



## Speleogenesis in Dinaric karst area

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Dinaric Karst is one of the largest karst regions in Europe and in the World. It is the paramount karst of Europe and type site of many karst features. Dinaric Karst Area covers an extensive part of the Dinarides, a mountain chain in Southern Europe named after Dinara Mt., an impressive and outstanding rocky wall on the border between Dalmatian part of Croatia and Bosnia and Herzegovina. The Dinaric Karst occupies an area from the Friuli Plain (Doberdo Karst Plateau) and Slovenian mountains near Postojna cave on the northwest, to Skadar Lake and Prokletije Mt. on the southeast, from Central Bosnian Mountains on the northeast, and the Adriatic Sea seafloor with its islands. The Dinarides outspread in a so-called “Dinaric strike” (NW–SE) for 650 km in length and are up to 150 km wide across SW-NE. The biggest part of the Dinaric Karst Area is situated within Croatian territory (continental, Adriatic coastal and seafloor karst) comprising all karst features with exceptional examples exposed on the surface as well as in the underground. Classical karst area is the one situated in Slovenia, where typical karst features were described for the first time. Presentation of the outstanding values of Dinaric karst is based on the values that can be met in Italy, Bosnia and Herzegovina, Montenegro, Serbia and Albania, too.

Dinaric Karst is the World’s natural heritage because of its unique and outstanding geological characteristics and its living world; some of them are of outstanding natural beauty.

Dinaric karst is an integral, compact karst area with extremely great thickness of carbonate rocks of predominantly Mesozoic age which in some areas exceeds 8.000 m. It bears several cycles of karstification thus giving world uniqueness to the area, especially regarding the wealth of submerged karst phenomena, among which vruljes are world unique features. Dinaric karst is one of the largest karst regions in the World. From the scientific perspective, the Dinaric Karst is one of very well-known karst region, where the first scientific researches were conducted.

Abundance of all types of karst features and karstification processes active in many intervals of geological history is documented in the sequences of sedimentation (outcrops of paleokarst) from Carboniferous to present times. Animal and plant fossil and today living species support geological documentation too, which are significant tools in reconstruction of evolution of ecosystems and communities.

Dinaric karst contain the most important and significant natural habitats for in-situ conservation of biological diversity of the area, and its unique animal and plant life.

The Dinaric Karst is a heterogeneous geographical area made up of carbonate rocks; it represents a karst landscape typical for humid temperate regions. Its natural features are unique and have a universal value. Scientific karst terminology comes from typical natural features of the area, their genesis and several-hundred-year long study of karst and its phenomena in the Dinaric Karst. The term ‘karst’ is on a global level established and accepted around the world. There are also a number of other terms originating from the Dinaric Karst that have been established in the language of science: doline, uvala, polje, ponor, kamenitza and hum among them. The Kras/Carso plateau and the Classical Karst being a part of the Dinaric Karst, are of universal cultural and historical significance.

The development of the Dinaric Karst is peculiar due to a unique combination of lithology, thrust and strike-slip tectonics, exogenous processes and climate characteristics (in the past and present). The first one resulted in a combination of imbricated structures of carbonate and low permeable rock, which created hydrogeological barriers. The latter created the conditions that enabled the development of large poljes. A combination of surface and underground activity of water and its chemical processes resulted in deep karstification and a remarkable variety in types of caves. It is estimated that the Dinaric Karst has at least 100,000 caves, only a fifth of which have been explored and suitably documented so far. Karst caves are truly unique by a variety of their types (dry caves, water caves, cave systems, shafts, spring caves, etc.), by their dimensions (the longest cave systems can reach over 100 km, the deepest ones are more than 1,430 metres deep), and by their great spatial frequency. In the Classical Karst, in area around the town Sežana and Ferneti/Fernetiči there are up to 60 caves/km<sup>2</sup> – the number which is unprecedented. The great numbers of cave channels covered in dripstone, types of dripstone and its forms (stalactites, stalagmite, curtains, cave pearls, etc.) only contribute to this abundance. One should not forget the significance of cave sediments for scientific explorations. Their dating was used to determine the age of caves and scientifically explain the dynamics of karst evolution. Another important set of karst features are numerous

submarine springs.

This is the area where the science of karstology and speleology started to develop, where the basic ideas about the karstification processes (corrosion) and karst hydrology were born. The international term karst and the scientific investigation of karst originate in this region as well as many other international professional terms.

Many words, describing karst features, originate from the Dinaric Karst Area, and belong to internationally accepted karst terminology (karst, dolina, polje, vrtača, ponikva, vrulja etc.). The word „karst“ was first mentioned in Charter of Juraj Pariježić in 1230 in which “kras” locality near Dobrinj on the Island Krk in Croatia was subject of donation. The first written note that mentions the Italian word "Carso" dates back to the year 1292. In an Austrian document term "Karst" was cited for the first time in 1423. From the etymological point of view the word "Karst" is expression of Indo-European (Persian - Farsi) origin coming from the word "kar", "gar", "khar" or "ghar" meaning a “rock” or today a “cave” too. After using the German name „Karst“ for the plateau Kras (Slovenia) above Trieste (Italy), the international scientific term derives to designate “karst” and the whole science of karst phenomena, “karstology”. In 1972 a Glossary of multilingual equivalents of karst terms was published by UNESCO and FAO. From 2005 Union Internationale de Speleologie (UIS) on internet have Caver’s MultiLingual Dictionary with 24 languages till today.

The geological history (and speleogenesis) of/in the Dinaric karst in Croatia can be divided into six periods , or according to the facies sedimentary features on six mega sequences . From the older to the younger ones are: (1) younger Carboniferous - Permian older ( region of Lika , Ričica ), (2) older Permian - Middle Triassic ( Lika , Brusani , Paklenica , Knin polje, Vrlika ) , (3) younger Triassic (younger Noricum ) - Early Jurassic (older Toarcium ) (the so-called areas . Haupt dolomite ), (4) younger Toarcium - younger Cenomanian / Turonian older ( mountain Dinara, Istria , areas of Rudistic limestones), (5) older Turonian – the end of the Cretaceous ( Istria , Cres , Obrovac, Zrmanja river ), (6) Eocene (areas of foraminiferal limestones), (7) Oligocene - Miocene ( Drnis , Sinj , Imotski , Promina , Benkovac , southern Velebit Mt) and (8) Pliocene - Holocene (Velebit mountain ). The boundaries between megasequences marked as important geological events such as interruptions due to sedimentation and uplift with geological regression with karst formation or deepening of depositional environments .

The stages of karstification only through time and places where it is still visible today .

- perm older - karstification upper Carboniferous and lower Permian limestone , Ričice and Rizvanuša ;
- Ladinian - younger - older Noricum - karstification Middle Triassic dyploporious limestones , on Orlic , mountains of Štirovača to Gračac ( type locality Bađek ) , Bruvno ;
- Kimmeridgian – and karstification of Oxfordian and older Kimmeridgian limestones , Rovinj ) ;
- Tithonian - Berriasian - karstification Kimmeridgian – lower Tithonian limestone , Dinara ( Bravčev Dolac ) ;
- apt -upper - lower Albian - karstification (western Istria);
- Cenomanian - karstification older Cenomanian limestone , Dugi otok (Luka) ;
- Cenomanian - Santonian - karstification Cenomanian limestone , west of Karlovac ;
- Upper Cretaceous - Eocene - karstification of Rudistic limestone range Cenomanian - Coniacian , the whole area Karst Dinarides in contact with foraminiferal limestones ;
- Cretaceous rudistic and Eocene limestones in contact with Promina breccias in Ravni kotari, Dalmatinska Zagora;
- part of all surface areas from Oligocene to today.

In all these Karstification processes all three types genetic phase (initial , main and late phase or fossil karst features . They are easily distinguishable in relatively younger sediments , and only sporadically indicated in the Permian sediments. Chance of a more detailed study of paleokarstic phase karst come to the realization that their intensities through geological history of this area were not identical , ie , altered, depending on the speed of descent or uplift of individual parts, the time in which they were exposed to the processes of karstification and tectonic and hydrogeological and paleohydrogeological conditions. The most intense examples of karstification are recorded in the Cretaceous and from the Eocene to Paleocene areas in Croatian parts of Dinaric karst.

The deepest cave explored till the end of 2014. year in Dinaric Karst is Cave System of Lukina jama (depth -1431 meters; length – 3741 meters)) and the longest cave in Dinaric karst area is Cave system of Kita Gacesina (length – 27802 meters, depth – 737 meters). Both of caves are in Croatian part of Dinaric karst area in Velebit mountain.