

Vzroki in mehanizem zemeljskega plazjenja na Rebrnicah v Vipavski dolini

Reasons and mechanism for soil sliding processes in the Rebrnice area, Vipava valley, SW Slovenia

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Abstract

A motorway Razdrto–Podnanos is being built across Rebrnice area in Vipava valley. There is limestone scree material deposited on flysch rocks. Limestone scree is unstable and gradually slides downslopes because of slope inclination, underground water and clayey zones. Clayey zones have been created on the contact between scree and flysch rocks. Material movements can be observed on the surface but they were also measured in wells. Limestone scree composition and reasons for landslides were described in this article.

Izvleček

Trasa hitre ceste Razdrto–Podnanos prečka območje Rebrnic v Vipavski dolini, kjer so apnenčevi pobočni grušči odloženi na flišnih kamninah. Pobočni grušči so zaradi nagnjenosti terena, prisotnosti talne vode in zaglinjenih con, ki se pojavljajo na kontaktu grušča s flišem, nestabilni in postopoma drsijo po podlagi. Premiki se kažejo na površini, potrjujejo pa jih tudi meritve v vrtinah. V prispevku podrobneje opisujem sestavo pobočnega grušča in navajam vzroke za nastanek plazov.

Uvod

Rebrnice obsegajo del jugozahodnega pobočja Nanosa, med Podnanosom in Razdrtim. Proti zahodu prehajajo v Vipavsko dolino, proti jugovzhodu pa v Pivško kotlino. Območje prečka regionalna cesta, trenutno pa preko Rebrnic gradijo tudi hitro cesto, odsek Razdrto–Vipava. V prispevku obravnavam pas ozemlja med kilometroma 4,7 in 6,3 omenjene hitre ceste. Pas zajema pobočje od apnenčevih sten Nanosa do izravnave pri Lozicah, ki pripada zgornjemu delu Vipavske doline.

Današnja geološka struktura širšega območja je posledica starejše terciarne narivne

tektonike (Placer, 1981). Kredni apnenci so narinjeni na eocenske flišne kamnine. Pas flišnih kamnin, ki se ob južnemu robu Nanosa vleče v Vipavsko dolino, pripada Snežniški narivni grudi (Placer, 1981; Janež et al., 1997). Na Snežniško narivno grudo je narinjen Hruški pokrov, ki zajema tudi Nanos. Zaradi mehanskega preperevanja in drobljenja zgornjekrednih rudistnih apnenec je nastala velika količina apnenčevega pobočnega grušča, ki se je odložil na spodaj ležečih flišnih kamninah.

V okviru gradnje hitre ceste se v zadnjem času izvajajo podrobnejše geološke raziskave terena. Zaradi neugodne kamninske zgradbe se gradbeniki pri gradnji nekaterih

objektov, predvsem vkopov in viaduktov, srečujejo s številnimi problemi. Za utrditev omenjenih objektov se poslužujejo dragih podpornih konstrukcij.

S pomočjo podatkov zbranih pri inženirsko-geološkem kartiranju ter podatkov iz geomehanskih vrtin sem izdelal inženirsko-geološko karto v merilu 1 : 5000. Namen kartiranja je bil ugotoviti razprostranjenost pobočnih gruščev in vpad flišnih kamnin ter ugotoviti znake fosilnega plazenja gruščev. Na podlagi pridobljenih podatkov lahko pojasnimo dinamiko in mehanizem plazenja.

Inženirsko-geološka karta

Rebrnice kot samostojna enota niso posebej obravnavane nikjer v strokovni literaturi. Kljub temu pa so mnogi avtorji pri opisovanju geologije Nanosa in Vipavske doline zajeli tudi ta del ozemlja. O veliki količini gruščev v Vipavski dolini je pisal že Hacquet (1789). Kasneje so pri obravnavi širšega območja o južnem robu Nanosa pisali Stur (1858), Stache (1889), Kossmat (1905), Winkler (1924) in Limanovsky (1910), v okviru izdelave Osnovne geološke karte v merilu 1 : 100.000, listov Gorica in Postojna pa Buser (1986), Buser in sodelavci (1967) ter Pleničar (1970). Veliko podatkov je bilo zbranih tudi pri geološkem kartiranju posameznih izvirov in njihovih zaledij na območju Visokega krasa (Janež et al., 1997).

Obravnavano ozemlje obsega del pobočja ob odseku hitre ceste med 4,7 in 6,3 kilometrom in v širini 2 km. Eocenske kamnine so razvite v značilnem flišnem razvoju. V glavnem se menjavajo sivi skrilavi laporovci in kremenovi ter apnenčevi peščenjaki. Na redkih mestih izdanjajo debele plasti kalkarenita ter kalkrudita in plasti zelenkasto siviga glinavca. Generalni vpad flišnih plasti je proti severovzhodu, plasti vpadajo v pobočje. Z izjemo kalkarenitov in kalkruditov so flišne plasti nepropustne in tvorijo talno hidrogeološko pregrado za kraške vode Nanosa (Janež et al., 1997). Na eocenske kamnine so narinjeni kredni apnenici, ki gradijo Nanoško planoto. Jugozahodni rob planote sestavljajo debeloplastnati organogeni rudistni apnenici zgornjekredne, senonijske starosti (Buser, 1973). Debele plasti apnenca vpadajo proti severu oziroma severovzhodu, enako kot spodaj ležeče flišne plasti. Z mehanskim prepere-

vanjem in razpadanjem krednih apnencev nastaja pobočni grušč, ki se v obliki melišč odlaga na flišnih kamninah. Grušči, ki so na nekaterih mestih sprjeti v brečo, pokrivajo približno 2/3 obravnavanega ozemlja. Izpod apnenčevih sten se območja grušča v jezičasti obliki širijo proti dolini. Grušč tvori grebene oziroma rebra. Debelino sedimenta je na terenu težko določiti, iz reliefnih oblik lahko sklepamo, da ponekod presega 30 metrov. Položaj in odnos krednih ter eocenskih kamnin in kvartarnih pobočnih sedimentov je prikazan na sliki 1.

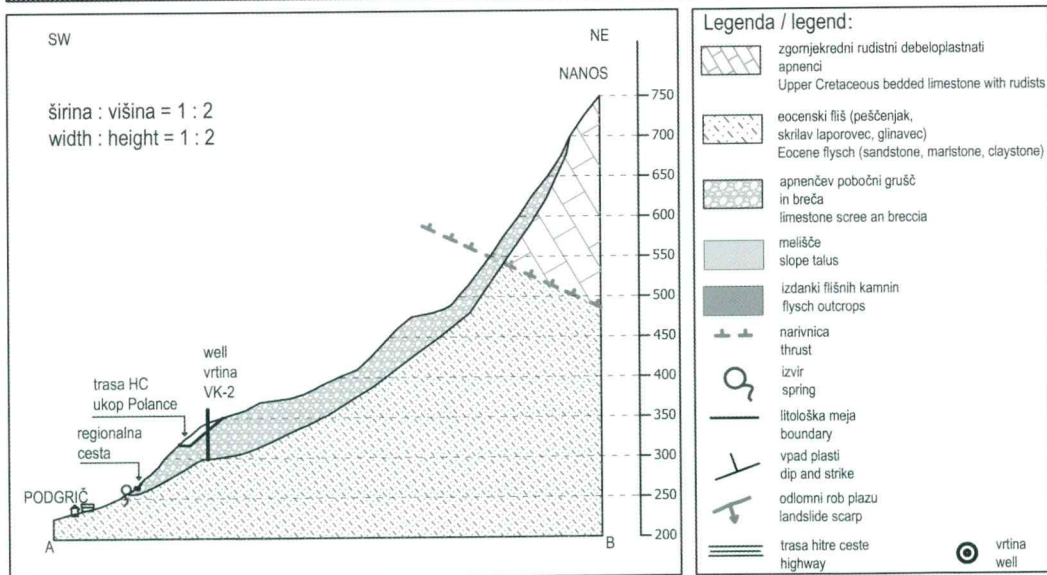
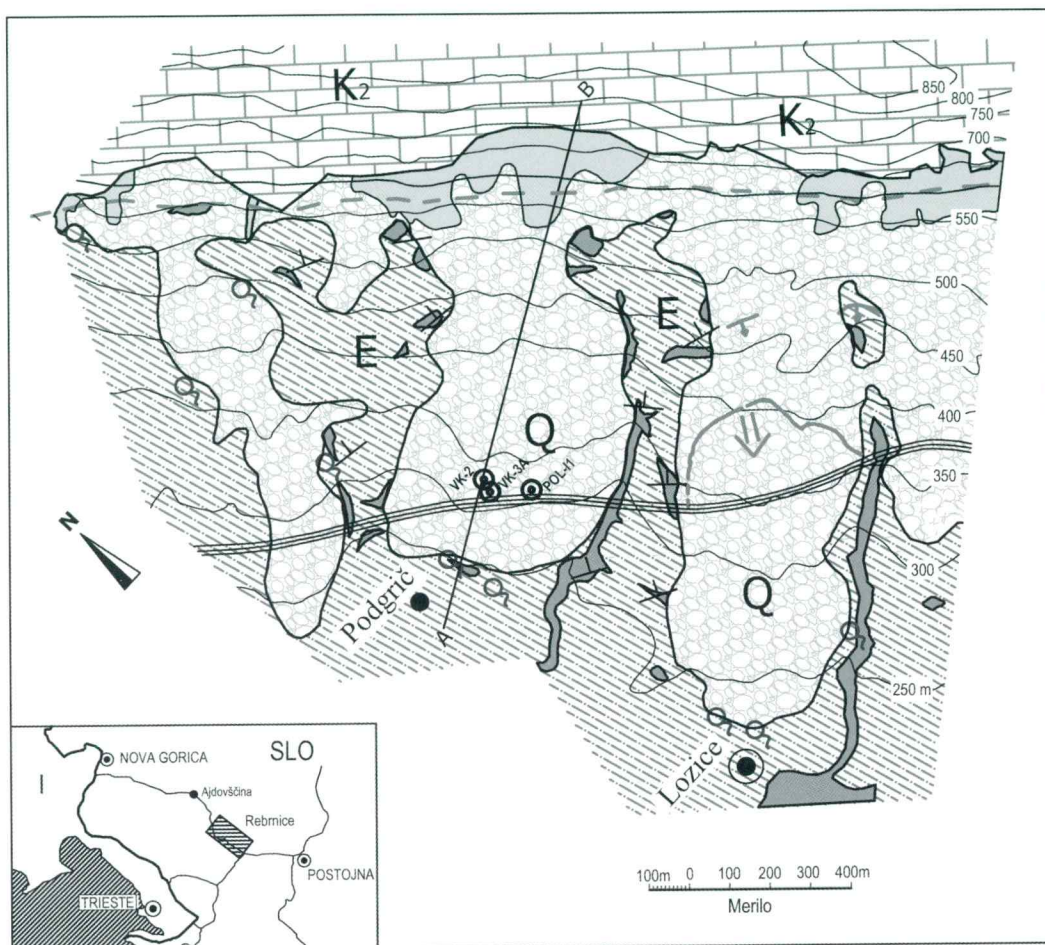
Na sliki 1 je viden tudi profil A–B preko inženirsko-geološke karte. Profil je lociran v bližini vasi Podgrič in poteka v smeri NE–SW. Podatek o debelini pobočnega grušča je pridobljen iz geomehanske vrtine VK-2 (Umek, 2000).

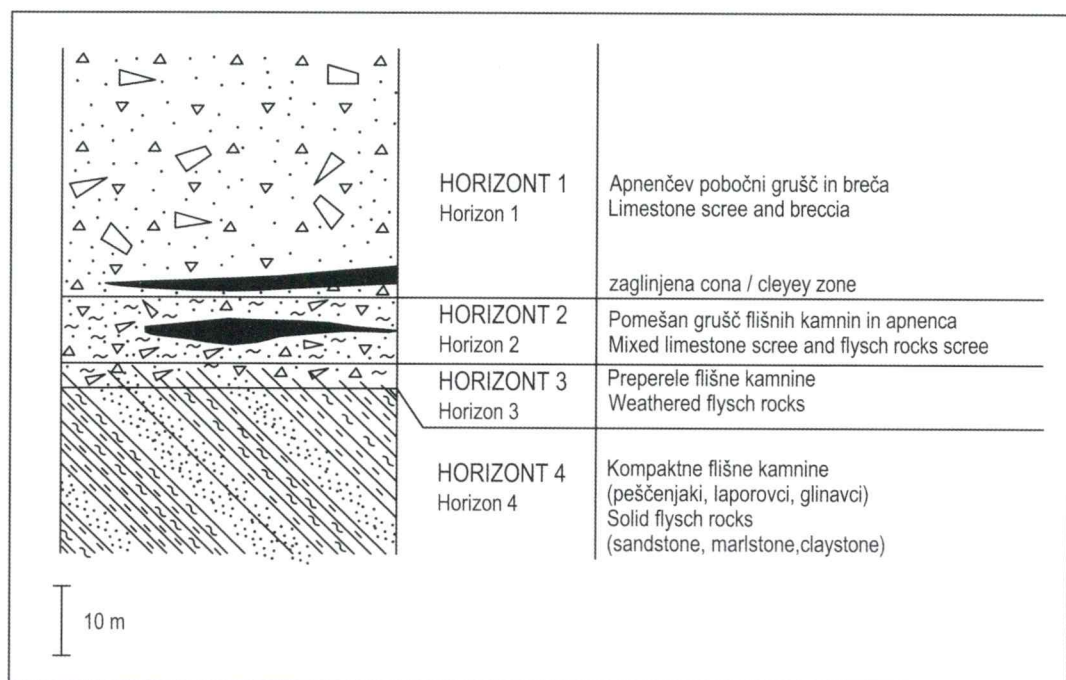
Pobočni grušči in breče

Večji del Rebrnic pokrivajo pobočni grušči in breče. Odnos med sedimenti je glavno gibalno pobočnih procesov, ki se tu dogajajo. Njihovih izdankov je na obravnavanem terenu malo, zato podrobnejši opis gruščev povzemam po geomehanskih vrtinah in profilih v večjih vkopih. Vrtine locirane na pobočnem grušču so prevrtale štiri glavne horizonte (sl. 2). Zgornji horizont gradi apnenčev pobočni grušč. Sestavljajo ga različno veliki apnenčevi kosi ter skalni bloki. Ponekod je grušč sprjet v pobočno brečo. Kosi apnenca so ostrorobi, običajno merijo od 5 do 15 cm, lahko pa se v grušču pojavljajo tudi večje skalne samice, ki merijo od 20 cm do 2 m. Skalni apnenčevi bloki in breča so delno zakraseli ali kavernozi. Grušč je svetlo rjave do sive barve, običajno peščen, meljast ali lokalno zaglinjen. Gostoto grušča določajo zrna glinaste in meljaste frakcije. Običajno je dobro prepusten. Zaledna voda se preceja šele na dnu tega horizonta. Debelina horizonta se lokalno zelo spreminja, v eni od vrtin njegova debelina znaša kar 45 metrov. Navzdol sledi drugi horizont, ki ga sestavlja pomešan grušč flišnih kamnin in apnenca. Tudi znotraj tega horizonta so posamezni večji bloki apnenca, ki se jim pridružujejo kosi flišnega pe-

Slika 1. Inženirsko-geološka karta dela Rebrnic s profilom

Figure 1. Engineering-geological map of part of Rebrnice area with profile





Slika 2. Skica glavnih horizontov, ki sestavljajo pobočni grušč

Figure 2. Sketch of the main horizons which compose scree

ščenjaka. Pomešan grušč je navadno močnejše zaglinjen, kot čist apnenčev grušč. Voda se preceja po prepustnejših delih horizonta. V tretji horizont uvrščam na mestu preperele flišne kamnine. Kamnine nastopajo delno kot poltrdna kamnina, delno pa so razpadle v glinast grušč. Klasti laporovca in peščenjaka so veliki največ do 5 cm. Zaledna voda se tudi tu preceja po prepustnejših delih horizonta. Grušč je temno siv do temno rjav. Spodnji, četrti horizont, zastopa kompaktna kamnina, ki jo sestavljajo flišni laporovci, meljevci in drobnnozrnati peščenjaki. Na nekaterih območjih, kjer flišne kamnine niso pokrite z apnenčevim gruščem in brečo, zgornja dva horizonta manjkata. Nadomešča jih preperina flišnih kamnin. Sestavlja jo glinena preperina z drobnim gruščem flišnih kamnin.

Hidrogeološke lastnosti apnenčevih pobočnih gruščev in breč se lokalno spreminjajo (Janež et al., 1997). V odvisnosti od zrnavosti in količine glinene frakcije se od lokacije do lokacije precej spreminja predvsem prepustnost. Bolje prepustni grušči so sestavljeni iz debelih odlomkov apnenca in vsebujejo manj glinenih in meljastih zrn. V splošnem velja, da so grušči dobro prepust-

ni. Talna voda se v sedimentih pretaka po močnejše zaglinjenih conah, ki se običajno pojavljajo v spodnjem delu zgornjega apnenčastega horizonta oziroma znotraj drugega horizonta. Tovrstno pretakanje je bilo mogoče zaznati tudi v mnogih geomehanskih vrtinah. Voda je potemtakem vezana na kontakt grušča s flišem, čeprav je tega težko natančno določiti, ker je ravno v coni, kjer se mešata gruščnat apnenčev in flišni material. Pretakanje talne vode pod gruščem dokazujejo tudi številni izviri, ki se pojavljajo na spodnjih delih gruščnatih pokrovov (sl. 1). Pretakanje vode še poslabša že tako slabe geomehanske lastnosti zaglinjenih con.

Dinamika in vzroki plazanja

Že sam položaj in razprostranjenost pobočnih sedimentov na Rebrnicah nam da slutiti, da se grušči v obliki različnih pobočnih procesov premikajo. Poleg tega nam to potrjujejo tudi premiki, ki so bili izmerjeni s pomočjo inklinometriških vrtin ter nekateri recentni plazovi. Znaki drsenja so opazni v deformacijah na obstoječi

regionalni cesti, v razpokah na nekaterih odsekih nove hitre ceste ter na poškodbah objektov v vasi Lozice. Meritve premikov v geomehansko-inklinometriških vrtinah kažejo premike reda velikosti nekaj milimetrov do maksimalno 15 milimetrov mesečno. Navezujemo se predvsem na premike v vrtinah VK-2, VK-3 in POL-I1, ki so locirane na objektih Vkop Polance in viadukt Na Polancah (Umek, 2000, 2004). Približno 500 m severovzhodno od vasi Lozice, se je spomladi leta 2001 nad traso hitre ceste aktiviral plaz, imenovan Rebrnica. Nad večjim vkopom je drselo okrog 400.000 m³ pobočnega grušča. Drсна ploskev se je oblikovala na meji med gruščem in flišnimi kamninami. Visoko v pobočju je nastal do 3 m širok odlomni rob. Plaz so uspeli zaustaviti s sidrano pilotno steno.

Apnenčev material, ki nastaja pri mehanskem preperovanju apnencev jugozahodnega roba Nanosa, se v obliki melišč odlaga na spodaj ležeče flišne kamnine. Zaradi kontinuiranega povečevanja količine materiala začnejo melišča pod vplivom gravitacije drseti po podlagi. V zgornjem delu melišča drsijo po krožni drsini, kar dokazujejo številne izravnave oziroma zatrepi, ki se vzdolž Rebrnic pojavljajo pod apnenčevimi stenami. Melišče, ki je običajno nagnjeno pod kotom 45°, je zaradi krožnega drsenja prišlo v vodoraven položaj. V zaledju grušč sočasno na novo nastaja, zato se dogodki ponavljajo. Mlajša melišča pred seboj potiskajo starejše pobočne grušče, ki so se med tem časom že lahko povezali v pobočne breče. Na tak način so pobočni grušči splazeli vse do doline.

Vzroki za opisano plazenje ter manjše premike in zdrse se med seboj kombinirajo. Povprečen nagib pobočja na Rebrnicah znaša med 15 in 20°, kar teren uvršča med zmerno nagnjena pobočja. Strmeje je nagnjen le zgornji del pobočja, kjer nastajajo melišča. Zmeren nagib pobočja že omogoča drsenje sedimenta pod vplivom gravitacije. Drugi vzrok so zaglinjene cone, ki se pojavljajo na meji med gruščem in flišnimi kamninami. Gline imajo slabe geomehanske lastnosti, znotraj njih se lahko oblikujejo drsne ploskve. Poleg tega se v teh conah pretaka podzemna voda, ki dodatno zmanjšuje geomehansko trdnost gline. Tretji razlog so gradbeni posegi na trasi hitre ceste. Pri gradnji velikih vkopov skozi gruščnate grebene se stabilnost pobočnih sedimentov nad traso ceste močno zmanjša.

Zaključki in razprava

Današnji premiki velikih mas apnenčevih pobočnih gruščev in breč na Rebrnicah so le del plazjenja, ki se je dogajalo že v preteklosti. To potrjuje jezičasta oblika gruščnatih pokrovov, ki je značilna za regionalne plazove (sl. 1). Mešanje apnenčevih kosov in kosov flišnih kamnin v drugem horizontu, na kontaktu apnenčevega grušča s flišem, je prav tako posledica fosilnega plazjenja. Sočasno z drsenjem so se mešale preperle flišne kamnine z apnenčevimi kosi. V primeru, da bi bil apnenčev grušč normalno odložen na fliš, mešanega horizonta ne bi bilo. Zaglinjene cone, ki se pojavljajo znotraj tega horizonta oziroma neposredno nad njim, omogočajo precejšnje talne vode. Voda pripomore tudi k nastanku drsne ploskve. Nazoren primer vpliva precejšnje talne vode na nastanek drsne ploskve je razviden v inklinometriških vrtinah VK-2, VK-3A in POL-I1. V vrtini VK-3A so zaznali premik na globini 15 metrov (Umek, 2004). Cono sestavlja delno vlažen zaglinjen grušč apnenca in fliša z vmesnim slojem rjave gline. V vrtini VK-2 je premik nastal na globini 26 metrov, v coni močno zaglinjenega drobnega grušča apnenca. Na globini 25,8 m so zaznali dotok podzemne vode. Tudi v vrtini POL-I1 so v coni zaglinjenega grušča apnenca in fliša z vložki rdečerrjave gline izmerili premik na globini 26 metrov. Sediment je mestoma vlažen. Dotok vode iz zaledja so v isti vrtini zaznali na globini 29,7 m.

Obravnavane plazove uvrščamo v posamezne kategorije. Glede na vrsto plazacega materiala spada med zemljinske plazove. Geološka struktura in globina drsne ploskve jih umeščata med kompaktne regionalne plazove. Podolgovata oblika drsne ploskve pogojuje nastanek zdrsov po naprej pogojeni drsini, glede na hitrost zdrsa pa jih uvrščamo med počasno plazenje. Oblika plazov je enostavna. Glede na vsebnost vode spada plazina med suhe plazine.

Počasno aktivno plazenje na Rebrnicah v tem trenutku ogroža regionalno in hitro cesto Razdrto-Vipava, medtem ko naselji Lozice in Podgrič nista ogroženi. V prihodnosti bi lahko katastrofični dogodki v smislu nenadnega hitrega zdrsa večjih količin grušča ogrozili tudi omenjeni naselji. Katastrofične dogodke bi lahko povzročili neugodni naravni pogoji, kot so dolgotrajno deževje in potresi ali kombinacija obojega.

Inženirsko-geološke raziskave z namenom odpravljati težave pri gradnji hitre ceste Razdrto–Podnanos so v zadnjem času na Rebrnicah pogoste. Aktualna je tudi tema o pobočnih procesih. Ker so omenjeni procesi neposredno vezani tudi na strukturno geološke elemente, bi bilo v prihodnje smiselno natančno strukturno geološko kartiranje celotnega pobočja Nanosa med Razdrtom in Vipavo. S tem bi pridobili podatke o natančnem poteku naravnice, o položaju in legi flišnih plasti, o tektonski deformiranosti kamnin ter vplivu aktivnega narivanja na nastajanje plazov.

Reasons and mechanism for soil sliding processes in the Rebrnice area, Vipava valley, SW Slovenia

Introduction

The Rebrnice area extends over the part of the southwest slope of the Nanos, between Podnanos and Razdrto. To the west, it proceeds to the Vipava Valley, to the southeast, to the Pivška kotlina basin. The area is crossed by a regional road. At the moment, a motorway section Razdrto–Podnanos is being built here. The area dealt with in the article stretches from the Nanos limestone walls to the flat land near Lozice, which is a part of the Upper Vipava Valley.

Today's geological structure of the broader area results from early Tertiary thrust tectonics (Placer, 1981). Cretaceous limestone is thrust on the Eocene flysch rocks. The belt of flysch rocks, going past the southern edge of the Nanos into the Vipava Valley, is a part of the Snežnik thrust sheet (Placer, 1981; Janež et al., 1997). The Hrušica nappe together with the Nanos as a part of it is then thrust into the rocks of the Snežnik thrust sheet. Because of physical weathering of the Upper Cretaceous rudist limestone, a large amount of limestone scree material has been formed and deposited on the underlying flysch rocks.

Recently, a lot of detailed geological investigations of the terrain have been conducted for the purposes of building the motorway. There are many problems concerning the building of some objects, such as digs and viaducts, because of unstable rock deposition. To consolidate them, expensive sustaining constructions have to be built.

With data, obtained from the engineering-geological mapping, and the ones gathered from the geomechanical wells, an engineering-geological map has been made. The purpose of mapping was to find out the expansion of scree material and the dip of the flysch rocks as well as to disclose the signs of scree fossil sliding. On the basis of the collected data it is possible to explain the dynamics and the mechanism of sliding processes.

An engineering-geological map

The Rebrnice area has never been dealt with as an independent unit in the literature separately although it has been included into the treatment of the Nanos and the Vipava Valley by many authors. Beside Hacquet (1789), who wrote about a huge amount of scree material in the Vipava Valley, there were many others who followed him later, dealing with the southern edge of the Nanos, taking into account broader area Stur (1858), Stache (1889), Kossmat (1905), Winkler (1924) and Limanovsky (1910). The geological situation of this area was also described while mapping the Basic Geological Map 1:100 000, as well as the Gorica (Buser, 1986) and the Postojna (Buser et al., 1967, Pleničar, 1970) map sheets. Many data were obtained from geological mapping of individual springs and its hinterlands in the High altitude karst area (Janež et al., 1997).

The area consists of part of the slope at the motorway section between 4.7 and 6.3 km, in width 2 km. Eocene rocks are developed in a typical flysch. Mainly, there alternate grey shalley marlstone and quartzitic and carbonatic sandstones. On few places outcrop thick layers of calcarenit and calcrudit as well as the layers of greenish grey claystone. The general dip inclines towards northeast, the rocks dip into the slope. With the exception of calcarenit and calcrudit, flysch layers are impermeabil and form underground hidrogeological break for the Nanos karst water (Janež et al., 1997). Cretaceous limestones, of which the Nanos Plateau consists, are thrust on the Eocene rocks. The southwestern edge of the plateau is composed of the thick-layer organogenetic rudist limestone of the Upper Cretaceous, Senonian age (Buser, 1973). Both the thick limestone and the underlying

flysch layers dip into the north or northeast. Physical weathering and the Cretaceous limestone disintegration cause the formation of scree material, which is then deposited on the flysch rocks in the form of slope talus. Scree material, which can in some places be formed as breccia, covers approximately 2/3 of the area. From under the limestone walls, the zones of the tongue-shaped scree material, which forms the ridges or ribs, expand towards the valley. The thickness of sediment is difficult to determine on the terrain. As it can be concluded from relief configurations, it exceeds 30 m in some places. The position and contact of both Cretaceous and Eocene rocks and Quaternary slope sediments are shown in Figure 1. In it, the profile A–B can be seen on the engineering-geological map. It is located near the village Podgrič and is directed NE–SW. The thickness of scree material is measured in the VK-2 geomechanical well (Umek, 2000).

Scree material and breccia

Larger part of the Rebrnice area is covered with scree material and breccia. The processes occurring there depend on the contact of the sediments. There are very few outcrops on the terrain, hence a detailed description of scree is taken from geomechanical wells and profiles in larger digs. The wells located on scree material have perforated four main horizons (fig. 2). The upper horizon is composed of limestone scree, namely limestone fragments and blocks of different size. Scree is sometimes transformed into breccia. Sharp-edged limestone fragments are 5 to 15-centimetre large. There can also appear 0,2 to 2 metre large individual blocks in scree material. Limestone blocks and breccias are partly karstified or cavernous. Scree is usually sandy, silty or locally clayey, ranging from fair brown to grey. The density of usually permeable scree is determined by clayey and silty grains. Hinterland water is not filtered before the bottom of that horizon. The thickness of the horizon changes significantly; in one of the wells, for instance, measures 45 metres. Downwards, there follows the second horizon, composed of mixed talus of flysch components and limestone. Inside it are found individual larger limestone blocks together with fragments of flysch sandstone. Mixed talus is usually more clayey than pure limestone scree. Water is filtered thro-

ugh more permeable parts of the horizon. In-situ weathered flysch rocks, being partly semi solid rocks and partly disintegrated into clayey scree, form the third horizon. Marlstone and sandstone grains measure up to 5 cm. Also in this horizon is hinterland water filtered through more permeable parts of it. Scree ranges from dark grey to dark brown. The lowest – fourth – horizon is of solid rock, composed of flysch marlstone, siltstone and fine-grained sandstones. In areas where flysch rocks are not covered with limestone scree and breccia, the upper two horizons are missing. They are replaced by clayey weathered residual of flysch rocks with fine flysch scree.

Hidrogeological characteristics of limestone scree and breccia change locally (Janež et al., 1997). Depending on gradation and the quantity of fine grains it is permeability that changes a lot. More permeable scree consists of thick fragments of limestone which has fewer clayey and silty grains. In general, scree is of good permeability. Underground water flows into sediments between the more clayey zones, which are usually found either in the lower part of the upper limestone horizon or in the second horizon. This can also occur in numerous geomechanical wells. Therefore, water appears on the contact between scree and flysch. The contact is difficult to determine because it is found in the zone where scree limestone and flysch material are mixed. Underground water flows under scree, thus worsening the already bad geomechanical characteristics of the clayey zones. The flowing can be observed by numerous springs emerging in the lower parts of the scree cover (fig. 1).

Dynamics and reasons for sliding processes

Due to the position and extension of the sediments on the Rebrnice area, scree material moves in forms of various slope processes, which can be seen from the movements measured by means of inclinometer wells and by some recent landslides. Sliding has already caused the regional road deformations, the cracks on some new motorway sections and the damage on the objects in the village Lozice. The movements in geomechanical-inclinometer wells measure between a few millimetres and a maximum of 15 millimetres monthly. Taken into account are particularly the movements in the

VK-2, VK-3 and POL-I1 wells, all located on the objects The Polance Dig and the Na Polancah Viaduct (Umek, 2000, 2004). Approximately 500 metres southeast of Lozice, above the motorway, the Rebrnica landslide activated in spring 2001. Above the larger dig slid around 400,000 m³ of scree material. A shear plane was formed on the edge between scree material and flysch rocks. There formed up to 3-metre wide scarp high in the slope. The landslide was stopped by the anchor pile wall.

Limestone material, resulting from physical weathering of the Nanos southwestern edge limestone, is deposited on the underlying flysch rocks in the form of slope talus. Due to continuous increase of the quantity of material, slope talus starts to slide on the foundation because of gravity. In the upper part, it slides across the circular shear plane, resulting in numerous flat lands along the Rebrnice limestone walls. Slope talus, which is usually inclined by 45°, reached a horizontal position because of the circular sliding. In the hinterland, scree is formed simultaneously, hence the repeating of the processes. Younger slope talus pushes forward the older ones, which have meanwhile formed into breccias. Thus has the scree material slid downwards to the valley.

Causes for such sliding and minor movements are combine with one another. Firstly, the Rebrnice slope is moderately-inclined with the average slope inclination of 15–20°, which can already cause the sediment to slide because of gravity. More inclined is only upper part of the area, where slope talus is formed. Secondly, on the contact of scree and flysch rocks there appear clayey zones with bad geomechanical characteristics. Shear planes are formed there. Besides, underground water flowing in those zones, adds to the decrease of clay geomechanical solidity. Lastly, with building dips through scree ridges, the slope sediment stability above the motorway section is severely decreased.

Conclusion

Recent movements of large masses of limestone scree material and breccias are only a part of the sliding occurring already in the past. This can be seen from the tongue-shaped scree covers, which is typical of great regional landslides (fig. 1). Another consequence of fossil landslides is the mixing of

limestone fragments and the fragments of flysch rocks in the second horizon, on the contact between limestone scree and flysch. While sliding, weathered flysch rocks mixed with limestone fragments. If limestone scree had been normally deposited on the flysch, there would have been no mixed horizon. Clayey zones, appearing inside this horizon or just above it, enable the filtration of underground water, which also adds to the formation of shear planes. The influence of filtration of underground water on the formation of a shear plane can be seen in the VK-2, VK-3A and POL-I1 inclinometer wells. In the VK-3A well the movement at the depth of 15 metres was observed (Umek, 2004). The zone consists of partly damp clayey limestone scree and flysch with the brown clay in between. In the VK-2 well the movement occurred at the depth of 26 metres, in the zone of strongly clayey fine limestone scree. At the depth of 25.8 m the inflow of ground water was observed. At the depth of 26 m, the movement was measured in the POL-I1 well in the zone of clayey limestone scree and flysch with the insertion of reddish brown clay. The sediment is damp in some parts. In the same well, the inflow of hinterland water was observed at the depth of 29.7 m.

The mentioned landslides can be arranged in separate categories. According to the type of sliding material, they belong to soil landslides. They can be grouped under compact regional landslides due to their geological structure and the depth of a shear plane. The emersion of slides on the well-known shear plane is conditioned by oblong shear plane shape condition. With respect to the slide speed, they are slow-sliding. The shape of landslides is simple. According to the quantity of containable water the scree material belongs to dry material.

Although slow but active sliding in the Rebrnice area affects regional road and a motorway (Razdrto–Vipava), the villages Lozice and Podgrič are not under threat. This could, however, change in the future in case of catastrophes, such as a sudden quick slide of larger quantities of scree, caused by unfavourable natural conditions (e.g. long-lasting rainfalls, earthquakes or a combination of both).

There have been many engineering-geological investigations carried out in the Rebrnice area to resolve the difficulties in building a motorway Razdrto–Podnanos.

Issues concerning slope processes are also topical. Due to the fact that the processes are directly interconnected with the structural geological elements, a detailed structural geological mapping of the whole slope of the Nanos from Razdrto to Vipava would be appropriate. Thus the data on the exact position of thrust plane, flysch bed position, tectonic rock deformation and the impact of activity thrusting on the formation of landslides would be obtained.

Literatura – References

- Buser, S. 1973: Tolmač za list Gorica. OGK 1 : 100.000 – Zvezni geol. zavod, 50 p. Beograd.
- Buser, S. 1986: Osnovna geološka karta SFRJ 1 : 100.000, list Gorica. – Zvezni geološki zavod, Beograd.
- Buser, S., Grad, K. & Pleničar, M. 1967: Osnovna geološka karta SFRJ 1 : 100.000, list Postojna. – Zvezni geološki zavod, Beograd.
- Hacquet, B. 1789: *Oryctographia Carniolica* oder Physikalische Erdbeschreibung des Herzogthums Krain, Istrien und zum Theil der benachbarten Länder, 91 pp., Leipzig.
- Janež, J., Čar, J., Habič, P. & Podobnik, R. 1997: Vodno bogastvo Visokega krasa. Ranljivost
- kraške podzemne vode Banjšic, Trnovskega gozda, Nanosa in Hrušice, Geologija d.o.o. 1–167, Idrija.
- Kossmat, F. 1905: Geologische Spezialkarte etc. Blatt: Heidenschaft und Adelsberg 1 : 75.000, Geol. R.-A., Wien.
- Limanovsky, M. 1910: Wielkie przemieszenie mas skalnych w Dynarydach kolo Postojny. – Raz. Wydz. przyr. Akad. Umiej. Serye 3, 109–171, Krakow.
- Placer, L. 1981: Geološka zgradba jugozahodne Slovenije. – Geologija, 24/1, 27–60, Ljubljana.
- Pleničar, M. 1970: Tolmač za list Postojna. OGK 1 : 100.000 – Zvezni geol. zavod, 62 p. Beograd.
- Stache, G. 1889: Die Liburnische Stufe und deren Grenzhorizonte. Abh. k.k. geol. 1–170, Wien.
- Stur, D. 1858: Das Isonzo – Thal von Flitsch abwärts bis Görts, die Umgebung von Wippach, Adelsberg, Planina und Wochein. – Jahrb. Geol., 324–366, Wien.
- Umek, U. 2000: Geomehanska vrtina VK-2, vkop v P290. – GEOT d.d. Tehnološki park Gradbenega inštituta ZRMK, Ljubljana.
- Umek, U. 2004: Geomehanska vrtina VK-3A, vkop v P290, desno 12 m. – GEOT d.d. Tehnološki park Gradbenega inštituta ZRMK, Ljubljana.
- Umek, U. 2004: Geomehanska vrtina POL-II, viadukt Na Polancah. – GEOT d.d. Tehnološki park Gradbenega inštituta ZRMK, Ljubljana.
- Winkler, A. 1924: Über den Bau der östlichen Südalpen. Mitt. Geol. Ges. 16, Wien.