2. NATURAL BACKGROUND

2.1. PHYSICAL GEOGRAPHY OF TRNOVSKO-BANJŠKA PLANOTA (P. HABIČ)

The test area of the 7th Symposium on Water Tracing includes a part of High Dinaric Karst in the western Slovenia; it is bounded by the valleys of the rivers Soča, Idrijca, Vipava and Pivka. From the Soča river in the north-west up to the sinking karst rivers Pivka and Ljubljanica in the south-east, there are, within otherwise uninterrupted landscape of the High Karst, morphologically slightly different areas as for example Banjšice, Trnovski Gozd, Črnovrška Planota, Hrušica and Nanos. This area of the High Karst is usually referred to as Trnovsko-Banjška Planota (TBP).

The belt of the High Karst between the northern border of the Adriatic Sea and eastern foot-hills of the Southern Limestone Alps narrows the most in the western Slovenia. A block of carbonate rocks belonging structurally to the Dinaric Mountains, is from 10 to 15 kilometres wide and about 50 km long, covering roughly 700 km^2 of the surface. Deeply karstified Cretaceous and Jurassic limestones and Triassic dolomites prevail; towards the north-west they underlie younger, mostly Eocene flysch rocks. Flysch encompasses karstified limestones of Trnovski Gozd and neighbouring plateaux in the southern and eastern side thus acting as a partial, hanging hydrogeological barrier. In the north the High Karst is surrounded by mostly impermeable Middle and Lower Triassic, partly also Permian and Carboniferous rocks. The valleys of the Belca, Idrijca, Trebuša, Hotenka, Kanomlja and Zala rivers are cut into these rocks. In their river basins, specially on the Vojsko Plateau, there are some sinking streams, caves and karst springs.

For several reasons this final edge of the High Dinaric Karst between the Vipava valley and the foot-hills of the Julian Alps dissected by the valleys of the Idrijca and Soča rivers was chosen as a test area of Association of Tracer Hydrology for the preparation of the 7th International Symposium on Water Tracing.

From a physiographic and hydrogeological point of view this is a relatively well-confined mountainous karst area bounded by lower, non-karstic margin regions from almost all the parts. The rainfall from this entire area sinks into deep karst aquifer feeding abundant karst springs located at its foot along the tributaries of the Idrijca, Vipava, Soča and Ljubljanica rivers. Smaller sinking streams may only be found in the western and eastern side of Trnovski Gozd. In the valleys on its border major karst springs are distributed, such as Mrzlek, Avščck, Kajža and Vogršček along the Soča; Lijak, Hubelj and Vipava along the Vipava; and Divje Jezero, Podroteja and Hotešk along the Idrijca. The rivers Idrijca, Soča and Vipava belong to the Adriatic water system, and Ljubljanica to the Black Sea basin. Thus the underground watershed between the Adriatic and Black Sea is found within the High Karst.

Karst springs in the border of the High Karst are captured for water supply of villages in Vipava valley, on Goriško and along the Soča and Idrijca. As these are the only abundant sources of drinking water in western Slovenia their karst background must be protected against pollution. Due to hydrographical complexity within this karst aquifer, it has not yet been possible to define the extent, size and capacity as well as threat to each karst spring separately. For the same reason, protection measures were not introduced separately but for the area as a whole.

Previous hydrological and geological researches indicated the main drainage directions of karst waters, but a series of unsolved hydrological questions remained. To solve these would provide better exploitation and better protection of water resources.

Intensive karstification is evidenced by solution channels, runnels and karren on bare rocky surfaces. There are numerous, karst dolines and ouvalas, more than 100 m deep, and many caves and shafts, some more than 300 m deep. In the ice-cave Velika Ledena Jama v Paradani cavers have reached a depth of almost 700 m. This external image of intensive karstification is complemented by hydrological indicators. After rainfall the discharge in springs increases rapidly and also decreases relatively fast.

Deep karstification is shown also by the location of karst springs in the bottom of the valleys and by their deep siphon outflow passages; at Mrzlek they are below the Soča riverbed, in Divje Jezero cave divers reached more than 100 m below the Idrijca valley without getting to the end of this typical Vauclusian spring.

Karst relief dominates over the entire area. Among the elevations typical cone-shaped features prevail; isolated peaks are distributed in levels over the central ridge but they appear also on lower, more flattened borders. Between the elevations there are deep dry valleys with dolines. Such a relief neutralises the superficial watershed. Deep fluvial valleys are cut on the border of the High Karst plateau only. The bottoms of river valleys are from 50 to 300 a.s.l. and this is also the altitude where are the lowest probable free surface springs.

Central karst plateaux reach altitudes from 600 to 1500 m a.s.l.; the slopes of the valleys are steep and high. The south-western edge of the High Karst from Razdrto past Vipava and Ajdovščina up to Gorica is nearly vertical and at the foot of limestone walls there are recent and fossil scree slopes above the Vipava valley.

Carbonate rubble and breccia on the flysch base represent smaller porous aquifers. Calcarenite, breccia and conglomerate inliers of carbonates in Eocene flysch along the Soča to the western border of Banjška Planota represent aquifers of karst and fissure porosity of local importance. In the eastern and western side of Trnovski Gozd, specially on Banjšice, along northern border of Nanos, near Črni Vrh and on Pivka they contribute a part of waters to the central karst aquifer which is seen also in the hydrochemical properties of related springs.

Orographic properties of the surface are controlled by geological structure and by younger tectonic movements and by geomorphologic development from the Middle Pliocene onwards. The main ridge of the High Karst trends from north-west to south-east, but it is slightly displaced towards the north-east border. The highest elevations in the central part of Trnovski Gozd are the peaks named Veliki Golak (1495 m) and Mali Golak (1480 m). On the southern and western border of the main ridge of Trnovski Gozd there are some marginal shelves preserved as remains of former, broader planations. There were found the remains of fluvial gravel deposited by waters from neighbouring Pre-alpine valleys when the rivers flowed over the actual High Karst towards the Adriatic Sea.

Transverse and also longitudinal dry valleys are downcut into an old, levelled surface. The most expressive is the valley of Čepovan, 20 km long and more than 300 m deep. It widens in its southern part and passes into a smaller karst margin polje near Grgar (280 m). The lowest exit of Grgar lies in the continuation of a dry valley on Preval, 336 m a.s.l. between Sveta Gora (681 m) and Škabrijel (546 m) which is almost 300 m above the present riverbed of the Soča near Gorica. The bottom of the dry valley reaches the highest point in the north of Čepovan, at 620 m and it lowers to 540 m in its northern border near Vrata to remain hanging in a steep edge, 270 m above the Idrijca riverbed. The valley of Čepovan is a natural border between Banjšice to the west and Trnovski Gozd to the east.

The highest main ridge of Trnovski Gozd between Paradana, Mala and Velika Lazna and Krnica is cut by a transverse dry valley. Similar are transverse valleys in the south-eastern side of Trnovski Gozd between Mala Gora and Kovk and between Črni Vrh and Col. Transverse dry valleys are important for traffic and they are used for local and forest roads. However, main traffic roads lead along the High Karst by the valleys of the Idrijca and Vipava. An important cross traffic road passes along the western border of the High Karst by the Soča valley between Gorica and Tolmin.

There is little soil on the karstified limestones of Trnovski Gozd (The Wood of Trnovo) and wood prevails there as its name indicates. The rather humid mountainous climate is favourable for fir and beech trees. These two species comprise Vast fir-beech forests. On the highest ridge of Trnovski Gozd the trees are exposed to strong wind, the bora, and therefore the trees are lower with typically shaped branches bent and blasted by the wind. The highest Golaki displays the features of upper tree limit. Instead of beech, dwarf pines appear there. This species may also be found at the bottom of deep karst dolines where cooler air accumulates. In these frost-places the vegetation belts are inversely distributed. A belt of beech is followed downwards by a belt of spruce and at the bottom of doline there is a belt of dwarf pines; in the deepest karst dolines, in particular at the entrance to ice-caves, a belt of mountainous meadows without trees may even appear. These vegetation specialities of Trnovski Gozd very early aroused the attention of experts. Forest management, that is regulation and protection of karst woods accompanied by a suitable exploitation, has a several hundred years long tradition.

From a climatic point of view the High Karst is a typical transitional area between the Mediterranean climatic influences of the Adriatic and the continental and Alpine climatic region of inner Slovenia. The high karst ridge is a sort of barrier against the frequent south-western wind that brings the humidity from Mediterranean. As humid air lifts over the first mountainous barrier it releases heavy precipitation. Thus the central part of Trnovski Gozd receives annually more than 3000 mm, and the maximal daily rainfall may even surpass 300 mm. The mean annual temperature varies from 7 to 9° C. The mean air temperature in January is about -2° C, and in July about 16° C. On Golaki where the upper tree limit is at 1440 m a.s.l. the mean air temperature in July is about 12° C. In the cold half of the year cool air from the south-eastern side frequently passes from the High Karst towards the Mediterranean; this occurs as a strong wind in gusts, called the bora, which may reach more than 200 km/h in the Vipava valley and in dry transverse valleys. Relatively early in autumn snow falls on the peaks of Trnovski Gozd and in spite of some thawing during the winter it may be found in deep dolines up to May, and in caves with large entrances throughout the summer. In many ice caves the local people used to cut out the ice and transport it to the valley and to Triest and Gorica to chill food and drink in times when electric refrigerators did not yet exist.

On the border of Trnovsko-Banjška Planota and on Nanos the trees were cut down. At first the land was used for pastures, and later permanent settlements grew. The most dense population is found on Banjšice as far as Grgar to the south and Čepovan and Lokovec to the north. On flysch rock there is more soil which favours agriculture. On Lokovec north from Čepovan and around Trnovo, Voglarji and Lokev south from the Čepovan valley there are less cultivated surfaces. Slightly more soil is provided by disintegrated

cherts that occur as lens-shaped inliers in Cretaceous and Jurassic limestones. The same may be said for the inhabited south-eastern part of Trnovski Gozd where modest farms are scattered on the border of the plateau from Predmeja, over Otlica, Kovk, Gozd and Križna Gora to Col, Podkraj and Vodice.

Some scattered farms may also be found to the north of the main ridge of the High Karst near Zadlog, Črni Vrh and Lomi. In the western border of Nanos the former Vast pastures are more and more overgrown by vegetation and only two farms remain there. Sparse population and low agricultural activity are relatively favourable to protecting the karst aquifer. But, together with endeavours to protect karst waters, there exists a wish to increase the economic development of these villages. In the past they mostly survived by cattle breeding and forestry. Later local people travelled to work in the valleys, and in factories in Gorica, Ajdovščina, Vipava and Idrija; in recent years they try to get work at home in craft and smaller industries. Former rainwater reservoirs are replaced by piped water supply; water is pumped from lower lying springs and increased quantities of waste water flow mostly untreated, underground. The economic development on Trnovsko-Banjška Planota must as soon as possible be co-ordinated with protection of this important karst aquifer which is capable of supplying the larger and more inhabited valley area of the High Karst around Vipava, Gorica and Idrija with drinking water.

2.2. HYDROLOGY (N. TRIŠIČ)

2.2.1. Basic description of the area

The area of the Trnovski Gozd, the Banjšice, the Nanos, and a part of the Hrušice plateaux hydrologically belongs to the Soča river basin extending over approx. 2000 km^2 in Slovenia, which is almost one tenth of Slovenian territory (Fig. 2.1). The river basin stretches from the central part of the Julian Alps over the pre-Alpine mountains, the territories of Cerkljansko and Idrijsko, the high karst area of the Nanos and the Trnovsko-Banjška Planota, the flysch area of the Vipavska Dolina, to the level gravel-sand accumulation of the Soča and its tributaries on Italian side. In Slovenia, the Soča river basin borders on the Upper Sava river basin, and the Ljubljanica and the Timava river basins, and on Italian side, on the Tagliamento river basin (Fig. 2.1).

The strongest tributaries of the Soča are two left tributaries, the Idrijca and the Vipava, which drain the area of Idrijsko and Cerkljansko, the high karst area of the Trnovsko-Banjška Planota, the Nanos, a part of the Hrušica, and the flysch area of the Vipavska Dolina valley. The entire area can be studied as two separate hydrological units, one of which as the catchment area of the karstic springs of the Vipava, and the other one as the catchment area of the karstic springs at the rims of the Trnovsko-Banjška Planota.