as springs with juvenile water, i.e. water filtered through soil and bed-rocks. Fauna doesn't confirm any direct connections between constant epigeic water bodies and mentioned springs. At the same time it doesn't exclude any connections through dry channels, or temporary overflowed channels, in the recharge area. Presence of relatively rich subterranean fauna, with relatively small number of specimens indicate that concentration of organic material, like communal sewage or water from waste dumps, is low.

2.9. VEGETATION CHARACTERISTICS OF THE TRNOVSKI GOZD (T. PIPAN)

Trnovski Gozd can be placed in the Dinaric phytogeographic region but forms its extreme north-western part. There is represented, therefore, a kind of transitional zone between the Dinaric and Alpine phytogeographic regions. This is most clearly reflected in the smaller number of Dinaric (Ilyric) samples of flora and the larger number of Alpine species. The southern margin of the Trnovski Gozd towards Vipava valley forms the direct border with the Submediterranean phytogeographic region. Because of the configuration of the terrain, the border is very sharp in places, the zone of transitional vegetation being mostly narrow.

Due to its characteristic geographical position, Trnovski Gozd is a kind of cross-roads of different species of flora in miniature. At the margin towards Vipava valley and on up the Čepovan valley, there are examples of quite a number of Submediterranean species. On the plateau, however, the Dinaric-Ilyrian meets with the Alpine. The most well known tract with all three types of flora mixed is Čaven where an extraordinary variety of flora flourishes. The Paleoendemit parsnips discovered by Hladnik, *Hladnika pastinacifolia* also thrive in the Trnovski Gozd, growing only on the Čaven and Poldanovec. The reason for the mixture of species, is not known; studies show that neither darkness nor temperature are causes.

The entire plateau of the Trnovski Gozd, except frost place tracts, is covered with the Dinaric plant association of beech and fir (*Omphalodo - Fagetum s. lat.*). A height zone at between 900 to 1,000 meters and 1,300 to 1,400 meters is formed in the Dinaric phytogeographic region. The combined beech and fir forest grows on other tracts of our mountainous karst (Snežnik, Javorniki, Hrušica and Kočevski Rog) besides in the Trnovski Gozd. It is distinguishable from the similar plant association of our Alpine tracts by the presence of Dinaric-Ilyrian species in the undergrowth and by the presence of a number of Central European species. However, the number of Dinaric-Ilyrian species are considerably less when compared to other tracts of the mountain karst as the Trnovski Gozd represents a kind of transitional zone between the Dinaric and Alpine regions.

Another type of vegetation in the Trnovski Gozd, is spruce. Spruce in the Dinaric region does not form a particular high zone alone but only when combined with beech. Real forest communities are only formed on the level plates with ground from chert (Mala Lazna and Velika Lazna) and in the sinkholes of Smrekova Draga. The reason for this, is the real characteristic of a frost place for these tracts. The Phytosociological forms two associations. The first is the Dinaric Subalpine spruce forest (*Lonicero caeruleae - Piceetum*), the second, spruce (*Stellario montani - Piceetum*) which is spread over Mala Lazna and Velika Lazna. In the Dinaric phytogeographic region, the last forest zone of beech grows, that is that belonging to the association, Subalpine beech, *Polysticho lonchistir - Fagetum s. lat.* Beech in this association is no longer a tree but rather more a bush which, towards the border of the forest, grows as low as two to three meters. On the margins of the Trnovski Gozd, towards the Vipava valley, beech belonging to the Submediterranean association, *Seslerio - Ostryetum* grows. In the narrow or wide zones which are still influenced by Submediterranean flora, grows a special association, *Seslerio - Fagetum* which represents the encroachment of the beech forest into the mountain forest of the karst (ZUPANČIČ et al. 1987).

Frost places

Frost places are extreme types of biotops. In the orographic, ecological and botanical respect, they are sharply distinguishable from their surroundings. Due to different causes, their temperature regime is considerably sharper than in their surroundings, determining the thriving of plant life. The majority of frost places are on the mountain karst but they also exist in the Alps and even in the Submediterranean tracts (MARTINČIČ 1977).

Mala Lazna

Mala Lazna is a frost place formed on acid chert. During the day, there is no difference between the limestone parts and the chert but at night there is great radiation of heat and on the chert, the ground cools to below 0° C. The frost place is consequently formed due to nightly temperature inversion. The thickness of inverse layers of air is two to four meters. A specific temperature regime is formed, the result of the chemical reaction of the ground. Here thrives fir which likes the cold more than beech. Most probably, the beech has disappeared due to thinning out and this has caused a biological imbalance. Trees in the association have normal growth. The sporadic examples of changed appearance (e.g. more than one top) is due to temperature inversion. The spruce in the association have considerably smaller top growths; there is no difference in thickness, which is not unusual, because of different placing of photosynthates which does not limit this direction of growth (FILIPIČ 1959).

Velika Ledena Jama V Paradani

A funnel shaped sink hole, more than 50 meters deep, can be found on the plateau of Trnovski Gozd under Golaki. The bottom opens out as a pocket into a cave where there is ice and snow all year round. The lower part of the slopes are very gravely. There is an entrance to the ice cave on the shady side 1,090 meters above sea level where there is an opening in the mighty overhanging wall. Ground temperatures from the edge of the sinkhole downwards fall rather evenly. The lowest are close to the snow and ice where they come to 1 to 2° C all year. Because this part is always in the shade, the nightly oscillation is only some tenths of a degree. The difference between the surface and lower layers of ground is equally as great. The air temperature regime is inverted in sunny weather only at a height of 0,5 meters above the ground as the ground layer of air may heat up to 30° C on the foundation of the ground. Only in cloudy weather, this effect doesn't exist so the inversion is expressed over the whole ground profile of air. The temperature inversion which causes vegetation inversion means the air temperature from the edge of the sinkhole downwards falls and, in parallel, the temperature of the ground also falls. Temperature inversion is best seen if the temperature is measured on the vertical profile. Usually a real temperature inversion develops only on the parts which are always in the shade. On the slopes, which are exposed throughout the day to sun insulation, the surface can be strongly warmed along with the air at ground level. At this time, temperature inversion is formed only at the height of one meter where the air is not warmed by the ground. BECK (1906) is verified by the ice cave in Paradana where there is a classic example of vegetation inversion as zones of vegetation are the other way around than in the Alps. The inversion is almost perfect, there being missing only the zone of dwarf mountain pine. Analysis of the flora demonstrates that the zone is developed and we call it zone of Subalpine bushes only that its structure is fragmented and dwarf mountain pine (*Pinus mugo*) is missing. As this species is quite common in the Trnovski Gozd, it is questionable whether its presence is primary or secondary (MARTINČIČ 1989).

From a floral-vegetation and ecological view point, we distinguish between the following zones in the Paradana: the zone of Dinaric beech-fir forest, the spruce zone, the zone of willow, the zone of Subalpine bushes, the zone of alpine herbs and the zone of mosses. Total inversion is exclusively present only on the exposed slopes, the east and west inclines chiefly offer a different picture (ZUPANČIČ 1980).

The zone of beech and fir forest (*Omphalodo - Fagetum s. lat.*) starts approximately 30 meters above the cave entrance and grows all around the area.

The spruce (*Lonicero caeruleae - Piceetum*) zone covers only a small area. There are present progressively worsening conditions for growth in the down-

ward direction and this is reflected in the size of the spruce. On the zone's lower edge, spruce thrives only in the form of bushes less than two meters high.

The zone of willows (*Salicetum appendiculate*) represents conditions as they are at the height of the forest border as they are very common there. This is also confirmed by other species thriving in this zone. The height of the willow is dependent on temperatures which change quickly on the downward slopes. On the upper border they reach some 3,5 meters high, on the lower only 25 centimetres.

The zone of Subalpine bushes (as a fragment of the association *Pinetum mugi*), in the phytocenological and ecological sense, is a zone of dwarf mountain pine. However, for unknown reasons, the most important species is missing. The floral inventory of the zone is very rich. Among the species preserved by the ice case are also glacial relics such as the remains of ice age flora which at this time was common in the Trnovski Gozd. The most important species are: *Rhododendron hirsutum*, *Rhodothamnus chamaecistus*, *Salix retusa* (willow), *Carex feruginea* (sedge) and *Valeriana saxatilis* (valerian).

In the zone of Alpine herbs there is a distinct mountain micro-climate. Lower temperatures, and with this worsening living conditions on the downward slope, prevents the thriving of the more demanding lignificated plants. Floral inventory is very poor. Here there thrives exclusively, cold loving species. The willow, *Salix retusa* is the only tree but Alpine meadow grass (*Poa alpina*), the two petal violet (*Viola biflora*) and the speedwell (*Veronica lutea*) can also be found.

Around the cave entrance, in the vicinity of snow and ice, is a zone of mosses. The whole area is always in the shade; temperatures are always between 1 and 3° C. Extreme micro-climatic conditions prevent the thriving of flowers. The only exception to this is the species alternate-leafed golden-saxifrages (*Chrysosplenium alternifolium*) which is, however, often sterile or even stunted. Low temperature is not the only cause of the absence of flowers, too little light also plays a part; it is insufficient for netophotosynthesis.

Frost places on conglomerated ground

Cold loving vegetation in the sink holes grows especially on part of the slope, less or not at all on the bottom. In any case the ground is skeletal, gravely or conglomerate. It is composed of relatively rough material with air spaces in between which are interconnected in an uninterrupted system. The skeletal ground is mostly due to crumbling of rock walls so frost places of this type are mainly in collapse dolines; they can also be found on open slopes. The ground at the lower part of the conglomerated slopes is the coldest. Between the skeletal material, can be found greater or smaller holes and fissures from which blows very cold air. The strongly cooling air circulating in

the ground is the most important factor for its coldness. Sometimes its effect is so great that the whole surface layer of the ground, in spite of intensive insulation, can not warm up. Air enters the upper part of the slope in a system of fissures and spaces where cooling is witnessed. Because it is heavier, it slides into the internal downwards with additional cooling; in the lower part of the slope, it comes from the fissures. However, this method of cooling only, is not sufficient. Ice is sure to form at unknown depths which has a stronger cooling effect. In the sinkholes, the ground temperature is lower in the downward direction and, as a rule, is lowest just before the bottom. The temperature can be more or less equal on the whole profile of the sinkhole. Only in the depths of the sinkhole, with steep inclines, temperature inversion in the air layer can be found at the same time which can be some metres wide. Always the night temperature is inverted (MARTINČIČ 1989).

Smrekova Draga *(Photo 13)*

The Smrekova Draga frost place is an extensive karst hollow on the northern side of Mali Golak. It is approximately 140 meters deep; its bottom is 1,100 meters above sea level. The sink hole lies in the climatic zone of the fir association, *Omphalodo - Fagetum s. lat.* which covers the higher parts of

Photo 13: Smrekova Draga karst depression with vegetation inversion (Photo by P. Habič).

the slopes and the whole surroundings. The foot and lower part of the inclines are covered with spruce and dwarf mountain pine. The only reason for the changing vegetation conditions is the very cold ground and not temperature inversion.

In the dwarf mountain pine zone, the temperature does not exceed 5° C all year. In the spruce zone it is 5 to 10° C and in the beech-fir zone the temperature is at least 10° C. In sunny weather, the ground's surface is heated strongly so there is a difference between deep and surface layers of 20° C and more. The air temperature does not show any inversion except at night. Often the highest air temperature is at the base in the zone of dwarf mountain pine. The temperature oscillates during the day and night, increasing towards the base as the nightly air temperature falls below 0° C even in summer. Extreme micro-climatic conditions affect the thriving of two cold loving communities. *Lonicero caeruleae - Piceetum* grows over most of the sinkhole and in the western part, *Pinetum mugi*. The border between spruce and dwarf pine is very sharp. The transitional zone of low spruce doesn't exist as the height of spruce at the edge is almost the same as in the association. The zone of dwarf mountain pine is limited to the coldest ground. It flourishes all over where the ground temperature at 20 to 30 cm deep does not exceed 1 to 6° C in the summer. In many places the ground temperature is only 1 to 2° C. It is not surprising that, on such ground, dwarf mountain pine grows to barely 0,5 meters although at the edge it is 3,5 meters high. From a vegetation point of view, the dwarf mountain pine is a fragment of the alpine association *Pinetum mugi*. Vegetation is sparse with most Alpine species. *Sphagnum nemoreum*, *Vaccinium uliginosum* and *Oxycoccus palustris* represent specialities forming on smaller surface areas of the high marshland.

* New names of associations:

MARINČEK, L., MUCINA, L., ZUPANČIČ, M., POLDINI, L., DAKSKOBLER, I., ACCETO, M., 1992: Nomenklatorische Revision der illyrischen Buchenwälder (Verband Anemonio - Fagion).- Studia Geobotanica, 12, 121 - 135, Trieste.

ZUPANČIČ, M., 1994: Popravki imen nekaterih rastlinskih združb v luči novega kodeksa. Hladnikia, 2, 33 - 40, Ljubljana.