Podgora and Drašnica) (Alfirević, 1969). The depth of karstification (weathering) in the zone of this speleological site is estimated at several hundreds of meters, with an estimated maximum of 1500 meters, while the zone of vertical circulation ranges from 500 meters to 1700 meters. This is followed by the zone of inclined or horizontal circulation through which the water is carried toward the Adriatic Sea. Impermeable Triassic and maybe even Palaeozoic clastite or dolomite formations are situated in the substratum. As Triassic dolomites are from the hydrogeological standpoint permeable, due to intensive secondary porosity (jointing), it can reasonably be expected that several similar and genetically correspondent joints, formed in the anticline due to general subduction, are situated in continuation of these sites (or are parallel to them). These possible caves are not accessible from the surface and might be linked to the mentioned hydrogeological system in the lower parts of Biokovo. A note should also be made of the Pavlinovići cave situated some ten kilometres to the northeast of the tunnel, where the ground water oscillation of as many as 236 meters has been registered. This information is particularly relevant for the tunnel zone approaching the impermeable substratum. In fact, such increase in the ground water level shows that sometimes in rainy season the capacity of underground chanals becomes insufficient to transport the water through Biokovo toward the sea, and so the water level rises enormously once this temporary hydrogeological barrier is reached.

Based on the position, morphology and other geological characteristics of three newly-investigated vertical caves situated in the service tube of the Sveti Ilija Tunnel, it has been established that the speleogenesis of these caves can be compared with that of other deepest caves in Croatia. Although the caves were not accessed from the ground surface, i.e. their entrances are about 1300 below the ground surface, they have most certainly been formed under conditions of intensive weathering and can as such be analysed from the geological point as well. An excellent correspondence of their occurrence shows that statistical processing of caverns located in tunnels is finally giving some results in correlation with the tectonics. It should also be noted that a certain trace of karstification and dripstone formation has been found in Croatian karst in a deep borehole in the Adriatic Sea, where a speleothem was found at the depth of 3125 m in a smaller cavern.

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