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CAVE AREA OF THE CANIN-PLATEAU – A NATURALLY GEODIVERSE LAND IN THE MIDDLE OF EUROPE

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Summary – The Canin-Plateau (Julian Alps) I one of the most extended karst massif of Erope. This study introduces the area from the point of view of geodiversity, describes its geological, hydrological struvtures, cave development and the climatic periods of karst development. The plateu has different hydrological zones, which shows different cave morphology. The underground and surface karst development has followed the changes of the climate in the Pleistocene. The research of this unique geographic land is important to reserve the geodiversity of the karst face.

Key worlds: Canin-plateau, geodiversity, geology, tectonics, hydrology, karst-development, alpine tourism

1. INTRODUCTION

The interdisciplinary research of the natural and man-made environment of humanity is getting more important. One of the most important results of such research is the knowledge about biodiversity. The diversity of the animals, plants, and other kind of living beings all around in our environment is based on the variousness of the habitat, and on the connections and processes between the types and levels of the different habitats. There is strong relation between the conditions of the abiotic environmental elements and the complexity, stability and the ability of regeneration of the living environment. Thus the basis of biodiversity is geodiversity. Nature conservation can only be based on considering both of these two ideas (Keveiné Bárány 2008).

Relying upon these findings, mapping our environment from the point of view of geodiversity is one of the primal tasks, and it is important to highlight the naturally stable zones and those endangered by human impact.

Europe is covered with a network of human activity. This study presents a naturally stable, geodiverse land, the Canin-plateau, which is situated in the middle of Europe. This study shows the special values of this land, the factors ensuring its stability, and the potential dangers.

Karsts are important objects of geodiversity research, because of the complexity of their biotic and abiotic processes. The Canin is one of the most extensive deep-karst systems of Europe. While the surface and the processes on the surface can be surveyed using remote sensing methods, the collection of information from the deep-karst zone is only possible with speleology. Explorers from different nations, e.g. Italians, Slovenians,

Polish, Czechs and Slovaks have worked on the speleological discovery of the depths. The Hungarian team has been working on the exploration for 15 years and got excellent results.

The knowledge and information collected in the course of research are very valuable, because this is the only way to get to know this unique phenomenon of nature, a huge three-dimension labyrinth, which is 1.5 km thick and extends to 20 km^2.

The recent face of the karst is a result of its petrographic, tectonic and paleo-climatic development. However these days the main agent of karst development is its hydrological system. This study summarizes these fields, and presents a suggession to the advanced protection of this particular land.

2. THE STUDY AREA

The Canin-plateau is the westernmost part of the Julian-Alps, which is crossed by the border between Italy and Slovenia. The central part of the mountain is about 20 km^2, which extends above 1500 meters of the sea level. The highest summits are about 2500 meters high.

3. THE GEOLOGICAL, PETROGRAPHICAL STRUCTURE AND THE TECTONICAL DEVELOPMENT

The plateau is built of two types of Triassic stone, limestone and dolomite. The dolomite lies below and it is covered by a nearly 1 km thick layer of Dachstein limestone. The basic stucture was rearranged by the later tectonic movements, which modified the potential of future karst development (Börcsök and Sásdi 2003).

The tectonical construction of the Canin-plateau is determined by the anticlinal stucture, which is parallel with the valleys surrounding the massif in the north and south (Casagrande et al. 1999). The wave of the anticlinal was denuded to a sinform anticlinal creating the main ridge of the Canin. The fault–system developed in consequence of the folded structure, which is parallel with it; the main fault directions are east – west and northwest – south-east. The later rise and depression of the different structural units happened along these faults. Tectonical development is very important, because it determines both the surface and underground morphology. Tectonics also provides the keys of understanding the hydrological processes.

4. PLEISTOCENE FORMS ON THE CANIN-PLATEAU

As it is proved by the denuded surface, the plateau was covered by glaciers in the Pleictocene. At present the ice-formed terrain is partly covered by debris, and the postglacial karstic processes have transformed the surface. The limestone-massif had been destroyed during the Pleistocene. The stone has dissolved in the course of karr and pothole development in the interglacials, while the surface and the caves were destroyed by the ice in the glacial periods.

5. THE KARST-DEVELOPMENT OF THE CANIN-MASSIF

The plateau is one of the biggest and most spectacular karst mountains of Europe. Hundreds of kilometers of the galleries and the shafts have become known by the work of the cavers in the last half century, but it is still only a small part of the underground Canin.

As opposed to the underground karst development, which is an older process, the karr forms on the surface have developed since the melting of the glaciers of the Ice Age. The border of the forest is at about 1700-1800 meters asl; above this the bare surface of the stone is cut up by karr-channels. There are dolines and sinkholes which have seen the destruction of the glacial times or were dissolved in the Holocene. There are entrances of the shafts from earlier cave development periods among the karr-channels.

6. CLIMATIC CONDITIONS

The total amount of rainfall on the Canin can reach 3100 mm in a year (Börcsök and Sásdi 2003). The snow fallen in winter can persist throughout the year, especially in the shaded, north-exposed depressions. The continuously melting snow keeps the underground water system active. The time of the most intensive underground floods are the wet summer months, June, July and August. The other time when the underground channels become full is when the snow is melting in the spring and the beginning of the summer. The driest period, when the weather is usually stable, is the end of the winter, so this is the most secure time for underground exploration. However the main problems with caving in winter are the rapidly changing snow conditions and the danger of avalanches.

The deep karst hydro-system of the Canin was formed under warmer weather-conditions than the recent one. That's why it is important to understand the karst development of the Canin to model and date the paleo-climatic periods.

7. THE HYDROLOGICAL AND DEEP-KARST MORPHOLOGICAL ZONES OF THE CENTRAL-CANIN

The whole massif is covered with a network of galleries, shafts and fissures. Like in every karst, the rain gets to the erosion basis across underground ways, not on the surface valley-system (Veress 2004). We can divide the Central-Canin into four hydrological parts, the northwest, southwest, northeast and southeast zones (Casagrande et al. 1999). A hydrological section means a catchment area on the surface, the spring belonging to it and the zone of the descending water between the two. We currently have information about seven main springs, and, as is known from the tracing experiments, the hydro-zones are not totally separate from each other; the tracing material appears mainly in the main spring, but all of the observed springs give more or less positive results in every tracing experiment.

The hydrological zones were formed as a result of the karst development of the plateau. Since karst development depends on the tectonical stucture, the hydrological zones can be separated or examined by their morphological structures as well (Fig. 1).

The main characteristic of the nearly one kilometer deep northwestern zone, the surroundings of the Col del Erbe (Grass Hill) is that it consists of separated horizontal and

vertical systems (Fig. 2). The horizontal levels positioned under each other were formed in the mixing corrosion zone, which moved parallel to the rising of the tectonic unit. Most of these horizontal levels are inactive and they don't take part in the transport of water anymore, except for the lower levels. The lower horizontal maender collects all the descending waters and takes them into the siphon at the endpoint. The horizontal gallery-levels are connected by series of shafts. These shafts can either be active in the water-transport or inactive. Most shafts are open from the surface, and take their water directly into the lowest water reservoir meander-zone. The series of shafts are not necessarily penetrable from the surface all the way to the reservoir: the smaller ones are enlarged to a shaft only somewhere in the middle of the stone-massif, especially around 500 meter depth, while the upper and the lower part of their water-transport happens across fissures too narrow to be crossed by a caver. The lower 200 meters above the reservoir is the zone of the big shafts: 100-200 meter deep pits are found here.

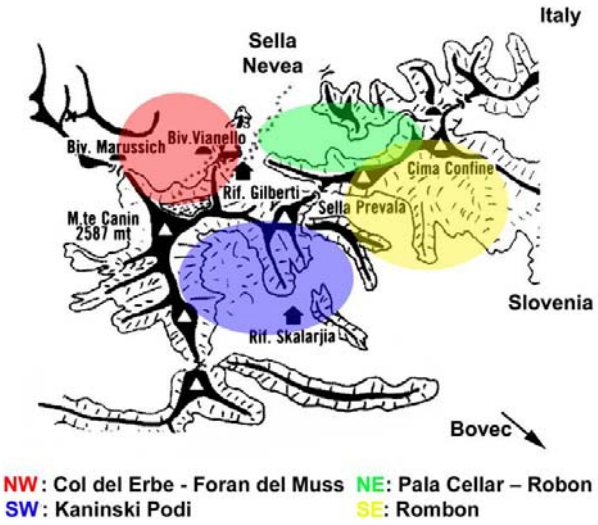

Fig. 1 The hydrological zones of the Central Canin

The northwestern zone is divided into tectonical units by faults. The sharp tectonical borders between the cave-systems of the different units are known, but the connections of the cave-zones are not explored yet.

The biggest system in the northwest zone is the 935 meter deep and 40 kilometer long Michele Gortani. The half of its length was explored by a Hungarian series of expeditions between 1994 and 2006. Several teams have tried to connect the Gortani and the nearby 1140 meter deep Foran del Muss system, but it seems that a stong fault-zone forming a valley on the surface separates the two systems from each other.

This part of the plateau is situated in medium altitude, 1500-2000 meters above the sea level, and the Goriuda-spring is at 900 meters.

The southeastern hydrological zone, the Kaninski podi is characterised by a wide and high-altitude plateau and the strong verticality of its caves (Fig. 2). The caves include huge, 2-300 meter deep pits, and the deepest shaft of the world is found here, the 643

meters deep Vrtiglavica. The plateau is situated very high, at 2000-2300 meters asl, and the Boka spring steps out of the massif at a height of 433 meter. The big, 1600-1700 meter level difference suggests further huge, unexplored caves. The only known system is the Mala Boka-BC4 that follows the way of the water from the catchment area on the plateau to the spring across 1300 meter difference of level.

The cave morphology of the southeastern and the southwestern cave zones is determined by the geological structure (Fig. 2). The deepest caves, like the Veliko Sbrego (-1198 m), the Cehi 2 (-1502 m) and the just mentioned Mala Boka, cross the nearly 1000 meter thick limestone layer, and reaching the border between the stones, follows the sloping surface of the dolomite in the direction of the springs. So these abysses contain a deep series of shafts and a long slope water collector gallery.

The avarage height of the southeastern hydrological zone is about 2000 meters, and the belonging Gliun spring is at 430 meters above the sea level.

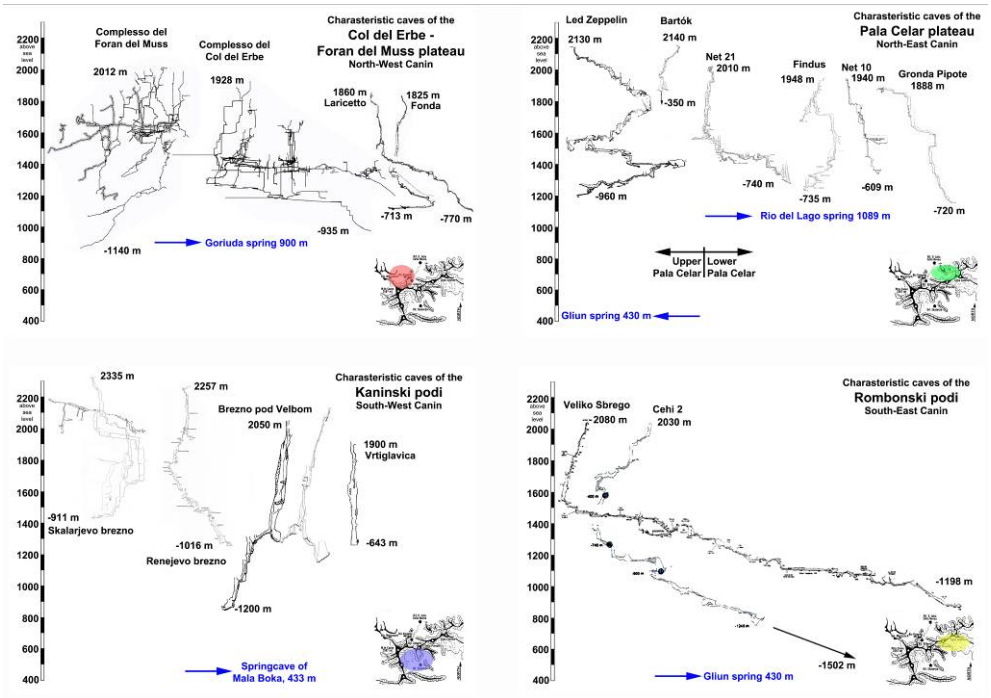

Fig. 2 Charasteristic abysses of the four hydrological zone of the Central-Canin

The hydrology of the karst regions is always interesting and totally different from the run-off of the non-karst regions (Fig. 2). The Pala Celar can be found on the northeastern, Italian part of the plateau. The upper (southern) part belongs to the catchment basin of the southeastern hydrological zone. The big abysses, like the Led Zeppelin (-960 m) collect the rainfall, and, in the above-mentioned way, drain to the border of the stone types and, directly to north, to the Slovenian springs (Antonini and Squassino 1992). Thus the borders of the catchment basin don't follow the morphology of the surface and contain both sides of a high ridge. This is possible due to a huge fault zone dividing the Pala Celar

into two sides. The lowest (north) part doesn't have a main reservoir, the springs belonging to it are situated above the Rio del Lago valley at about 1000 meters asl.

The structure of the Pala Celar is more complicated; its tectonical development has four periods.

The first event was a dislocation which divided the southern and northern parts. The caves of the upper part are more developed and older than the young abysses of the lower part. The tectonical development of the upper part happened earlier than the lower one's. Lastly, a strong tectonical movement reformed the upper Pala Celar in the last period: some big series of shafts were cut and a huge, more than 100 meter deep escarpment doline were created.

8. THE KARST DEVELOPMENT OF THE CANIN PLATEAU ON THE SURFACE AND IN THE DEPTHS

The main task of the research is the modelling of the processes which formed the present face of the plateau. The processes were built on each other and consisted of several periods. Although the early litographical, orographical and tectonical development is important, the period we focused our research on started in the Pleistocene.

The process sketched hereunder is clear and mainly proven, but there are a lot of questions about the exact order, time frame and efficiency of the different events, which should be cleared.

In the following let's see a climatic period in details:

1. The huge abysses consisting of series of shafts have no genetic connection to the present surface. As we can see on the illustration (Fig. 3a), there were sinkholes on the paleo-terrain. These holes concentrated the runoff in their catchment area. The underground water-system developed in the wet, perhaps subtropical climate of the interglacial periods. The solution of the cavities could happen not only in one, but in more interglacial periods.

2. The plateaus were covered by glaciers in the cold periods of the Pleistocene (Fig. 3b). The glacier destroyed the original surface (Fig. 3b). The recent shafts open to the surface developed inside the massif. The karst channel system didn't develop under the ice cover (Jakucs 1971). The debris which covers the surface started to weather by frost in the glacial periods.

There is an interesting type of sediment in the depths of the Pala Celar. This kind of layered sediment is cemented from small, rounded pebbles and contains clayey layers. It is found everywhere between 1150 and 1350 meters above the sea level. In the last glacial periods the lower part of the cavities of the Canin were filled up by this weathered sediment. Later on the water has dissolved the sediment again, but the climatic conditions didn't allow the enlargement of the shafts since the last glacial period.

3. As the climate started to warm the glaciers melted, and the surface has been formed by two processes, karr-development and frost weathering (as well as the gravitational movements due to the weathering) (Fig. 3f). The karr surface above 1800 meters altitude is developing without soil coverage. Now the intensity of the functioning of the hydrological system is in accordance with the recent climate, and definitely less than the original capacity.

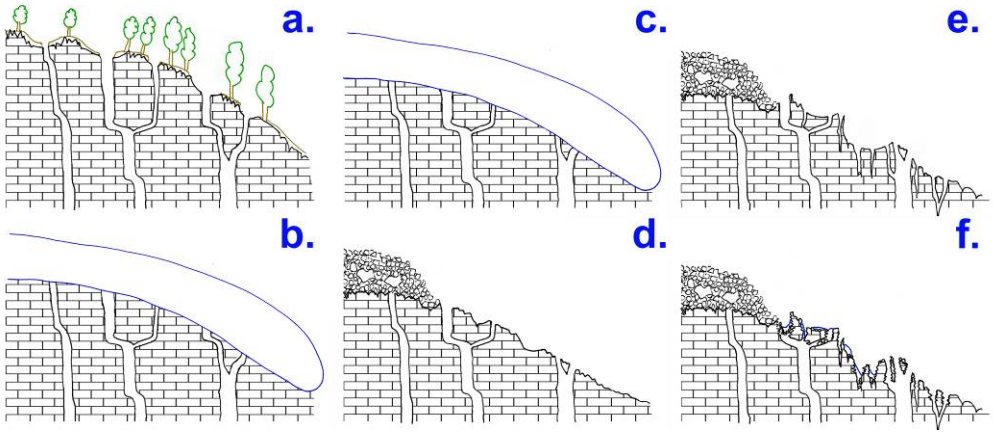

Fig. 3 Illustration of a climatic karst-development period from a warm interglacial across a cold glacial to a medium-climated recent time

9. CAVE DEVELOPMENT ON THE CANIN-PLATEAU - SUMMARY

We need further information to model the climate period exactly. The situation is more difficult, because these processes could happen several times, during more glacial and warming periods. There are other difficulties with including the tectonical events and fault movements into the model. Where to encorporate the tectonical rising movements the horizontal structure of the Col del Erbe originates from, or the tectonical stages of the Pala Celar into the series of events determined by the climate?

10. FACTORS ENDANGERING THE CANIN-PLATEAU

The alpine high-mountain lands are not very endangered by human impact. These lands are not useful for the agriculture; the circumstances for sylviculture are not profitable. Such areas are not suitable for settlements or industrial investments; motorways, and railways won't be built across the ranges either. The high mountains are naturally protected. We can mention three kinds of human impact affecting the Canin-plateau: the First World War, caving and alpine tourism.

Of these three World War I had the strongest effect. The long defense lines built by the Italian army fighting against the troops of the Monarchy crossed the plateau. The stone walls of the bunkers, barracks can still be seen all around. A lot of rusty cartridge hull splinters remain of the fights from 90 years ago.

The war strongly damaged the natural environment. As it can be seen on the archive photos, the woods suffered the biggest loss in the lower region, above Sella Nevea. Not even the trees of steep slopes were safe. The forest apparently overcame the devastation caused by the war, but we don't know of any research concerning this topic.

The whole of the karstic system of the cavities is protected. There are only two things able to enter into the caves, the water and the cavers. Because on the surface there is

no industrial or communal activity, the cleanlyness of the water for the moment is not endangered.

A further impact on nature is that of the cavers. The underground world, where unaffected by the floods, is totally untouched. The like of this cannot be seen anywhere else. The described processes work slowly. There is very little life in the caves, and no soil. The biological processes that dissimilate organic waste don't work under the ground. The caves have no capacity to buffer the human impact. Everything that gets into the caves originates from human activity. The most exposed places are the underground campsites used by the cavers, where they store their equipment and food.

The stuff we brought down ino the caves is garbage from nature's point of view. Compared to the extent of the whole cavity system, its quantity is nothing, but given the intactness of the underground world, it can be considered intensive pollution. The Italian and the Hungarian explorer teams usually take care of keeping the caves clean.

The most popular alpine sport, skiing means a bigger problem. There are ski lifts and ski tracks on both sides of the Canin, above Sella Nevea in Italy and above Bovec in Slovenia, and a mass of skiers arrives here in the winter season. A new track and lift will be finished next year that will connect the ski-centers on the two sides of the mountain across the ridge. The popularity surely will grow; the attendance of the mountain in the summer season will also increase. The monitoring of the effect of that increasing attendance would be important.

However the outdoor culture of the alpine nations is satisfying. The populations of rock-goats (Capra ibex) and beared vulture (Gypaëtus barbatus) that were re-introduced within the frame of an enviromental programme found their essential conditions, and are absolutely unafraid from the tourists. It shows the positive and careful attitude of the people who go into the mountains.

11. SUMMARY

From the point of view of geodiversity, the most important value of the Canin-plateau is its untouched three-dimension structure. The Canin takes an important part in supllying the population with water. The massif is naturally protected by its hard accessibility, which is nevertheless endangered by the increasing tourism. Further research of the karstic processes and the monitoring of human impact would be needed.

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