Strike-slip faults

The region discussed is limited on the northeast side by a 300 to 1500 m wide fault zone of the Idrija fault. Within the broader fault area numerous accompanying faults are in progress, branching from the main fault plane and repeatedly joining it. The most important accompanying fault zone is the Zala fault. In the enclosed map of the Idrija fault zone it appears between Most na Soči and Hotedršcica. A significant regional fault, which cuts across the entire region discussed, is the Avče fault, whose east past is also referred to as the Predjama fault. It extends from the Soča valley near Avče to the periphery of the Pivka basin. Between Idrija and the Avče fault an even greater number of significant tectonic zones can be observed in Banjščica and in the surroundings of Grgar. These faults undoubtedly cut across the central and southeast part of the Trnovski Gozd, but were not defined in detail by previous geological mappings.

Running along the southwest side of the region discussed is the regional Raša fault, which disappears below Lijak into the flysch rocks of the Vipava Valley. The Grgar valley on the northeast side of the Raša fault is cut by several quite extensive fault zones. At present their continuation in the direction south-east is still not known.

Tectonic lithological mapping on a scale of 1:5000 proves that the areas between the above-mentioned faults are interwoven with numerous crushed zones of varying width extending in the direction north-south, east-west or north-northwest, south-southeast. A similar structure can also be expected in Hrušica, Nanos, Pivka basin and its periphery.

2.6.2. Hydrogeology (J. JANEŽ)

2.6.2.1. The review of the previous investigation

Underground water of Nanos, Trnovski Gozd and Banjšice is the subject of hydrologic and hydrogeologic investigations for about 40 years. P. HABIČ published the largest number of works and papers (HABIČ 1968, 1981, 1983, 1985, 1987.). The same researcher was the author of many waters tracing tests in the catchment area of Mrzlek, Podroteja in Hubelj. Underground water tracing investigations in Slovenia 1972-1975 (GOSPODARIČ & HABIČ 1976) confirm important water connections in the catchment area of Podroteja and Divje Jezero. PLACER & ČAR (1974) explained the regional hydrogeological position of the karst springs. ČAR & GOSPODARIČ (1988), JANEŽ (1990) and PETRIČ (1994) wrote about the Lijak boiling spring. JANEČ & ČAR (1990) defined the geology and the catchment area of the spring Kajža.

2.6.2.2. Hydrogeological Classification

The surface of the Trnovski Gozd, Banjšice, Nanos and Hrušica covers about 700 km^2. That is 3.4 % of the total Slovenian territory respectively 7.8 % of the Slovenian karst surface. The total discharge of the karst springs in dry periods reaches more than 2 m^3/s (7 % of Slovenian karst underground water). During high water the main karst springs (Mrzlek, Lijak, Hubelj, Vipava, Podroteja, Divje Jezero, Kajža and Hotešk) drain about 280 m^3/s of water.

The whole area can be divided according to the permeability of their lithological characteristics in several hydrogeological units (compare Fig. 2.23):

- well permeable rocks - aquifer(s) with karst and fissure porosity
- well permeable rocks with intergranular porosity
- medium permeable rocks - aquifers with fissure porosity
- impermeable rocks.

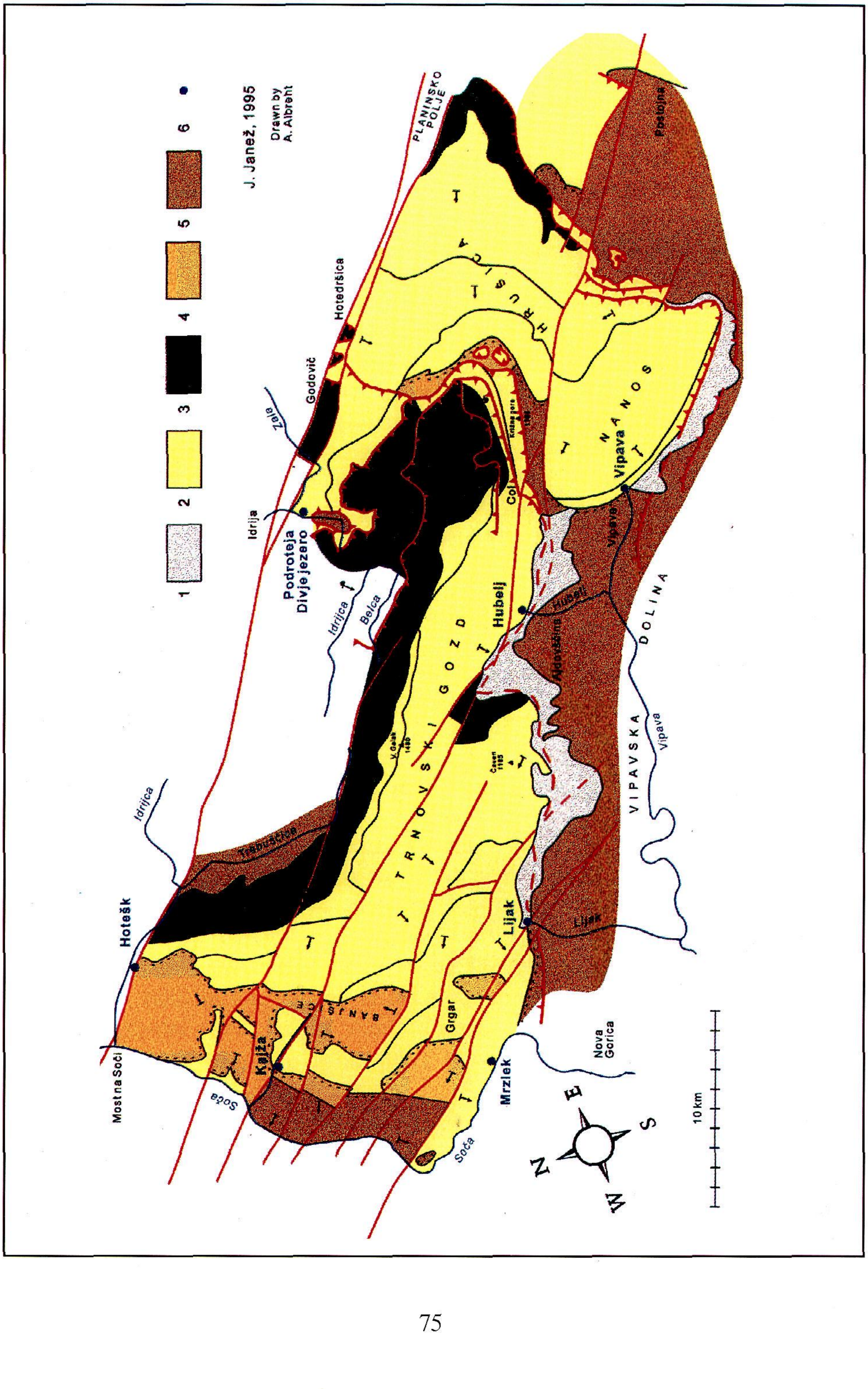
The karst porosity aquifers are formed in Upper Triassic Dachstein limestone, Liassic, Dogger and Malm limestone, Lower and Upper Cretaceous limestone and Upper Cretaceous lime breccia. The main hydrogeologic units are the karst aquifer of Hrušica, the karst aquifer of Nanos, the karst aquifer of Črni Vrh plateau, the karst aquifer in the catchment area of Hubelj and the karst aquifer of the western part of Trnovski Gozd and Banjšice. In all these cases the existence of deep karst systems is in question.

Well permeable rock with intergranular porosity are built by coarse grained to block shaped Quaternary periglacial breccias and unconsolidated Holocene slope debris. They cover big surface in form of an almost uninterrupted belt on the southern border of Trnovski Gozd and Nanos. The discharges of the slope debris springs yield up to 15 l/s.

As relative hydrogeological barriers the fissure aquifers have to be assumed. Aquifers with fissure porosity are built by dolomite of different age. The biggest extent has the Upper Triassic dolomite. It borders the karst aquifer from the northern side and partly direct the underground water runoff. The discharges of the springs in the dolomites reach up to 10 l/s.

Uncrushed Carboniferous clastic rocks, Medium Permian (Gröden) siltstone and sandstone, pure tuff beds of Ladinian age (in Idrija region), Carnian clastic rocks (impermeable footwall of the Upper Triassic dolomite in the valley of the Trebušica river) and Palaeocene and Eocene flysch marl (in the

Fig. 2.23: Hydrogeological sketchmap of Banjšice, Trnovski Gozd, Nanos and Hrušica: 1 - well permeable rocks and sediment, intergranular porosity; 2 - well permeable rocks, karst aquifer; 3 - medium permeable rocks, fissure porous aquifers; 4 - impermeable rocks, relative hanging hydrogeological barrier; 5 - impermeable rock, lateral and footwall hydrogeological barrier, 6 - karst spring.


1
2
3
4
5
6
J. Janež, 1995
Drawn by
A. Albreht
PLANINSKO
POLJE
Postojna
Hotedršica
Godovič
Zala
Idrija
Podroteja
Divje jezero
Idrijca
Belca
HRUŠICA
NANOS
Vipava
Col
Hubelj
TRNOVSKI GOZD
VIPAVSKA DOLINA
Vipava
Lijak
Hotešk
Trebuščica
Most na Soči
Kojča
BANJŠCE
Grgar
Mrzlek
Nova
Gorica
Soča
10 km
N
E
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W

surrounding of Trnovski Gozd and Nanos) form the impermeable lithostratigraphic horizons. But due to the fact that those series are characterised by an alternating lithological setting with smaller inliers of more permeable sediments, fissured or karst aquifers between the impermeable rocks are important (Lower Schythian marly shists with lenses of oolitic limestone; Ladinian piroclastites with beds of silicified limestone; the clastites of Carnian age with various limestone inliers; flysch rocks of Palaeocene and Eocene age with calcirudite and calcarenite lenses).

The hydrogeological role of lithostratigraphic units is controlled not only by permeability but also by primary stratigraphic superposition, tectonic setting and neotectonic geomorphologic terrain development. The hydrogeological barriers (footwall and sideways), hanging hydrogeological wall and relative hydrogeological barrier are distinguished. To hanging hydrogeological barrier belongs the area between Banjšice and Idrijca river where flysch rocks are found on the karstified base. The hanging hydrogeological barrier is depending on lithological structure and thickness of flysch either locally vertically or horizontally permeable. Limestone, sandstone and breccias intercalated as lenses or beds in water tight flysch marlstone and quartz sandstone accumulate some water that reappears in feeble springs.

2.6.2.3. Karst Aquifer of Nanos and Hrušica

Nanos karst plateau is a karst fissured aquifer bordered on three sides by impermeable Eocene flysch. On the north-eastern side it continues along the Predjama fault to the karst aquifer of Hrušica. The interpretation of the geological setting (PLACER 1981) infers that flysch below the carbonate nappe of Hrušica lies higher (level about 0 m a.s.l.) than the flysch below the limestone of Nanos (in the north-western part of Nanos even up to -1300 m).

The underground water flows out across the lowest gap in the flysch border in the Vipava spring. The minimal discharge of Vipava springs yields 700 l/s, medium annual discharges are from 6 to 9 m^3/s, and the maximal about 7 m^3/s (HABIČ 1973). The catchment area is bigger than 150 km^2 and comprises the entire massif of Nanos and substantial parts of flysch and limestone surface near Postojna.

2.6.2.4. Hydrogeologic Structure of Trnovski Gozd and Banjšice Plateau

The result of the overthrust tectonic in older Tertiary and neotectonic fault displacement is the superposition of thrust sheets, nappes and smaller interjacent slices. Hydrogeological conditions of Trnovski Gozd and Banjšice depend on that geologic structure and lithology.

The flysch of Vipava valley belongs, according to PLACER (1981), to several tectonic units. The southern side is a part of the Komen thrust sheet. The flysch on the northern side belongs comparable to Nanos and Hrušica, to the Hrušica nappe superposed to the Snežnik nappe near Postojna. The flysch of the Hrušica nappe represents the impermeable footwall for the karst aquifer of Trnovski Gozd and Banjšice as well as the impermeable southern and southwestern sideways barrier in the Vipava valley. On the East it is thinned out and exhibits a carbonatic development. Therefore it represents an only partially (locally) hydrogeological barrier. Flysch beds that are near Javornik on the 1000 m a.s.l. strike towards west. In tectonic windows near Idrija the flysch reappears on the surface at the altitude of about 300 m. Near Lijak the flysch was drilled at the altitude -16 m (ČAR & GOSPODARIČ 1988) while the boreholes at Prilesje did not reach the flysch at the depth of -220 m. The shape and the inclination of the impermeable base essentially influence on the direction of runoff of the karst underground water.

Upper Triassic, Jurassic and Cretaceous limestone rocks of the Trnovski Gozd and Banjšice belong to tectonic unit of Trnovo nappe and build the central part of the karst aquifer. The underground water lies extremely deep. Between Soča river and Lijak low waters are found at the Hill 77 m being fed by the water level of the accumulation lake on Soča (JANEŽ 1992). The underground water level is higher in the northern part of Banjšice (the Kajža spring 191 m a.s.l.; JANEŽ & ČAR 1990) and especially in the background of Hubelj (270 to 290 m a.s.l.; HABIČ 1985).

The underground water of the karst aquifers of Nanos and Trnovski Gozd (the springs of the Vipava river, Hubelj, Lijak) appear on the surface at the lowest points of the impermeable flysch border (PLACER & ČAR 1974) or on the erosion basis (Mrzlek spring near the Soča river).

The northern border of the karst aquifer is built by dolomite rocks of the Upper Triassic age outcropping along the valleys of Trebušica and Belca at the base of the impermeable Carnian clastic rocks. Upper Triassic dolomites are locally important aquifers with fissured porosity with spring yields of up to 10 l/s.

Between Hrušica and Trnovo nappe there are near Idrija two tectonic and hydrogeologic units. The Koševnik interjacent slice lying on the Hrušica nappe flysch is built by karstified limestones of the Cretaceous age forming the central catchment area of Podroteja and Divje Jezero. The Čekovnik interjacent slice is built by the Upper Triassic dolomite in the inverse position where the underground water in the fissured aquifer is under pressure.

2.6.2.5. Important Springs

The Podroteja karst spring (329 m a.s.l.) (Photo 7) is situated on the confluence of the river Idrijca and its right tributary Zala. The famous lake Divje Jezero lies 500 m Southwest from Podroteja (330 m a.s.l.). In both

Photo 7: Podroteja springs (Photo by A. Mihevc).

springs the water flows on the surface out of dark bituminous thick bedded Lower Cretaceous limestone. The Vauclusian spring Divje Jezero has a karst channel of exceptional shape where divers have reached the deepest point in Slovenia till now, 122 m of depth. In Podroteja the underground channels are more narrow and inaccessible. The Podroteja discharge oscillates among 0,2 to some m^3/s. During low water Divje Jezero does not flow over the rim although the siphon's depression is always filled. During the high water the runoff of Divje Jezero is more than 60 m^3 per second.

Hubelj spring emerges on the highest altitude of all springs on the southern border of Trnovski Gozd. With a spring outlet at 240 m in dry periods. At high water the water table rises up 40 m higher (Photo 8). During the drought 300 to 400 l/s of water flow out of karstified limestone, but the highest discharges reach more than 40 m^3/s.

The Vipava springs emerges at the western foot of Nanos (Photos 9 - 11). The most abundant permanent springs are in the Vipava town, 98 m a.s.l. To the Northwest there are several periodical springs. The minimal discharge of Vipava springs yields 700 l/s, medium annual discharge is from 6 to 9 m^3/s, and the maximal about 70 m^3/s (HABIČ 1983). The catchment area is bigger than 150 km^2 and comprises the entire massif of Nanos and substantial part of flysch surface near Postojna.

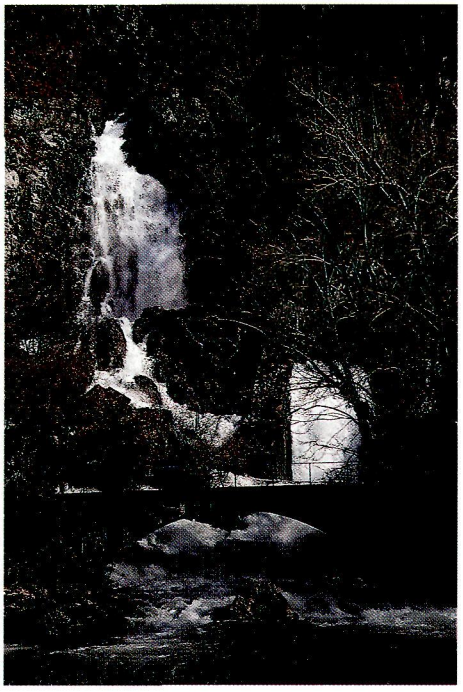

Photo 8: High discharge of the spring Hubelj in November 1996 (Photo by P. Habič).

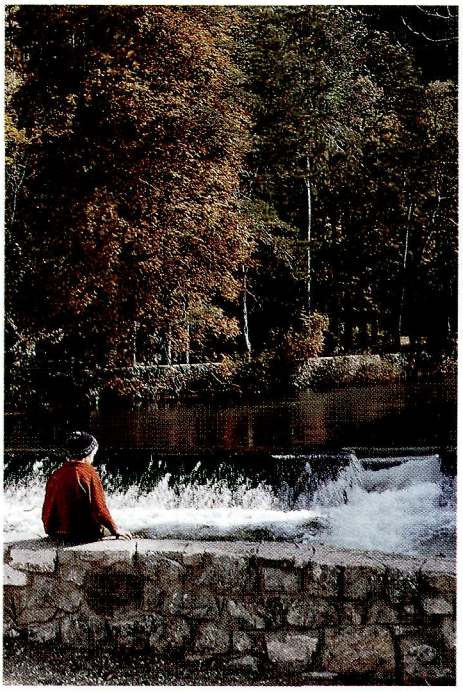

Photo 9: Karst springs of Vipava - Za Gradom (Photo by P. Habič).

Lijak, a periodical karst spring near Nova Gorica, represents a hydrological curiosity due to extremely high but short lasting discharges. The spring acts as flood overflow spring for karst underground water of Trnovski Gozd that otherwise flow north-westward to 6 km distant springs along Soča river. The limestone walls above Lijak are separated from the flysch of Vipava valley by a vertical fault. The boreholes near Lijak hitted the karst channels 90 m deep. Lijak resurgence is active seven to ten times per year. Its activity lasts from one to several days, the most up to 20 days. The biggest discharge measured since was 32,6 m^3/s. The low water level approaches to the Soča accumulation lake level (77 m a.s.l.). The artificial changes of the water level in the accumulation lake have a clear response in the limnigraphic records of the Lijak. The influences are noticeable during low and medium water tables while during higher waters the influence of precipitation is stronger (JANEŽ 1990).

The water supply of Nova Gorica is based on the karst water of the Mrzlek spring (Photo 12), emerging directly in the Soča valley. The water quantities flowing directly into the Soča river can not be directly measured. It was

Photo 10: Karst springs of Vipava - Pod Skalco (Photo by P. Habič).

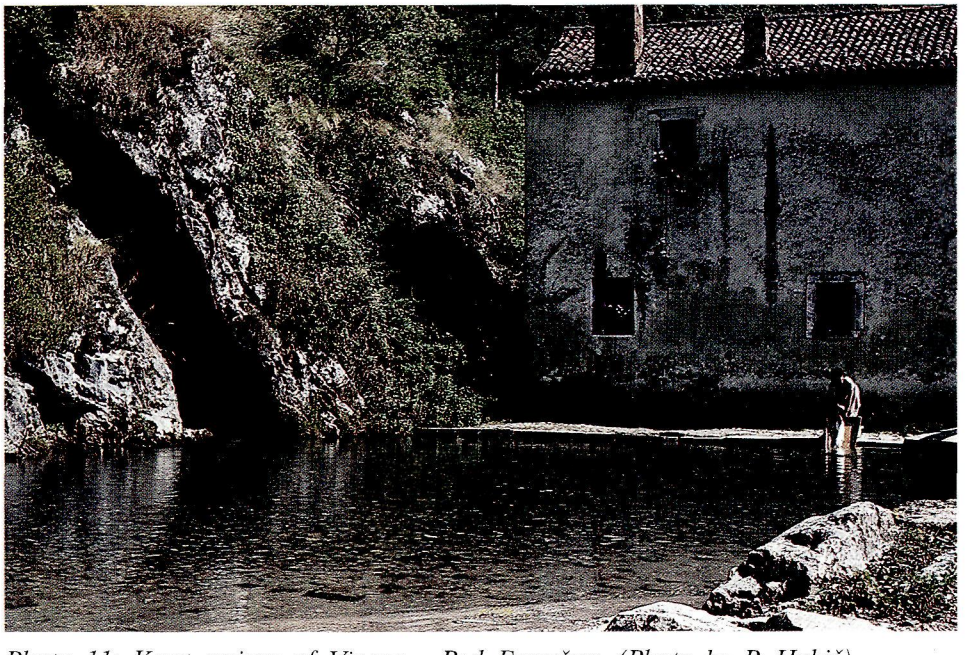

Photo 11: Karst springs of Vipava - Pod Farovžem (Photo by P. Habič).

Photo 12: Karst spring Mrzlek, mixing with the Soča river water is well visible (Photo by P. Habič).

estimated that their amount at low water is about 600 l/s and 40 m^3/s at high water (HABIČ 1982). Since the construction of the hydropower station Solkan the pumps are flooded and superficial Soča water breaks into the water supply system.

Kajža spring lies in the valley of Avščck brook at 191 m a.s.l.. Water appears on the surface at the contact of Cretaceous limestone and 20 m wide belt of strongly crushed rocks of the Avče fault. The lowest discharge of the spring is 7 l/s, t raises up to 1,5 to 2 m^3/s after heavy rain falls (JANEŽ & ČAR 1990).

Hotešk is a karst spring in the north-western part of Trnovo plateau along the Idrijca river. Water catchment area of the spring is built by Upper Cretaceous and Upper Triassic limestone. The discharge oscillates from 30 l/s at low water to 6 m^3/s at high water.

Čepovan valley is limited from the Trebušica by a ridge built of dolomites of Upper Triassic age. Most of the underground water drains towards Trebušica, smaller part only reaches the resurgence in the Čepovan valley about 610 m a.s.l.. It seems that the underground water has through flown to the Trebuša side due to dried up "Čepovan river" and deepening of the Idrijca and Trebušica valleys.