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Scientific Research of Škocjanske Jame Caves (UNESCO World Heritage) – since Antiquity to Modern Times

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Abstract

Posidonius (135-50 BC) studied springs of the Timavus River and he was the first to state, to be later repeated by Strabo, the hydrological connection between Škocjanske Jame Caves and ?karst springs. One of the earliest water tracings that proved the mentioned connection was published by F. Imperato in 1599. Valvasor only mentions the caves but due to heavy access he did not make any research. In the middle of the 19th century modern exploration of caves started with purpose to find out where the underground river is flowing. The task was fulfilled at the end of the century. When the members of the cave department of the DÖAV Section Küstenland took over the exploration they already have scientific observations in mind. They regularly measured temperatures outside and in the caves. Meteorological (speleometeorological) research continues through the 20th century and turned out to regular monitoring. Different methods of water tracing were carried out from the beginning of the 20th century. Škocjanske Jame hydrology was the topic of the first doctoral thesis in 1924 already. Its attraction for doctoral studies continued and still today there are advanced-degree candidates working on the caves. Regarding the fact that caves are near the border, they were object of some bilateral research projects too. Partly published bibliography of Škocjanske Jame contains 399 works and many of them are results and reports of scientific research. As for the conclusion it can be said that more research and scientific data are gathered, more interest and need for new and deepened researches occur.

Keywords

Karst, cave research, cave history, Škocjanske Jame Caves, UNESCO Natural Heritage.

Introduction

Škocjanske Jame Caves with its underground river, discharge reaching nearly 300 m^3/s^{-1} when full, with immense underground voids (Martel's Chamber over 2 millions m^3), and underground canyons, are the most important and impressive caves of the larger region. Therefore it is not surprising, that man took interest in them very early; almost 200 years they are open for tourists, and they are among the first caves inscribed on the UNESCO List of World Heritage, as a Natural Heritage (1986). Palaeolithic man used them for shelter, during later periods, during the Iron Age especially they served as a sort of sacred place, used for a cemetery and for special funerary ceremonies (BELTRAM et al. 2012).

Archaeological researches prove that man in prehistoric times descended to the bottom of collapsed dolines, to the entrances of the caves, and to the sinking river at their bottom. It is not sure that later people ventured so far. VALVASOR (1689) for example knew the caves just from the surface and did not report that people visited the bottom or the river. Not earlier as at the end of the 18th century the painter's Cassas illustrations showed the view from the bottom of the 160 m deep collapsed doline at the caves' entrance (LAVALLÉE 1802). Due to technically very difficult exploration the first researcher-caver known entered the caves few years before 1818 (HOPPE & HORNSCHUCH 1818). Attempts to follow the underground river in years 1839-1840, and in 1851 offered no important result until the foundation of the Cave Department of the "Section Küstenland" of the "Deutsche und Österreichische Alpenverein" at Trieste in 1884 (PAZZE 1893). To 1893 they explored the main parts of the caves and reached the final siphon; in 1904 the so called "Tiha Jama (The Silent Cave)" (upper levels of the caves) was discovered, and in 1991 the final siphon was dived through and the channels behind it were seen by the man for the first time (MOREL 1992). This speleological research as heroic as it was cannot be called scientific research although a real scientific research aimed to inventory or monitoring is impossible without previous serious speleological research, including the survey. The last detailed and accurate plan by the help of laser telemeter and profiler was achieved during 1990-ties (MIHEVC 1995).

Scientific Research

Hydrology

Definition of the scientific research depends upon the time and the type of society or its evolution. Therefore some old authors can be mentioned although their work and writing is not conformal to the modern sense of scientific

research. For the scholars who could not enter the caves, the sinking Reka River was of the main interest. This is also the reason why the hydrological research of Škocjanske Jame and the Reka-Timavo River are emphasized in the present paper. The very first we know till now that had mentioned Škocjanske Jame was Poseidonios of Apameia (135 – 50 BC) who studied the springs of the Timavus River on the Adriatic coast on account of his interest in tide. He writes that "...a river, the Timavus, runs out of the mountains, falls down into the chasm, and then, after running underground about 130 stadia, makes its exit near the sea." By the chasm are meant Škocjanske Jame. Did he ascertain this hydrological connection, that the river from Škocjanske Jame flows underground to the springs of Timava River by the field study or he just "knew" it, we do not know. The next who studied Škocjanske Jame hydrology was Ferrante Imperato (1525? – 1615?), an apothecary of Naples, who in his work on Historia Naturale (IMPERATO 1599) writes that he unsuccessfully tried to prove the connection between Škocjanske jame and Timava springs by "floaters". Also the first attempts of water tracing by different "colorants" can be attributed to Škocjanske Jame study. P. Kandler (1804-1872) who said by himself that he "explored as much as possible the underground and surface river courses" (MERLATO 2013), traced the sinking Reka River by "blue dye", that is indigo, in 1864, but the result is unknown. It was F. Müller who was the first to make a successful tracing by Uranine in 1891. The first aim was thus achieved: the connection between the Reka River in Škocjanske Jame and the springs of the Timavo was proved. But to find out hydrological details, quantities of water, different effluents, water velocity, chemical composition, etc. many years and many researches were needed. At the beginning of the 20th century tracing experiments with lithium chloride and radioactive substances were performed by Timeus and Vortman, later (1961-1964) tritium was used (D'AMBROSI 1964). Beside very special research the general works on hydrology were published. One of the first and really detailed was Oedl's in 1924; at the same time, his work was probably the first dissertation having hydrology of Škocjanske Jame as the thesis (OEDL 1924). Among the complete published studies the book Il Timavo must be mentioned as it includes all the previous data (BOEGAN 1938). Hydrological research continued up to nowadays. Some researches are more oriented towards general characteristics, as are water balance and watershed calculations, while the others are more specific, often related to general trends of the period. Such examples are studies of water pollution and protection, hydrochemistry, percolation water (Fig. 1). More and more attention is paid not to singular measurements but to monitoring of different parameters (CUCCHI et al. 1997) or different events (GABROVŠEK & PERIC 2006) (Fig. 2). Although now is the time of very detailed and sophisticated analyses the general works and works of synthesis are not missing, as shows recently published book on water tracing of the Timavo (GALLI 2012). The above mentioned studies on hydrological research are based on publications. But observations and researches which were never published exist also. Such an example is so called "Höhlenbuch" (Cave Book), hand written diary of the Caving Department of the "Section Küstenland". Marinitsch who visited caves practically every Sunday, measured air temperature on the surface and on different points in the caves as well as the temperature of the Reka River and noted the data beside other information in the mentioned "Höhlenbuch", for the period 1886-1914. I am sorry to say that the last traces of this book are from the "Haus der Natur" in Salzburg, but where the book is now is unknown to the author. In recent times there were projects which included hydrological research but the results were never published, such as the international IGCP-UNESCO Program No. 299 Geology, Climate, Hydrogeology and Karst Formation.

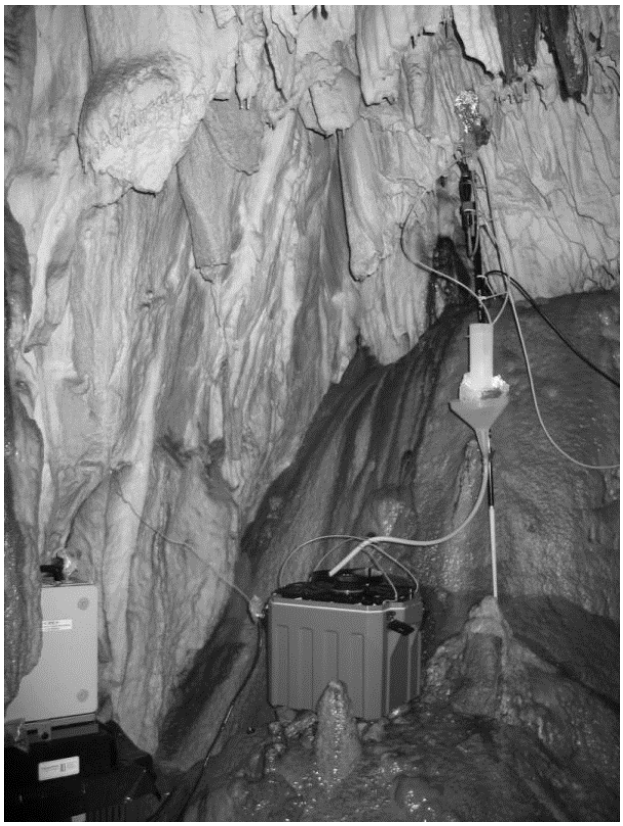

Figure 1: Automatic sampling of percolation water (Photo J. Kogovšek).

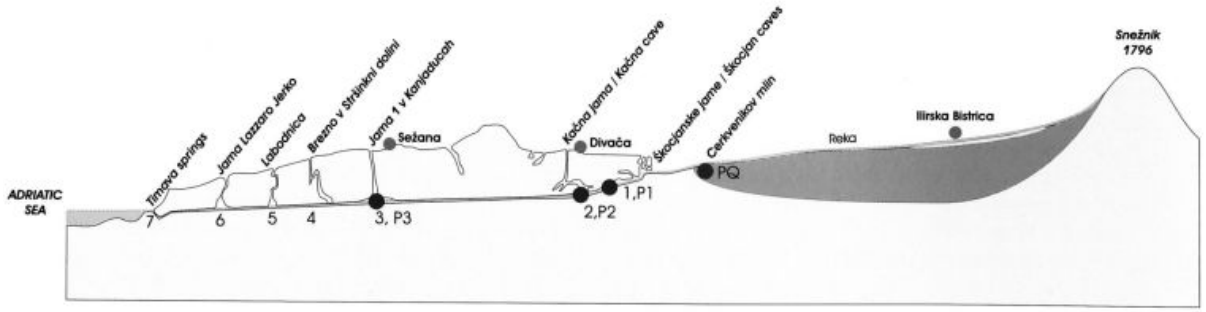

Figure 2: Measurement points for the flood pulse observation downstream the underground Reka River (after GABROVŠEK & PERIC 2006).

Other Physical Characteristics

Since 1956 deepened geological researches of the caves themselves or of the larger region, including the caves started. Geological research does not mean just traditional geological mapping and defining the type and age of a rock, but it includes special researches. Special attention was paid to the study of bedding planes in the entrance wall of the caves, to find out which and why galleries developed along the specific bedding planes. The result of the research was the doctoral degree in geology and the publication of the book on this topic (KNEZ 1996). The importance of Škocjanske Jame can be seen by research techniques and methods used. The first electromagnetic research was performed in 1931 already (SOLER 1931) and followed in the years 1954 and 1957. Study of sediments merit to be mentioned separately, both study of chemical sediments – flowstone, and of fluvial ones. There was research of speleothem forms, intensity and principles of its deposition. It included also the dating of speleothems, one of the first performed on the karst of Slovenia (GOSPODARIČ 1981). "Ponvice" (Massive Gours) are a sort of symbol of Škocjanske Jame and recently specific research project was proposed: "Gours in Škocjanske Jame – condition, protection, and regeneration" (Fig. 3). Fluvial sediments carried by the river into the caves were studied mostly in 1980-ies and a part of gathered data and analyses were used for the preparation of a doctoral thesis in geography (KRANJC 1989). Climatic or better speleoclimatic or microclimatic observations at the end of the 19th century were already mentioned. According to the instruments available at the time, first monitoring of microclimate in the caves started in 1928 (VERCELLI 1931). In the collapsed doline the temperature inversion was observed in 1960-ies and detailed study of temperatures along the underground river was performed in 2000 (KRANJC & OPARA 2002) (Fig. 4). The gathered data were the base for the preparation of the university diploma. Regular temperature monitoring is performed nowadays as a part of general monitoring system, but it cannot be treated as the scientific research any more, this is just useful and necessary practice. The cave air was the object of other observations too – the content of the radon and the composition of aerosol, started in 1979. In the recent time it too became a part of regular observations.

Figure 3: "Ponvice" (Gours) at Škocjanske Jame (photo Archive of Park Škocjanske Jame).

Biology

The first researchers interested in speleobiology have dealt mainly with the study of Copepods (KIEFER 1930). Also later efforts in 1960-ies and 1980-ies were dedicated to Copepod studies. Proteus practically does not live in the caves in a strict sense and therefore it is seldom mentioned. Research was focused on eels and their migrations with the aim to use them as a natural tracer for underground water connections (SELLA 1929). Škocjanske Jame are wintering place for bats, their population began to be seriously followed in 1971 (FRANK 1971). It seems unusual that a lot of work was consecrated to the study of flora and speleoflora especially. In collapse dolines where some of caves entrances open, the temperature inversion occurs and they contain so called relict flora, while mosses and lichens penetrate deeper in the passages. Thus these types of flora representatives were studied

mostly and even started early (MORTON 1935). Recently the research is oriented to smaller living creatures as are algae, bacteria, and meiofauna (GERIČ STARE et al. 2004). This research is performed as the basic research as well as directly applied or useful research for cave managers and cave protection regarding algae growth and "Lampenflora" in general (MULEC et al. 2007; MULec & KOSI 2009).

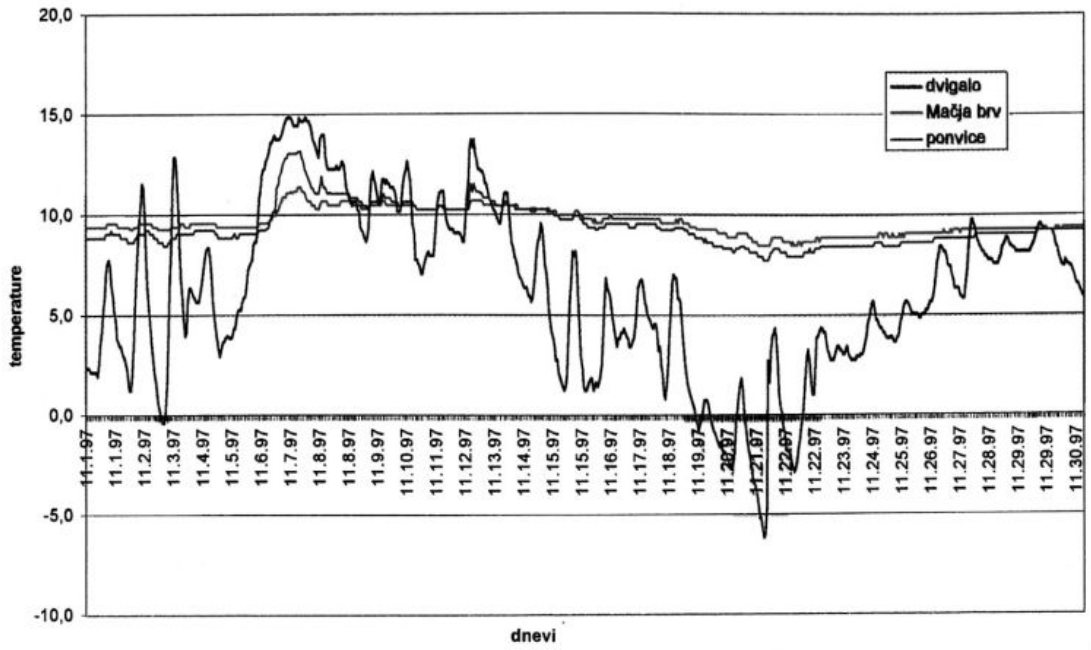

Figure 4: Hourly air temperature curves (October 1997) (KRANJC & OPARA 2002).

Archaeology

Regarding the fact that interest in Škocjanske Jame can be traced far back, through prehistorical and historical periods it is normal that the traces of man activities can be found in the caves, at the caves' entrances, and on the surface above the caves. Therefore Škocjanske Jame are an important archaeological object. The first known archaeological research started in 1888 (MARCHESETTI 1889) and the investigations continued through Austro-Hungarian (SZOMBATHY 1913), Italian (BATTAGLIA 1924), and Yugoslav (LEBEN 1956) periods to present (POHAR 1995). In the Park Škocjanske Jame the museum collections are sheltered and put into the exhibition also as a result of special research project. General topographic names are material remains just when cut in the rock or written on a durable plate, nevertheless they constitute an important part of cultural heritage which is evident especially in the case of Škocjanske Jame. Local Slovene names existing before the Cave Department of "Section Küstenland" took over the explorations were assigned just for the caves and surface features around and above them. During the exploration and simultaneous preparation of tourist walkways the cavers named passages and chambers as well as small geomorphological details in German language. Under the Italian period (1921-1943) all the names, Slovene and German were translated in Italian or completely altered and in Yugoslav period Slovene names appeared (KRANJC 1994).

Conclusions

It is impossible to enumerate all the scientific researches performed in Škocjanske Jame during the last four centuries. For the past periods the access to original reports if they were ever made at all is very difficult or even impossible. For the recent period, let us say for the last few decenniums, they exist but even now it is quite difficult to find them in various libraries, institutes, ministries and local departments... So this review is based mostly on publications up to 1986 when Škocjanske Jame became the World Natural Heritage. In the bibliography of Škocjanske Jame (KRANJC 1996), which cannot be complete, there are 399 entries, most of them are reports of researches or based on such researches. In addition to this bibliography, published 5 years later, there are another 191 entries (KRANJC 2001). It is difficult to establish their number after 2000, in any case there are many of them. Just for the illustration: in the journal Acta carsologica, published in Slovenia but having international character, there are 37 papers related to Škocjanske Jame published in 41 volumes.

It is well understandable that after 1986 the number of (proposed) projects for Škocjanske Jame research augmented. They are at least 15 having as a topic general (complex) research "Škocjanske Jame and its surrounding" for example, to very specialized as "Waste removal and reconstruction of the walkway in Hanke's Gallery". These projects were financed by local or central administration, through INTERREG (Slovenia-Italy) or through international (IGCP No. 299) projects, often supported by Slovenian Commission for the UNESCO. What is it possible to see from this short review of research? That important caves are intimately connected with research – the cave which has no base in scientific research cannot be of great importance, especially not World Natural Heritage, and the important cave has great opportunity and means to initiate and to support scientific research. And more research are done, more scientific data gathered, greater is interest and need for new and deepened research.

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