2.6.3. Geological structure and hydrogeological position of the Hubelj spring (J. JANEŽ)

First hydrological data about the Hubelj spring were published by PUTICK (1928). Much later the studies about this spring were presented by HABIČ (1970, 1985, 1987). PLACER & ČAR (1974) explained the regional hydrogeological position of the Hubelj spring.

2.6.3.1. Extent and method of mapping

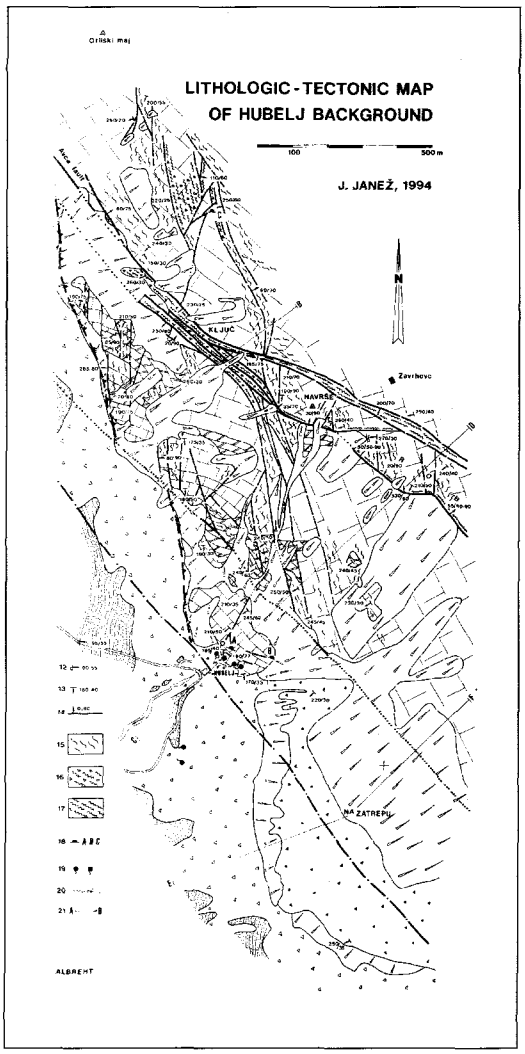

Fig. 2.24 Lithologic-tectonic map of Hubelj background: 1 - slope rubble, collapse block, screes; 2 - coarse-grained to block-like limestone slope breccia, younger, Quaternary; 3 - slope breccia, older, Quaternary; 4 - marlstone, siltstone and sandstone; flysch, Eocene; 5 - light brown limestone, usually grained, rarely thick, oolitic limestone, non-bedded, bedded to thick-bedded, Jurassic - Upper Lias and Dogger; 6 - pure grained dolomite, dolomitized oolitic limestone, bedded to thick-bedded or non-bedded - Jurassic - Upper Lias and Dogger; 7 - strong fault, visible and covered; 8 - weak fault, visible and covered; 9 - supposed fault; 10 - nappe border; 11 - lithological limit; 12 - dip and strike of inverse beds; 13 - dip and strike of normal beds; 14 - dip and strike of fault plane; 15 - fissure zone; 16 - broken zone; 17 - crushed zone; 18 - karst caves: A - Veliki Hubelj, B - Hubljeva Kuhinja, C - Otliška Jama; 19 - spring; 20 - surface water; 21 - cross-section.

Slightly more than 2 km^2 of the immediately background of the Hubelj spring was examined by a detailed geological mapping in 1994. The steep slope of the Trnovo plateau, including the edge of the plateau at the north-eastern side and the first outcrops of the Eocene flysch (impermeable edge of the karst aquifer) in the South and south-west were mapped (Fig. 2.24 and 2.25). The average incline of the terrain with numerous overhangs is over 45°. The altitude difference between the lowest (190 m) and the highest point (855 m) is 655 m.

The method of mapping of all outcrops is used. The scale of the map is 1:5000. The terrain is uncovered and the weathering zone is thin, so the identification of the bedrock is not difficult. Conditions on the flysch beds are rather different. Diluvium and weathering sediment cover the solid rocks and the outcrops are very rare. Besides, a thick layer of slope sediments - the Quaternary slope breccia, collapse blocks, slope rubbles and recent still active screes - covers a large part of Mesozoic and Tertiary bedrock and complicates the geological interpretation.

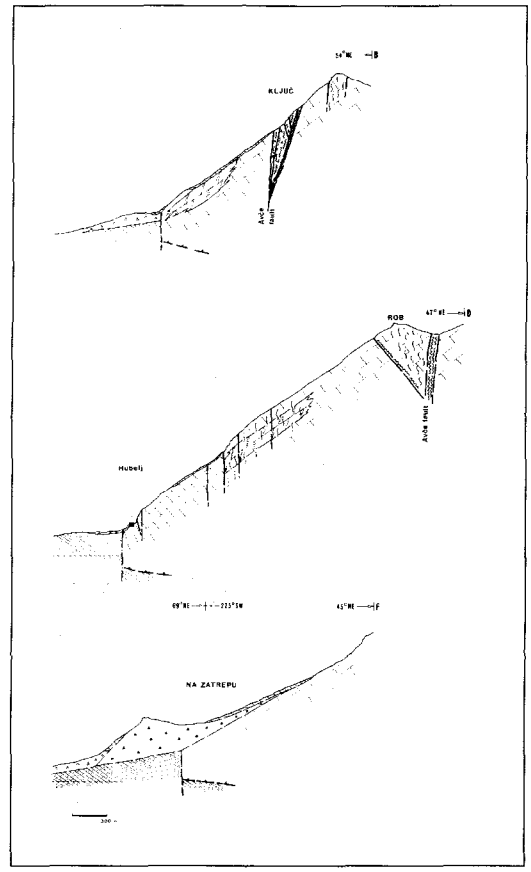

Fig. 2.25 Geological cross-sections near Hubelj.

The objects of geological mapping were mainly the lithology of rocks, the character of the contact between different rock types and the tectonic conditions. The method of mapping and interpretation of the crushed zones character, introduced by PLACER (1982), was used. Further ČAR (1982) developed this method for geological mapping of karst. Crushed, broken and fissured zones can be distinguished on the base of the tectonic damage of the rock. ČAR & GOSPODARIČ (1988), JANEŽ & ČAR (1990) and ČAR & JANEŽ (1992) tested the method successfully for the explanation of geological, structural and hydrogeological position of karst springs on the edge of the Trnovo plateau and in Julian Alps. ŠEBELA & ČAR (1991) use this method to explain the evolution of some typical karst objects. It can also be applied

for definition of hydrogeological background and protecting areas of karst springs (JANEŽ 1986).

Stratigraphic definition of the mapped lithologic units in respect to their age and position is based on the relevant literature (BUSER 1968, 1973).

2.6.3.2. Geological structure near the Hubelj spring

The mapped area consists of Jurassic, Eocene and Quaternary rocks. The slope of the Trnovo plateau between Otliški Maj, Navrše, Sinji Vrh and Hubelj spring is mainly built by light brown limestone. The limestone is usually grained, rarely thick. On several places it changes continuously into oolitic limestone. The limestone on Otliški Maj, Navrše and Rob is mostly non-bedded with rarely notable beds. Lower, in the spring area of Hubelj, the limestone beds are 40 cm to 2 m thick, some of them even 10 m.

The limestone is in several places dolomitized or recrystallized into a pure grained dolomite. Often, oolitic limestone changes into the oolitic dolomite. The transition from limestone to dolomite is progressive. Same as the limestone, the dolomite is bedded to thick-bedded or non-bedded.

Following the basic geological map, sheet Gorica (BUSER 1968; 1973), the carbonate rocks above the Hubelj spring are defined as Upper Jurassic (Oxfordian and Lower Kimmeridgian, $J_3^{1,2}$), but the beds are more likely of the Upper Lias and Dogger age ($J_{1,2}$ - brown and grey oolitic limestone, thick limestone, grained dolomite), due to their obvious lithological features.

The Eocene (Ypresian and Lower Lutetian ($E_{1,2}$)) flysch in the Vipava valley consists of changeable beds of marlstone, siltstone and sandstone. The beds are 5 cm to 30 cm thick. Flysch on the mapped area has no inliers of limestone breccia and calcarenites.

Slope breccia, collapse blocks, slope rubbles and recent still active screes present the Quaternary sediments. There are two types of breccia. The older breccia builds the overhang ridge and the flattened area south-eastern from the Hubelj spring. It is partly bedded, agglutinated and has greater share of rounded clasts. The younger breccia is more chaotic, coarse-grained and block like. The unconsolidated slope sediments, collapse blocks and slope rubbles are also of different age. The youngest are recent active screes, that can be found at the foot of the rocky overhangs of today still active tectonic zones.

The most expressive tectonic deformations are the result of the young fault tectonic activity. The main tectonic line is according to the interpretation found of BUSER (1968) the obvious continuation or one of the legs of the regional Avče-Dol fault. South-west under the Otliški Maj on the altitude of 500 m the visible fault plane (45/90) confines the limestone massive. The screes and slope rubbles accumulate on the south-western side of this plane. First outcrops of flysch can be found at the distance of 120 m. On location Ključ, southern from the Otlica cave, the fault zone is 50 to 70 m wide. At

this point it divides into two legs that encircle the lens like peak of Navrše (857 m). The south-western fault plane builds the wall of Rob and the north-eastern leg represents 10 to 30 m wide broken zone. The valley southern from farm Zavrhovc was formed along this zone.

The course of the second fault line in the Dinaric direction is above the Hubelj spring at the altitude about 405 m. It is narrower, less marked and mostly covered with slope rubbles. It is displayed with a characteristic morphological step and with disposition of the connecting faults and crushed zones, those are interrupted at this line.

On the geological map (Fig. 2.24, and Fig. 2.25: geological cross sections) a supposed fault is drawn south-eastern from the springs of Hubelj. It is indicated by an outcrop of the tectonic breccia behind the abandoned army barracks near the Hubelj spring and by the geological and morphological conditions of the wider area.

Between these described tectonic lines there are the connecting crushed zones in the direction northwest-southeast. Their intensity varies from open wide fissured zones to crushed and broken zones. The broken zones are narrow and we present then on the geological map only with a line of a fault plane.

The beds of Jurassic limestone dip in general towards south-west. The dip angle changes between 30° and 60°. An evidently different dip direction can be established only at the western edge of the limestone, western and north-western above the Hubelj spring. In a narrow, up to 100 m wide belt at the contact between flysch and limestone, the dip direction turns towards south (strike 170° - 190°) and the dip angle reaches 75°. At the Hubelj spring the dip angle is a little lower (22° - 40°) and the beds dip towards south.

The character of the contact between the Mesozoic carbonate rocks of the Trnovo plateau and the flysch beds of the Vipava valley north-western from the mapped terrain is not problematic even though the contact is covered. This is undoubtedly a subvertical fault. But more unclear is the character of the contact between the carbonate rocks in the background of the Hubelj spring and the flysch beds south-western from the Avče-Dol fault on the section from Gosta Meja to the Hubelj spring, and also eastern from the Hubelj spring. On Gosta Meja location flysch undoubtedly lies under the thin layer of slope breccia at the altitude of 475 m, whereas near the Hubelj spring thus 235 m lower at the altitude of 240 m. The morphology of the terrain indicates, that towards east the upwarding of flysch is more gently. PLACER & ČAR (1974) described the structure as a depression, a synclinal bow of the Trnovo nappe thrust plane with the axis in the northeast-southwest direction. The change of a dip direction of the Jurassic beds from south-west to south and simultaneous rise of the dip angle at the contact with the flysch is also a proof for such explanation. The thrust character of the contact at the section between Gosta Meja and Hubelj spring is transformed with younger northwest-southeast and north-south oriented fault deformations.

2.6.3.3. Hydrogeological position of the Hubelj spring

It can be seen from the structural characteristics, that the Hubelj spring lies in the bottom of the expressive, narrow and deep structural depression in the thrust plane of the Trnovo nappe. Springs are situated in about 70 m wide belt at the altitudes from 240 to 265 m. Water generally comes from the bedplanes, widened by corrosion. The highest springs are in the eastern part and the altitudes of springs constantly decrease towards west. Above the permanent springs there are two caves. The "Veliki Hubelj" cave has the entrance at the altitude 280 m. Eastern from the spring there is the "Hubljeva Kuhinja" cave, which is not explored enough yet. The "Veliki Hubelj" cave is a horizontal cave - a temporary spring at high water - with permanent water inside also during draughts. The hydraulic gradient of the underground water behind the spring is very high (HABIČ 1985). The reason for such position of the water level is according to HABIČ (1970) the low permeability of the Jurassic limestone. PLACER & ČAR (1974) gave an additional interpretation on the basis of the flysch basement shape near the Hubelj spring. For the correct explanation also the influence of the neotectonic movements must be considered. The arrangement of the karst rooms and the position of the underground water indicate the neotectonic lifting of the block. The karst corrosion is slower than lifting and it is not able to fuse the underground flow. The opposite process was examined at the Lijak spring, which lies in the structural lowered block with the karst channel in the depth of 90 m (ČAR & GOSPODARIČ 1988). Naturally, there are no karst features formed above the spring Lijak because of the neotectonic lowering. In this case the term "immersed karst" has also the neotectonic meaning. Finally, the determination of the depth to the impermeable flysch basement of the karst aquifer would be very important for the final explanation of the hydrogeological structure of the Hubelj spring.

2.6.4. Geologic conditions and some hydrogeologic characteristics of the Vipava karst springs

(J. JANEŽ, J. ČAR)

2.6.4.1. The aim and method of investigation

The aim of the investigation was to explain the detailed geologic position of the Vipava karst springs. The same as in the case of the Hubelj spring we used the method of mapping of lithology and structural elements. The scale of mapping was 1:5000. The lithologic-tectonic map of the Vipava area is given in Fig. 2.26.