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Geology of Planina pri Jezeru and its environs (Slovenia)

Geologija Planine pri Jezeru z okolico

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Ključne besede: visokogorska jezera, trias, jura, pleistocen, ledeniški sedimenti, Bohinj, Triglavska jezera, Julijske Alpe

Abstract

The article describes the results of detailed geological mapping of the wider environs of Planina pri Jezeru north of Bohinj. In the literature the Upper Triassic massive and bedded limestone, Jurassic limestone, Cretaceous clastic rocks and Pleistocene sediments have been reported in this area up to now. The article supplements existing lithostratigraphic information by defining exact locations of the Pleistocene sediments at Planina pri Jezeru and Planina v Lazu, and of Jurassic rocks. In Poljane a Neptunian dyke and bioclastic limestone, while north of Mizčna glava a flat-bedded microsparitic limestone were described for the first time. Correlation to the Triglav Lakes Valley Jurassic beds indicates equivalent facieses. Allochthon Cretaceous biocalcarenite and jasper situated east of Planina pri Jezeru are also described due to their importance for further glaciological studies. The results show that the recent lake Jezero na Planini pri Jezeru is formed due to the accumulation of Pleistocene glacial-lacustrine fine-grained sediment in till, deposited on the Dachstein limestone.

Izvleček

Članek podaja rezultate podrobnega geološkega kartiranja širše okolice Planine pri Jezeru severno od Bohinja. Na obravnavanem območju so bili v literaturi doslej opisani zgornje triasni masivni in plastoviti apnenec, jurski apnenec, kredni klastiti in pleistocenski sedimenti. Članek dopolnjuje obstoječe litostratigrafske podatke, saj so v njem predstavljene natančne lokacije pleistocenskih sedimentov na Planini pri Jezeru in Planini v Lazu ter jurskih kamnin. Na Poljanah sta prvič opisana neptunski dajk in bioklastični apnenec, severno od Mizčne glave pa ploščasti mikrosparitni apnenec. Primerjava z jurskimi plastmi v Dolini Triglavskih jezer kaže na sorodne faciese. Vzhodno od Planine pri Jezeru sta zaradi pomena za prihodnje raziskave poledenitev v Julijskih Alpah opisana alohtona kredni biokalkarenit in jaspis. Iz omenjenih rezultatov izhaja, da je recentno Jezero na Planini pri Jezeru posledica prisotnosti pleistocenskih ledeniško-jezerskih drobnozrnatih sedimentov v tilu, odloženem na Dachsteinskem apnencu.

Introduction

Lakes in high mountainous environment are sensitive indicators of environmental change. These changes are reflected in ecological conditions and limnological processes such as temperature profiles, sedimentation rates, stratification of water column etc. In the recent years these are the reasons why many limnological studies in the literature are dedicated to such environment. Unaffected ecological conditions in these lakes depend largely on local geology, which is very often not properly known. Consequently, interpretations of measurements and conclusions are erroneous or incomplete. Local geology of lakes should be studied at the very beginning of all other investigations and should represent a firm basis for further interpretations.

Recently, the lake Jezero na Planini pri Jezeru has been thoroughly investigated (Vreča, 2000, 2003; Vreča & Muri, 2006) as part of the high mountain lakes research of the Julian Alps (Brancelj, 2004). Brancelj (2002) and his co-workers presented an overview of the hydrological, biological, chemical and physical characteristics of the Triglav Lakes group. Several questions arose, especially those connected with hydrological balance. It has been realised that new, more detailed geological mapping is needed for solving open questions on the hydrological condition in the area, as there are two possible geological factors enabling the lake Jezero formation. The existence of low permeable Jurassic rocks can cause water accumulation, as it is already proven for some of the Triglav Valley Lakes (Gams, 1962). On the other hand, it was suggested that accumulation of the Pleistocene fine-grained sediment can lead to the same result. The outcome of the geological mapping is presented in the paper.

Geographical setting

Planina pri Jezeru is located in the Julian Alps in northwest Slovenia. The wider area is called Fužinske planine and represents a part of the Triglav National Park (Fig. 1). The lake Jezero (46°19'N, 13°50'E) is situated at an elevation of 1430 m a.s.l. in a small depression and belongs to the Triglav Lakes group. It has an average surface of 0.0176 km^2 and a maximum depth of 11 m. It is of elliptic shape with the longer axis in direction east – west. In the present state it is highly eutrophic (Dobravec & šiško, 2002). On the south shore seepage springs are positioned, while a small swallow hole is situated on the north shore. Planina pri Jezeru is surrounded by hills of Mizčna glava (1622 m) in the north, Griva (1757 m) in the west and Gorenji Viševnik (1723 m) and Vodični vrh (1621 m) in the south.

Figure 1. Location of the investigated area in the Triglav National Park, Julian Alps

Slika 1. Lega preiskanega območja v Triglavskem narodnem parku, Julijskih Alpah

Geological setting

The geology of the area was studied by Kossmat (1913), Seidl (1929) and Grimšičar (1961). With the Basic Geological Map of Yugoslavia 1: 100 000, sheet Tolmin and Videm with explanatory note (Buser, 1986, 1987), the first geological synthesis of the wider area was presented. Ogorelec & Buser (1996) gave a detailed description of the Dachstein limestone of the Julian nappe. Formal geotectonic division was made by Placer (1999), while paleogeographical by Buser (1996). Ramovš (2000) provided an overview of Kossmat's and Seidl's work and the terminology of the Slatna nappe which was studied also more recently (Celarc & Herlec, 2007). Jurassic beds and tectonics of the Triglav Lakes Valley were in detail investigated by Šmuc (2005). Beside him quite a few authors discussed occurrence of Jurassic iron-manganese nodules observed in various parts of the Julian Alps (Jurkovšek et al., 1989; Ogorelec et al., 2006). Geomorphology and genesis of the Triglav Lakes were studied by Gams (1962).

The investigated area belongs to the Dinarides (Buser, 1986; Placer, 1999). Massive Cordevolian and bedded Dachstein limestone were deposited on the shallow-water Julian Carbonate Platform, which existed from Late Triassic to Early Jurassic. During the interrupted shallow-water sedimentation in Jul and Tuval limestone with chert nodules was deposited (Šmuc, 2005). Condensed sedimentation, which resulted in occurrence of different limestone and clastic rocks, took place on the deeper-water Julian High from late Early Jurassic till early Cretaceous. In Pleistocene the Fužinske planine area was covered by the Bohinj glacier (Melik, 1950).

Julian Alps belong to geotectonic unit of the Southern Alps (Placer, 1999), a subdivision of the Dinarides, which are situated on the Adriatic Microplate. There are three structures distinctive near Planina pri Jezeru. The most wide spread is the Krn nappe (Buser, 1986, 1987) or the Julian nappe (Placer, 1999), which consists of bedded Upper Triassic and lowermost Jurassic limestone plus unconformably deposited Jurassic and Cretaceous rocks. This nappe is overthrust by the Pokljuka nappe, consisting of Julian – Tuvalian limestone with chert nodules. The uppermost structure is the Slatna nappe (Buser, 1986, 1987) or the Zlatna structure (Placer, 1999), composed of massive Cordevolian limestone.

In Eocene the western part of the Southern Alps was changed by thrusting in Dinaric direction (NE-SW), while thrusting in the South Alpine direction (N-S) took place between Eocene and Middle to Late Oligocene (Placer, 1999). In Pliocene and Pleistocene (Buser, 1986, 1987) Dinaric (NW-SE) and cross-Dinaric (NE-SW) faults cut the Julian Alps. Middle Triassic faults in N-S and W-E direction were reactivated in Neogene and Holocene and do not cause significant shifts. Three important Dinaric faults cut Fužinske planine from north to south: the Studor fault, the Bohinj fault and the Viševnik fault.

Methodology

Detailed geological mapping of Planina pri Jezeru and its surroundings was performed in scale 1: 5 000, while elaborated geological map is in scale 1: 10 000. For general overview existing geological maps (Buser, 1986, 1986 b, 1987; Šmuc, 2005) were used. In order to solve questions about relative age and microfacies of newly identified rocks thin-sections of limestone in Poljane area and Mizčna glava were analysed, petrographically classified according to Dunham (1962) and compared to Jurassic beds in the Triglav Lakes Valley described by Šmuc (2005). Additionally, biocalcarenite clasts found east of Planina pri Jezeru were also described as they can be useful for further studies. For rocks identified already by Buser (1986, 1987) a macroscopic description is given and their age was quoted. The age of newly located Jurassic rocks was determined by correlation with the Triglav Lakes Valley (Šmuc, 2005).

Lithostratigraphy

In the area around Planina pri Jezeru Triassic, Jurassic and Cretaceous rocks as well as Quaternary sediments were identified.

Triassic rocks

Triassic rocks were already identified by Buser (1986, 1987), however, our detailed mapping revealed that their position is slightly different as referred. On these rocks the main high Alpine karst forms are developed.

The oldest stratigraphic unit belongs to white massive Cordevolian (Buser, 1986) limestone which outcrops west of Planina Viševnik and Planina Dedno polje, north of Planina pri Jezeru and around the hill Mizčna glava. It is also present on Planina v Lazu (Fig. 6). The Cordevolian limestone represents the highest nappe structure in the investigated area therefore its lower boundary is tectonic (Fig. 5). In the vicinity of Planina Viševnik and around Mizčna glava very rare black angular limestone clasts of around 1 cm in diameter occur inside 10 cm thick white limestone zones. Due to their position this mud supported breccia can be of tectonic origin.

A thin-bedded light brown to reddish limestone appears in the area of Planina Vodični vrh (Fig. 6). This Julian – Tuvalian (Buser, 1986) limestone contains numerous 3 to 15 cm large nodules of brown chert (Fig. 5). Along the mountain trail east of Planina Vodični vrh up to 3 cm thick beds of brown fine-grained marly limestone and sandstone are intercalated within this limestone. The mapping revealed that Julian – Tuvalian rocks are in tectonic contact with other lithoostratigraphic units.

In most of the area Norian – Rhaetian (Buser, 1986) Dachstein limestone prevails. It forms a rather flat area between Alpine meadows Planina Viševnik, Planina Dedno polje, Planina v Lazu, Planina pri Jezeru and Planina Vodični vrh (Fig. 6). Its lower boundary is not observed in the investigated area whereas the upper boundary is either stratigraphic, as in the case of Jurassic rocks, or tectonic, as in the case of other Triassic rocks (Fig. 5). Three distinctive Lofer cyclothems (Fischer, 1964) were observed in this limestone. Abundant and the thickest one is C member, which is characterized by thick-bedded light grey or brown limestone containing up to 1 mm large bioclasts, rare megalodontid shells, gastropods and fragments of oncoids and thin-shelled bivalves. However, as reported by the speleologists (Anđelič & Malečkar, 1978) the megalodontids are rather abundant in layers between 1150-1350 m a.s.l. in the deep cave system Brezno pri gamsovi glavici. Near the trail from Planina Viševnik to Planina Dedno polje the limestone contains intercalations of brown marly limestone and is much more dolomitized than otherwise. Rocks classified as member B appear mostly west of Planina pri Jezeru. This middle-thick stromatolitic limestone is fairly dolomitized and contains skeletal algae. Rare beds classified as member A with breccia outcrop south of Planina v Lazu. Sub-rounded up to 15 cm large clasts of brown or grey limestone are embedded in brown limestone matrix. Breccia is quite abundant with palaeokarstic filling such as cocard textures and red-to-violet lamellas. Similar breccia, but with up to 30 cm large clasts of green parallel-laminated marlstone with cocard textures forms a low rock wall near the parking place south of Planina Blato (around 1150 m a.s.l.). Similar rocks were noticed in the cave system Brezno pri gamsovi glavici at 1150-1350 m a.s.l. (Anđelič & Malečkar, 1978).

Jurassic rocks

There was only one section of Jurassic rocks known east of the Triglav Lakes Valley. During this geological mapping three new locations of Jurassic rocks were found.

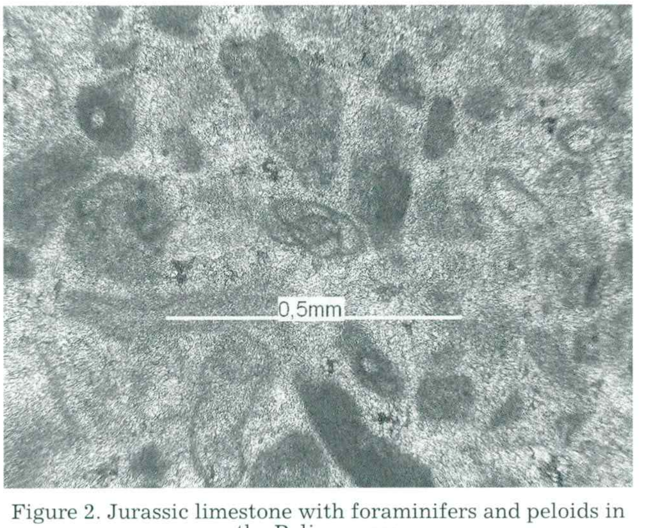

Figure 2. Jurassic limestone with foraminifers and peloids in the Poljane area

Slika 2. Jurski apnenec s foraminiferami in peloidi v okolici Poljan

The newly located bioclastic limestone outcrops in a rock wall southeast of the mountain Rob pod Kredo, west of the Poljane area (Fig. 6). The sequence thickness is at least 30 m. Since the layers lie normally above the Dachstein limestone and no index fossils were found, the Lower Jurassic age was presumed (Fig. 5). The upper boundary is tectonic. This thin to middle-bedded grey wackestone to packstone, sometimes grainstone, is characterised by normal gradation formed by numerous echinoderm fragments, foraminifers, peloids and ooids (Fig. 2). According to similar sequence in the Triglav Lakes Valley (Šmuc, 2005) the lower Pliensbachian (?) age is assumed.

On the mountain trail northeast of Planina Viševnik (Fig. 6) already known, but not described section of the Upper Liassic and Malm (Buser, 1986) rocks outcrops. Its lower boundary is erosive stratigraphic whereas the upper one is covered and probably tectonic (Fig. 5). The sequence starts with 1,5 m thick package of limestone, which gradually changes from light brown to reddish-brown-to-green colour, becomes slightly dolomitized and gets thin marlstone intercalations. Above these beds a package of about 30 cm of dark red marly limestone with 5-10 cm thick nodular bedding was found. These rocks are followed by a 5 m package of thick dark red limestone and red calcarenite with crinoids. Both contain black manganese nodules of up to 1 cm in diameter. This section ends with 2 m of thin-bedded greenish-to-greyish limestone with nodular bedding. Comparison to Jurassic beds in the Triglav Lakes Valley indicates great similarity. For this reason Jurassic section on Planina Viševnik can be classified as Lower Member of the Prehodavci formation of the Bajocian to Callovian age (Šmuc, 2005).

New findings are also rocks that form a northeastern toe of the hill Mizčna glava (Fig. 6). The lower boundary of this around 30 m thick package of microsparitic limestone is not known as it is covered in gravel, while the upper boundary with Cordevolian limestone is tectonic (Fig. 5). This chocolate brown-to-red limestone is at first thin-bedded, but in the upper part it becomes thicker. Nodular bedding is indistinct and thin clay film occurs between individual beds. The limestone is classified as wackestone to packstone and does not contain many fossils, as only some sponge spicules and calcified radiolarian moulds were found. However, in some parts wackestone with filaments, peloids, rare ooids and even rarer foraminifers appear (Fig. 3). The sequence is almost identical to nodular limestone of the upper part of the Lower Member of the Prehodavci formation of Callovian age (Šmuc, 2005), just there pyrite was found. As quite some thickness is referred in this article, it is possible that described limestone is overlain by red nodular limestone of Ammonitico Rosso type (the Upper Member of Kimmeridgian to early Tithonian age) in the upper part of the high rock wall.

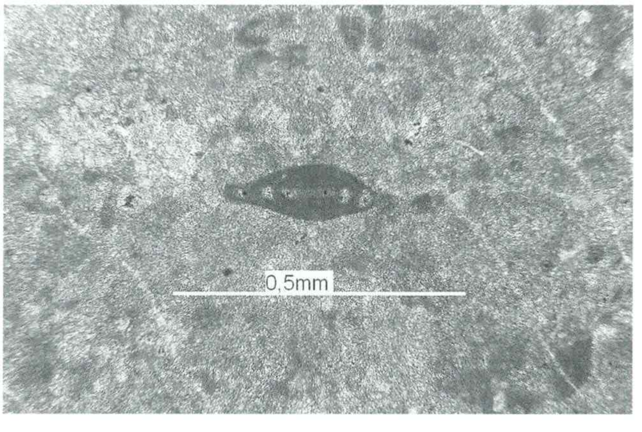

Figure 3. Jurassic limestone with foraminifer and peloids below Mizčna glava

Slika 3. Jurski apnenec s foraminifero in peloidi pod Mizčno glavo

In Poljane, northeast of Mizčna glava, a first-time described Neptunian dyke of a few meters in diameter is situated in the Dachstein limestone (Fig. 6). Due to rather flat topography its depth cannot be estimated, but erosive boundary (Fig. 5) is distinctive. The dyke consists of sub-rounded clasts of reddish and brownish limestone and calcarenite. The latter is reddish or slightly green with up to 0,5 cm large echinoderm fragments and up to 1,5 cm long brachiopods and bivalve shells. For accurate age determination thin-sections should be investigated, however, from comparison with the Triglav Lakes Valley Jurassic beds (Šmuc, 2005) Kimmeridgian age can be expected.

Cretaceous rocks

In the central part of Planina Viševnik (Fig. 6) clasts of dark red claystone, marlstone and fine-grained sandstone can be found in soil (Fig. 5). Due to the fact that this accumulation is dense, quite localised and forms rather wide wetlands where a spring occurs also, we assume that they represent secondary Cretaceous (Buser, 1986, 1987) outcrops. Based on general tectonic settings of Planina Viševnik tectonic boundaries were presumed.

Quaternary rocks and sediments

Pleistocene glacial deposits are present as till, tillstone and fine-grained sediment deposits, whereas Holocene sediments form scree below limestone walls.

Detailed geological mapping demonstrated that there are no Jurassic rocks present in the vicinity of the lake Jezero. For this reason the hypothesis of Jurassic rocks causing the lake formation is rejected. On the other hand, a significant accumulation of Pleistocene (Buser, 1986) fine-grained glacial-lacustrine deposit in till has been found along the south shore of the lake where seepage of groundwater appears. Smaller accumulations were perceived also over the whole Planina pri Jezeru area covered by till. Arising from this, we accept the hypothesis that the recent lake Jezero exists due to the Pleistocene fine-grained sediment accumulation in the lowest part of the Planina pri Jezeru depression.

Coarser-grained matrix supported tills were deposited on Planina pri Jezeru and Planina v Lazu (Fig. 6). Thickness of the Planina pri Jezeru till is estimated to at least 5 m, as it covers the entire depression. This till with clasts up to 30 cm in diameter was classified as sub-rounded silty to poorly graded gravel (Fig. 5). On the contrary, thickness of the till on Planina v Lazu is not known. The tillstone appears in blocks of different size near a mountain trail from Planina

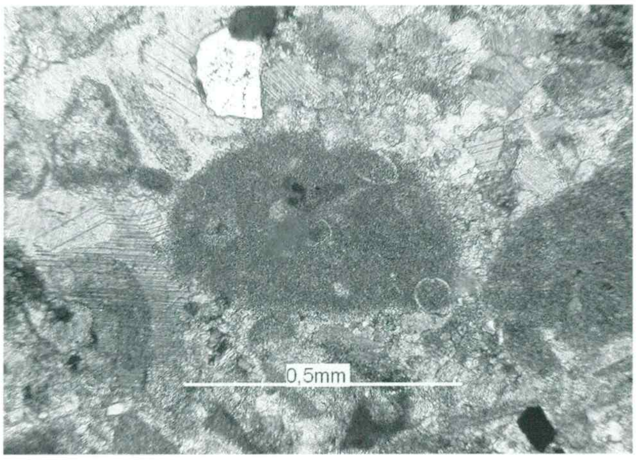

Figure 4. Cretaceous biocalcarenite: clasts of Biancone limestone with *Calpionella* sp., quartz and phosphates grains

Slika 4. Kredni biokalkarenit: klasti Biancone apnenca s *Calpionella* sp., kremenova in fosfatna zrna

Viševnik to Planina pri Jezeru and from there to Planina Blato. It consists of up to 10 cm clasts of micritic limestone, limestone with chert and oolitic limestone cemented by orange-brown mixture of fine sand and silt.

A small accumulation of allochthon chert and biocalcarenite exists near the mountain trail from Planina pri Jezeru to Planina v Lazu at the height of 1470 m a.s.l. The clasts are not presented on the geological map as they are not important from stratigraphic point of view, but might be helpful for future studies of glacial movements in the Julian Alps. Sub-rounded clasts of green-to-brown medium-to-coarse-grained biocalcarenite reach up to 10 cm in diameter. Smaller clasts of sub-rounded chert/jasper are brown on the edge and reddish in the centre. The biocalcarenite is a grainstone that consists of sub-rounded echinoderm fragments, rounded clasts of micritic (Biancone) limestone with *Calpionella sp.* (Fig. 4), angular clasts of detritic monocrystal and polycrystal quartz, rounded clasts of phosphates and glauconit and numerous foraminifers and stromatoporids. The cement is slightly chloritized. Based on clasts of the Biancone limestone the biocalcarenite can be dated as Lower Cretaceous.

The Holocene sediments appear as scree under higher rock walls west and south of Planina pri Jezeru and north of Mizčna glava (Fig. 6). Small amount of angular gravel (Fig. 5) can be found all along the Slatna nappe thrust zone and near stronger fault zones.

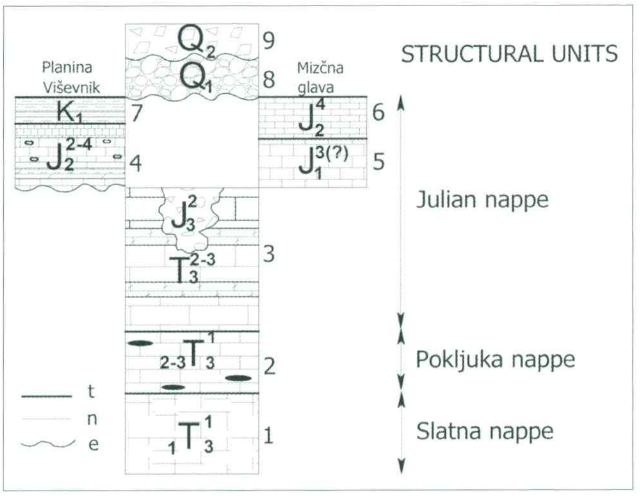

Figure 5. Schematic geological column of the investigated rocks; (1) Cordevolian massive limestone, (2) Julian-Tuvalian limestone with chert, (3) Dachstein limestone with Neptunian dyke, (4) Jurassic limestone, marlstone and calcarenite with iron-manganese nodules, (5) Jurassic bioclastic limestone, (6) Jurassic flat-bedded limestone, (7) Cretaceous claystone, marlstone and sandstone, (8) Pleistocene till, tillstone and glacial-lacustrine fine-grained sediment, (9) Holocene gravel, (t) tectonic geological boundary, (n) normal stratigraphic geological boundary and (e) erosive geological boundary

Slika 5. Shematski geološki stolpec preiskanih kamnin; (1) cordevolski masivni apnenec, (2) julsko-tuvalski apnenec z rožencem (3) dachsteinski apnenec z neptunskim dajkom, (4) jurski apnenec, laporovec in kalkarenit z železovo-manganovimi gomolji, (5) jurski bioklastični apnenec, (6) jurski ploščast apnenec, (7) kredni glinavec, laporovec in peščenjak, (8) pleistocenski til, tilit in ledeniško-jezerski drobnozrnati sediment, (9) holocenski grušč, (t) tektonska geološka meja, (n) normalna stratigrafska geološka meja in (e) erozijska geološka meja

Tectonics

In the investigated area three nappes and three major faults are defined and we improved their spatial resolution.

The massive Cordevolian limestone of the Slatna nappe overlies rocks of the Julian nappe west and north of Planina pri Jezeru. This mapping indicated that the position of this structure between Planina pri Jezeru and Planina v Lazu is slightly different as referred by Buser (1987). The thrust plane is morphologically distinctive by forming rock walls between Planina Viševnik and Planina Dedno polje, south and north of Mizčna glava, whereas south of Planina v Lazu it is not so well defined (Fig. 6). It winds in different directions but its angle stays quite steep varying from 50 to 70°. This indicates reverse faults rather than a nappe, which was already inferred by Placer (1999). The altitude of the thrust plane decreases to the north, from 1620 m near Planina Viševnik to 1490 m near Planina v Lazu. The rocks on the thrust contact are folded and contain numerous veins of white calcite and orange limonite.

Referring to Buser (1986) only the Julian-Tuvalian limestone with chert on Planina Vodični vrh is a representative of the Pokljuka nappe in the investigated area. This limestone dips to the northeast and is separated from the Dachstein limestone of the Julian nappe by faults (Fig. 6). On the contact it contains lots of thick limonite veins.

The Julian nappe is the lowest structure included in this geological mapping. It forms most of the area between Planina Viševnik, Planina v Lazu and Planina Vodični vrh (Fig. 6). It consists of the Dachstein limestone, Jurassic limestones and calcarenite and Cretaceous clastic rocks, with layers dipping mostly to the west or southwest.

Three major dextral stike-slip faults in Dinaric direction are connected with many normal con-

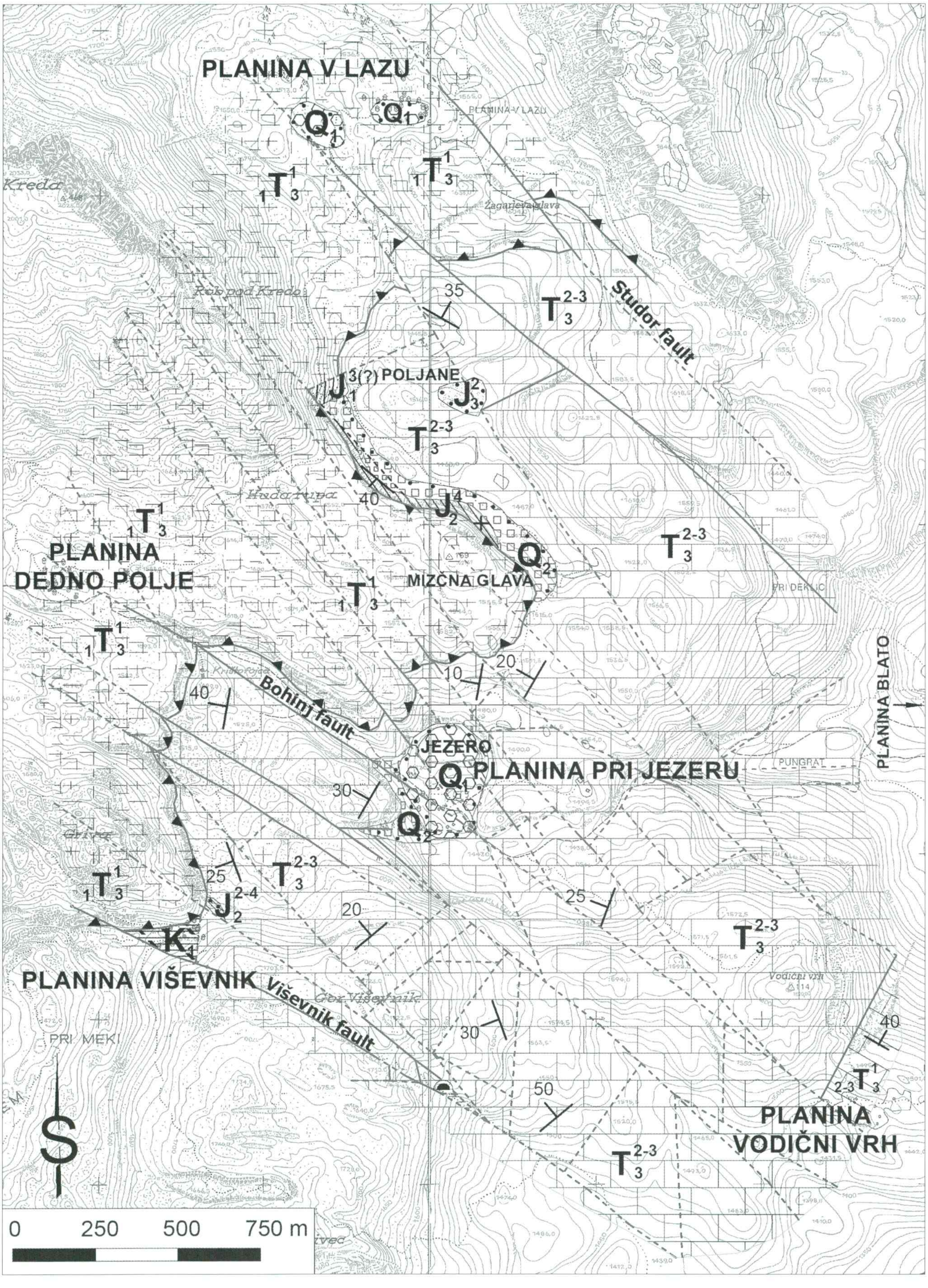

Figure 6. Detailed geological map of Planina pri Jezeru and its environs with legend

Slika 6. Podrobna geološka karta Planine pri Jezeru z okolico in legendo junctional faults. Rocks on the contact are often limonitized, dolomitized, crushed and slightly folded.

A mountain trail from Planina Vogar to Planina Viševnik coincides with the Viševnik fault (Fig. 6). Here many faults with general direction ranging from 110°-290° to 140°-320° can be observed. The fault angles change from 230/75 near Planina Viševnik to 30/80-85 near Gorenji Viševnik. In this zone numerous karstified fractures, caves and shafts with the largest one 819 m deep Brezno pri gamsovi glavici (Anđelić & Malečkar, 1978) are formed. Between Gorenji Viševnik and Planina pri Jezeru fault planes with angles 80/40-60 and 30/80 are usually accompanied by faults in direction 40°-220°.

The Bohinj fault is very distinctive near the mountain trail from Planina pri Jezeru to Planina Dedno polje, where a right lateral shift of the Slatna nappe is noticeable (Fig. 6). The rock walls south of the trail are cut by a fault plane with angle 28/70. A few meters away a lot of small vertical caves and fractures in direction 130°-310° exist. South of Planina pri Jezeru the Bohinj fault probably splits into two faults: the north one with angle 20/70 and the south one in direction 135°-315°. On the north side of the Planina pri Jezeru area a zone of parallel normal faults with angles around 50/70 is developed. Similar effect appears near the spring Krištofojca, where dolomitization occurs in the vicinity of faults.

The Studor fault also forms a zone of parallel faults (40/75 to 255/75) noticeable between Planina v Lazu and Planina Blato (Fig. 6). Faults are morphologically expressed by rock walls under which a mountain trail between the two locations was made. Along this fault, east of the huts on Planina v Lazu, the only location of kataclastic breccia was ascertained. This impermeable zone resulted in the occurrence of a mountain spring east of Planina v Lazu.

Conclusions

The surroundings of Planina pri Jezeru was geologically mapped in scale 1:10 000 (Fig. 6) and the litostratigraphic position of rocks is presented in Figure 5. The mapping confirmed existence of three types of the Upper Triassic limestone and improved their microlocations. Besides, it revealed that a few types of Jurassic limestone outcrop on the eastern side of the Slatna nappe, too. However, the Jurassic limestone must be investigated more thoroughly in order to define the age and lithostratigraphic position precisely. The location of the transported Cretaceous rocks might be useful for glaciological studies in the future. The main result of the investigation is confirmation that the Pleistocene glacial-lacustrine fine-grained sediment is present in significant amounts in till on Planina pri Jezeru. As numerous faults enforce karstification of the limestone and enhance overall rock permeability, the latter sediment is of major importance for the recent lake Jezero existence. These sediments should be investigated in detail in order to determine their mineralogical composition and overall permeability, as the properties will enable execution of hydrological balance of the lake Jezero. It can be said that also very detailed study of tectonics and Quaternary glacial deposits must be done in order to determine age and genesis of the lake Jezero.

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LEGEND OF LITHOSTRATIGRAPHIC UNITS / LEGENDA LITOSTRATIGRAFSKIH ENOT

Q_2 gravel / grušč

Q_1 till, tillstone, glacial-lacustrine fine-grained deposits / til, tilit, ledeniško-jezerska kreda

JULIAN NAPPE ROCKS

K_1 claystone, marlstone, sandstone / glinavec, laporovec, peščenjak

J_3^2 neptunian dyke / neptunski dajk

J_3^4 flat-bedded limestone / ploščast apnenec

J_2^{2-4} limestone, marly limestone, calcarenite / apnenec, laporast apnenec, kalkarenit

$J_1^{3(?)}$ bioclastic limestone / bioklastični apnenec

T_3^{2-3} Dachstein limestone / dachsteinski apnenec

POKLJUKA NAPPE ROCKS

${}_{2\text{-}3}T_3^1$ bedded limestone with chert / plastovit apnenec z roženci

SLATNA NAPPE ROCKS

${}_1T_3^1$ massive limestone / masivni apnenec

LEGEND OF GEOLOGICAL BOUNDARIES / LEGENDA GEOLOŠKIH MEJ

fault / prelom

inferred fault / domnevni prelom

thrust boundary / narivna geološka meja

normal stratigraphical geological boundary / normalna stratigrafska geološka meja

erosive geological boundary / erozijska geološka meja

40 dip of beds / naklon plasti

cave Brezno pri Gamsovi Glavici / jama Brezno pri Gamsovi Glavici

References

Anđelić, J. & Malečkar, F. 1978: Brezno pri gamsovi glavici v Julijskih Alpah. Naše jame (Ljubljana) 20: 49-58.

Buser, S. 1986: Tolmač lista Tolmin in Videm (Udine) Osnovne geološke karte SFRJ 1:100.000. Zvezni geološki zavod, Beograd.

Buser, S. 1986 b: List Tolmin in Videm (Udine) Osnovne geološke karte SFRJ 1:100.000. List Slap Savica, manuskriptna geološka karta 1:25.000. Zvezni geološki zavod, Beograd.

Buser, S. 1987: List Tolmin in Videm (Udine) Osnovne geološke karte SFRJ 1:100.000. Zvezni geološki zavod, Beograd.

Buser, S. 1996: Geology of Western Slovenia and its paleogeographic evolution. In: Drobne, K., Goričan, Š. & Kotnik, B. (eds.), The role of impact processes in the geological and biological evolution of planet Earth: international workshop, Postojna, Slovenia. Založba ZRC, ZRC SAZU (Ljubljana) 236 pp.

Brancelj, A. (ed.) 2002: Visokogorska jezera v vzhodnem delu Julijskih Alp. Založba ZRC, ZRC SAZU (Ljubljana) 266 pp.

Brancelj, A. 2004: Visokogorska jezera v Alpah. In: Trilar, T. (ed.), Narava Slovenije: Alpe (razstavni katalog). Prirodoslovni muzej Slovenije (Ljubljana): 63-67.

Celarc, B. & Herlec, U. 2007: Nariv Slatenske plošče na Jurske apnence v Kanjavcu. In: Horvat, A. (ed.), 18. posvetovanje slovenskih geologov. Univerza v Ljubljani, Naravoslovnotehniška fakulteta, Oddelek za geologijo (Ljubljana): 9-11.

Dobravec, J. & Šiško, M. 2002: Geografska lega in opis jezer. In: Brancelj, A. (ed.), Visokogorska jezera v vzhodnem delu Julijskih Alp. Založba ZRC, ZRC SAZU (Ljubljana): 49-76.

Dunham, R.J. 1962: Classification of carbonate rocks according to depositional texsture. In: Ham, W.E. (ed.), Classification of carbonate rocks. American Association of Petroleum Geologists 1: 108-121.

Fischer, A.G. 1964: The Lofer Cyclothems of the Alpine Triassic. Kansas Geological Survey Bulletin 169: 107-149.

Gams, I. 1962: Visokogorska jezera v Sloveniji, gradivo. Acta geographica (Ljubljana) VII: 237-238.

Grimšičar, A. 1961: O geoloških razmerah med Bohinjem in Triglavskimi jezeri. Geologija (Ljubljana) 7: 283-285.

Jurkovšek, B., Šribar, L., Ogorelec, B., Kolar-Jurkovšek, T. 1989: Pelagične jurske in kredne plasti v zahodnem delu Julijskih Alp. Geologija (Ljubljana) 31/32: 285-328.

Kossmat, F. 1913: Die adriatische Unrandung in der alpinen Faltenregion. Mitt. Geol. Ges. Wien (Wien) 1: 61-165.

Melik, A. 1950: Planine v Julijskih Alpah 1. Založba ZRC, ZRC SAZU (Ljubljana) 301 pp.

Ogorelec, B. & Buser, S. 1996: Dachstein Limestone from Krn in Julian Alps (Slovenia). Geologija (Ljubljana) 39: 133-157.

Ogorelec, B., Buser, S. & Mišič, M. 2006: Manganovi gomolji v jurskem apnencu Južnih Alp Slovenije. Geologija (Ljubljana) 49/1: 69-84.

Placer, L. 1999: Contribution to the macrotectonic subdivision of the border region between Southern Alps and External Dinarides. Geologija (Ljubljana) 41: 223-255.

Ramovš, A. 2000: O Zlatenski plošči *sensu* Kossmat, 1913, Slatenskem pokrovu *sensu* Buser, 1986, Slatenskem narivu *sensu* Jurkovšek, 1987 in Triglavskem pokrovu *sensu* Ramovš, 1985. Geologija (Ljubljana) 43/1: 109-113.

Seidl, F. 1929: Zlatenska plošča v Osrednjih Julijskih Alpah. Glasnik Muzejskega društva za Slovenijo (Ljubljana) 10: 1-29.

Šmuc, A. 2005: Jurassic and Cretaceous stratigraphy and sedimentary evolution of the Julian Alps, NW Slovenia. Založba ZRC, ZRC SAZU (Ljubljana) 98 pp.

Vreča, P. 2000: Kroženje biogenih prvin v evtrofnem visokogorskem jezeru na Planini pri Jezeru, doktorska disertacija NTF (Ljubljana) 116 pp.

Vreča, P. 2003: Carbon cycling at the sediment-water interface in a eutrophic mountain lake (Jezero na Planini pri Jezeru, Slovenia). Organic Geochemistry 34: 671-680.

Vreča, P. & Muri, G. 2006: Changes in accumulation of organic matter and stable carbon and nitrogen isotopes in sediments of two Slovenian mountain lakes (Lake Ledvica and Lake Planina), induced by eutrophication changes. Limnology and Oceanography 51 (1, part 2): 781-790.