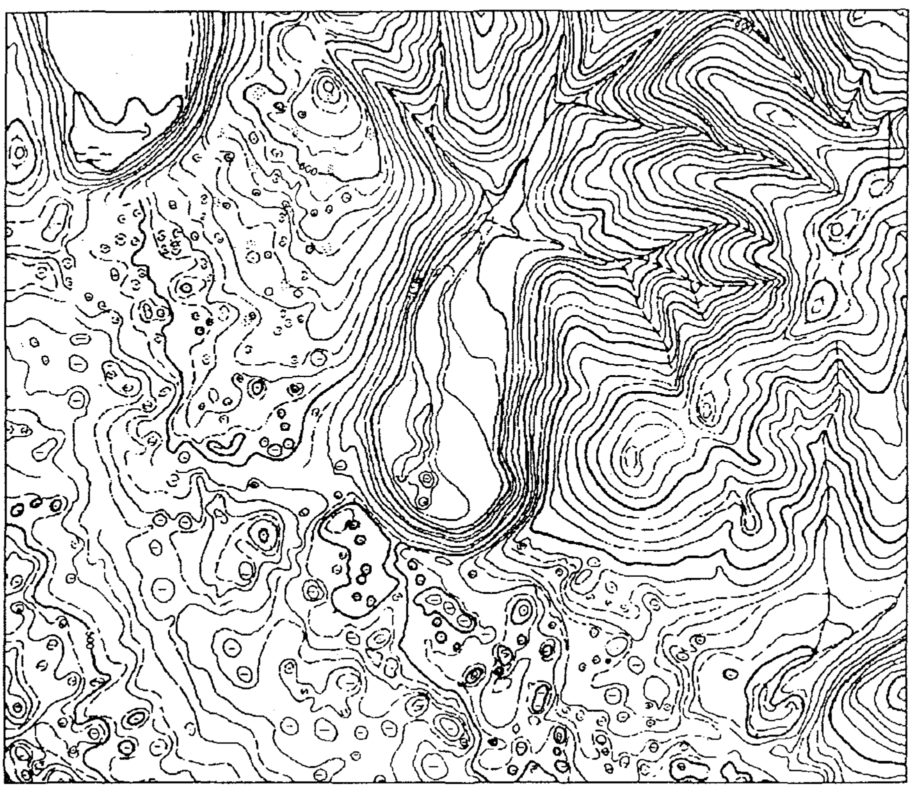
SPELEOLOGICAL ASSOCIATION OF SLOVENIA
and
KARST RESEARCH INSTITUTE ZRC SAZU

9th INTERNATIONAL KARSTOLOGICAL SCHOOL CLASSICAL KARST



CONTACT KARST

Andrej Mihevc

Guide-booklet for the excursions
Postojna, June 2001

Organiser:
Karst Research Institute
Centre of Scientific Research of the
Slovene Academy of Sciences and Arts

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Program

Tuesday, June 26, 2001
Arrival of participants
18.00-21.00 Registration

Wednesday, June 27, 2001

8.00-12.00	Registration
8.30-10.00	**Opening and lectures**
10.00-10.30	Break
10.30-12.00	**Lectures**
13.00-19.30	Field work: **Contact karst of Šibje and Kočevska reka**
20.00	Poster presentations
	Slide projections

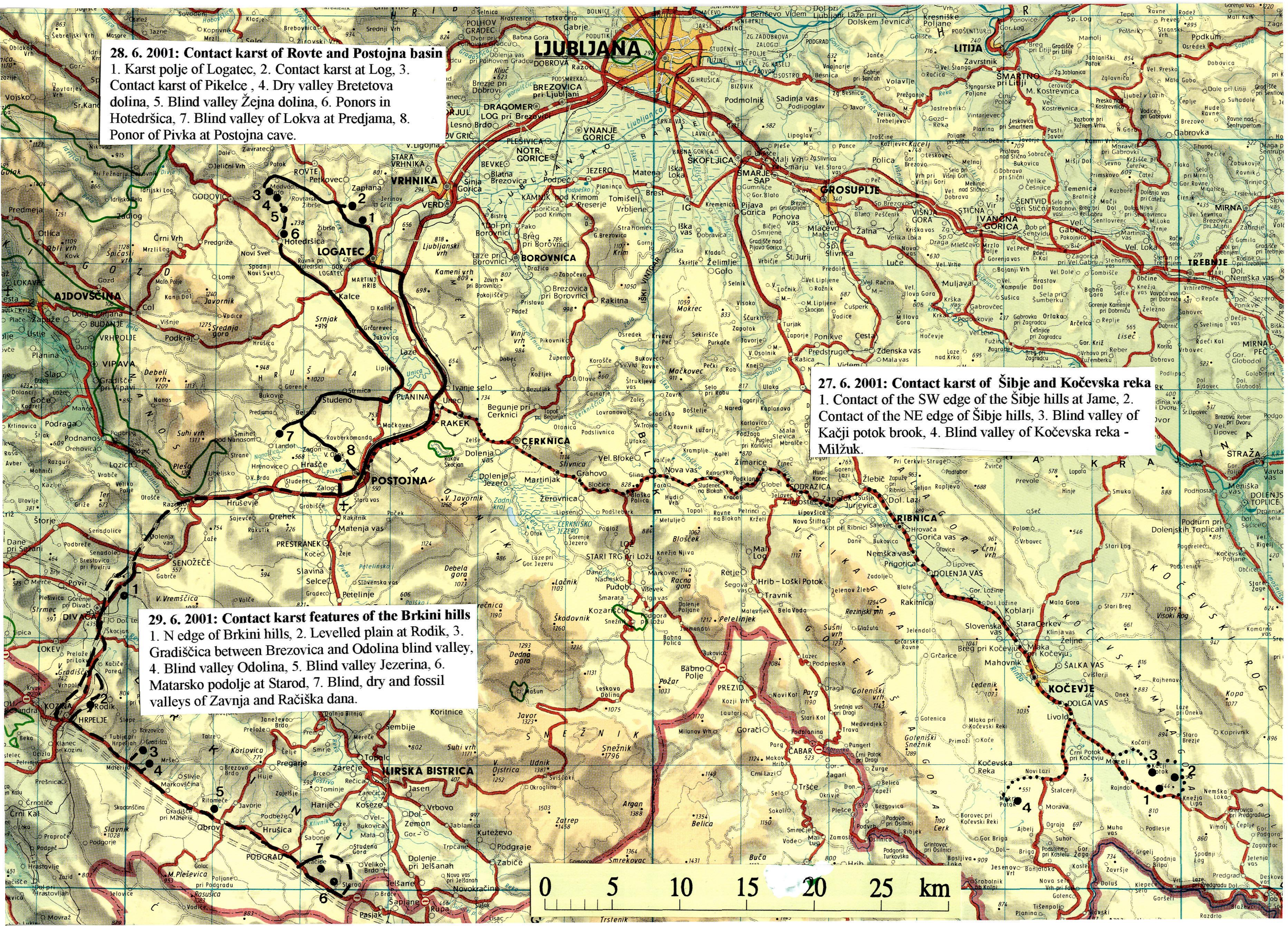
Thursday, June 28, 2001

8.30-10.00	**Lectures**
10.00-10.30	Break
10.30-12.00	**Lectures**
13.00-19.00	Field work: **Contact karst of Rovte and Postojna basin**
20.00-21.30	Reception at the Karst research institute
21.30	Poster presentations
	Slide projections

Friday, June 29, 2001
8.30-18.0 Whole day excursion: **Blind valleys and contact karst of the Brkini hills**

Important

The areas of the field trips are heavily populated by the infected ticks. Do not forget to check yourself carefully for the ticks after the excursions.


28. 6. 2001: Contact karst of Rovte and Postojna basin
1. Karst polje of Logatec, 2. Contact karst at Log, 3. Contact karst of Pikelce , 4. Dry valley Bretetova dolina, 5. Blind valley Žejna dolina, 6. Ponors in Hotedršica, 7. Blind valley of Lokva at Predjama, 8. Ponor of Pivka at Postojna cave.
27. 6. 2001: Contact karst of Šibje and Kočevska reka
1. Contact of the SW edge of the Šibje hills at Jame, 2. Contact of the NE edge of Šibje hills, 3. Blind valley of Kačji potok brook, 4. Blind valley of Kočevska reka - Milžuk.
29. 6. 2001: Contact karst features of the Brkini hills
1. N edge of Brkini hills, 2. Levelled plain at Rodik, 3. Gradiščica between Brezovica and Odolina blind valley, 4. Blind valley Odolina, 5. Blind valley Jezerina, 6. Matarsko podolje at Starod, 7. Blind, dry and fossil valleys of Zavnja and Račiška dana.
LJUBLJANA
LOGATEC
POSTOJNA
CERKNICA
KOČEVJE
RIBNICA
ILIRSKA BISTRICA
0 5 10 15 20 25 km

INTRODUCTION

One of the possible classifications of the karst is by the dominant morphological process. Karst formed by the influence of the allogenic flow could be designated by the term of contact karst.

The term grows familiar in Slovenia on the Classical Karst where the karst contacts non carbonate rocks and specific relief forms developed. The term is reasonable, because such karst essentially differs from the karst which surface and underground was formed without such influence. In the international karstological literature these forms and phenomena are usually named as karst influenced by allogenic inputs (Ford & Williams, 1989).

Contact karst develops usually where water flows from fluvial relief onto karst. Alogene water, because of its quantity, regime, sediment and chemical characteristics, alters the karst process and forms particular relief morphology. This relief has some characteristics of fluvial relief, but karst features dominate. Phenomena and forms that develop at the contact of fluvial and karst relief are a result of the interaction of both morphological systems.

The distribution of contact karst is preconditioned by the contact and effect of surface and underground watercourse networks; the contact is usually linked to the spatial distribution of karstic and non-karstic rock. The contact of various rocks gave its name to this type of karst, although various forms of contact karst can be found in the midst of karst rocks, on which a river network may exist due to various other factors. Differentiation between karst and contact karst was decided upon for practical karst description and research reasons.

In Slovenia some 220 sinking rivers in 19 larger areas are drawn into 1:25.000 scale maps. Smaller scale maps show that the number of sinking rivers is much higher. The proportion of contact karst in the total karst is relatively low, but it is significant for understanding the formation and functioning of karst.

CONTACT KARST OF ŠIBJE AND KOČEVSKA REKA

Wednesday, June 27.

CONTACT KARST OF ŠIBJE

Šibje is a ridge six kilometres long and up to one kilometre wide. It is composed of non-carbonate rock and is located among karst plain that extends from the Kočevsko polje. To the east it borders the higher Petrov and the Prerigelj hill. The ridge is up to 660m a.s.l. and the flats surrounding it are up to 60m lower to the north-west and up to 150m lower to the south-east than the central part of the ridge.

Šibje is composed of mica slates and sandstones of Permian age (Germovšek, 1961). The southern side is surrounded mainly by dolomite rock, and with limestone to the north-east. In the lower part of the beds of the streams and in some locations on boundary limestone, beds of Holocene clays, quartz sand and rubble of up to a few metres thick cover the relief.

Structurally, Šibje is a part of the Krim overthrust cover. The south-western boundary is an overthrust on the Cerknica overthrust, from the north-east it is covered by the Ortnek overthrust cover (Premru, 1982) of limestone and dolomite.

Hydrology of the Šibje hills

Non-carbonate rock in Šibje covers an area of 6.25 square kilometres, on which 67 separate water streams have formed and sink along the 16.5 kilometre contact of Šibje with carbonate rock. On average, streams collect run-off from only 0.09km^2 each, with the largest Kačji potok draining 0.67km^2. The mean flow of the larger streams, with watersheds of 0.4 to 0.5km^2, is around 10 l/s.

Water in all the streams has similar chemical characteristics. The specific electric conductivity of the Kačji potok during tracing was 70μS/cm, the flow rate was 8 l/s, and the temperature 6.9 degrees Celsius. Similar or even lower values were found in other streams.

Tracing experiments showed that the Kačji potok flows from the north-eastern edge of Šibje and 19km away into the 365m lower sources of the Obrh and the Radeščica; the apparent velocity of the tracer was 1.1cm/s. Water from the sinkingwater flow at the village of Rimsko, on the southern edge of Šibje, flows 6km away into the 320m lower Bilpa sources near the Kolpa river (Habič & al. 1990).

Relief of the Šibje contact karst

Characteristic features of the Šibje contact karst are the funnel-shaped dolines that formed by suffusion processes in weathered non-carbonate rock, directly at the contact of the carbonate and non-carbonate rocks. Larger ones have small water flows on the non-carbonate side of the contact. The depressions at the ponors of larger streams are no longer of a regular shape; the flanks are steeper and sink recess s and in some cases vertical walls have formed on the carbonate side of the contact.

Some smaller blind valleys and dry valleys have also formed; these extend into the flattened Šahen or the Kočevsko polje.

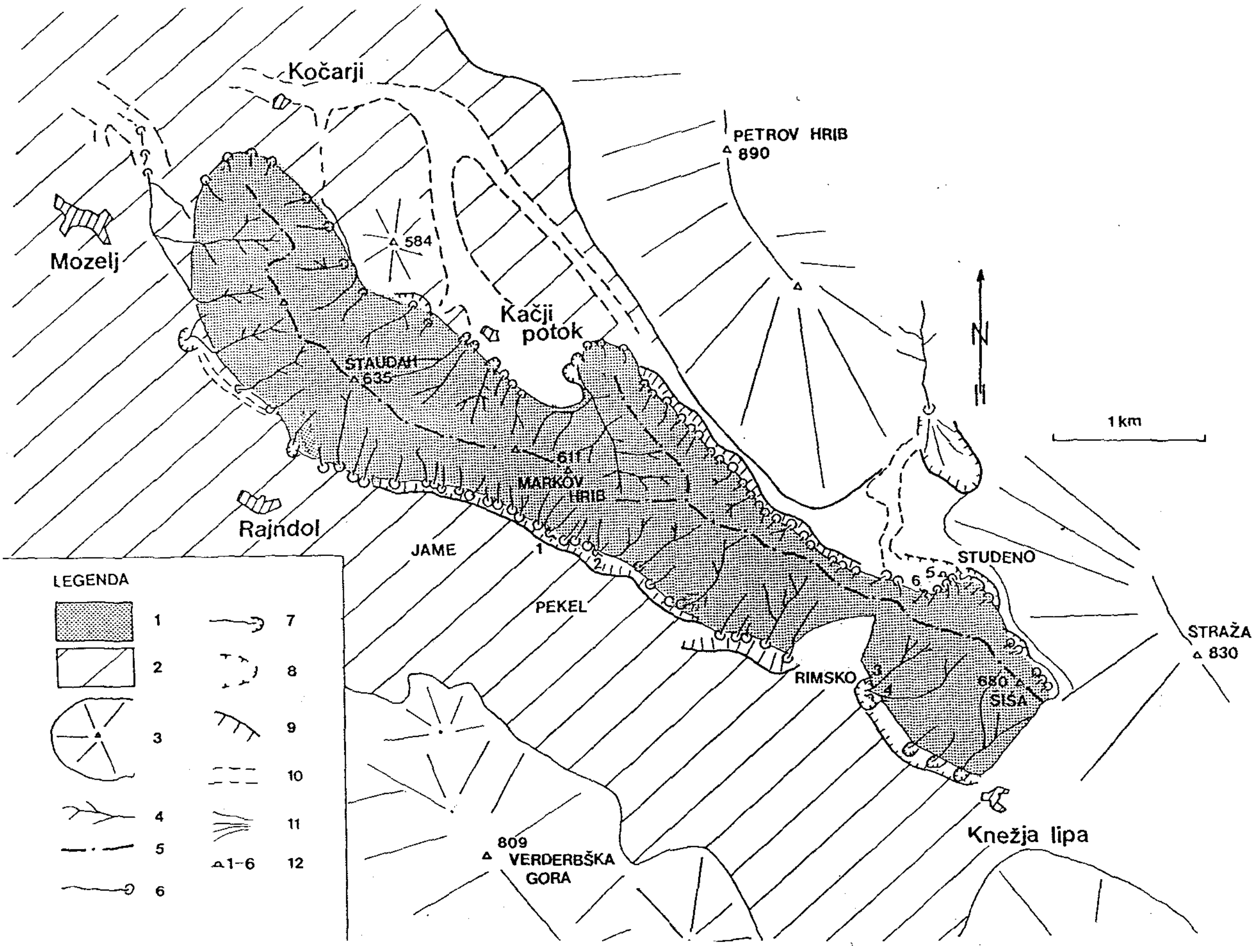


Fig 1: Contact karst of Šibje.
Legend: 1. impermeable rocks, 2. Šahen - karst plain with solution dolines as dominant form, 3. karst mountains with conical hills as dominant form, 4. stream, brook, 5. watershed, 6. stream with suffosion depression at the ponor, 7. blind valley, 8. fossil blind valley, 9. ponor recess or steep head, 10. dry valley, 11. alluvial fan, 12. caves (1. Jazbina, 2. Höhlenloch, 3. Römergrunt II, 4. Römergrunt I, 5. Brlog na Rimskem, 6. Kavranova jama).

The formation of contact karst in Šibje most likely started when the Kolpa river valley was forming and the once whole Kočevsko polje was dissected into two parts. Due to the increase in gradient, various contact phenomena occurred everywhere along the lithologic contact, in particular sufossion dolines, sinks and ponors. Smaller blind valleys were formed at the larger streams and in some places dry or karst valleys above them extend towards the Kočevsko polje.

Karst phenomena of the boundary limestone strongly affected the formation of the surface water flow networks on the non-carbonate rock of Šibje.

Contact karst at S edge of Šibje

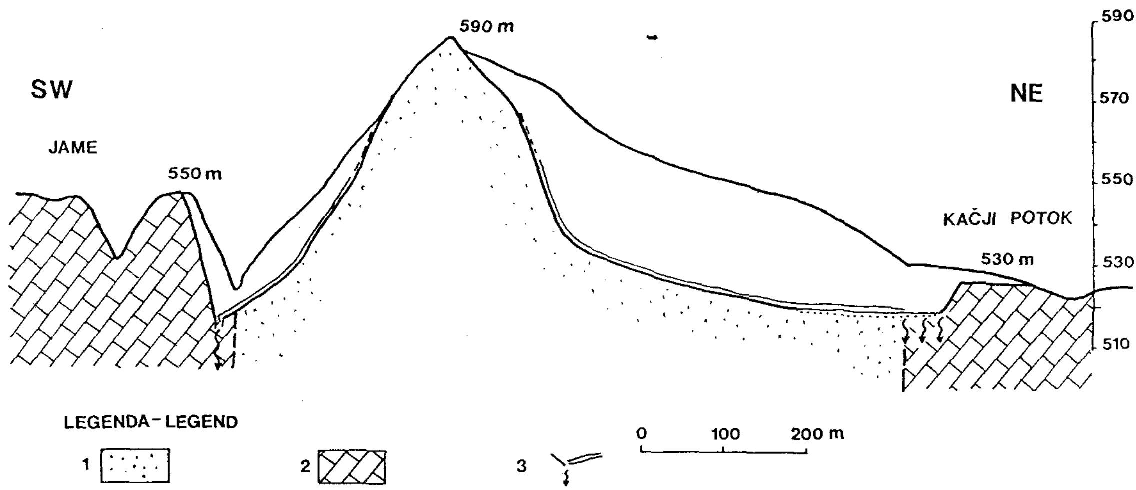


Fig 2: Cross section of the Šibje hills between Jame and Kačji potok.
Legend: 1. non-carbonate rocks of Šibje, 2. limestone or dolomite, 3. sinking stream.

On dolomites and dolomitised limestone that surround Šibje karst plain with solution dolines formed. On the contact with Šibje swallow-holes, funnel-like dolines, blind valleys formed and create, by lateral overgrowing, an elongated boundary depression. This area was named by non-cavers Pekel (Hell) and Jame (caves). Its edge is located at 540m a.s.l., its bottom 20–30m lower. At this level, the bottom of the depression was covered with fluvial sediments; the river beds of the sinking rivers were deeply cut into it, the lowest part being the sink and the entrance to the Jazbina and the Höllenloch caves at approximately 480m a.s.l.. The streams that flow into the boundary depression sink separately. The slope that formed in dolomite is steep, above some swallow-holes even vertical, and gives a characteristic appearance to the whole boundary depression.

Contact karst features at NE edge of the Šibje

Contact karst on the north-east edge of Šibje at the foot of the slopes of Petrov hrib (890m) developed at the contact of well karstified Jurassic limestone with dolomite and non-carbonate rock.

A belt of lower relief developed along the contact of the rocks. The relief is disected with dolines on the carbonate side of the of contact. Ridges and smooth slopes incline from Šibje towards it. The relief is fragmented by many funnel-like suffosion dolines at the contact; flow networks are already developed in the larger ones. These forms are so close together along the rock contact that in some places steep slopes have formed in above a system of valleys, forming to 20m deep boundary depression.

Blind valley of Kačji potok

The Kačji potok cut a larger river valley with side valleys into Šibje. Despite the amount of water available, its blind valley on carbonate rock is not much larger than the valleys of smaller streams. A shallow dry valley extends past the swallow-holes towards the north and north-west and then sinks in the shallow doline-like depression in the flat Šahen areas north of Kočarji.

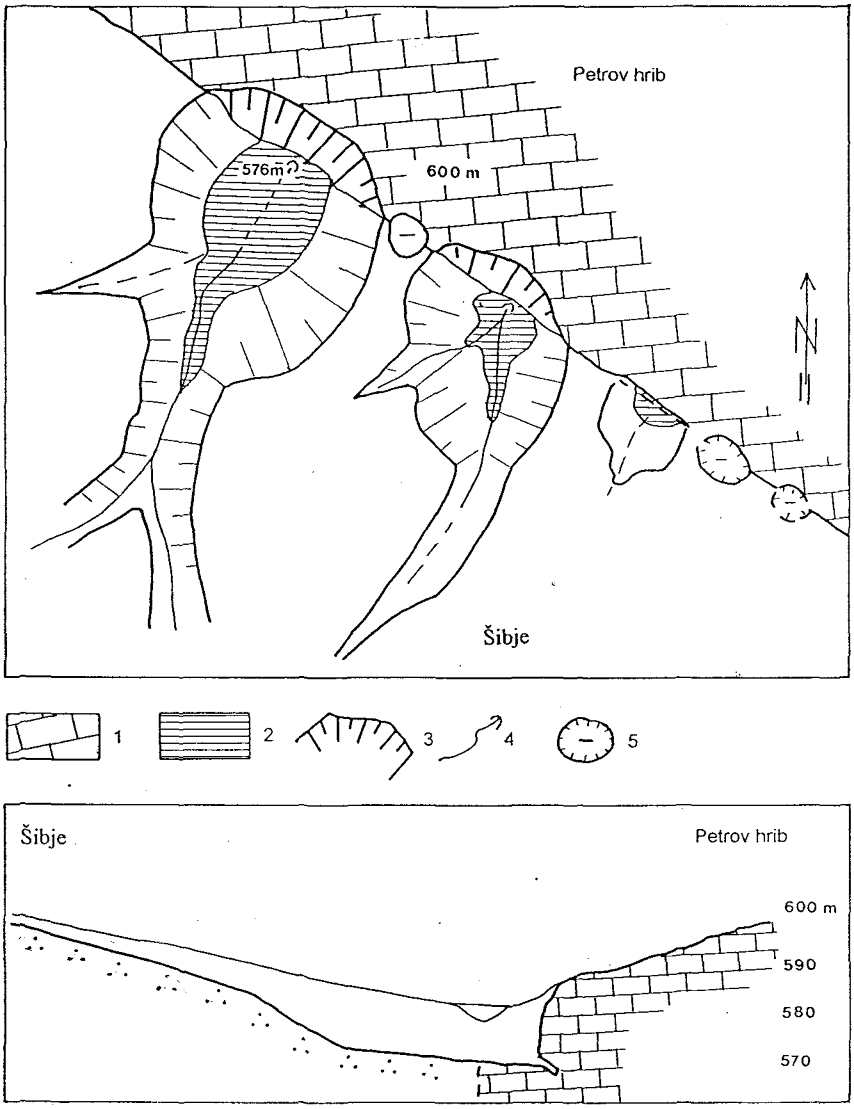


Fig 3: Schematic sketch of the contact karst features at NE edge of the Šibje hills.
Legend: 1. limestone, 2. non-carbonate sediment in the bottom of depression, 3. recess above the ponors or sufossion points, 4. stream with ponor, 5. sufossion depressions on contact.

Caves at the edge of Šibje

On the edge of Šibje there are six accessible caves that are directly connected to contact and sinking streams. Two caves are located underneath the ruins of the village of Römergrund on the southern edge of Šibje, with two caves in the area of Pekel. The Jazbina cave is 85 metres long and is a simple ponor water filled cave. Alongside the neighbouring stream, a larger cave named Höllenloch, 411m long, has formed. The entrance is situated 480m a.s.l. at the confluence of a number of streams running off the southern slope of Šibje. The largest, 380m long and 31m deep, cave Brlog na Rimskem, is located on the northern edge of Šibje. The cave's features are paragenetically formed ceilings and remains of the filling of non-carbonate rubble and sand, which still fill the cave up to the levelled ceiling.

CONTACT KARST OF KOČEVSKA REKA RIVER

The southern part of the valley of Gotenica between Kočevska Reka, Borovec and Morava is a vast, 16km^2 large area of predominantly non-carbonate Permian sandstone, marl and conglomerate. Streams flowing from this area sink on its edge in blind valleys and boundary depressions at the contact of well karstified Jurassic limestone and dolomite, while some water flows on the surface towards the Kolpa river.

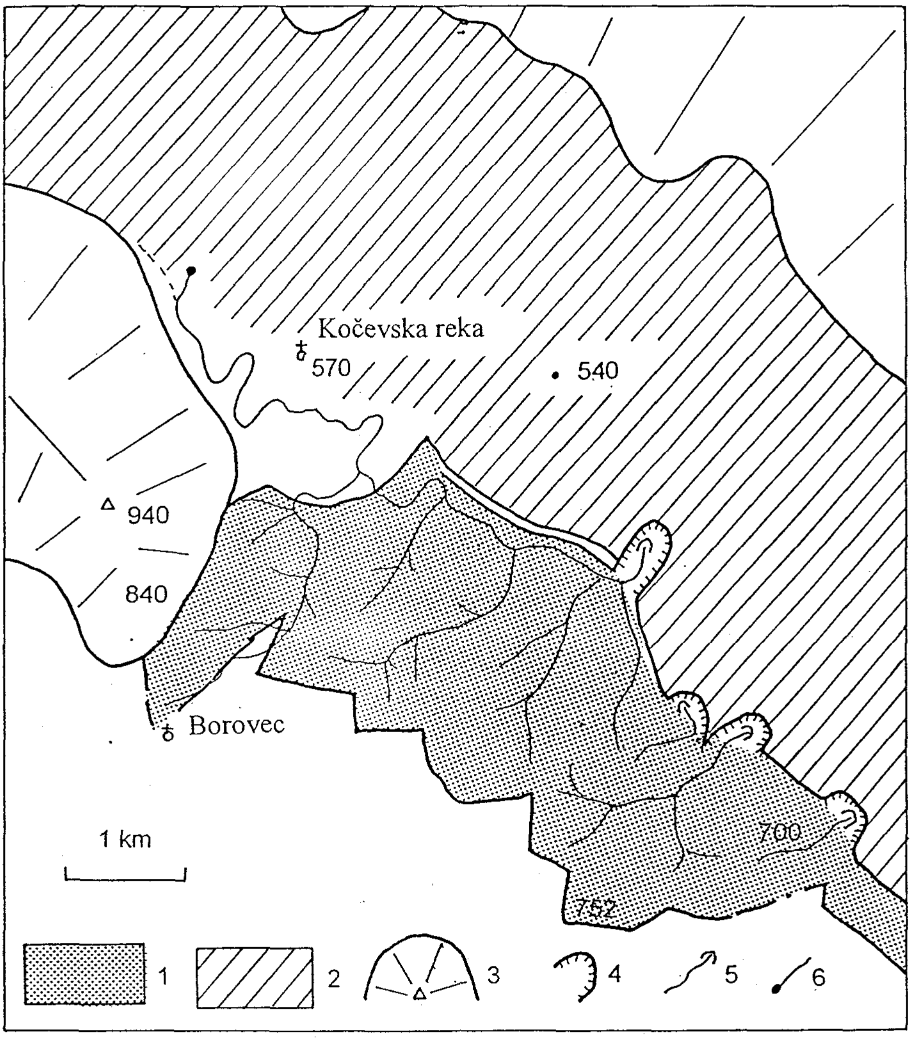


Fig 4: Contact karst of Kočevska reka river.
Legend: 1. impermeable rocks, 2. karst plain with solution dolines as dominant form, 3. karst mountains, 4. contact karst features,5. stream with ponor 6. spring of Kočevska reka river.

The largest sinking river is the Kočevska Reka. It originates in the closed valley west of the settlement of the same name at 520m a.s.l.. Its upper course is across dolomite, into which it frequently completely sinks. The lower course has a continuous flow across non-carbonate rock. The river valley meanders between the karst levelled plain and the higher non-carbonate land up to 752m a.s.l.. East of the ruins of the village of Vecenpah, the river turns to the north, enters a blind valley and sinks.

The Kočevska Reka valley and the blind valley of it are filled with a few metres thick fluvial sediment. The sedimentation and current erosion of the beds are affected by the change of transport of new sediments and flow conditions in the karst.

Blind valley Milžuk

The blind valley is 550m long and 250m wide. Its slopes are smooth and incline steadily towards the terraces or recent riverbeds. Only a thin layer of sediment and slope gravel, mostly on the lower section, cover them. A pile of non-carbonate gravel up to 490m a.s.l. is preserved in the north-west section of the blind valley. The boundary of the blind valley that cuts into the levelled karst plain at 550m a.s.l..

The bottom of the Reka valley at the swallow-holes is at 460m a.s.l.. The riverbed is up to 10m wide and approximately 3m deeply cut into the fluvial plain. The terrace declivity is new and points to the rapid erosion of fluvial sediments in the valley.

Above the fluvial plain, two rock terraces are situated; these are developed only on the left or western side of the blind valley. The first terrace is located 10–15m above the riverbed. The terrace is of rock and covered by fluvial sand and rubble. Riverbeds are cut into the terrace; these extend into alluvial sinkholes.

The second rock terrace is about 20m above the present riverbed and floods do not reach it. The dolines are very distinct along the contact of the terrace and the steep slope of the blind valley, where a series of elongated dolines, up to 10m deep, are situated.

In the wall overlooking the swallow-holes, grottoes that swallow floodwater are preserved at various levels. The floodwater can rise by about 20m in the final section. Research is on going in the accessible caves.

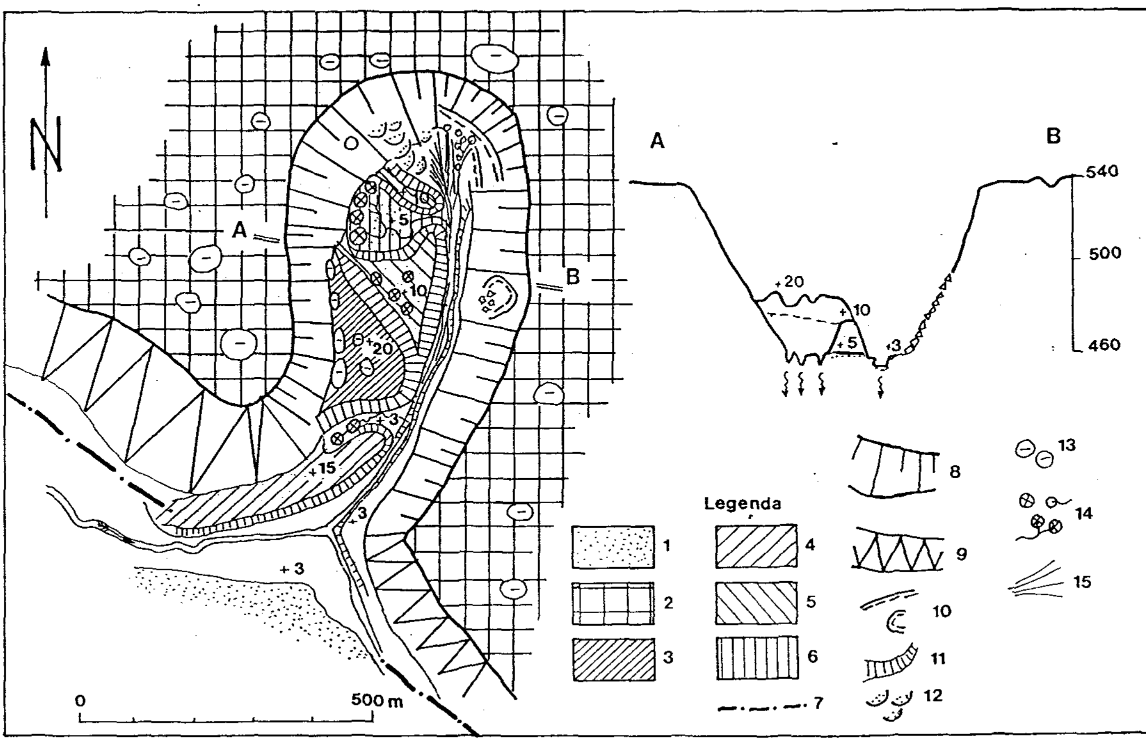


Fig 5: Morphology of the Milžuk - blind valley of Kočevska reka river.
Legend: 1. impermeable rocks, 2. karst plain with solution dolines as dominant form, 3. rock terrace with relative height above the river bed, 4. sediment terrace with relative height above the river bed, 5. rock terrace with thin fluvial sediment and alluvial sinks, 6. lower terrace with ponors, 7. geological contact, 8. edge and slopes of the blind valley, 9. vertical parts of the blind valley, 11. edge of alluvial terrace, 12. mass movements on the slopes, 13. dolines, 14. alluvial sinks and ponors, 15. alluvial fan.

CONTACT KARST OF ROVTE AND POSTOJNA BASIN

Thursday, June 28.

CONTACT KARST OF ROVTE

The relief of ridges and valleys in Logaške Rovte cover an area of approximately 100km^2 between the Hotenjsko podolje karst plain to the west, the Logaško polje to the south and the tectonic basin of Ljubljana Barje to the East. To north there are prealpine hills and mountains. The area of Rovte structurally forms the south-eastern part of a vast nape structure overthrusted on the Mesozoic limestone (Placer, 1973). The nape structure was cut through by faults in NW-SE, "Dinaric" direction, therefore the lithologic structure of the territory is complicated. The oldest rocks are non-carbonate Palaeozoic and Triassic slate, conglomerates and sandstone. The larger part of the relief is composed of carbonate rock, predominantly Triassic dolomite. Limestones are lithologically diverse and karstificated to various degrees, which is why the relief formed on them alters frequently.

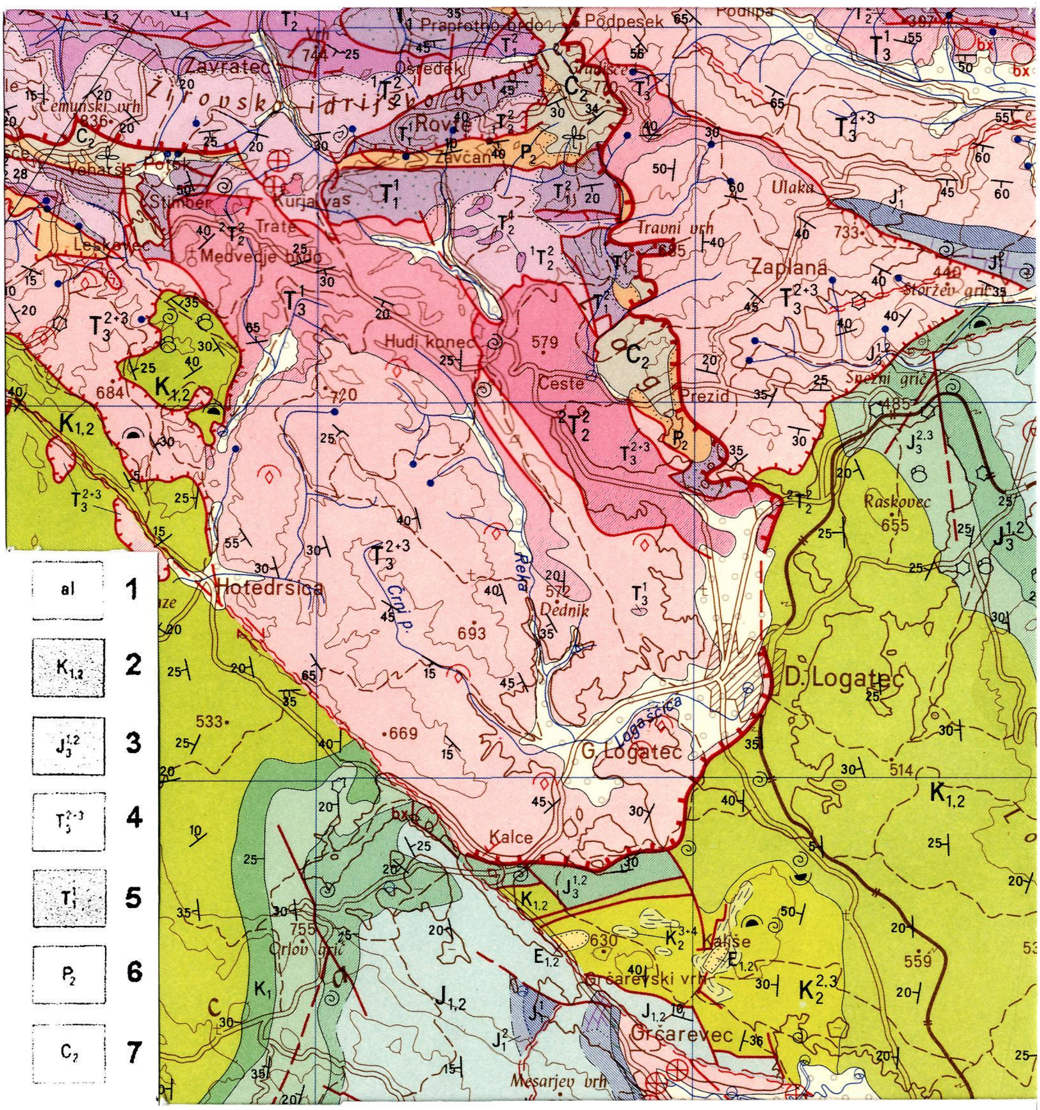


Fig 6: Geology of Rovte.

Legend: 1.Quaternary, 2. Cretaceous: dark grey limestone, dolomite, 3. Jurassic: light grey oolitic limestone, 4. Triassic: main dolomite, 5. Triassic: oolitic limestone, sandy shale with mica, dolomite with mica, 6. Permian: quartz sandstone, argillaceous slate, 7. Carboniferous: marly limestone, dolomite with mica, argillaceous slate.

Hydrology of the Rovte

Surface flows in the northern and eastern part of Rovte flow into the valleys of the Idrijca, Sora and Ljubljanica rivers, while the central and southern part have only karstic discharge. There are 9 larger and 16 small sinking streams in this area. From these, water flows to the springs of Idrijca and Ljubljanica. Underground flowing of water from the Hotenjka, Žejski potok and Pikeljski potok into the sources of Ljubljanica and Idrija has been proven (Gospodarič and Habič, 1976).

Most sinking rivers, the Petkovski potok, Rovtariça, Žejski potok and many other small streams sink amidst the mountains. The Logaščica and Hotenjka sink on karst plain on the edge.

Morphology of the Rovte contact karst

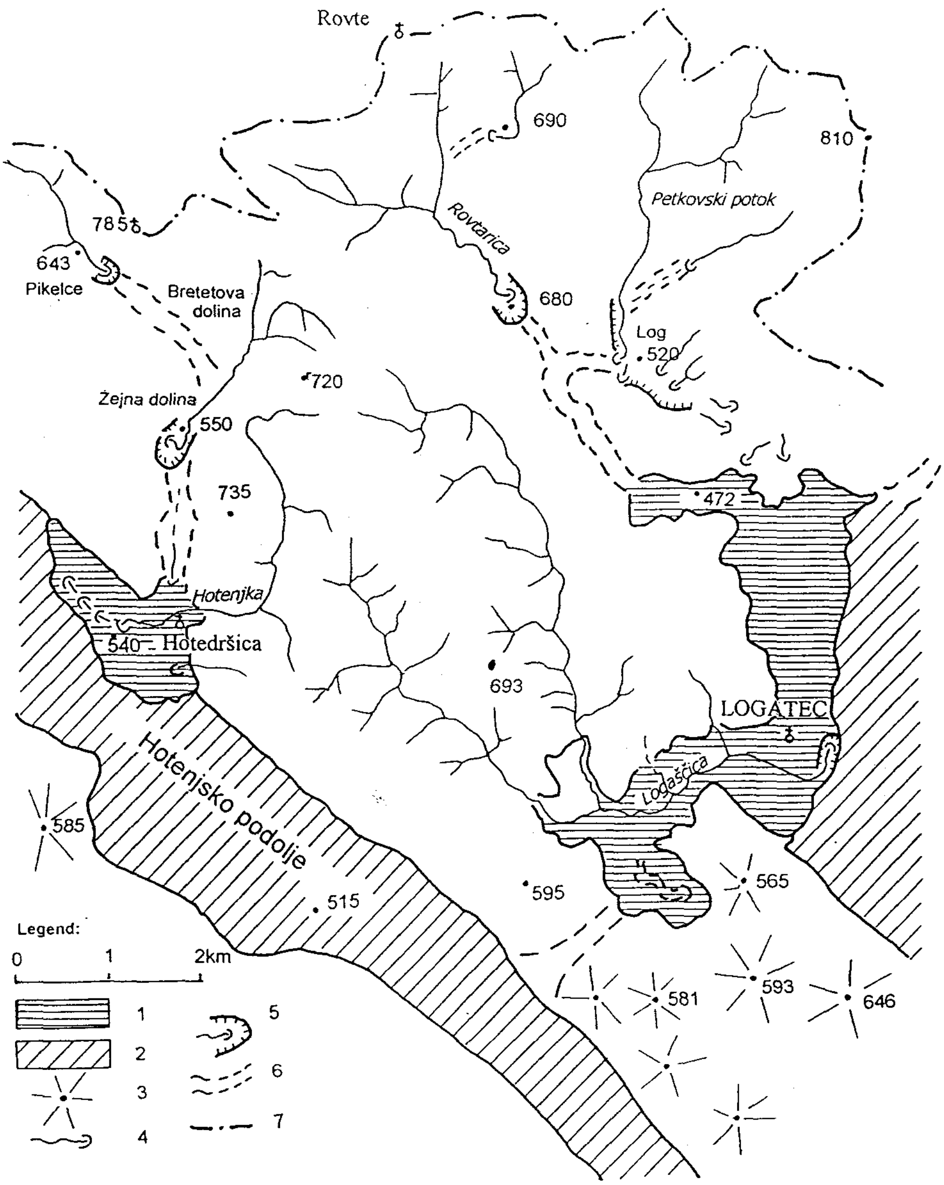


Fig 7: Contact karst of Rovte.
***Legend:** 1. karst polje, 2. karst plain with solution dolines as dominant form, 3. higher karst with conical hills as dominant form, 4. stream with a ponor, 5. contact karst depression, blind valley, 6. dry valley, 7. surface watershed.*

In general, the relief of Rovte has fluvial or fluviokarst forms. Large relief forms are ridges and medium-sized up to 200m deep fluvial valleys and dry valleys, which extend into levelled karst plains on the edge: to the Logaško polje and the Hotenjsko polje plain. Looking at it in greater detail, the relief has many contact karst features. It is characteristic that rivers sink at the bottom of the valleys they flow across; from there dry or intermittently dry valleys extend. Great contact depressions sometimes formed next to swallow-holes, which were later filled with fluvial sediments. Young erosion terraces or alluvial dolines and sinks formed in them later (Mihevc, 1986).

The formation points to the long morphologic development during the period when surface flows cut into the relief and the water from the water flow penetrated into the karst. The complete fragmentation of the river valleys did not occur. Vast karst karst plains and karst fields formed at the edge, and all the valleys are balanced on them. Although newer geomorphologic development – the cutting of the Idrijca river valley to the north-west and the formation of the Ljubljansko Barje depression – allowed a greater gradient in the karst, small alteration in the environment can cause the filling of swallow-holes and the renewing of the water flow network in old dry valleys.

Logatec karst polje

The Logatec polje developed on the contact of dolomite and limestone between 470 and 480m a.s.l.. A number of small streams flow onto in, the largest being the Logaščica, which collects run-off from a dolomite area of $19km^2$. The mean flow is $0.3m^3/s$. Short lasting floods occur at the swallow-holes on the Logaško polje when the flow exceeds $30m^3/s$.

In the past, another large water flow flowed to the Logaško polje – the Petkovski potok brook with the Rovtarica brook. The Petkovski potok flowed across the present dry valley away from Log and deposited thick beds of non-carbonate rubble on the northern part of the Logaško polje. The covered valley relief was already fragmented by transport of the sediment onto the karst (Melik, 1955).

Contact karst of Log at ponors of Petkovski potok river

The Petkovski potok collects water from an area of $8.6km^2$. A vast boundary depression formed along the contact of limestone and slate and sandstone at swallow-holes in Log. Its bottom is covered with approximately 15m of thick beds of non-carbonate gravel, sand and loam, which were probably deposited by the Petkovski potok during the Pleistocene cold climate during which whole area was above the forest line and denudation of slopes and gravel production was much greater than today. The stream cut a number of terraces into the sediment; the terrace levels correspond to various sinking points. The stream, with a mean flow of $0.2m^3/s$, sinks at the edge of the basin into a vertical shaft. When the water level is high, the stream also sinks in a cave situated a few metres higher in Log.

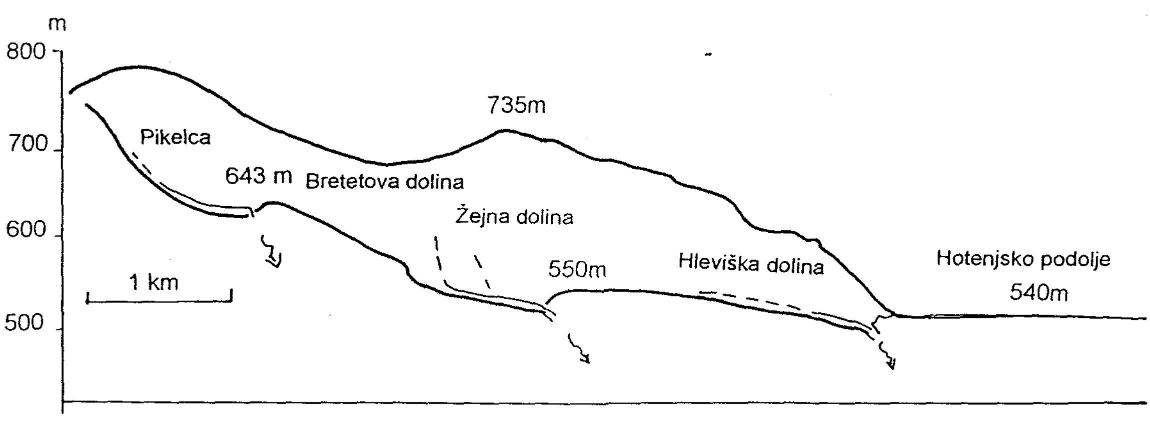


Fig 8: Schematic cross section from valley of brook Petkovski potok to Logaško polje.
Legend: 1. temporary or permanent stream, 2. sink with underground flow.

At the level of the Pleistocene filling and above the swallow-holes, a dry valley leading to the Logaško polje is situated. The same sediments can be traced to the bottom of the dry valley on the Logaško polje.

Contact karst of Pikelce brook and Žejna dolina valley

Pikeljski potok flows across slate, dolomite and limestone in its upper course as the primary Hotenjka stream, in which the Pikeljcebrook blind valley, the Bretetova dry valley, the Željski brook dry valley and the Hlevišarka dry valley are situated.

The Pikeljce brook formed a small plain on the lower part of the valley, where it flows across slate and dolomite onto limestone at 643m a.s.l.. It cut a short valley into the plain; at the end of it, the stream sinks into the Pikeljce cave. The Bretetova dolina dry valley continues in cretaceous limestone underneath the blind valley and extends into the Žejna dolina valley.

In Žejna dolina valley, water from dolomite and slate is collected by the Žejski potok. The stream cut a wide valley that narrows upon reaching the swallow-holes in the rock. The water sinks at 549m a.s.l. into the 340m long cave Kmetovo brezno, which formed at the contact of Triassic dolomite and cretaceous limestone. A dry valley extends from the swallow-holes to the south.

Water from the dolomite slopes is collected into the small Hlevišarka stream in this dry valley. The Hlevišarka sinks at the contact with limestone next to the first houses in Hotedršica 540m a.s.l..

During the floods that occur every few years, the Žejski potok floods the land around the swallow-holes and flows through the dry valley together with the Hlevišarka to Hotedršica, where it sinks in swallow-holes on the karst flats or field.

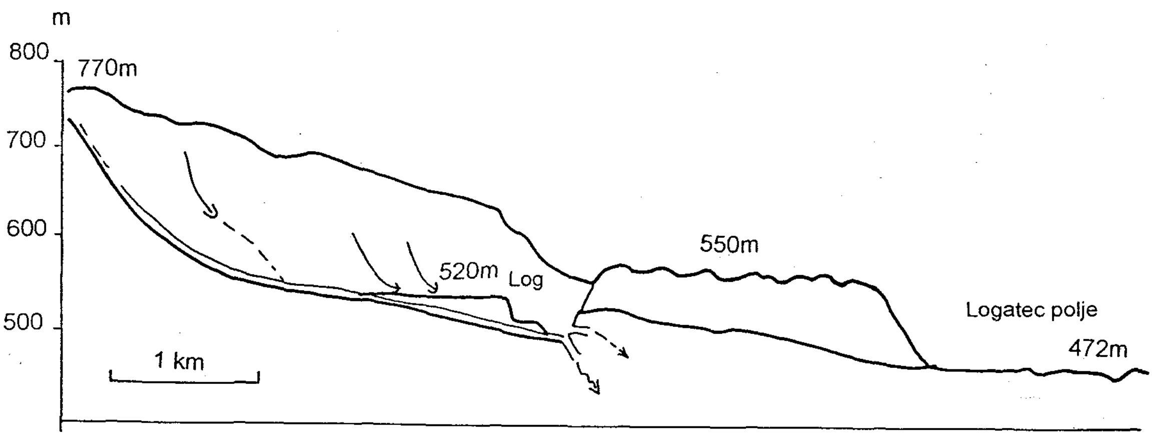


Fig 9: Schematic cross section from the valley of Pikelce to Hotenjsko polje.

CONTACT KARST OF PIVKA BASIN

The bottom of the Pivka basin, an area of about 70km^2, is of Eocene flysch rock. A river network has formed on the floor of the basin; the water flows into the boundary limestone rock (Brodar, 1952; Melik, 1951, 1955; Gams, 1962; Habe, 1965, 1976, 19) going to different river basins (Habič, 1982, 1989).

Karstificated limestone surrounds the valley from all sides; at the contact on higher levels there is flysch. Along the 59km long lithologic contact of flysch and limestone, 17 larger and a number of small rivers sink, transforming only 2.3km^2 of karst. The surrounding karst relief forms distinct morphostructur units, at the contact of each, different contact karst forms have developed. This indicates a separate morphological development at each of these morphostructur units (Mihevc, 1990).

Nanos and Javorniki have no sinking rivers and no contact karst. The Orehovški kras is situated in the middle of flysch rock and water sinks into it on one edge and springs from it on the other, or even crosses it on the surface. The karst part of the Postojna karst and the Slavenski Ravnik have similar features, in particular large fossil blind valleys, and both were in the past probably the most important courses of water removal from the Pivka basin. The forms of contact karst and caves lead to the assumption that the gradient between swallow-holes and springs was small and stable throughout the long period. This is the reason why large cave systems developed in the epiphreatic conditions, large blind valleys and border depressions between the swallow-holes.

The Podgora karst is characterised by a steep gradient underground and in the catchment area of surface rivers too. Sinking streams therefore formed dendritic river network. Due to the steep gradient, the sinking Lokva river will soon include into its river basins the Nanoščica and Pivka rivers and thus decollate swallow-holes in front of the Postojna Çaves.

Alterations in conductivity of the karst boundary, probably because of the gradient changes in karst have occurred previously in the Pivka basin, changing the direction of outflow. Large, inactive blind valleys, e.g. Beševci, Risovec and Ivačevci, indicate this.

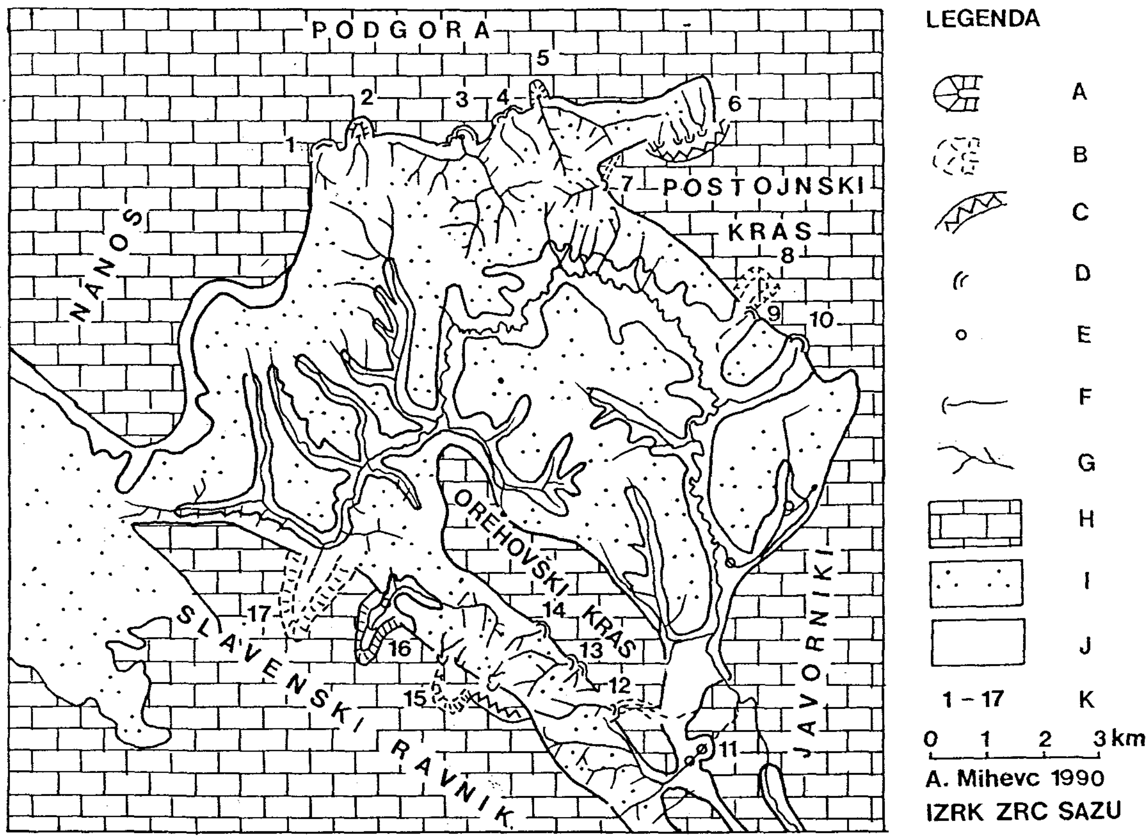


Fig 10: Contact karst of Pivka basin.
Legend: A blind valley, B fossil blind valley, C edge of the border depression, D ponor recess, E sinks in the bottom of the karst polje, F flow with ponor, G river net of the flysch part of the basin, H limestone, I flysch, J quaternary alluvial or slope sediments

Contact karst at ponors of Lokva at Predjama

The Lokva river collects water from the north, from a 4.5km^2 large area of the flysch basin, where it formed a dendritic river network with a difference of 125m between the ridges and the ponor located at 462m a.s.l., which is also the lowest point of the Pivka basin. Water flows to the sources of the Vipava 13km away, at about 100m a.s.l..

The ponor is situated at the foot of a 130m wall in which the remains of higher floors are located and in which Predjama Castle was built. The ponor was later named after the castle. The cave under the castle is 13km long and 143m deep, with terminal sump at about 420m a.s.l..

The contact karst depression of the Lokva developed at the contact of a karst levelled surface with many dolines at approximately 600m a.s.l.; ridges in the flysch are approximately at the same level. The Lokva flows onto limestone for about 150m before the swallow-hole, but contact karst depression is about 300m wide at the ponors only, form that can be named ponor recess or ponor steep head, but not the blind valley.

Contact karst at ponors of Pivka

The Pivka, with a mean flow of 6m^3, is the largest sinking river in the basin. Most of its water flows from karst sources on the southern part of the basin, at the foot of the Javorniki, where a karst polje formed on limestone. For a large part of the year, the Pivka is dry; when waters are high, it floods the floor of the field.

The main inflow into the Pivka from flysch rock is the Nanoščica, which flows from W,: it collects water in the western part of the flysch basin, from the once dry Biševci valley and from karst springs at the edge of the Orehovec karst. The river network points to the dominant effect of the geologic structure; the water meanders on the flooded flat floor only on the lower part at about 515m a.s.l. before reaching the swallow-holes. This is the confluence level with the Pivka river.

Situated on the eastern part of the plain is the inactive blind valley Risovec. To the south, the Pivka flows into the 20km long Postojna Caves at about 511m a.s.l.. The caves have several levels, the main level being 520 to 530m a.s.l.. The lowest parts of the caves are located at the outflow sump at 477m a.s.l., while sources on the edge of the Planina polje are at 453m a.s.l.. (Gospodarič, 1976).

A feature of the contact karst at the swallow-holes of Pivka is an old and inactive blind valley, Risovec and ponor of Pivka.

The Risovec blind valley is 500m long and has a 100m wide floor filled with fluvial sediment. The valley extends into the Otoška cave at 530m a.s.l.. The blind valley cut into the Postojna karst relief, which is located at about 570–600m a.s.l..

At the Pivka's ponor a very inexpressive contact karst relief have formed. The straight-lined edge of karst, where contact with flysch occurs was altered in a length of about 400 m for only about 100m. There are old entrances into the Postojna Caves at various levels near this ponor recess . Water sinks through the closest entrance at 511m a.s.l..

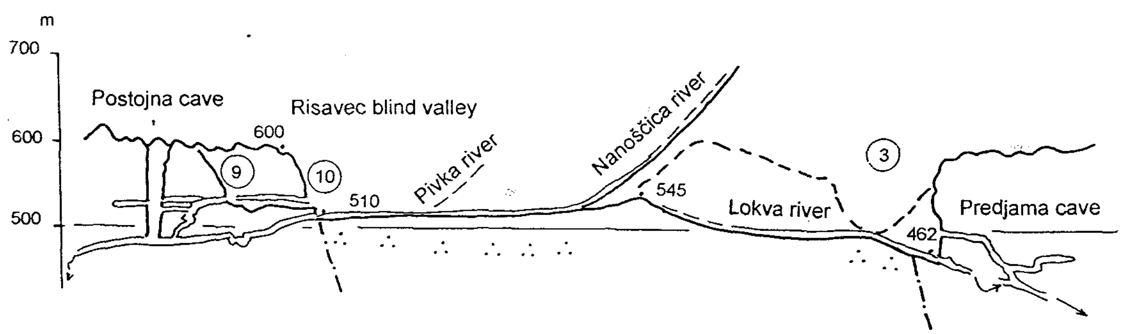


Fig 11: Schematic cross section of contact karst at Lokva across the bottom of the flysch basin and Pivka river sinking into Postojna cave.
Legend: 3. Lokva river and blind valley, 9.Risovec fossil blind valley, 10. sink of the Pivka into Postojna cave.

BLIND VALLEYS AND OTHER CONTACT KARST FEATURES OF THE BRKINI HILLS

Friday, June 29

CONTACT KARST OF S EDGE OF THE BRKINI HILLS

The Brkini, together with the Jelšanska brda, form a 25km long and up to 10km wide flysch upland. The hills border onto the Reka valley towards the north, and towards the south onto the karst levelled karst plains Matarsko and Brgudsko podolje (levelled lowland in Slovene language) where 24 streams sinks. The relief forms, in particular the blind valleys, have been the subject of many studies. They have been explained as the remains of a pre-karst river network (Melik,1955; Roglič, 1957) and as the beginning of boundary levelling in places where streams deposited non-carbonate rubble. Under the influence of climatic geomorphology, the varying speed of erosion on carbonate rock in various climatic conditions of the Pliocene and Pleistocene have also been stressed (Radinja, 1972). The forms and dimensions of blind valleys are supposed to reflect the chemical characteristics of sinking water flows and deposited sediments (Gams, 1962). Geomorphologic mapping and comparisons of different forms on the contact (Mihevc, 1993) showed a significant impact of the water level and/or the gradient in karst and traces of tectonic shifts at the contact well expressed and preserved in karst relief.

The blind valley of the Reka has also been researched in detail (Radinja, 1967; Gams, 1974, 1983, 1986; Kranjc, 1989, Slabe, 1995), as has the development of Divača karst and caves behind ponor in the Škocjan caves (Mihevc, 2001).

The water that collects on the southern edge of the Brkini flows into 24 sinking flows; the largest sinking river, the Reka, collects water from the northern edge. The flows, called the Brkini sinking rivers, discharge 29.2 km^2, while the Reka collects the precipitations from 189km^2. The geologic contact of flysch and surrounding limestone is 99km long, but it is transformed into contact karst only for 9.45km. The surface of contact karst along the Brkini covers an area of 11.3km^2 in addition to the 9.2km^2 along the Reka's swallow-holes. Of this, 4.2km^2 consists of fossil relief forms, meaning forms from which water from flysch no longer flows. There is 8.2km^2 of this type of relief along the Reka (Mihevc, 1991, 1993).

Eocene flysch is composed of marl, loam, sandstone, calcarenites, breccia and conglomerate. To the south-west of the Brkini, the rock is Palaeogene limestone, followed by Cretaceous limestone and dolomite and limestone breccia. Limestone inclines into flysch at a 20 to 60 degree angle.

Levelled surface at Rodik

Smaller streams flow from the foot of the highest part of the Brkini. A stream that used to flow south of the village of Rodik at 520m a.s.l. was sinking in the levelled karst plain, but made no blind valley or other depression. Only remains of sediment, the smooth relief and the absence of dolines indicate the existence of the old stream course. Dolines appear at the edge of the sediments.

Blind valley Odolina

Characteristic forms of the Brkini contact karst are blind valleys with corrosion widened bottoms. A characteristic example of such valley is Odolina blind valley. The blind valley was formed by the sinking stream draining 4.3 km² large water basin. The average discharge of the brook is about 15 l/s, but oscillations due to precipitation regime are frequent. Periodical water hardness measurements indicated 111 mg of dissolved carbonates originating from the flysch marls.

Close to the brook's passage to the limestone the narrow fluvial valley widens. A valley, 1 km long and 300 m wide, developed on the limestone. Close to the contact it is 150 m deep and on the southern end it is deepened into the karst plain for 60 m.

The valley's bottom is covered by the sediments, gravel and sands. Flood plain is cut by some younger, up to 25 m deep alluvial sinkholes and riverbed of the brook, sinking in the final part of the valley in 120 m deep cave. In the sinkholes and in the riverbed the rocks are exposed showing that the relief below the sediments ranging up to 20 m.

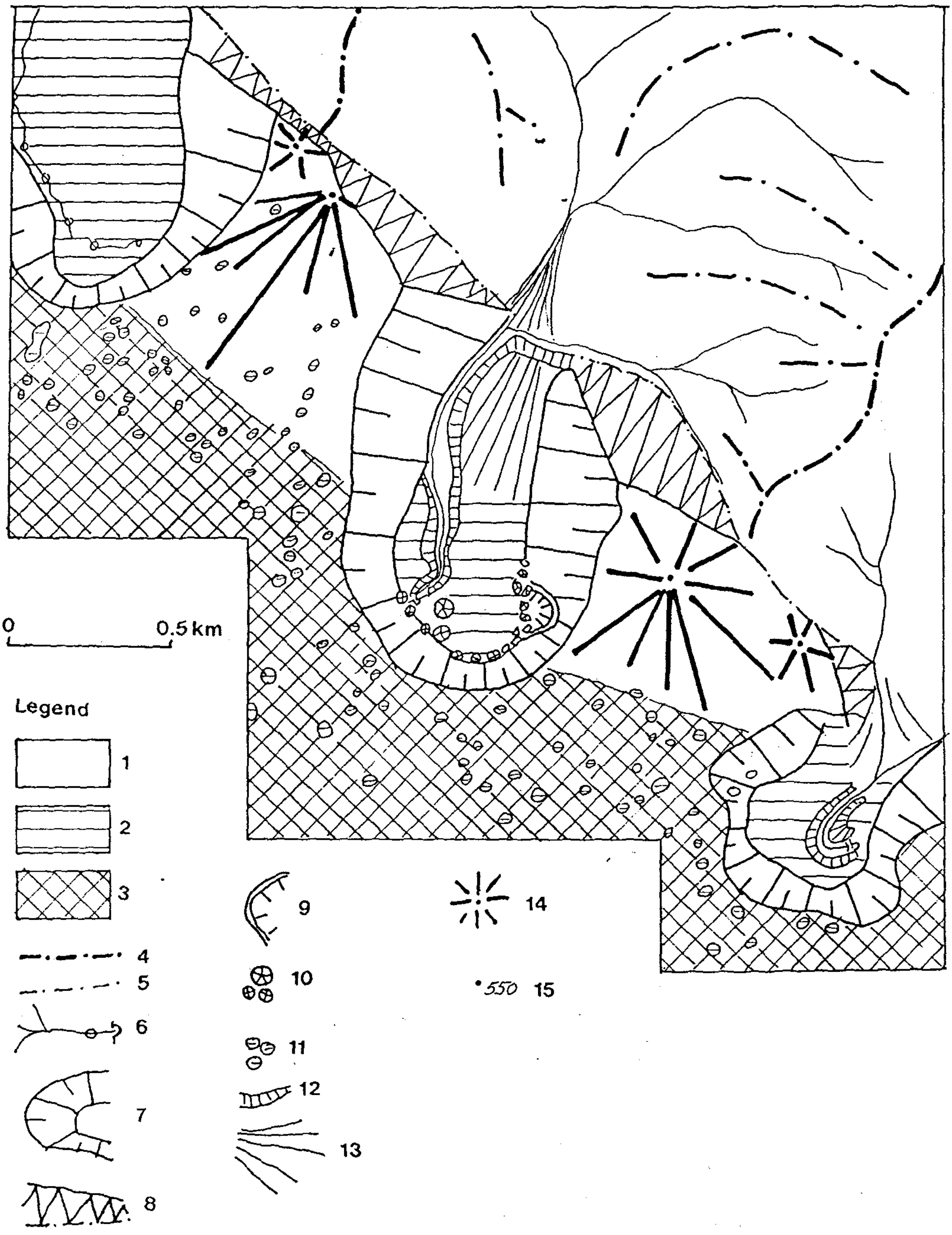


Fig 12: Morphological sketch of the contact karst at the Odolina blind valley. Brezovica blind valley is top left, Odolina in centre and Hotična blind valley lower right.
Legend: 1. surface on flysch, 2. levelled bottom of the blind valley covered with sediments, 3. surface in limestone, 4. watershed, 5. geologic contact flysch/limestone, 6. brook with a ponor, 7. slope of the blind valley, 8. slope along the lithological contact, 9. recess above the ponor, 10. alluvial dolines, 11. solution dolines, 12. alluvial terrace edge, 13. alluvial fan, 14. conical hill, 15. elevation in m.

Blind valley Jezerina

Is one of the largest blind valleys. The valley's bottom is covered by the sediments, in altitude of 500 - 510 m. The plain is cut by some younger, up to 20 m deep alluvial sinkholes and riverbed of two brooks. One of the sinks is 120 m deep cave.

Two important caves are located at the edge of the valley. The Mitjeva cave is situated at the level of the deposited valley floor; in it there are the same sediments as in the valley floor itself. Dating of stalagmites that formed on the sediment show that 12Ka have passed since depositing stopped (Mihevc, 2001).

Blind valley Račiška dana

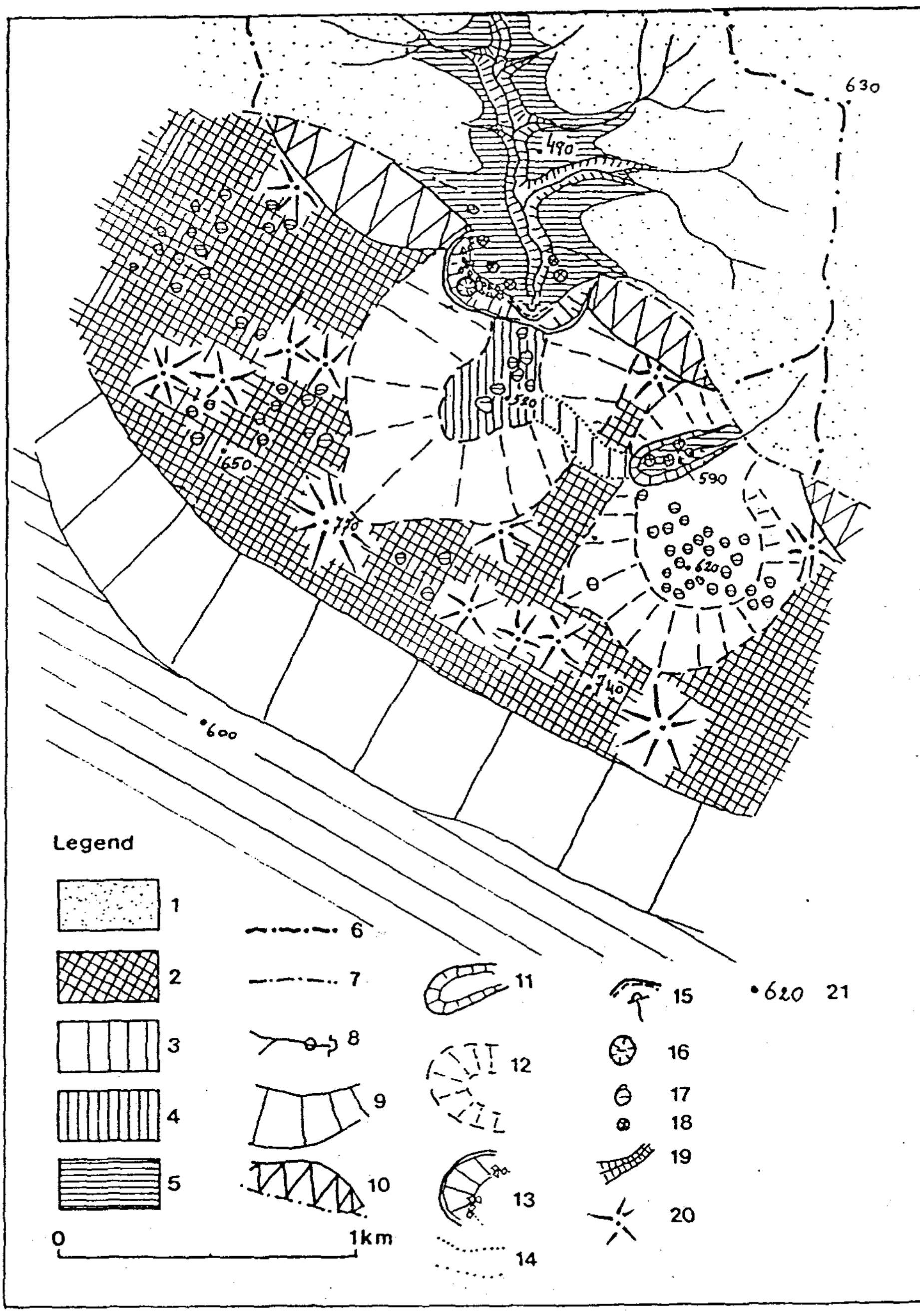


Fig 13: Morphological sketch of the contact karst at the Račiška dana blind valley.
Legend: 1. surface on flysch, 2. surface of Gradine (limestone), 3.Matarsko podolje, 4. levelled bottom of the fossil Račice blind valley, 5. sediments in bottoms of blind valleys, 6. watershed, 7. geologic contact flysch/limestone, 8. brook with a ponor 9. slopes of Gradine above the Matarsko podolje, 10. slope along the lithological contact, 11. blind valley Zavnja, 12. fossil blind valley of Račice and Zavnja, 13. ponor recess or ponor step head, 14. dry valley of Zavnja, 15. wall and collapse in the ponor steep head, 16. collapse dolina, 17. solution dolina, 18. alluvial sink, 19. slope of the alluvial terrace, 20. conical hill, 21. elevation in m.

To the south of Podgrad, the relief of the Brkini is lower than on limestone. Between the Brkini and the valleys, a higher and up to 2 km wide limestone area called Gradine is located. Its highest peaks are above 700m a.s.l..

Streams flow from flysch onto the edge of Gradine, where they have formed fossil and active relief forms of contact karst: the active and fossil blind Račiška valleys, the blind valley in Zavnja and Brdanska Dana, to the south, in Croatia, the blind valley at the foot of Brdec and the blind valley over Šapjane.

The sinking Račiška river collects run-off from a basin of 3.12km^2. The gradient of affluxes is steep. The watershed ridges with the Reka tributaries are at 550m a.s.l.. Even higher up, at around 640m a.s.l., is the watershed with tributaries of the Brdanska Dana. A short and wide ponor recess and vast fossil blind valley formed above the ponors in Račiška dana blind valley.

The sinking stream flows across flysch onto limestone for approximately 400m before it sinks. A 250m wide and long ponor recess formed in the slope at the contact with limestone. Located at 475m a.s.l. is an alluvial plain transformed by sinks. At the foot of the 30m vertical wall, the Račiška Dana brook sinks in an approximately 600m long and 58m deep cave. The main section of the cave is an almost horizontal and paragenetically transformed tunnel. From it, a series of steps lead to the lowest point of the cave.

A large fossil blind valley is situated above the recent ponor recess . Its floor is situated at 500–525m a.s.l.. Its boundary, made visible by the bend in the slopes, is about at 750m. The valley is up to one kilometre wide in the upper section of the course and is 1300m long. The blind valley is positioned between cone summits, among which there is a levelled surface with dolines at 650–750m.

The floor of the blind fossil valley is levelled but deep dolines have already formed in it. It extends into the slopes without any sharp folds. The south-eastern part of the boundary of the Račiška Dana blind fossil valley is broken up. This is where the small Zavnja blind valley formed in three development stages: the presently active blind valley in Zavnja, the blind valley connected to the Račiška Dana blind valley and the older blind valley.

The deposited floor of the Zavnja is situated at 585m a.s.l.. A short streams flows across it and sinks into its own deposit material. The fluvial plain is up to 100m wide and ends with a 5m higher channel edge. A dry valley extending into the Račiška Dana blind fossil valley that is situated further in the Zavnja valley. The dry valley has smooth slopes.

A relief form, which is probably the Zavnja fossil blind valley lies to the south of Zavnja. The floor, located at 630m a.s.l., is fragmented by shallow dolines. Above the floor, the slopes rise to approximately 700m a.s.l.. The blind fossil valley is about 700m wide; the front sections are approximately 800 away from the contact of flysch and limestone.

Matarsko podolje

The Matarsko podolje is 20 km long and 2-5 km wide levelled karst surface south of Brkini hills. Surface is not a base-levelled plain, cross sections indicate that the bottom, disseminated by the dolines, is inclined south-westwards and in the longitudinal section it gently raises from about 490 m on NW to 650 m on SE side. The lowered surface continues towards SE but from the highest point near the blind valley Brdanska dana it lowers on the distance of 2 km for 200 m towards SE to surface of Brgudsko podolje. This bend is most likely result of neotectonic movements (Mihevc, 1994).

The geomorphologic sketch of the entire contact indicates a certain diversity of the forms of the brooks flowing from the flysch.

The first sinking streams in a series flow to the border limestone in the altitudes about 500 m in the lowest, NW part of the lowered surface. These brooks, for instance the brook at Rodik did not form the blind valley on the limestone. Most of the brooks namely developed blind valleys bottom widened by corrosion bottom. The bottoms of these valleys are situated between 490 to 510 m. As the valleys are incised in the border of the karst, uplifted towards SE, the blind valleys lying more to the south are deeper. The first , Brezovica blind valley is cut for 50 m only while the deepest is the last Račiška and Brdanska blind valleys. They are deepened into border limestone for 250 m and its bottom lies 120 m below the bottom of the lowered surface.

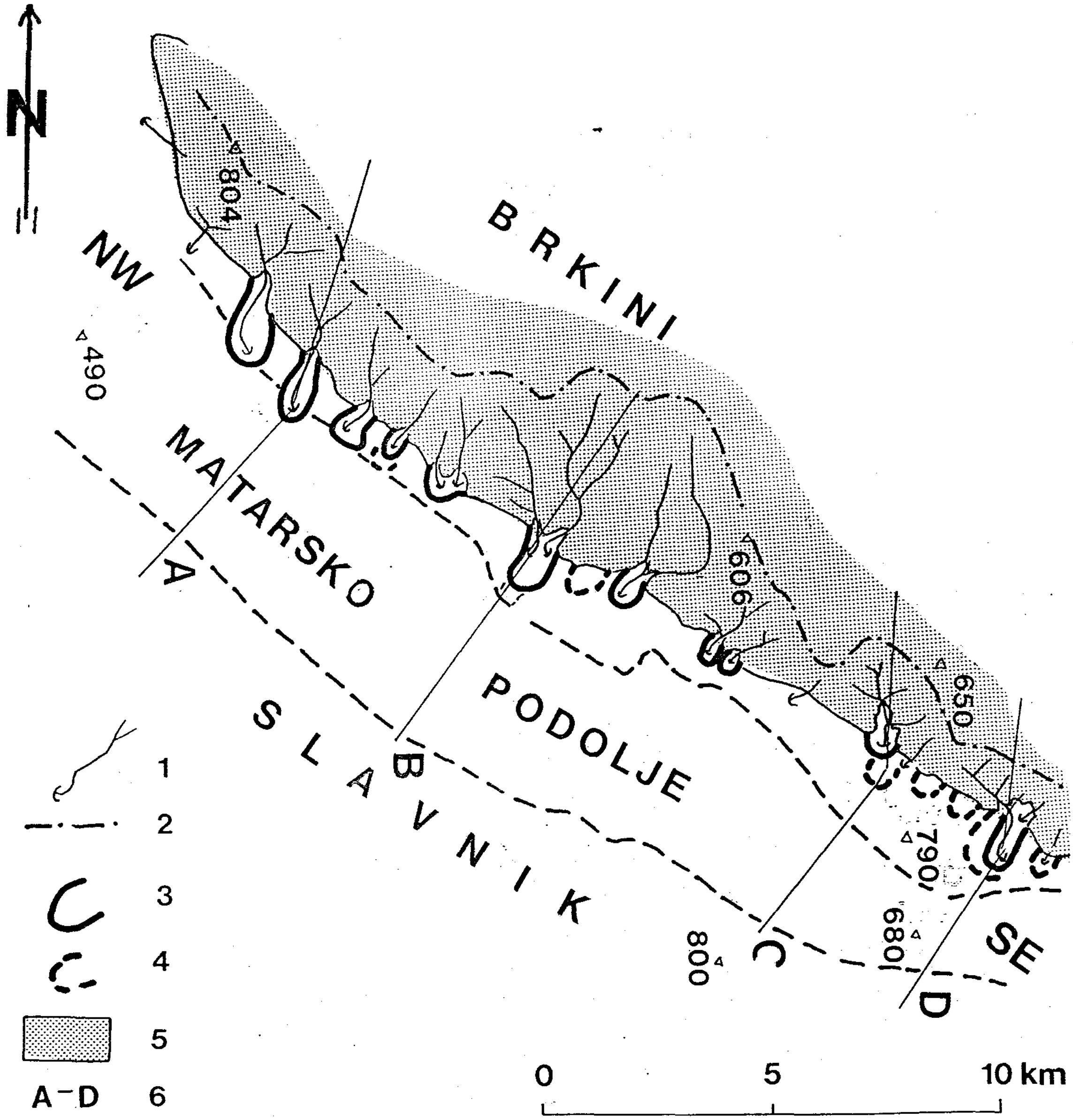


Fig 14: Geomorfological sketch of the contact karst at the contact of Brkini hills with levelled karst plain Matarsko podolje (lowland). Between Brkini and podolje is narrow belt of higher relief formed in limestone (Gradine).
Legend: 1. brook with a ponor, 2.watershed, 3. blind valley, 4. fossil blind valley, 5. flysch, 6. cross sections over blind valleys (see fig. 15).

Possible sequence of the morphological events and dominant factors which were decisive for the formation of the actual relief forms were as follows:

1. The former shape along the ponors on the border of impermeable hills was karst corrosion plain. The water flowing on it had modest gradient in karst and was capable of the aplanation of the surface only.

2. The lowering of the piezometric level in the karst enabled the development of the relief depressions along the ponors. The deepening and the contemporaneous widening of the valleys followed the lowering of the karst water to the altitudes about 500 m. Bad permeability of the karst caused the

deposition of the sediments in front of ponors and the deposits affected the planation and corrosion of the bottom of the blind valleys. The sedimentation was intensive in the cold periods of the Quaternary and these deposits are preserved on the bottom of most of the blind valleys. The blind valleys started to cut into the corrosion plain with small transverse and longitudinal gradient as in the contrary case the fluvial valleys should develop in them. They should be preserved on karst as dry valleys. There are no such dry valleys, surface is dissected by solution dolines and by some bigger collapse dolines only.

3. The corrosion plains along the ponors were controlled by the piezometric level. Stronger tectonic uplift in the SE part upraised the lowered surface above the impermeable flysch part and due to stronger uplift incomparable fossil blind valleys developed – they are not incised on the northern part and are in the level of Matarsko podolje, while in the SE part this incision is for 150 m.

4. In actual conditions the karst water table stays deep under the altitude of the blind valley bottoms. They are out of reach of the floods of the sinking streams in front of ponors and the gradient in the karst is so big that the rivers are washing old deposits from the surface into the karst.

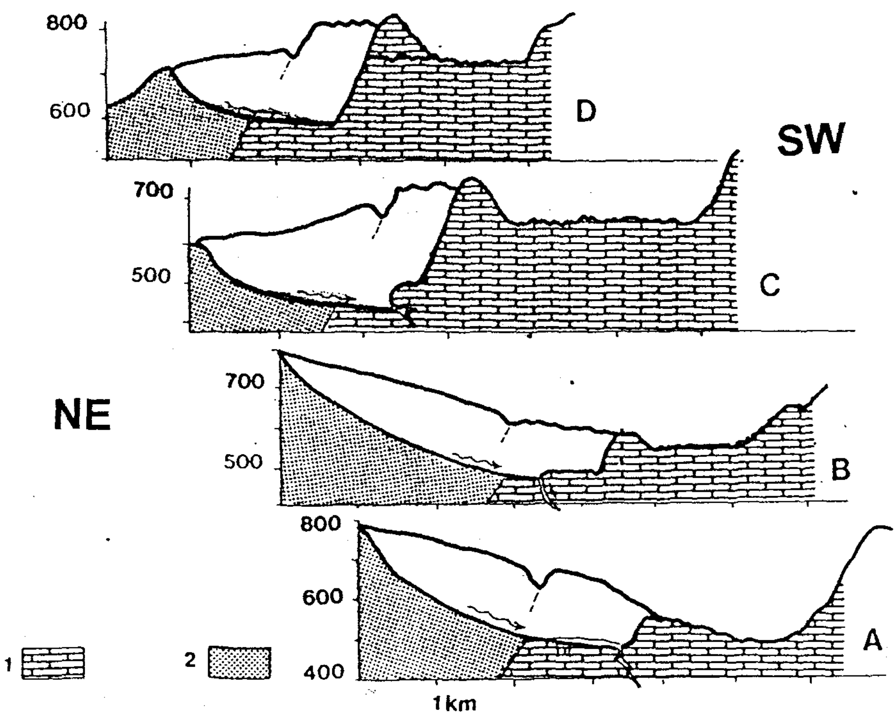


Fig 15: Cross sections over the Brkini blind valleys.
Legend: 1. limestone, 2. flysch, Blind valleys: A Odolina, B Jezerina, C Račiška, D: Brdanska.

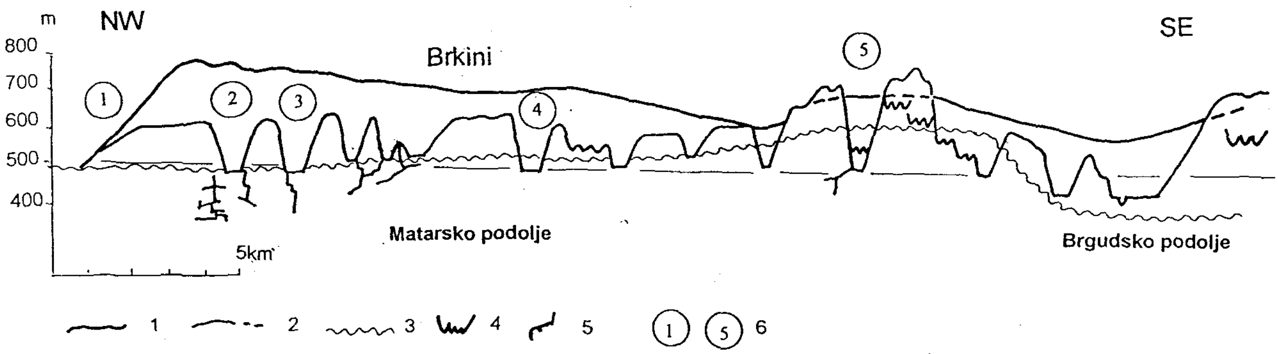


Fig 16: Schematic sections along the Brkini and Matarsko podolje contact.
Legend: 1. ridge of the Brkini, 2. line of the contact limestone/flysch, 3. level of the karst plains Matarsko and Brgudsko podolje, 4. fossil blind valleys, 5. important caves, 6: 1-levelled surface at Rodik, 2-blind valley Brezovica, 3- blind valley Odolina, 4- blind valley Jezerina, 5- blind valley Račiška dana.

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ABSTRACTS OF THE PRESENTATIONS

MEANING AND PRESENTATION OF BOUNDARIES IN KARST TYPE MAPS

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In numerous existing karst type maps boundaries are presented in a uniform way: thin unicolored (often black or grey) lines that divide different areas. For the users of such maps it is not possible to get any further information about the boundary, e.g. criteria for and precision of the position.

There is nearly no disadvantage in small scale maps because of generalisation needs. In large scale maps however the situation is quite different. Here exists a greater potential to increase the amount of information about the karst types by differentiation of boundaries. For that differentiation it is necessary to answer two crucial questions: what & how.

1. Which information shall be represented? (meaning of boundaries)
2. How can this informaftion be represented? (presentation of boundaries)

ad 1) The first question directly leads to the typification method. Many possibilities exist to typify karst. The chosen method depends on several factors: purpose of typification and visualisation, scale (degree of generalisation), characteristics of the karst area, available data, available technologies, economical considerations, knowledge and skills of the participating persons,...

ad 2) For the representation of boundaries one can vary the cartographical variables (graphic-, time- and sound-related) concerning line and ribbon signatures. The decision for a specific kind of visualisation depends mainly on the same factors as the ones listed above. The only difference is the absence of the data availability. An example will illustrate the advantages of boundary differentiation.

A DEEP CAVE SYSTEM DEVELOPING INTO CALCAREOUS SCHISTS IN A GLACIAL ENVIRONMENT: THE FEICHTNER SHAFT, -1024 M (KITZSTEINHORN, SALZBURG, AUSTRIA)

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The Kitzsteinhorn (3208 m) in the Central Alps of Salzburg, Austria, is a partly glaciated karst area with two deep caves recently surveyed. Both the "Zeferethöhle" (-560 m) as well as the "Feichtner-Schachthöhle" (-1024 m) are developing into micaceous calcareous schists. Observations on the genesis, hydrology, sedimentology and the cave climate are discussed.

HOW THE TECTONIC STRUCTURES CONTROL THE WORKING AND THE GEOMETRY OF AN ACTIVE KARSTIC DOMAIN? EXAMPLES OF TWO REGIONS IN THE SOUTH OF MOROCCO

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The karstic activity is conditioned by several parameters between the most important are geology and climate. Geological conditions are closely linked to tectonic structures and lithological composition.
We show through two regional examples in the South of Morocco, how geological features, especially tectonic events, influence working and geometry of the karstic device.

In the western High-Atlas, the region of Imouzzer Ida Outanane is a vast calcareous domain of Jurassic age, which developed typical and varied karstic forms: lapiez, dolines, chasms, travertines...etc, and in particular, the underground river of Wintimdouine, the biggest currently known in North Africa.

The distribution of these karstic forms is closely sealed by the tectonic structures assigned to the atlasic orogenic cycle (alpine cycle). Thus, lapiez take places right on the NNE-SSW, E-W and NNW-SSE main fractures, whereas, dolines occupy depressions defined by wide E-W trending synclines, while chasms stand in the NNE-SSW and subequatorial fractures intersection (Qurtobi, 1996). The underground network (cave and galleries), which partly expresses the intense karstic activity of this domain, shows a geometry perfectly superimposed to the fractures network of the atlasic structuring (Qurtobi, 1996; Belfoul et al., 2001). The form of the all karstic device is everywhere, as centrocline, slightly developed in the E-W trend, according to the atlasic regional folds.

In the domain of the Anti-Atlas, the region of Akhssas is a high karstic plateau formed by dolomites and massive limestones assigned to the terminal proterozoique and to the lower Cambrian times. Structurally, it represents a N-S passageway, taken in "sandwich" between two precambrian basements: Ifni in the West and Kerdous toward the East. These blocks were mobilised during the hercynian shortening in Carboniferous time, of which the consequence is the up extrusion of the cover and its structuring as N-S, right and squeezed folds with foliation. In the same way, develops some meridian trend deep faults of which the dynamics vary between wrench and vertical movement. On the map, this domain presents the shape of a "tie in butterfly" oriented N-S. The central part is the most compressed and therefore the most deformed, the north and south borders overflow laterally on the precambrian basement, with an attenuated distortion.

The karstic system developed in this region shows several shapes represented by some dolines, lapiez, chasms, travertines... The tectonic structures condition the ways of water infiltration and the predisposition of rocks to be dissolved. This reverberates on the distribution of the karstic shapes which trace the network of fractures and tectonic discontinuities. The extension of this karstic domain is defined by N-S subverticale deep boundary faults, which assure the transition to the precambrian basement.

Through these two examples, belonging to different structural domains, it is proved that the geometry and the distribution of the main forms of karstic device are clearly linked to the tectonic network.

KARSTIC NETWORKS OF CALCAREOUS BOUNDARY OF THE CRYSTALLINE CÉVENNES (SOUTHERN FRANCE)

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The Causses and mediterranean Garrigues are bordering the Cévennes crystalline basement (South of French Massif Central). This karstic area presents a long continental evolution from late Cretaceous. The reef limestone of the Séranne, the dolomite of the Monts-de-St-Guilhem and Tithonic limestone of Sauvas syncline explain the good conservation of the endokarst and of the landscapes.

The karstic networks analysis provides geomorphological indicators to reconstruct the paleogeography of this contact area while geological indicators are missing. The network's levels of the South Larzac and South Ardèche calcareous plateaus are connected with the landscape karstic forms : poljes, canyons, peripheric valleys. The endokarst preserves sedimentological and paleoclimatic witnesses and also hollowing shapes that traduce the successive stages of the paleogeographic evolution. We particulary study the fluvial dynamics of karstic networks. The results show that in the contact karst area the allochtonous alluvial deposits derived from crystalline Cévennes have a chrono-stratigraphic signification.

These results are used to estimate valleys and canyon incision rates, water table variations and surrection amplitude and age of some tectonic movements.

CONTACT KARST OF NEW BRITAIN (PRELIMINARY RESULTS)

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Recent studies of tropical karst (French expedition NIUGINI 2001, January-march 2001) allowed many observations of fluvial dynamics cave network. Two different networks present successive levels of galeries, the Arrakis network, explored in 1985, and the Omega-Illana network. We present the first results.

KARST FEATURES OF NARROW LIMESTONE BELTS - CASE STUDY OF THE RIDGE DŽEVRINSKA GREDA, EASTERN SERBIA

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Areas of narrow limestone belts and outcrops differ from classical karst areas due to relatively strong fluvial influences from the surrounding non-carbonate terrains. Instead of dispersed infiltration, water enters the karst in the form of streams, which, depending on various factors, either form caves, or entrench in limestone and form short gorges and canyons. In many cases caves are filled with considerable quantities of fluvial sediments, or show indications of former periods of filling.

The study area - limestone ridge Dževrinska Greda, situated near the Danube Gorge in Eastern Serbia and stretching in N-S direction, is 20 km long. Its average width is 100-300 m, while in the narrowest parts it is only several tens of metres wide. Various types of contact between carbonate (Upper Jurassic limestones) and non-carbonate rocks are present, because on the west the contact is tectonic (conspicuous regional fault), while on the east flysch beds are deposited over limestone, making a sedimentary contact. With the total area of only about 5 square km, the karst of Dževrinska Greda abounds in characteristic features occurring at the fluvial-karstic interface.

KARST CHARACTERISTICS OF THRUST CONTACT LIMESTONE-DOLOMITE NEAR PREDJAMA

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Contact karst near Predjama (SW Slovenia) is not limited just to the thrust contact between Upper Cretaceous limestone and Eocene flysch. We can speak about special contact karst on the thrust contact between Upper Triassic dolomite and Upper Cretaceous limestone. On the studied area different karst features as dolines and sinks occur. According to geological map of Postojna (Pleničar, 1970) the studied area belongs to Javorniki-Snežnik thrust unit over which tectonic unit of Hrušica is overthrusted in the North. Placer (1981) unites Nanos and Hrušica into one so-called Hrušica thrust unit. In the South there is flysch of Postojna and Pivka valley. Predjama fault runs between Nanos and Hrušica. The thrust contact between Upper Triassic dolomite and Upper Cretaceous limestone is especially interesting because it can be followed in Predjama cave system which is the second longest cave system in Slovenia (13 km).

With detailed tectonic-lithological mapping in the scale 1:5000 we studied the area North from Predjama near Bukovje. The geological mapping was performed on the contact between Jurassic dolomite and Upper Triassic dolomite. The traverse between them is normal stratigraphic. In some parts the stratigraphic traverse is complicated by Dinaric-oriented (NW-SE) dextral strike-slip fault. The main tectonic structure is thrust between Upper Triassic dolomite and Upper Cretaceous limestone. Along thrust we can observe more meters thick zone of cataclastic breccia. This tectonic structure is cut by systems of dextral strike-slip faults which displace the thrust. In inner fault zone the rocks are broken to the degree of broken and crushed zones, which are in hydrological sense very favorable for doline formation.

The doline classification made by Čar (in print, 2001) was use to determine types of dolines. Most of the studied dolines is developed in dolomite, although the tectonically calcified dolomite can be found inside fault zones.

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POLIANI POLJE (SW GREECE) AN INDIRECT INDICATOR OF NEOTECTONIC EVOLUTION (ACTIVE TECTONICS)

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Poliani's polje being the largest karstic form at the Kalamata's major area (SW Greece) is located at an altitude of 650m., between two neotectonic macrostructures, the Megalopolis graben to the north and the Kato Messinia graben to the southwest. The geological and geophysical survey gave us evidences to understand the morphology and that the karstic form developed in neritic cretaceous limestones of Tripolis unit.

The polje was formed by the unification of two pre-existed dolines, which formed its triangle shape. The dolines have formed along faults striking NE-SW and N-S and have been filled in with fluvial deposits that comprise silt, clay and polymictic conglomerates. The latter display high percentage of metamorphic pebbles that come from Arna Unit (phyllites and quartzites). The maximum thickness of these deposits is about 90 meters; their age is Middle to Upper Pleistocene and are partially covered by talus deposits, the composition of which markedly differs from that of the underlying sediments, as they consist mainly of fragments of clastic composition (from the eocene flysch of Tripolis Unit).

DYNAMICS OF KARSTIFICATION AT CONTACTS: A MODELLING APPROACH

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The "contact karst" in a broad sense can be regarded as karst where karstification is influenced by the presence of boundaries between soluble and non-soluble rocks or rocks with different geochemical parameters. Numerical models of the evolution of a single fracture and fracture networks in various settings with contacts are presented and discussed.

ON THE NOTION AND FORMS OF CONTACT KARST

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Contact karst is an effect of local accelerated solution in border karst on the effluent side of the impermeable land. Its typical forms can be classifed as:

- cave situated along the horizontal contact of permeable karst caprock and impermeable or less permeable base rock (case of Gouffre de la Pierre-Saint-Martin),
- old cave beneath impermeable caprock, which prevents filling up the voids with flowstone deposited by percolation water (case of Mammoth - Flind Ridge Cave),
- interstratal (sandwich) karst (case of Optimističeskaja cave).
- cave and pothole with allogenic river draining impermeable rock or glacier (case of Triglav shaft),
- gorge, valley, dry valley, periodically dry valley, with allogenic water and with alternative ponors and springs (case of Neretva gorge),
- valley with ponor and steep head, blind valley, border polje, peripheral polje (case of Postojna peripheral polje),
- overflow polje (case of Planina polje),
- piedmont polje, karst plain (case of Kistanje plain in Dalmatia),
- contact karst land with many forms mentioned above (case of Škocjan Kras, Gunong Mulu National Park in Sarawak)

Forms and their extension are controlled by different height of impermeable and permeable land, their dimension, specifc run-off, allogenic water aggressivity, river load, water permeability of rock, age of process etc.

Many contact karst forms are the most prominent karst features in the world.

MORPHOLOGY, HYDROLOGY AND GENESIS OF THE GRØNLI - SETER SYSTEM, MO I RANA, NORWAY

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This paper reports the progress in our synthesis of the speleogenetic modes and history of one of the largest and classic cave systems in northern Norway. This is done by comparing the recent karst hydrology with past conditions of the fossil aquifer. Present-day hydrology is studied through a monitoring and tracer experiment program; paleohydrological conditions are deduced from detailed morphological and sedimentological mapping of the drained parts of the aquifer. The results will be tested against previous and new speleogenetic hypotheses proposed for the system.

The Grønli-Seter cave system at Mo I Rana, Northern Norway is situated at The Arctic Circle (66°N), and comprises an aggregate length of approximately 7 km known passages. The caves are developed within a sloping stratum of calcite and dolomite marbles, confined beneath massive strata of mica schist. The marble-schist interface forms the limb of a recumbent anticlinal structure with a marble core. The Grønli cave is the only operating tourist cave with light and regular guiding in Norway, and it is also one of the oldest systems known. The first explorations and cave descriptions commenced some 150 years ago. We have decided to re-survey the whole cave system in closer detail, producing a new, 3-dimensional map. Mapping comprises a traditional centreline with passage details to BCRA Grade 5 & 6. Also, geological structures (foliation, fracturing, intrusives, etc.), scallops and sediments are linked to the survey. This survey has expectedly 'expanded' the caves from previous length estimates. So far 100 % of the known passages of the Grønli cave has been surveyed to a total length of 4,175 m (previously reported to 2,000 m), and about 98% of the Seter cave system at 3,100 m (previously 2,400 m). The cave surveys are linked to a detailed lithostratigraphic log based on surface exposures. This log is accompanied with chemical analyses and measurements of dissolution rates of the various lithologies, testing whether chemical effects, tectonics or hydraulic effects would account for the stratigraphic position of the karstification.

The cave system contains large amounts of sediments at a wide range of grain sizes, representing extreme environments of sedimentation. Sediment distribution is mapped by traditional techniques, accompanied with granulometry, mineral analysis and dating. In a few cases, the sediments are cemented by speleothem calcite, providing potential for getting U-series dates from them.

The present-day aquifer is fed from a stream-sink some hundred meters upstream of the Grønli cave. The active streamway can be explored down 'bekkeslukten' to a tight, vertical fissure. From this point the water emerges in the Seter cave, and can be followed through streamways and pools to a final sump at the extreme end of the system. From here, the water emerges in a main, alluviated spring, 'Pøla'. The situation in a major, glacial gravel terrace, filling into a glacial valley through, suggests that the karst may inject water directly into the porous aquifer as well as to the surface spring.

Discharge (stage), water temperature and conductivity are monitored with data loggers at the main stream sink and spring. A systematic program of tracer experiments was carried out, injecting dye at various sites along the accessible streamcourse and monitoring breakthrough in the main spring. Combining these observations, they will hopefully give information on aquifer volume, flow velocity and chemical corrosion rates.

PONOR VALLEYS IN THE MORAVIAN KARST (CZECH REPUBLIC): RECONSTRUCTION OF SURFACE AND SUBSURFACE DRAINAGE

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The Moravian Karst (MK) is an example of a fluviokarst area with large cave systems created by subsurface streams. The karst area is divided to three segments (northern, central and southern) with separate drainage patterns. However, the streams formed deep karst canyons and half-blind ponor valleys at the boundary between limestones and non-karstic sediments, too. Reconstruction of the Cenozoic karst processes and development of the ponor valleys was proposed on the basis of the morphology of karst valleys filled with sediments as evidenced by geophysical survey and cave deposit paleomagnetic, U-series, cosmogenic isotope and radiocarbon datings.

In the late Paleogene, after erosion of the overlying Cretaceous sediments, surface streams started to create shallow valleys in the Devonian limestones of the MK. Valleys functioned as a local base level, associated with the formation of the first horizontal cave systems. However, no Paleogene sediments were preserved in these caves. Nappe formation and folding of Paleogene flysch sediments was taking place during the Savian phase of the Alpine Orogeny in the Carpathian Foredeep (SE of the MK), at the Oligocene/Miocene boundary. Northwesterly nappe advance resulted in uplift of the Drahanská Highland including the MK area. This uplift induced changes in stream gradients and hydrographic conditions of the whole area. Karst streams draining the MK deepened shallow Paleogene valleys into karst canyons. The end of the Lower Miocene (Karpatian) was characterized by docking of nappes in the Carpathian Foredeep. Movements and gradient changes of bottoms of surface valleys may have occurred at the tectonic contact between limestones and non-karstic sediments on the N and E periphery of the MK. With the tendency to reach former graded profiles again, streams created continuous cave systems with ponors in the deep half-blind valleys on the N and E margins and resurgences at the W periphery of the karst. In the earliest Middle Miocene (Lower Badenian), the eastern margin of the Bohemian Massif including the MK was transgressed by the sea. This marine transgression lasted 1 m.y. and interrupted all karstification processes. It was a major event, dividing the Cenozoic history of the MK into two periods.

Because of blocking of pre-Badenian resurgences by marine sediments, the rivers started to create higher levels of subsurface drainage, probably since the Miocene/Pliocene. Therefore, all large cave systems of the MK consist of lower pre-Badenian and upper post-Badenian cave levels. The ponor valleys were filled either with marine deposits during the Badenian transgression or by fluvial deposits, depending on the drainage through cave systems during the Pliocene and Pleistocene. The studies of cave sediments preserved in the ponor caves allow to reconstruct the processes of filling of both ponor valleys and cave passages. The cave systems underwent several stages of cave sediment deposition and erosion during the Quaternary. Stream activity in the caves alternated with speleothem deposition. Fluvial bodies formed in the Early, Middle and Late Pleistocene are preserved in ponor caves in the N segment of the MK. In the S segment, large sedimentary bodies were deposited by a subsurface stream during the Middle and Late Pleistocene.

Filling of cave corridors with sediments was induced by local events in many cases (e.g., the collapse of the Macocha Chasm roof, collapse of cave entrances). As a result, bodies of fluvial sediments in the caves of the MK cannot be correlated with fluvial terraces formed by surface streams.

ROCK AND FORMATIVE PROPERTIES AND ROCK RELIEF OF PILLARS IN PU CHAO CHUN STONE FOREST

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Stone forests developed from underground karren. The shape of stone pillars and their rock relief are generated by a network of rock layer properties where they develop at different levels and by traces of underground factors and rainwater. The shape and rock relief of a selected shi lin reflect first of all its evolution in rock beds of diversified thickness.

STRIPE KARST: CONTACT KARSTIFICATION IN NORWAY

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Almost all karst in Norway is devloped in metamorphic carbonates; in the Oslo region by contact (intrusive) metamorphosis, in northern Norway by regional, orogenic metamorphosis during the caledonian orogenesis. Subsequent erosion exposed marble lithology as bundles of narrow. but laterally very extensive bands, interbedded with mica schists or, less commonly, with granitic intrusives. The lithological contact surfaces are in some cases tectonized, due to mechanical contrast between the marble and wallrock. Moreover, the wallrock may contain iron oxide ores or sulphides, which also impregnate the marble at the contacts. Finally, metamorphic segregation of siliciclastic material have produced zones of extremely pure calcite marble talternating with zones high mica, quatrtz and Ca-silicate content.

This setting produces extremely large contact surface between the outcrops and the surrounding wallrock and intensive allogenic karstification. The morphological expression has given rise to the term 'Stripe

Karst', or *Streifenkarst* (Horn 1937) which is assigned as the 'Norwegian' karst type. Stripe karst contacts can be divided into three common types:

1) Confined *2) Perched* *3) Subvertical.*

All three may or may not be tectonized, but sulphide impregnation at the contacts is very common. This is revealed by a rusty coloration, significant increase in sulfur content towards the contacts, visible grains of pyrite in the rock and occurrence of gypsum crusts. In extreme cases the schist wallrock may be severly weathered and destroyed by expanding gypsum. Occasionally, acidic dripwater coming off mica schist ceilings corrode deep pits (30 mm diameter, tens of cm deep) into relatively recent breakdown slabs. Pyrite oxidation and sulphuric acid corrosion seem therefore as a very important mechanism of cave initialization.

In general, confined contact zones may contain maze- type caves, or phreatic loops . Perched situations give rise to more linear or looping systems, while subvertical contacts host mazes, loops or linear systems, dependent on fracturing and hydraulic gradients.

Determination of denudation rates by hydrologoical means in stripe karst poses special problems, which led to a re- evaluation of Corbel's formula and development of a more correct expression which is valid in all karsts (Lauritzen 1991).

Glaciation poses another 'contact' effect in stripe karst, accelerating speleogenesis and injects sedments which in turn produces paragenetic galleries.

In conclusion, stripe karst setting provide an extreme kind of allogenic contact karstification, particularly when the stripes are so thin that the contact effects from each side merge.

CONTACT KARST OF MT. MIROČ (EASTERN SERBIA)

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On its path from the Panonnian basin towards the Dacian basin, the Danube flows across the Carpatho-Balkanides mountain range, through the Djerdap gorge. Mt. Miroč is located near the exit part of the gorge, on its narrowest part. Mt. Miroč karst is located mostly on the eastern river bank, on a plateau at 400-500 m a.s.l. The karst occupies some 120 km^2 of an elongated area with well defined contact with surrounding non-karstic rocks. Numerous short streams drain towards Mt. Miroč karst, sinking at ponors along the contact. Some of the drainage patterns can only be assumed, since no tracing tests have been carried out and the springs on Danube banks have been submerged by an artificial lake.

This area has not been speleologically studied until 1990. Since then, several ponor caves of considerable lenghts and dephts, including the deepest cave in Serbia, have been explored on Mt. Miroč. High concentration of relatively deep caves on a small altitude distinguishes Mt. Miroč karst. However, the most interesting issue is the relation of speleogenesis with the downcutting of antecedent gorge of the Danube.

CAVE DEVELOPMENT AT THE CONTACT BETWEEN DACHSTEIN LIMESTONE AND HAUPTDOLOMIT IN NORTH-ALPINE REGIONS OF AUSTRIA

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Special caveforms are mostly developed at the contact between better and less water soluble karstic layers. The difference in solubility of hanging and underlaying rocks are not only responsible for a special morphology of underground passages, but also for various types of waterpaths and waterchemistry.

In the Northern Limestone Alps in Austria the alpine karst sometimes shows a borderline between the good karstified Dachstein-Limestone and a less soluble Hauptdolomit, at the surface as well as in the underground. The limestone is characterised by steep cliff-like walls which have mostly bedded layers, rocky debris falls with greater rocks and boulders which reach down to the bottom of the valleys. Dolomite often has a unbedded shape, cracked walls with mostly fine debris fans which extend from wall-foot down to flat valley bottoms. The surface has a different morphology and the typical karst forms are rare on dolomite.

Some of the greatest galleries of long cave systems are developed in Dachstein-Limestone and can sometimes be followed down to the contact-zone with Hauptdolomit. However, such situations are rare, but visible. For example in parts of Lamprechtsofen near Lofer and Warwas-Glatzen-Höhlensystem at Kräuterin (Styria). Both caves show running water on the bottom in some caveparts either on or nearby the contact zone. Frequently the contact planes with the cavities are strongly inclined and interlocked, or interbedded by mylonitic layers. Massive breakdowns and sediment-beds cover commonly the grown bottom of the cave passages. The border line between limestone and dolomite can hardly be seen in the semiphreatic - vados zone of these caves. Morphological features characterise the contact zone: these are, in the case of limestone wall-forms like scallops, ceiling tubes and hollowings and in the case of dolomite sharp edged forms.

Examples are given and discussed; from Lamprechtsofen, Birnbachloch, Warwas-Glatzen-Höhlensystem, some other caves and morphological effects on the contact between limestone beds concerning to different stages of dolomitisation.

CONTACT KARST

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One of the possible classifications of the different karst types is by the dominant morphological process involved. For karst with fluvial influence, term fluviokarst was introduced; with a special sub-type of it, contact fluviokarst. This is the karst where the contact of the surface and the underground drainage occurs.

The term grew familiar in Slovenia on the Classical Karst where such karst essentially differs from the very large karst areas which surface and underground features were formed without such contact influence. In the international karstological literature these forms and phenomena are usually named as karst influenced by allogenic inputs.

Allogene water, because of its quantity, regime, sediment and chemical characteristics, alters the karst process and forms particular relief morphology. This relief has some characteristics of fluvial relief, but karst features dominate.

Where the karst drainage system is well developed it can efficiently drain all the water and the sediments away and large fluvial surfaces can influence a small part of the karst surface only. But the influence of the allogene rivers in the caves can be seen far from the contact.

First observations of contact karst started with different hydro technic works on the ponors of the sinking rivers and with water tracing tests. Geomorphologic studies of the contact karst followed some models. The cyclic geomorphology approach has seen the contact karst as remains of the old pre-karst phase. Surface rivers later start to sink into the karst, leaving dry valleys behind and creating blind valley. Climatic geomorphology emphasise the importance of climate. Flat corrosion plains widen the bottoms of blind valley and levelled border plains developed in warm climate, while colder climate encourages the vertical dissection of the karst surfaces.

Extremely cold quaternary climate with powerful erosion and denudation was expressed on the contact karst by depositing of sediments, filling the ponors and even restoring the surface river net. These models are still very present in karst geomorphology.

Less schematic studies deal with the contact karst as a special geomorphic system that is a function of the allochtone recharge, hydraulic conductivity of the karst, hydraulic gradient in the karst, the type of recharge and the geologic time that was available. In the contact karst there are three different factors: of fluvial surface, geological structure and the properties of the karst drainage system. The relief forms and the phenomena are the result of the interaction of them all.

CAVES INSIDE FLYSCH FORMATIONS AT THE LIMESTONE-MARL CONTACT, FRIULI REGION - ITALY

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Most of the discovered caves inside Bernadiamountains and Natisone Valley (Northeast Italy) are positioned inside flysch formations at the limestone-marl interface. The longest contact cave in this area extends up to 7 kilometers, but several caves are more then one. The karstic flow pattern begins at the limestone marl interface, but caverns usually develop rapidly throughout the process of erosion and dissolution inside marl and grainstone beds, the limestone strata constitutes the compact and massive ceiling of the cave.

Several examples, with pictures and geological cross sections have been documented.

CONTACT KARST PHENOMENA ON THE EDGE OF THE GALYASÁG (GÖMÖR-TORNA KARST)

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The lowest part of the karst region, the Galyaság, incorporating low middle mountains and hilly territories is situated on the Southern border of the Gömör-Torna Karst. The Galyaság is the mosaic of diverse structural and superficial regions. Running from West to East it can be divided into 4, more or less morphologically diverse territories. Its Western part, resembling to the Aggteleki-plateau is built from limestone with strong inclination towards karstification. On the edge of the karst plateau, around the so-called Pitics-mount, non-karstified rocks also appear, which become predominant towards the East. The Teresztenye-plateau (Galya-wood) is only a karstic island in the ring of Lower Triassic slate and Pannon sediments. On the Eastern border of the Galyaság, on the territory neighbouring the Bódva-river no karstic rocks can be found. On the characteristic allogenic karst of the Galyaság, in the formation of the surface and sub-surface forms, besides the corrosion of the infiltrating waters, the corrosion-erosion effects of the outflowing and the dissappearing waters in swallow holes coming from the neighbouring non-karstic regions can be well observed. In my paper I would like to present my observations accomplished on the border area of the Galyaság, during the research of the phenomena of the Contact Karst.

DYNAMICS OF CAVE ORIGIN BY ALLOGENIC RECHARGE

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Streams that drain from non-karstic terrains tend to have great discharge fluctuations and low concentrations of dissolved solids. Caves that develop where these streams encounter karstic rocks have hydraulic and chemical dynamics quite different from those fed by autogenic recharge. Where recharge takes place from a karst surface, e.g. through dolines with limited catchment areas, caves develop by competition among many alternate flow paths. Caves form only along those paths in which the discharge can increase with time. Only a few favorable paths achieve this goal, while the others stagnate with small and perhaps even diminishing enlargement rates. In contrast, caves fed by allogenic streams enlarge rapidly along a few major paths with little competition among alternate routes.

In carbonate rocks, after a relatively short inception period, caves reach a mean-annual rate of dissolutional wall retreat typically about 0.01 cm/yr. In places within such caves, enlargement rates can be increased by abrasion from sediment. On a seasonal basis, enlargement rates increase with discharge, so that most of the annual growth of a cave takes place during a few major floods that occupy only a small fraction of the year. During floods, highly aggressive water is delivered rapidly to points deep within the karst aquifer. As discharge increases, cave streams become ponded by constrictions caused by detrital sediment, insoluble beds, or collapse material. The head loss across a constriction varies with the fifth power of the diameter ratio -- i.e., a 2X decrease in diameter involves roughly a 32X increase in hydraulic gradient, under pipe-full conditions The head loss also increases with the square of the discharge.

During low flow, water is able to pass through a typical cave without significant interference from constrictions. However, because the discharge during a flood rises by several orders of magnitude, the head loss across constrictions increases enormously, causing water to fill parts of the cave under considerable pressure. This highly aggressive water is injected into all available openings in the surrounding bedrock, enlarging them at a rapid and nearly uniform rate, similar to the maximum enlargement rate in the main passages. Depending on the structural nature of the bedrock, a dense array of blind fissures, pockets, anastomoses, or spongework is formed. Many such caves develop traversable mazes that serve either as bypass routes around constrictions, or as "karst annexes", which store and later release floodwaters. Many features that are sometimes attributed to

slow phreatic flow or mixing corrosion are actually generated by ponded floodwaters. Accelerated corrosion in collapse areas can encourage further collapse, creating subsidiary fractures with patterns different from those of regional joints. In caves that experience severe flooding, adjacent fractures with initial widths as low as 0.002 cm can grow to traversable size within 10,000 years.

FLUVIOKARST OF VELEBIT MT. (CROATIA)

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The origin and evolution of fluviokarst features on Velebit Mt. is conditioned by hydrogeological characteristics of the beds that build it. Since most of its structure is developed in permeable limestone beds, fluviokarst forms are rare. Besides hydrogeological characteristics of the beds important role in their development has slope inclination. It determines the coefficient of surface runoff and therefore the amount of karst corrosion.

Among fluviokarst forms ponors, blind valleys, dry and hanging valleys, canyons and poljes were mostly developed. A nice example of blind valley is one of Crno vrilo creek (near Baške Oštarije). The specific relief form is valley of Bunovac on the NE slope of southern Velebit. It consists of two blind valleys formed at contact between Upper Triassic clastites and partially impermeable Ladinian limestones and dolomites.

Fluviokarstic process has important role in development of speleological features. Combination of fluvial process and corrosion is well marked in the phreatic phase of speleogenesis when passages are fully flooded and in epiphreatic phase when passages are partially filled by water of changeable level. According to their hydrogeological role, speleological features of research area can be classified as percolating features, ponors and springs.

TECTONIC CONTROLL OF THE CONTACT KARST DRAINAGE SYSTEM OF LAKE VORALP (SWISS ALPS) PROOFED BY A TRACER STUDY

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Lake Voralp is a small karst lake located within the Churfirsten-Alvier range in the Eastern Swiss Alps. The range is part of the cretacious Helvetical nappes, which are formed by layers of marl and karstified limestones, flysch is occurring, too. The lake was dammed up by a pleistocene rockslide and has no surface drainage. According to the hydrogeological situation it looks quiet reasonnable to assume a flow path through rockslide material to a nearby major spring, but various tracer tests couldn't proof this hypothesis. A dye tracer test under flood conditions showed a widespread drainage system to remote springs and direct afflux to the porous aquifer of the Rhine Valley. These karstwater passages are leading through nonkarstified flysch and a marly layer. These layers are lithologically rather impermeable and the drainage systems through these layers is caused by previous tectonic processes. Inspite of less permeable lithology in the rockslide area the sublacustric drainage system of the lake is controlled by tectonic structures. Some of the fault zones are clearly visible in the field or documentated in previous works, but without the tracer test their dominating influence on the karst drainage system in the contact zone couldn't have been proofed. Understanding the drainage system of the lake is a key to cope with contrary demands of tourism, mountain pasturage and drinking water supply.

THE EFFECT OF DARAB SALTDOME ON THE QUALITY OF ADJACENT KARSTIC AND ALLUVIUM AQUIFERS, SOUTH OF IRAN

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Karstified carbonate formations are among the most important water resources in the south-central regions of Iran. If the karst water is not contaminated by salt domes, the electrical conductivity of water in the karst aquifer is less than 500 microsiemens in the south-center of Iran. The study area is located in the southern flank of Dalneshine anticline, 200 km east of Shiraz. This region is situated in the Zagros thrust zone. The Tarbur karstic formation (Late Campanian-Maestrichtian) is outcropped in the southern flank of Dalneshine anticline which is underlain by the impermeable Radioloriate Formation. The Darab saltdome is outcropped inside the karstified Tarbur Formation. The largest and smallest diameters of the Darabsaltdome are 3 km and 1.3 km respectively. Several springs emerge from theTarbur formation. The quality of all springs are in the range of unpolluted karst water, except for three springs which are located near the Darab salt dome. The electrical conductivity of these springs range from 1200 to 2000 microsiemens. Part of the alluvium near the Darab salt dome are salt marsh which is bounded by two channels. These channels direct the water of low quality springs to downstream agricultural farms. The electrical conductivity below the water table is about 1400 microsiemens, and it reduces to 400microsiemens at lower depth. Run-off from the Darab salt domes and seepage from the channel with low quality water are probably the main reasons of salt march development. Considerable amounts of polluted Tarbur karst water does not flow towards the marshland because: 1) most of the Tarbur karst water discharges from the springs, and 2) the alluvium aquifers not affected by polluted water at lower depths.

GEOLOGY AND STUDY HYDROGEOLOGY OF THE KATALEH-KHOR CAVE (IRAN-ZANJAN)

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Kataleh-Khor cave has simple maze Anastomoting pattern .Stories are formed by lowering water level and stabilize for a long time .New passages are formed in new levels.Passages of these multiphase cave has low slope connected together by some shafts,specially a shaft in the bottom Mehrdad talar. Eliptical,rectangular and T-Shaped cross sections shows that the cave is formed in saturation condition and later because of lowering water table and transmission to lower levels,chanalized conditions are formed and then bouyoncy forces are lost, cause to collapse of rock blocks and formation of Talars and Domes. Water mixing and corrosion in direction of fractures,cause to formation of Garland passages.

Hydrogeological parameter computation of the springs, shows the low karstification in the aquifer,but surface geomorphological phenomena such as cave and shafts,shows the development of surfacial karst.

MULTIVARIATE ANALYSES IN A GEOGRAPHICAL INFORMATION SYSTEM (GIS) OF PHYSICAL CONTROLS ON KARST FEATURES IN THE OZARK PLATEAUS OF MISSOURI, U.S.A.

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Physical controls on the genesis and aerial distribution of karst features can be identified. through detailed geological mapping and karst studies.Most cave openings and some springs occur in stromatolitic dolomite just below less permeable sandstone or chert. Most collapse dolines are stratigraphically and topographically in or just above the sandstones or cherts. Joints striking in a downdip or downslope direction are solutionally enlarged by meteoric and vadose water. Many authors in other areas have noted relationships between the orientation of cave passages and joint direction and the gross orientation of cave systems to larger structures such as fold axes. Our study tests the effects of geologic structures, lithology, and stratigraphic

position on the distribution of such karst features as caves, springs, and dolines in a 625 Km2 area in the Ozark Plateaus Province of Missouri, a region of relatively flat-lying Cambrian and Ordovician dolomite, sandstone, and chert. Joint attitude measurements at 1121 locations were interpolated to produce a grid representing local structural grain. Structure contours derived from detailed field mapping were used to interpolate a grid representing the attitude of local bedding surfaces. Aspect and slope grids were generated from the structure surface. Their cell values were then mathematically combined with grids representing the two predominate joint directions for the area to produce a final grid with a total value or predicted index of susceptibility to karstification. The known locations of karst features were superimposed on this grid and tested for correlation to the index scores. This methodology may be useful in other areas of relatively flat lying carbonate rocks to delineate areas with variable potential for karst development. In addition hydrology studies, land and water resource management, and collapse hazard assessments in karst terranes would benefit from such analysis.

WEATHERING OF CAVE WALLS IN KREMPLJAK, MATARSKO PODOLJE (SW SLOVENIA)

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Krempljak is a cave situated in karst area of Matarsko podolje in the south-west part of Slovenia. The cave lies close to the surface and it was formed in transition between Lower and Upper Cretaceous carbonate beds. Thin bedded limestone in the cave passes from medium to dark grey. Beds dip toward NE with dip angle about 20^0. The main tectonic structures in the area are in "Dinaric" direction (NW-SE) and in E-W direction. Cave generally follows these two tectonic directions. The main channel is transformed by many breakdowns of the walls and of the ceiling. In the cave a particularly interesting form of weathered limestone was found. In larger side passage Stranski rov all the walls are extremely weathered. Limestone beds are weathered from few millimetres to some centimetres in depth. Depth of the weathered zone depends on freshness of breakdowns. On non-transformed walls weathered zone is thick and on fresh breakdowns the walls and ceiling are not weathered yet. Typical weathered feature appears on the ceiling is alternation of weathered limestone laminas and calcite laminas which together form so called "waffle" structure. The weathered zone of limestone is in mineralogical and chemical composition almost identical to the non-weathered part of the limestone yet is much more porous. The main reason of limestone weathering in this part of the cave is probably corrosive moisture which has it origin in percolation water from the surface above the cave.