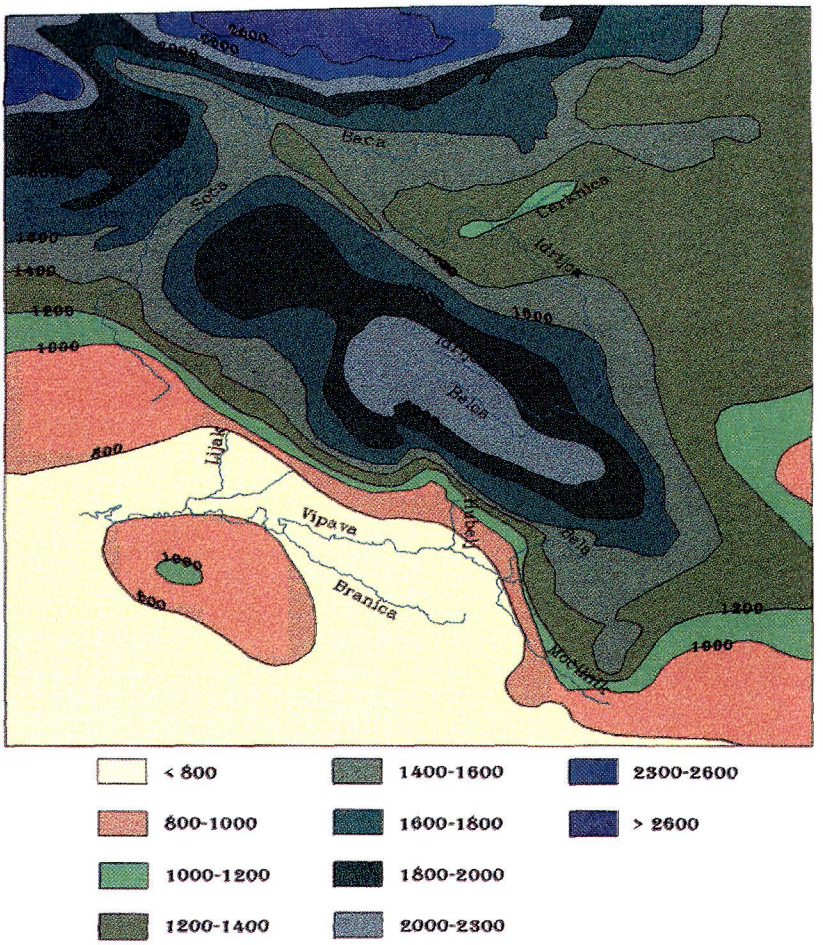


Fig. 2.14: The 1961-90 period discharge map (mm).

2.4. GEOMORPHOLOGIC REVIEW OF TRNOVSKO-BANJŠKA PLANOTA (P. HABIČ)

2.4.1. General orographic-hypsographic properties

Among the valleys of the Soča, Idrijca, Pivka and Vipava rivers in western Slovenia lies a mountain ridge of the High Karst, called Trnovsko-Banjška

Planota and sometimes Trnovski Gozd for short. The north-western part of the High Karst comprises a series of morphologically rounded units called, from the Soča valley towards Pivka or Postojna basin in the south-east, as Banjšice, Trnovski Gozd, Križna Gora, Javornik, Črnovška Planota, Hrušica and Nanos. Most of this entirely karst surface reaches altitudes between 800 to 1200 m; there are some dry valley incised in it and also some wider depressions, and at its border the surface is slightly lower. Only single peaks in a central ridge of Trnovski Gozd reach more than 1200 m a.s.l.; the highest of these is Veliki Golak (1495 m), in Javornik the highest is Srednja Gora (1275 m) and on Nanos it is Suhi Vrh (1313 m); the Črnovrška Planota lies mostly at altitudes between 600 and 800 m, and the same may be said for the western border of Banjšice; the lowest is its southern border where the bottom of a margin karst polje near Grgar lies between 285 to 300 m a.s.l (Fig. 2.4.1).

On the border of the High Karst the relatively narrow Soča valley is cut the deepest; near Gorica where it broadens to the Gorica Plain it lies at about 50 m a.s.l., but only 30 km upstream at the confluence with the Idrijca near

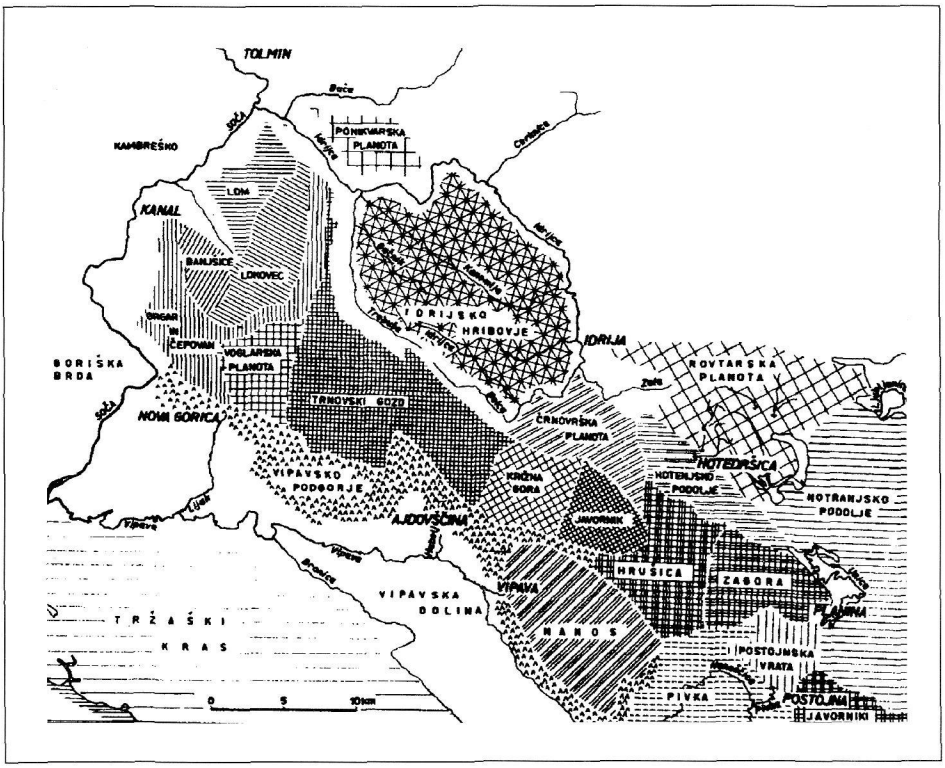


Fig. 2.4.1: The orographic units of the High Karst in western Slovenia.

Most na Soči it is 150 m a.s.l. The Idrijca valley rises for about 400 m up to the confluence with the Belca which is deeply cut in the northern border of Trnovski Gozd. The watershed between the valleys of the Belca and Trebuša, in the NE side of Trnovski Gozd lies about 1050 m high; the Trebuša flows into the Idrijca at 190 m a.s.l. Both valleys are relatively narrow, the slopes in the southern side of the highest part of Trnovski Gozd being higher and steeper, sometimes even vertical. Even more deeply downcut is the Vipava valley on the southern side which rises from its confluence with the Soča at 30 m a.s.l. up to the Vipava spring below the western slopes of Nanos at only 100 m a.s.l.; along its tributary Močivnik the watershed with the Pivka near Razdrto lies at 595 m a.s.l.

The valley of Vipava is in fact a low undulating surface on Eocene flysch between the Trieste-Komen Karst in the south and the High Karst in the north. Its valley bottom is relatively narrow, except between Vipava and Ajdovščina.

The contrast between the low flysch hills in the north and the steep and sometimes even subvertical slopes of the High Karst is a remarkable sight. Limestone overthrusted on flysch is exposed to intensive mechanical weathering and breakdown; therefore tectonic breccias, debris and breakdown blocks are accumulated at the foot.

The south-eastern karst border of the western High Karst comprises the valleys of the Nanoščica in a flysch part of the Postojna basin, from 510 to 600 m high, and a gap (Postojnska Vrata) between Hrušica and the Javorniki - Snežnik Mountains, between 600 and 750 m a.s.l.; further on there is the karst polje of Planina and a part of Notranjsko, or Hotenjsko Podolje between Logaško Polje and the valley of the Zala stream which flows near Podroteja into the Idrijca. Notranjsko Podolje at Planinsko Polje lies at about 450 m, but elsewhere the elevations between 500 and 650 m prevail. In the region between Kalce, Hotedršica and Godovič there is a karst plain up to two km wide in the Idrija fault zone. On its southern side it is bounded by the 300 m high steep edge of Hrušica and Javornik and on its northern side by Rovtarsko Žibrška Planota. To the east of Trnovski Gozd and Križna Gora the High Karst abruptly lowers to Črnovško Zadlaška Planota, up to 5 km wide, which forms the higher and broader part of Hotenjsko Podolje.

The studied part of the High Karst is composed of Cretaceous and Jurassic limestones and Upper Triassic dolomites that belong to the Trnovsko Hrušiški nappe within a thrust structure of western Slovenia. The carbonate rocks are thrust over the layers of Eocene flysch and over-thrusted blocks are fractured and tectonically displaced along longitudinal Dinaric and transverse faults (see chapter 2.6). The western part of the High Karst in the region between the Idrijca and Vipava rivers is from 10 to 15 km wide as an uniform block of karstified limestones and dolomites; between the Soča and Pivka rivers it is about 50 km long and covers roughly 700 km^2 of karst surface which is prac-

tically from all the sides bounded by lower fluvial areas. Flysch rocks encompass karstified limestones as a partial or complete hydrogeological barrier on the west, south and east. On Banjšice to the west of the High Karst flysch is preserved as a thin cover over karstified limestones and in some places the karstified base outcrops; however it mostly acts as a hanging hydrogeological barrier underlain by a typical karst circulation. In the north the High Karst is surrounded by impermeable Middle and Lower Triassic but also Permian and Carboniferous rocks. The river Idrijca and its tributaries the Belca, Zala, Kanomlja, Hotenja and Trebuša incised their superficial beds in them.

Taking into account the trend of the Idrijca headwater valleys and also corresponding hypsographic conditions we may assume that the Idrijca, Belca, Nikova and Kanomlja once flowed towards the south-east over Črnovrška Planota and by Hotenjsko Podolje into the formerly superficial Ljubljanica (MELIK 1963). It is supposed that river piracy in impermeable rocks around Idrija and karstification in the Ljubljanica riverbed contributed to diversion of the Idrijca headwaters into the Soča.

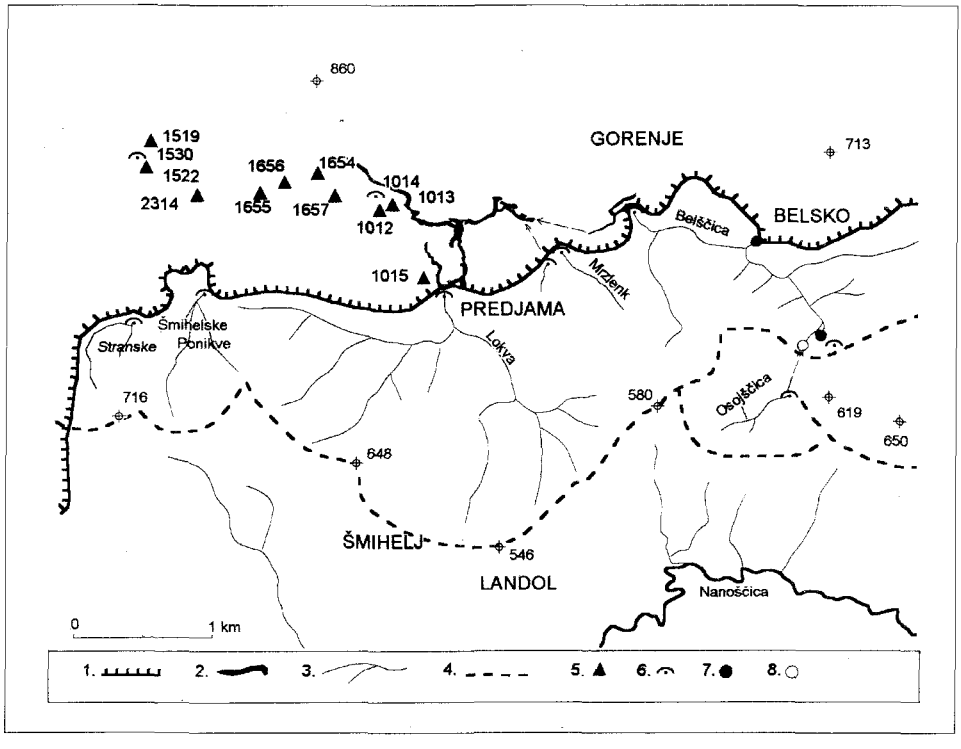


Fig. 2.4.2: The sinking streams and caves near Predjama.
Legend: 1 - overthrust, 2 - cave passage, 3 - sinking stream, 4 - Adriatic-Black Sea watershed, 5 - shaft, 6 - cave, 7 - karst spring, 8 - periodic spring.

In the Postojna basin to the east of the High Karst the deepest cut valley is that of Lokva which sinks near Predjama at 462 m a.s.l. and belongs to the Adriatic water basin together with nearby sinking streams called the Belščica, Mrzlek and Ribnik to the east and Šmihelske and Stranske Ponikve to the west of Predjama; the Pivka with its tributaries drains into the Black Sea, the watershed between the Black Sea and Adriatic passes over flysch ridges in the Postojna basin between Razdrto and Studeno at about 600 m a.s.l. Karstified Cretaceous limestones underlying the Eocene flysch enable karst bifurcation on Pivka; this is why the watershed is apparent just there. Karst bifurcation was proved also at the watershed between the Ljubljanica and Idrijca (HÖTZL et al. 1976) and it is supposed to be in Hrušica between the Ljubljanica and Vipava rivers (Fig. 2.4.2).

2.4.2. Geomorphology of single orographic units

2.4.2.1. Banjšice between the middle Soča valley and dry Čepovan valley

The central ridge of Trnovski Gozd passes towards the west into a lower plateau-like surface on both sides of the dry Čepovan valley, more than 300 m deep. Although this valley is the most impressive geomorphologic border between Trnovski Gozd in narrow sense of meaning and Banjšice, the karst surface of Voglarska Planota between Trnovo and Lokve in the south as well as Lokovec in the north of the valley display similar relief features. Obviously they were controlled by similar and interrelated morphological conditions. Major relief difference on both sides of the Čepovan valley occurred later when the impact of a different geological base had been felt and when the former Čepovan river was captured and the valley of the Soča between Tolmin and Gorica deepened.

Such geomorphologic changes were controlled by tectonic uplifting of the area in the entire region of Posočje on the northern side of Adriatic and the extreme end of the Julian Alps. Previous studies indicate that radial tectonics in the area of the Julian Alps and Dinarids was renewed in the Upper Pliocene and lasted during the whole Quaternary (HERAK 1991). Neotectonic activity was specially efficient along older Dinaric trended faults with right wrench-faults and by different uplifting of single parts of Posteocene thrusts and nappes (PLACER & ČAR 1974; PLACER 1981, 1982; ČAR & JANEŽ 1996).

Important morphological and hydrographical changes occurring in Posočje due to differentiated tectonic movements after a general levelling in the Tertiary are evidenced by meandering river valleys and by remains of the older surface between the Julian Alps and Adriatic. An accelerated karstification of

carbonate rocks took place, while in impermeable flysch rocks the valleys were erosionally deepened. Considerable erosion at the extreme end of the Julian Alps reveals complicated geological structure at the contact of the Southern Alps and the Inner and Outer Dinarids (HERAK 1991).

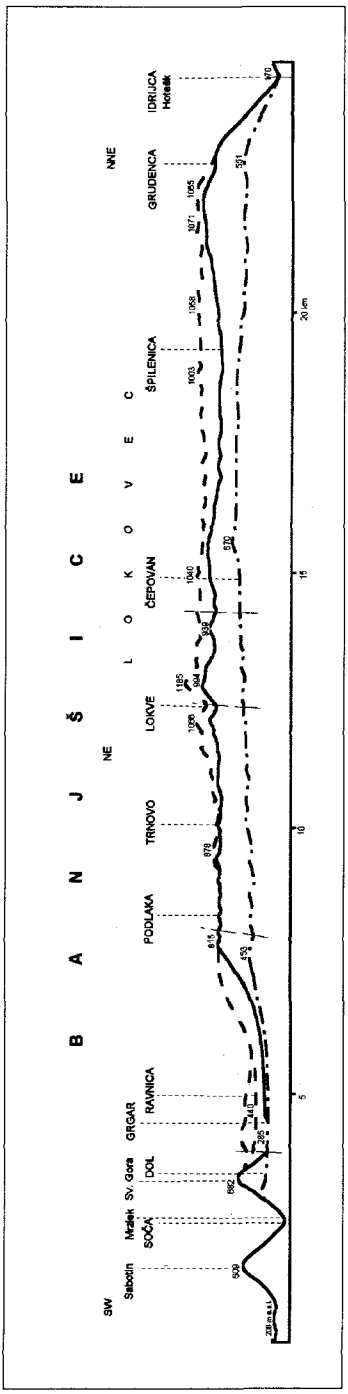
According to MELIK (1956) the superficial flows were in the Pliocene convergently directed from the region of the Julian Alps towards the northern Adriatic. He deduced this idea from the direction of the headwater valleys in upper and middle Posočje and also from single valleys and passes in their continuation towards the south-west. One of such flows is supposed to be the Čepovan River with headwater at upper Bača, Koritnica and Kneža. He supposed the former Tolminka with Zadlaščica somewhat parallel to the direction of the present Soča valley between Tolmin and Plave and over the present pass Vrhovlje into Goriška Brda. Relative stagnation of Banjška Planota, specially of its elevated part which is Trnovski Gozd, decisively influenced the morphological and hydrographical development of the central Posočje. The superficial waters in the present Idrijca river basin deepened their riverbeds along the Dinaric-trended faults of the Idrija fault zone. From the most uplifted area around Vojsko the rivers Trebuša, Gačnik and Hotenja flow directly towards the north-west, while the Belca, Idrijca, Nikova and Kanomlja flow at first towards the south-east and then they sharply turn towards the north-east to finish, together with the Zala, towards the north-west. The central confluence of all the waters occurred in the north of Trnovski Gozd near Tolmin where also the waters from Upper Posočje flow. Obviously the forerunner of the Tolminka succeeded in deepening the through valley in the western border of Banjšice towards the south-west. Thus the superficial rivers evaded the whole western border of the High Karst while in its central carbonate part the underground karst drainage prevailed completely with deeply etched karst at the surface.

The cross valley of the Soča between Tolmin and Plave is downcut into mostly impermeable flysch rocks, but in some places it reaches the limestones within a flysch basement. This occurs near Vogršček and Avče where there are seasonal karst springs. The central valley of the Soča in flysch is relatively wide; much more narrow is a canyon section of the Soča valley which is running between Plave and Solkan towards the south-east. There the Soča deepened its riverbed in the anticline folded Cretaceous limestones of Sabotin and Sveta Gora and thus brought Mrzlek, the lowest drainage of the High Karst underground waters, into a superficial riverbed.

Between the valleys of the Idrijca, Soča and Čepovan the uninterrupted high karst plateau is preserved only in its central highest part on Lokovec and also partly on Banjšice in its narrowest part between Trušnje, Sveto, Lohke and Podlaka. To the west and to the south where there is more flysch in the basement, the surface is deeply etched. In the western side the valley of Avščck, which flows into the Soča near Avče, is the deepest along the Dinaric

Avče fault. In the north on Lome, Levpa and Kal the fluviokarst relief predominates, with superficial gullies and dales which are more gentle towards headwater side; closer to the Soča they become steeper and are mostly karstified, or at least, lacking permanent superficial streams. There are no remarkable sinking streams in this part but they prevail in the western part of Banjšice, near Bate, Kanalski Vrh, Ravne, Ravnica and Grgar. At swallow-holes of small streams shallow karst depressions occur, a sort of ouvalas; the depression near Grgar bears all the traces of a karst margin polje. A fossil blind valley Dol near Grgar is also interesting; it is downcut into a continuation of the Čepovan valley and into a narrow pass called Preval between Škabrijel and Sveta Gora close to the Soča meander above Solkan. An upward step valley between Kanalski Vrh, Banjšice and Grgar with interlying treads, ouvalas and sinking streams near Bate, Dragovica and Ravne shows that waters from this part of Banjšice formerly flowed superficially towards the south and joined the Čepovan river near Grgar. When this one was captured due to the tectonic uplifting of Banjšice, the Grgar basin was deepened by local tributaries from the flysch until the uniform water network disintegrated to single sinking streams. At present all the waters from Banjšice, both those from flysch and from the karstified part, drain into the Soča subterraneously, in particular into the Mrzlek and Bokalci spring to the south; these two springs are drowned in the dammed Soča riverbed for the hydro-power station at Solkan. Exceptionally a part of Banjšice waters flows towards the west into the Avšček which reaches the Soča during the higher waters only; in dry periods it disappears in its own riverbed in front of Avče. It is not yet known where the Avšček water reach the Soča at times of low flow. The Vogršček is similar, for it drains out of the cave Babja Jama into the Soča above Doblar at high water flow and its low water outflow is not yet known. The only permanent spring in the northern border of Banjšice is Hotešk near Slap ob Idrijci which is, during high waters, at least, fed by a sinking stream in Čepovan and by part of Zgornji Lokovec (HABIČ 1982).

In terms of shape and size the Čepovan valley is without doubt the largest morphological feature in the western border of the High Karst. It crosses it at its widest part, a distance of almost 20 km. Undissected steep slopes descend from the plateau surface to the karstified bottom for 300 m. The bottom itself has an unusual shape as it is convex in its central part at altitudes between 650 and 670 m. From there the valley descends on both sides. Towards the north it descends for an additional 100 m and remains hanging at 550 m a.s.l., or 270 m above the present superficial riverbed of the Idrijca; to the south it descends for 200 m and close to Grgar it is at 450 m a.s.l.; on Preval above Dol, south of Grgar, it is 330 m a.s.l. or 190 m above the Soča riverbed near Solkan. This convex shape of a dry valley was perhaps caused by younger tectonic movements and it corresponds to the highest central ridge of Trnovski Gozd as supposed by WINKLER (1957); maybe its deepening on both sides



was caused by local superficial waters after the Čepovan river was captured. Superficial waters were partly preserved on the less permeable dolomite where small permanent springs are still available for water supply. They also feed the sinking stream that disappears immediately when it reaches the limestones and its Quaternary sediments are already accumulated more than a kilometre over the valley. Dammed waters on the border of the Grgar basin probably also contributed to deepening of the dry valley (Fig. 2.4.3).

The higher border in the northern part of the Čepovan valley is interesting from a morphogenetical point of view. To the east just a narrow ridge of Kobilica and Vrše (909 m) are preserved above the deep valley of Trebuša; to the west there is close to the steep edge on Zgornji Lokovec a morphological karstified terrace between 850 to 900 m a.s.l. where there are remains of sediments, sand and gravel of the former Čepovan river. Even older fluvial gravel is preserved on the highest crest of Lokovec between 900 and 1000 m a.s.l. (HABIČ 1968; 1982). The Čepovan river started entrenchment into a wide gravel covered plain; its remains are found today on the border above the Idrijca valley, slightly over 1000 m high and to the south on the border above the Grgar basin about 800 m high, up to the steep edge above the Vipava Valley where near Lijak it diminished in down-bending folds to 600 to 700 m. Along wide the levelled surface of Banjšice, which reaches Voglarska Planota between Trnovo and Lokve in a form of an alluvial fan, the central ridge of Trnovski Gozd had existed before the deepening of the Čepovan valley. In fact it preserved its orographic properties at a time when Banjšice had been already exposed to fluviokarstic dissection.

Fig. 2.4.3: The morphographic section of the Banjšice plateau and Čepovan dry valley.

2.4.2.2. Trnovski Gozd, Križna Gora, Javornik, Zadlog and Črni Vrh

We examined the morphological properties of Banjšice in detail as they are important to the understanding of the morphology and morphogenesis of Trnovski Gozd and its continuation over Križna Gora and Javornik to Hrušica. In morphological terms this is a rather confined unit of the High Karst bounded on the north and the south by steep, even precipitous slopes and deeply downcut valleys. The plateau karst surface between the Idrijca and Vipava has preserved some differences, in spite of the considerable distance from morphogenetical influences at its border due to tectonic isolation and prevailing karst transformation, which were enhanced by later endogenic and exogenic processes.

Our interest is focused on longitudinal and transverse ridges and dales which allow the morphographic classification of Trnovski Gozd into smaller units. Without doubt the central Dinarically trended ridge of Golaki is outstanding within the karst relief by its altitudes from 1400 to 1495 m, which is dome-like at the highest peaks and lowering towards the north-west over Bukovec (1445 m) to Veliki Češevik (1349 m) and Škol (1182 m) above Lokve but also towards the south-east over Javorški Vrh (1404 m) and Potegla (1251 m) to Vrh Hoje (1105 m) (Photo 1). Between conical-shaped hills, deep karst

Photo 1: The summits of Golaki in the central part of Trnovski Gozd, Julian Alps in the background (Photo by P. Habič).

dolines (also called "Kontas") are distributed and there are ouvalas like Mrzla, Mojska and Smrekova Draga at the border above Trebuša. Glacial debris is preserved in them from the last Glacial when the highest summits of Trnovski Gozd were ice-capped. The melting of ice without doubt had a decisive influence on the deepening of dolines and ouvalas and also on the formation of cirque-headed glacial valleys above the Trebuša valley.

Along the central ridge narrow ledges with lower conical-shaped summits are distributed on both sides. At the foot a wider ledge is preserved as a part of former border planation that had developed before the uplifting of the entire High Karst and accelerated erosional deepening of the flysch Vipava valley. The morphological equivalent of Voglarska Planota on the western side of Trnovski Gozd is Otliška Planota to south of Golaki between Predmeja, Kovk and Col. A corresponding border ledge on Čaven between Rijavci and Predmeja is not preserved so the rocky edges and slopes of Čaven between Ajdovščina and Šempas are the highest; at their foot there are immense breakdowns. A part of them slide down the flysch base to the bottom of the Vipava valley.

The central highest ridge of Trnovski Gozd is cut by transverse and longitudinal dry valleys and thus it is divided into four orographic units. To the west of the transverse valley there is Bukovec (1445 m) and in the south of the longitudinal one is Mrzovec (1410 m); to the east there is Golaki on the northern side and Čaven with Modrasovec and Praprot (1374 m) on the southern side of the longitudinal valley. The transverse gap lies near Paradana between Bukovec and Golaki, about 200 m deep. At its bottom opens the ice cave Velika Ledena Jama, more than 700 m deep. The dry valley continues over the ouvalas of Mala and Velika Lazna, Smrečje and Krnica and remains hanging in a steep slope above Vitovlje.

Mala Lazna in the middle of the transverse valley is etched also by a longitudinal valley that developed along a major Dinaric fault between Lokve and Predmeja. This fault, called the Avški or Predjamski fault, we already met near Avče and in the Avščck valley. On Lokovec the northern part is more raised than the southern one; on Lokve a dry valley developed which is suspended high on the margin above the Čepovan Valley and its start reaches the edges of Mala Lazna. From the pass near Strgarija a level dry valley continues to the other side towards Predmeja. There it is downcut by a steep edge; from Predmeja towards Col the precipice edge of Otliška Planota passes along the Avče fault. Between Podkraj and Predjama the Avče-Predjama fault divides the lower Hrušica from the higher Nanos. This typical Dinaric fault thus varies from a morphological point of view.

The Otlica border edge is displaced near Predmeja closely below the southern footslope of Golaki. It narrows most in its middle part near Otlica due to the slightly wider lowered surface of the central ridge between Obli Vrh (1109 m), Hoje (1105 m) and Marni Vrh (1080 m). On the hanging ledge

Photo 2: View over Otlica and eastern part of Trnovski Gozd (Photo by P. Habič).

of the Otliška Planota there are several lower conical summits and interlying hanging vales and smaller ouvalas. The highest isolated peak is Sinji Vrh (1002 m) with 200 m of relative height. At its eastern foot lies the transverse valley between Mala Gora and Kovk which represents the morphological border between Golaki and Križna Gora. Elongated ouvalas developed in the narrow bottom and along them is a broader ledge at altitudes between 800 and 900 m, extending from the southern to the northern border of the plateau. Karst dissection of the Otlica ledge is controlled by the structure of the rock basement (Photo 2). From a morphological and physiographic point of view Jurassic flat limestones with nodules and sheets of cherts are important. During weathering a thick, mostly silicate coating remains on them and thus more fertile soil is preserved above. Torrential waters transport debris from steep slopes over the surface and sculpture a sort of fluviokarstic gullies; finally they deposit the debris and fill up shallow ouvalas, dry valleys and dolines.

From a morphological point of view Križna Gora represents a special unit of Trnovski Gozd. Like the transverse valley in the western side between Kovk and Mala Gora, Križna Gora also is bounded on its northern side by a transverse dry valley which remains hanging in the northern side 200 m above Črni Vrh and in the southern side near Col in the slope above the Vipava valley. There are two larger ouvalas in it; closer to Črni Vrh is Mrzli Log with

partially filled up and partially doline-like bottom at altitudes between 790 to 800 m; closer to Col is the half open ouvala Malo Polje with a filled up bottom about 640 m a.s.l. The karst border is the lowest near Col; a dry valley from the slopes of Križna Gora on one side and those from Vodice and Javornik on the other proves that in this part of Trnovski Gozd fluviokarstic deepening lasted much longer than in the central, the most elevated part. It corresponds to the tectonic situation also, as in whole Dinaric ridge between Golaki and Javornik just the ridge of Križna Gora is the least uplifted. The highest peaks reach slightly more than 1000 m, and only the Špičasti Vrh (1128 m) near the southern border of Zadlog is a good 50 m higher than the others. Between conical peaks there are several shallow dry valleys and ouvalas; their bottoms are considerably higher than the bottoms in transverse valleys to the east and west.

Javornik with Kanji Dol and Vodice slightly differs from the morphological point of view from other units of Trnovski Gozd. According to its structure it belongs to the south-eastern part of the Trnovski nappe which is the most uplifted and where at the surface are exposed such units, as for example Čekovnik and Koševnik imbricate structure overlaid to the Hrušica nappe. Thus the relief indicates the transition from Trnovski Gozd to Hrušica. Near Col the Eocene flysch basement is almost at 600 m, near Podkraj it is already near to 900 m and below Streliški Vrh (1265 m) it reaches more than 1000 m; then it steeply descends to Vodice on one side and to Lome, to the east from Črni Vrh, on the other. As the flysch belt in the east of Col between Nanos and Javornik is relatively narrow and shallow except in the narrow valley of the Bela and on Vodice and Lome, it is not specially remarkable. Without doubt it is more important from the hydrogeological point of view as it directs the underground drainage from Javornik into Divje Jezero and Podroteja (HABIČ 1987).

The conical summits on Javornik (1240 m) are 100 m higher than those on Križna Gora. They are distributed in the northern, eastern and southern borders, in the central part there is a deep relief gap which starts at Vodice with a small margin karst polje, continues with elongated ouvala Široka Dolina and ends in the ouvala of Kanji Dol. A dry valley up to 300 m deep with local karst depressions, on Vodice at about 920 m and in Široka Dolina and Kanji Dol about 880 m a.s.l., winds from the east to the north. In a continuation there is above Kanji Dol a narrow pass, slightly above 1000 m, and to the west of Široka Dolina there is a pass at 960 m a.s.l.; from there towards Col a steep dry valley hangs up to the border ledge, about 650 m high. Considerable altitude differences between the elevations and valleys on Javornik are obviously due to abundant fluvio-denudation and karst dissection of the extreme eastern part of Trnovski Gozd. This was probably controlled by higher proportion of dolomite and fractured and broken rock within the markedly thrust structure. The deeply etched surface of Javornik essentially differs from the

levelled surface of Črnovrška Planota and also from evenly karst dissected Hrušica (Fig. 2.4.4).

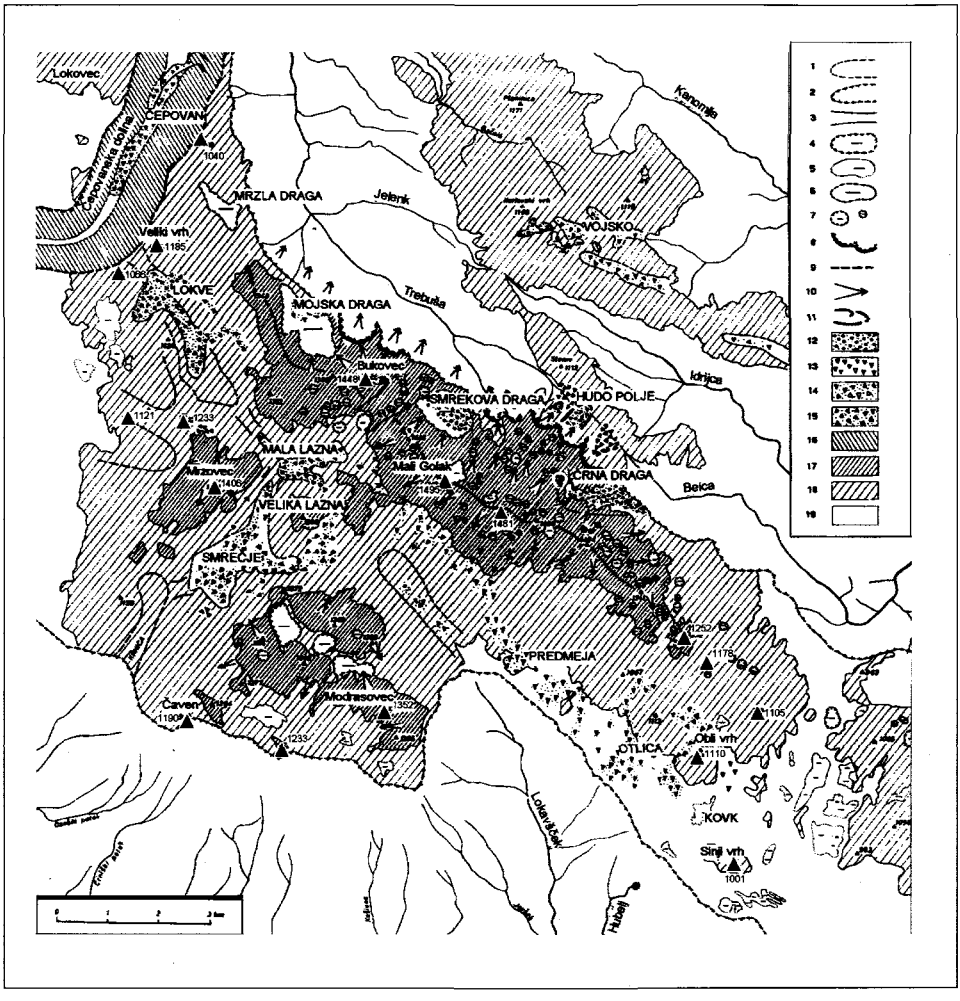


Fig. 2.4.4: The traces of glaciation in the area of Trnovski Gozd.
Legend: 1 - hanging dry valley, 2 - steep edge of High Karst, 3 - the transverse dry valley Paradana, 4 - deep karst depression, 5 - uvala, 6 - karst depression with rubble, 7 - glaciokarstic depression, 8 - glacial cirque, 9 - the central ridge of Golaki, 10 - the Pleistocene snow and ice flow direction, 11 - end moraine ridge, 12 - moraine scree material, 13 - carbonate scree and fossil talus, 14 - alluvial dolomitic scree and loam, 15 - silicate - chert scree and loam, 16 - steep slope of Čepovan dry valley, 17 - extension of Würm glaciation, 18 - periglacial area, 19 - karst plain (800 - 900 m).

2.4.2.3. Črnovrška Planota, Zadlog, Idrijski Log, Predgriže and Lome

The steep northern border of Križna Gora and Javornik descends from the altitudes between 1100 to 1240 m to a wide levelled ledge from 700 to 800 m high. A steep, mostly Dinarically verging slope is a remarkable boundary between the central ridge of the High Karst and Črnovrška Planota, about 5 to 6 km wide and 10 km long. According to the geological setting it belongs to Čekovnik and Koševnik imbricate structure and to Hrušica nappe in its base; hence this is a relief near Trnovo nappe and Idrija fault zone. A major part of Črnovrška Planota consists of Triassic dolomite which is overlain on the Cretaceous limestones in a layer some 100 m thick. The dolomite along the thrust planes is obviously very fractured and may retain the water on the surface, thus diminishing the role of karstified basement in respect to relief. It stands specially for Zadlog which is a peculiar karst polje having a seasonally flooded rocky plain from 2 to 3 km wide covered by a thin layer of dolomite debris and soil. The polje is bordered by dolomite ridges, up to 100 m high, which are on the external side downcut by streams; these flows sink in indistinct blind valleys at the contact of Triassic dolomites and Cretaceous limestones around Zadlog from Idrijski Log, Predgriže to Črni Vrh. As at Zadlog the bottoms of these valleys are also covered by a thin layer of dolomite debris. The superficial streams disappear somewhere in alluvium or in small swallow-holes; in nearby limestones there are many shafts sculptured by sinking streams. The most interesting among them is Habečkovo Brezno near Predgriže, 353 m deep (HABE et al. 1955).

In the south-eastern part of Črnovrška Planota a peculiar morphological unit, Lome, developed in a belt of Eocene flysch overlying the Hrušica nappe

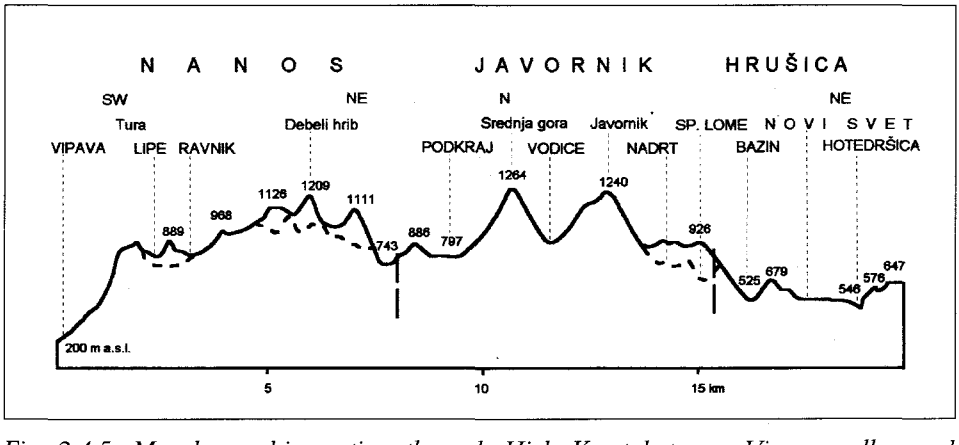
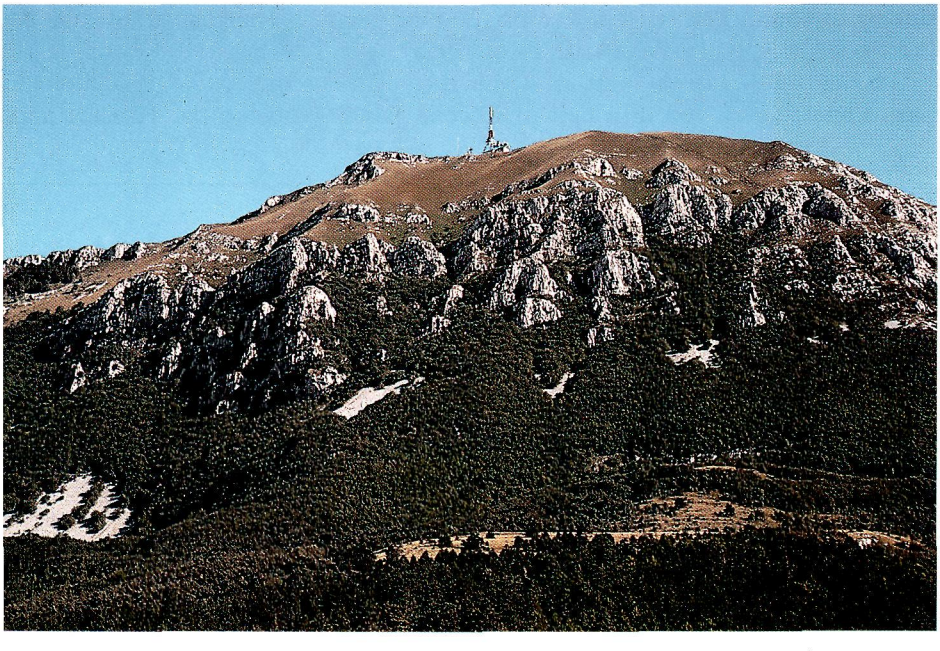


Fig. 2.4.5: Morphographic section through High Karst between Vipava valley and vale of Hotedrščica.

ı the base of Trnovo nappe. Smaller karst depressions developed in three hort belts in Gornje and Dolnje Lome and near Podjesen where the superfi- ial waters from nearby flysch disappear. In older phases the flysch waters ontributed to the formation of the karst plain in limestones at the border of olomite. But karstified limestones in a flysch basement shortened their uperficial flow. The north-eastern part of Črnovrška Planota is formed in retaceous limestones as a doline-like plain. The superficial waters from the resent Idrijca and Belca headwaters probably contributed to its former lanation when they had flowed superficially south-eastwards and helped to evelop Hotenjsko Podolje in the Idrija fault zone along the northern border f Hrušica (Fig. 2.4.5).

.4.2.4. Nanos with Hrušica and Zagora and the northern border of he Pivka basin

In the series of the High Karst morphological units of western Slovenia; Nanos Mt. takes a special place due to its wide ridge and background deep in Hrušica and Zagora. This speciality derives from its geological structure with nick beds of carbonate rocks, in particular Cretaceous and Jurassic limestones f the Hrušica nappe. On the southern side they are over-thrusted to the



hoto 3: Mt. Nanos above the village of Razdrto (Photo by P. Habič).

Javornik-Snežnik thrust sheet; from the northern side they are underlain by Trnovo nappe and interjacent slices (PLACER 1981). In its structure and at the surface also a recumbent fold thrust over flysch is well seen; it is jagged by the Idrija and Predjama fault zones and also by interjacent faults and it is differently tectonically displaced along them.

From northern, western and southern side Nanos Mt. (Photo 3) is bounded by flysch with deeply downcut superficial flows. These streams have contributed to an important exposure of the more resistant carbonate rocks and consequently to more abundant karstification. The High karst border of Nanos between Vipava and Pivka does not essentially differ from a similar one on Trnovski Gozd, but more important morphological differences appear in southern and eastern border. Nanos itself is about 12 km long and about 7 km wide, and forms together with Hrušica, the uninterrupted karst plateau between Vipavska Dolina and Hotenjsko Podolje of more than 15 km.

Nanos is highest on the north-eastern side, where its peak Suhi Vrh reaches 1313 m. It is relatively high on the eastern side also; Debeli Hrib is 1209 m high and in-between is a sort of plain with cones and valleys between 1000 and 1100 m a.s.l. The distribution of cones, dry valleys and ouvalas in this part of Nanos is controlled by the structure of the rock basement and also by long-lasting karstification which is typical of the highest parts of Trnovski Gozd, Nanos and Hrušica. In this part there are most caves and shafts, among them Slapenski Ledenik and Strmadna (HABIČ 1963). Westwards Nanos lowers in relief steps to a margin ledge similar to the one met at Voglarska Planota and Otlica; this one on Nanos is also between 800 to 900 m. This ledge is cut by a precipitous edge above Vipavska Dolina; parallel to it two dry valleys developed, called Ravnik and Lipe. The last one is deepened in its

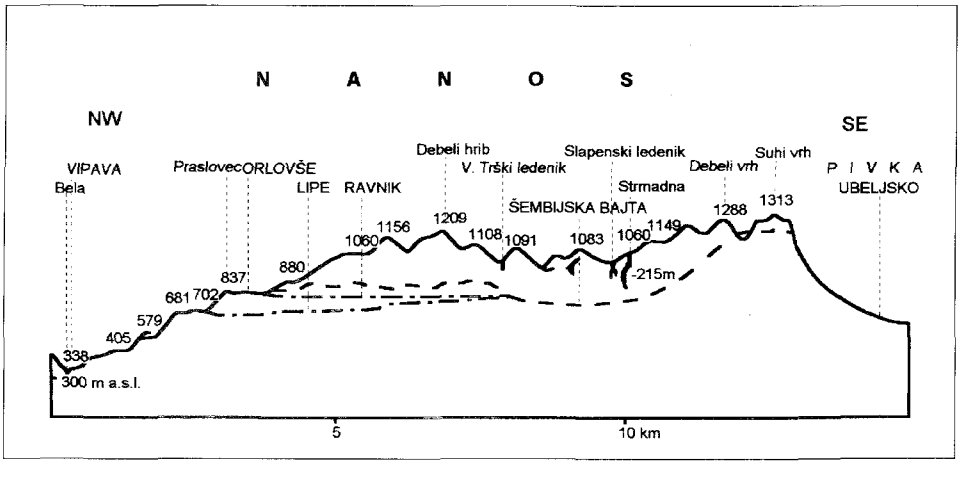


Fig. 2.4.6: Longitudinal section of the Nanos plateau.

upper part by the elongated ouvala of Šembije; towards the north-west it remains hanging, as at Ravnik, above the semi-circular border between the Vipava and Bela valley near Vrhpolje. The ledges on this slope of Nanos are structurally controlled and partly associated with gradual downcutting of the Bela stream into flysch between Vipava and Col. The intensive entrenchment of the Bela valley was enabled by tectonic subsidence of Vipavska Dolina between Vipava and Ajdovščina. Near Vipava the flysch barrier at the foot of Nanos had been eroded below the present valley's bottom. The subsided part of the valley was partly filled up by Quaternary sediments which dammed the runoff of karst waters from Nanos and thus caused the delta-like distribution of the Vipava springs (Fig. 2.4.6).

The flysch cover of Nanos extends in the western, southern and south-eastern part from Vipava, where it is below 100 m, to the border below Pleša (1262 m) where it reaches near Razdrto the height of about 800 m and near Sv. Bric below Suhi Vrh 1000 m. Below the precipitous wall called Rjava Stena above Strane it lowers to about 800 m and still more in a direction towards Stranske Ponikve and further on towards Predjama. In this part a flysch base is relatively lower, concordantly to Hrušica in the east from the Predjama fault. Also the steep eastern slope of Nanos corresponds to tectonically relatively uplifted block.

Thus Hrušica starts on the western side by Črnjavsko Podolje which is deepened at the foot of uplifted Nanos in the Predjama fault zone and remains hanging from a pass above the recent valley of the Bela near Podkraj towards Pivka basin. There the plain opens widely into a margin karst ledge called Podgora between Šmihel, Predjama and Studeno at the altitudes from 600 to 650 m. In fact it is a pediment shelf in the southern thrust edge of Hrušica. Above Predjama and Bukovje the steep slope of Hrušica reaches the altitudes slightly above 800 m, above Studeno and Strmica up to 1000 m. The higher eastern part belongs to tectonically uplifted Planinska Gora and Zagora which are separated from the lower Hrušica by a dry valley between Gorenje near Bukovje and Laniše near Kalce. To the south and east Zagora is bounded by a steep slope above Planinsko Polje and plain between Grčarevec and Kalce. Hrušica in a narrow sense of meaning is a sort of triangular inlier of karst surface between southern border of Trnovski Gozd and the northern part of the Pivka basin. To the east of Streliški Vrh (1265 m) and Javornik (1240 m) there is a karst ledge overlying the limestones of Hrušica nappe at about 1100 m; the next, lower, step surrounds Javornik from Nadrti above Hotenjsko Podolje to Podkraj above the Bela valley, about 900 m high. South from the road Kalce - Podkraj the lower, central, part of Hrušica continues along 150 m high slope in a south-west - north-east direction at altitudes from 800 to 900 m (Fig. 2.4.7).

On the extreme southern border of Hrušica at the contact with flysch the Pivka basin is located. This part of the basin is an morphologically and

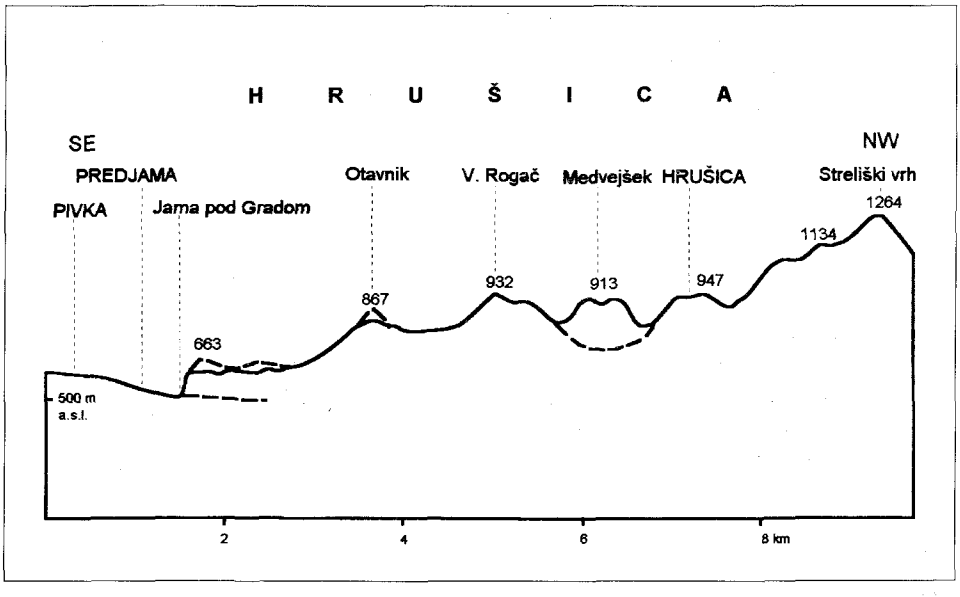


Fig. 2.4.7: The morphographic section through the Hrušica plateau.

hydrographically interesting area with small sinking flows, from the Stranske to Šmihelske Ponikve, Lokve, Ribnik, Mrzlek and Belščica, and also the Osojščica near Belska Žaga and five swallow-holes south of Studeno. Here lies the bifurcation watershed between the Vipava and the Pivka, between the Adriatic and the Black Sea. Blind valleys of sinking streams end with limestone walls where active influent caves developed at several levels. The largest is Jama pod Predjamskim Gradom (HABE 1970) which consists of underground passages that even reach Vipavska Jama and karst springs of the Vipava on the other side of Nanos.

2.4.3. Geomorphological Processes and Development

While reviewing the relief properties of single orographic units we noticed the differences in shape and development of surface that are supposedly due to differences in exogenic, climatic and lithologically controlled geomorphological processes in impermeable rocks with prevailing fluvio-denudation transformation on one hand and on the other hand by karstification of limestones and dolomites. An essential difference between erosional dissection and lowering of the surface on impermeable rocks and in preservation of older relief forms at the karstified surface was shown. During long-lasting geomorphological devel-

opment from the Upper Tertiary onwards, the geological setting became more and more important but so also did the differentiated tectonic dynamics. An older, levelled surface had been partly covered by fluvial sediments and later exposed by gradual tectonic uplifting to more differentiated erosional and corrosional factors. Important changes occurred in the fluvial net and also in the direction of superficial waters. On one hand the previous river net disintegrated due to karstification, and on the other hand the superficial flows changed their directions due to tectonic uplifting or relative stagnation of single parts. All these processes occurred in the active geotectonic area between the Adriatic and Southern Alps. From the hydrographic point of view the biggest changes occurred at the Adriatic-Black Sea divide.

From the climatic point of view the conditions at the passage between Submediterranean and Alpine continental climate were decisive. Climatic influences were particularly strong during the Pleistocene when warmer and cooler, more dry or more humid periods alternated. The traces of glaciation in the highest parts of Trnovski Gozd are preserved, and the Soča valley glacier reached down to confluence of the Soča and Idrijca. In cool periods a major part of the High Karst was exposed to typical periglacial processes. In that time also karstified limestones and dolomites suffered intensive mechanical weathering. This is evidenced by huge scree cones remaining, now covered by vegetation, at the foot of the karst border above Vipavska Dolina and also in headwater gullies and gorges in the northern side of Trnovski Gozd.

Periglacial and glacial debris had also been deposited in dolines and ouvalas on the whole plateau, especially over the less resistant flat limestones. In thick-bedded limestones corrosional deepening of dolines and ouvalas prevailed, giving them a shape of larger gently sloping dolines. These features are more frequent at altitudes above 1200 m; in lower-lying areas karstification is better expressed in fractured and broken fault zones. These features are connected by several deep shafts but also caves where snow and ice now remain during the whole year. The considerable vertical permeability of the karst underground is due to karstification in cold periods when solution reached deeper than in warmer periods when corrosion was more intensive on the surface itself.

The mostly bare rocky surface on the higher parts of Trnovski Gozd (Photo 4) shows the properties of high mountainous karst. Solution flutes and karren are in some places slightly changed and weathered, but some features remained that had already developed above the upper tree limit. In the cold period this limit was at about 600 m a.s.l. and the limit of permanent glaciation reached somewhere to altitudes between 1250 to 1300 m. When the climate warmed, climatic and vegetation belts rose and the present-day tree limit is at about 1450 m which is relatively low yet it is controlled by the isolation and exposure of the highest parts of Trnovski Gozd. A large amount of precipitation contributes to the intensity of recent erosion and dissolution processes in particular, as it occurs mostly in the winter half of the year and

Photo 4: Karren surface round Otlica (Trnovski Gozd) (Photo by P. Habič).

during the frequent summer storms with heavy rain. Intensive karstification and modest soil cover on the limestones enable the precipitation to drain underground quickly and feed abundant karst springs at the border of the High Karst.

Geomorphological processes and karst and other geomorphologic features are studied in detail in geomorphologic and speleological treatises by MELIK (1959, 1963), RADINJA (1972), GAMS (1974), HABIČ (1968, 1974, 1992) and others.

2.5. SPELEOLOGICAL PROPERTIES OF THE AREA

(A. MIHEVC)

There are 489 caves known and registered on the area of Trnovski Gozd and Banjšice plateau. The longest cave is the Predjama cave, the 7571 m long ponor cave of Lokva stream. The deepest caves are Velika Ledena Jama v Paradani, Jazben, Habečkov Brezen and Strmadna on Nanos plateau. There are 17 caves longer than 200 m and 18 deeper than 100 m.