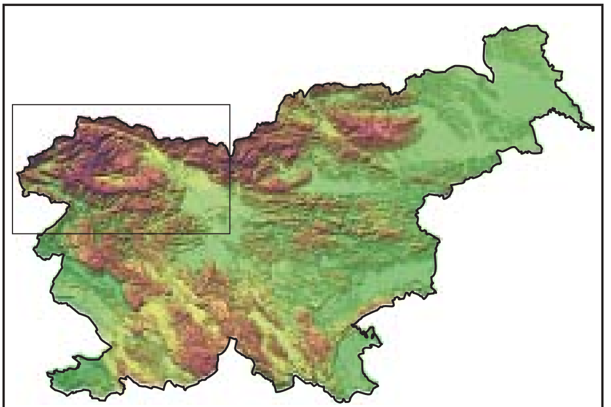
# ROCKFALLS IN SLOVENE ALPS

# PODORI V SLOVENSKIH ALPAH

Matija Zorn

Rockfall on Mount Krn triggered by the earthquake on April 12, 1998
(photography by Matija Zorn).
Podor na Krnu, ki se je sprožil ob potresu 12. 4. 1998
(fotografija Matija Zorn).



Abstract

UDC: 911.2:551.43(234.323.6)
COBISS: 1.01

# Rockfalls in Slovene Alps

**KEY WORDS: rockfalls, hillslope processes, natural disasters, geomorphology, Alps, Upper Soča region, Slovenia.**

The article is a contribution to a better understanding of the formation of mountain relief. It combines the knowledge of geography, geology, construction, forestry, history, and other fields that help provide an easier interpretation of the formation of Slovenia's alpine world.

The article is limited to rockfalls, an important process in reshaping the mountain relief. Rockfalls rank among constant reshapers of the rocky mountain relief and are a part of continuous geomorphic activity.

In the article, rockfalls are treated in three different time periods (prehistoric, historic, and recent), which contributes to more easily comprehending that rockfalls are a constant in the mountain world.

Along with a definition of rockfalls and their classification, the first part of the article presents the causes and triggers of rockfalls and their consequences (the effects of rockfalls on the landscape).

In the second part of the article, several concrete examples of rockfalls in the Slovene Alps are presented, grouped in three time periods.

Izvleček

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# Podori v slovenskih Alpah

**KLJUČNE BESEDE: skalni podori, pobočni procesi, naravne nesreče, geomorfologija, Alpe, Zgornje Posočje, Slovenija.**

Članek je prispevek k boljšemu razumevanju nastanka gorskega reliefa. V njem je združeno znanje geografskih, geoloških, gradbeniških, gozdarskih, zgodovinskih idr. spoznanj, ki pripomorejo k lažji interpretaciji nastanka slovenskega alpskega sveta.

Članek je omejen na pomemben proces preoblikovanja gorskega reliefa na skalne podore. Ti spadajo med stalne preoblikovalce kamnitega gorskega reliefa in so del neprestanega geomorfnega dogajanja.

Podori so v članku obravnavani v treh različnih časovnih obdobjih (kot prazgodovinski, zgodovinski in recentni podori), kar pripomore k lažjemu razumevanju, da so podori v gorskem svetu stalnica.

V prvem delu članka so poleg opredelitev podorov in njihove delitve, predstavljeni še vzroki in povodi podorov ter njihove posledice (pokrajinski učinki podorov).

V drugem delu članka so predstavljeni nekateri konkretni primeri podorov v slovenskih Alpah, razvrščeni v tri časovna obdobja.

The editiorialship received this paper for publishing in August 20th 2002.
Prispevek je prispel v uredništvo 20. avgusta 2002.

# Contents – Vsebina

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# 1 Introduction[1]

Walking in the mountains, one sometimes contemplates the transitory nature of things; only the mountains seem to remain eternally the same in their beauty. Mountains are formed and exist for long millions of years, but they too slowly disappear and finally make way for something new. This changing of the relief takes place before our eyes, but we generally do not notice it because of the short duration of our lives (Natek 1985).

Wind, water in all forms, temperature changes, and gravity slowly and steadily release and carry material from the mountains down to the valleys. Periodically, large rock masses or even entire hillslopes suddenly roll down into the valleys, which is why the relief in the Alps changes relatively quickly.

In the occurrence of rockfalls, Slovenia's Alps are no exception. We are never aware of smaller rockfalls because they occur more frequently in uninhabited or remote areas. We are only reminded of them by geomorphic processes of larger dimensions that cause damage to residential and infrastructure objects (Pavšek 1994, Komac and Zorn 2002).

Rockfalls are generally one of the more visible and faster geomorphic processes. They occur on steeper hillslopes in the mountain world as well on the steep banks of rivers and coastal cliffs. In this article, only a few examples from Slovenia's alpine world are treated.

Figure 1: Flysch cliffs on the Slovene coast where minor rockfalls occur (photography Matija Zorn).
Slika 1: Klifi iz fliša na slovenski obali, na katerih prihaja do manjših odlomov (fotografija Matija Zorn).

[1] The author's graduation thesis on which the present paper is based was awarded the University of Ljubljana's Prešeren Prize for Students (Univerzitetna Prešernova nagrada za študente) for the year 2001.

Figure 2: Rockfall in the conglomerate on the right bank of the Soča River near Čezsoča, which occurred during the earthquake on April 12, 1998 (photography Matija Zorn).
Slika 2: Odlom v konglomeratu na desnem bregu reke Soče pri Čezsoči, ki je nastal ob potresu 12. 4. 1998 (fotografija Matija Zorn).

# 2 Definition of rockfalls

In Slovenia, experts from several scientific fields of the natural sciences are engaged in studying of rockfalls, including geologists (Grimšičar 1960, 1983, 1988, Ribičič and Vidrih numerous cited works), forest engineers (Šneberger 1999, Zemljič and Horvat 1999), water engineers (Mikoš 1995, 2000, Mrak 1999), and geographers (Planina 1951, 1952, Gams 1956, 1989, Orožen Adamič 1990, Pavšek 1994, 1996, Kunaver 1995, Rojšek 1995, Hrvatin and Pavšek 1995, Golob and Hrvatin 1996, Zorn 2001, Komac and Zorn 2002, Zorn and Komac 2002).

Each of the mentioned fields treats and defines rockfalls differently. Geologists define them as »natural slides of large blocks of solid rock in alpine or mountainous terrain where hillslopes are inclined. They occur along various intersecting systems of fissures where one of the systems usually has a nearly vertical inclination« (Ribičič 1998, Ribičič 1999: 19). In geology literature, rockfalls are classified among slides, which are divided into landslides and rockfalls (Grimšičar 1983).

Similarly, water engineers also classify rockfalls or »rockfall erosion« among slides (Mikoš 2000: 103–104).

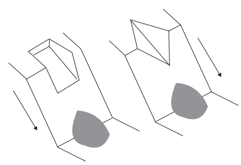
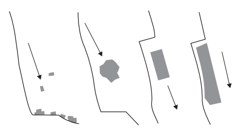
All the mentioned disciplines, including geography, classify rockfalls among »hillslope processes.« With this expression, we denote »the various kinds of downhill movements occurring under the pull of gravity« that are an important part of the denudation of the surface (Strahler and Strahler 1992: 287). In contrast to the other disciplines, we geographers do not classify rockfalls among slides, where the basic manner of movement is sliding, but treat them as a special category in which the movement of material predominantly occurs in the form of falling. Among hillslope processes, we distinguish three basic ways in which material moves: flowing, sliding, and falling (Thomson and Turk 1993, Zorn 2001, Zorn and Komac 2002).

Rockfalls can be most easily described as occurrences »when masses of rock break loose from bedrock and fall through the air to the slope below. Movement is mostly by free fall through the air, but it may also include some bouncing or rolling. Rockfalls are most common on near-vertical slopes where the bedrock is well jointed, providing many joint-bounded blocks that may break loose. The process is accelerated by artificial undercutting« (Easterbrook 1999: 74), for example, excavations, making cuts for roadways, or blasting hillslopes.

In this article, we classify among rockfalls, in a broader meaning of the word (see Table 1), all types of collapses of solid rock on hillslopes where the material falls freely toward the foot of the hillslope (their manner of movement is »falling«) regardless of the amount of the material moved. With this definition, we include all collapses in solid rock from smaller crumblings of rock to major collapses called »rockfalls« (in the narrow sense of the word). In the article, we also rank among rockfalls all those types of rockslides where the initial movement (upon the triggering of material) is »sliding« and could therefore also be ranked among slides. However, relative to the morphology of the mountain world, in the majority of cases this material soon passes into the phase of falling.

In the remainder of the article, we use the term »rockfall« in the broader sense of the word, except if otherwise stated.

TABLE 1: ROCKFALLS IN THE BROADER SENSE OF THE WORD (ZORN 2001, ZORN AND KOMAC 2002).
PREGLEDNICA 1: SKALNI PODORI V ŠIRŠEM POMENU BESEDE (ZORN 2001, ZORN IN KOMAC 2002).

| Rockfalls in the broader sense of the word | Manner of movement of material | Velocity of movement | Description | Example | Deposited material | Sketch |
|---|---|---|---|---|---|---|
| ROCKSLIDE | sliding | very slow to extremely fast | Slide of solid rock on one or more discontinuities. Later, it usually passes into falling due to the morphology of the hillslope. | wedged-shaped rockslide from the Šija ridge in the Lepena Valley (Fig. 14); rockslide along stratification on the hillslope of Mt. Javoršček (Fig. 15). | hillslope rubble, tumbled blocks, talus |  |
| ROCKFALL | falling | extremely fast | Material falls free or tumbles down the hillslope. | southwest wall of Mt. Krn (Fig. 12), Mt. Osojnica (Fig. 13), Čezsoča (Fig. 2). | |  |

# 3 Types of rockfalls

Many authors have dealt with the definition of types of rockfalls (Abele 1971, Zemljič and Horvat 1999, Ribičič and Vidrih 1998a, Vidrih and Ribičič 1999, Zorn 2001) and have defined rockfalls according to:
a) total volume of rockfall material,
b) manner and form of triggering,
c) age of material.

a)
In German geography literature, a division into *Bergsturz* and *Felssturz* (Abele 1971) is frequently used. A *Bergsturz* is a rockfall with a volume greater than 0.01 km$^3$ (10 million cubic meters). If the volume can-

not be determined, the standard employed is the size of the area covered by rockfall material. The border value is 0.5 $km^2$. With lower quantities of material, the term *Felssturz* is used.

Slovene forestry literature defines rockfalls by their quantity, as shown in Table 2. A weakness of the table lies in the absence of a category between falling stones and rockfalls. Please note that the terminology used in this table differs from that used elsewhere in the article.

TABLE 2: QUANTITATIVE DEFINITION OF ROCKFALLS ACCORDING TO VOLUME AND LENGTH OF ROCKFALL EDGE (ZEMLJIČ AND HORVAT 1999: 208, ŠNEBERGER 1999: 4).
PREGLEDNICA 2: KVANTITATIVNA OPREDELITEV PODOROV GLEDE NA PROSTORNINO IN DOLŽINO ODLOMNEGA ROBA (ZEMLJIČ IN HORVAT 1999: 208, ŠNEBERGER 1999: 4).

| Collapse of rock masses | Volume of collapsed blocks | Length of rockfall edge |
|---|---|---|
| stone fall / padanje kamenja | 0.01–0.1 $m^3$ | 0.2–0.5 m |
| rock fall / padanje skal | 0.1–2 $m^3$ | 0.5–1.5 m |
| block fall / skalni podor | 10,000–1,000,000 $m^3$ | 25–100 m |
| bergsturz / podor hriba | > 1,000,000 $m^3$ | > 100 m |

b)
The most typical types of rockfalls in Slovenia, relative to the manner and form of triggering of material, were defined by M. Ribičič and R. Vidrih (1998a, Vidrih and Ribičič 1999), who distinguish the following (Figure 3):
1. »planar rockslide (plane failure),« which occurs when the direction of the hillslope and the direction of a particular joint system are approximately the same,
2. »wedge-shaped rockslide (wedge failure),« which occurs when the secant of two joint systems has the same direction as the hillslope and is inclined downwards,
3. »rockslide along different systems of fissures,«
4. »rockslide along stratification upon a random fissure in the back,«
5. »rockslide in strongly fissured rock (circular failure),« which occurs very rarely. This happens when solid rock is crisscrossed by three or more systems of fissures and circular or fissure adaptive sliding occurs, where the rock behaves like a mass of regolith,
6. »rockfall at steeply inclined bedding plane,«
7. »rockfall at a vertical fissure in a hillslope undercut in the lower part,«
8. »slide of a block along an oblique fissure« that becomes a rockfall at a vertically inclined hillslope.

For rockfall types 6 through 8, a weak more or less vertically inclined plane is characteristic that is approximately parallel to the hillslope and occurs inside the rock mass behind the hillslope surface.

c)
We classify rockfalls according to the age of the deposited material or to the time of triggering into the following categories (Abele 1971, Abele 1974, Zorn 2001):
1. *fossil rockfalls* (occurring in older geological periods, their traces are preserved in rock record of the earth and they are therefore treated by sedimentology and not geomorphology),
2. *prehistoric rockfalls* (occurring in the Pleistocene and the prehistoric period of the Holocene),
3. *historic rockfalls* (occurring in the time of written historical records),
4. *recent rockfalls* (occurring in recent years or decades).

# 4 Causes and triggers for the occurrence of rockfalls

To understand ceaseless geomorphic activities, of which rockfalls are a part, it is important to distinguish between »*causes*« and »*triggers*.« At first glance, rockfalls are the consequence of earthquakes or stronger precipitation, but these are simply triggers. They are active for a relatively short time and only determine the time the material is released but not which or how much material will be released. The triggering depends

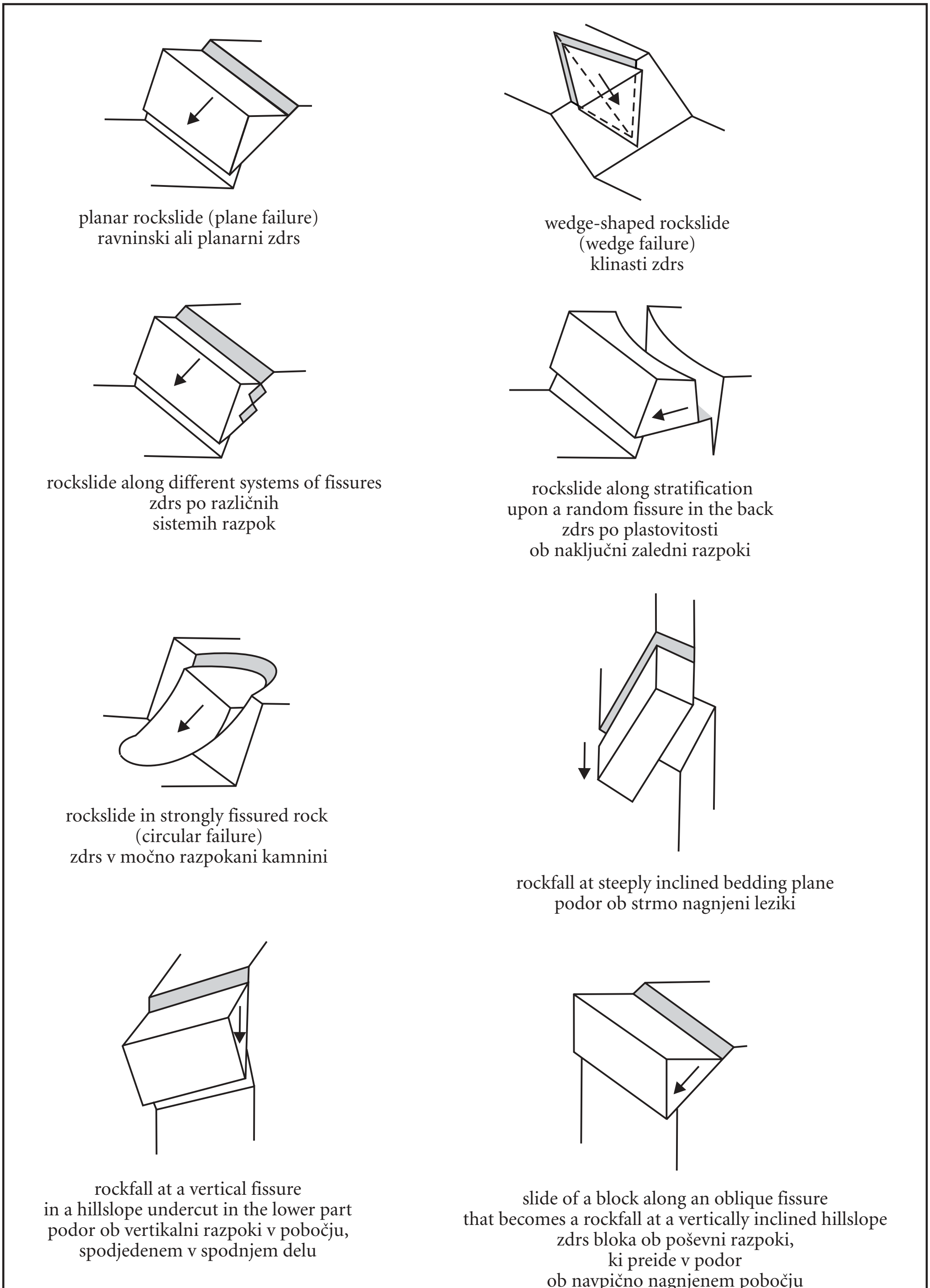



Figure 3: Types of rockfalls according to M. Ribičič and R. Vidrih (1998a, Vidrih and Ribičič 1999).
Slika 3: Vrste skalnih podorov po M. Ribičiču in R. Vidrihu (1998a, Vidrih in Ribičič 1999).

on a system of factors of longer duration or causes that with their speed and intensity determine whether part of a hillslope will actually shift when a trigger such as an earthquake occurs and whether a particular earthquake will just be one of the causes that gradually undermines the stability of a hillslope. A particular event is therefore a trigger only in that moment when the material is actually released; otherwise, it is just a piece in the mosaic of causes that lead to triggering (Zorn and Komac 2002).

Factors that work over a longer period on a potential trigger site and weaken the equilibrium in the hillslope with their activity are therefore the »causes« for the occurrence of rockfalls. The specific factor that finally destroys the dynamic balance is the »trigger.« After the triggering, a new equilibrium is established in the trigger area that lasts until some new causes undermine the stability of the hillslope, which some trigger can then again demolish (Zorn and Komac 2002).

The surface is an open system in which equilibrium is repeatedly reestablished, and therefore each change of external circumstances is followed by a series of adaptations within the entire system on the hillslopes, including their destruction (Zorn and Komac 2002).

TABLE 3: PRINCIPAL CAUSES AND TRIGGERS OF ROCKFALLS (ZORN 2001).
PREGLEDNICA 3: POGLAVITNI VZROKI IN POVODI PODOROV (ZORN 2001).

| Principal causes of rockfalls | Principle triggers of rockfalls |
|---|---|
| 1. earthquakes | 1. earthquakes |
| 2. weather activity | 2. weather events (extreme precipitation, spring thawing of fissures) |
| 3. weathering of rock (mechanic, chemical, biological) | 3. human encroachment into hillslopes |
| 4. erosion (glacial, fluvial, wind) | |
| 5. human encroachment into hillslopes | |

# 5 Landscape effects of rockfalls

Rockfalls and other hillslope processes affect nature as well as man. Their effects or the consequences on the landscape can be divided into three separated areas of activity (Mikoš 1995, Zorn 2001, Zorn and Komac 2002):
a) the area of occurrence or release (rockfall basin),
b) the area of movement or change (area of the route to the valley),
c) the area of deposited material where the rockfall came to rest (area of accumulation).

The effects are mutually intertwined and may act in all or in just one of the listed areas.

a)
In the area of occurrence appear:
- changes to relief on the hillslopes (shape of walls),
- tension fissures parallel to the failure surface,
- damage to alpine climbing routes and mountain trails.

b)
In the area of movement appear:
- relief damage,
- damage to soil and vegetation,
- wind gusts,
- damage to infrastructure objects,
- damage to residential and other buildings,
- damage to alpine climbing routes and mountain trails.

c)
In the area of deposited material appear:
- changes to the morphology of the area (piles of deposited material),
- changes in hydrological conditions or the appearance of rockfall lakes and floods,
- total destruction of soil and vegetation,
- microclimate changes,
- burying of settlements, individual residential or infrastructure objects, and roads,
- hydroelectric exploitation of rockfall lakes or direct industrial exploitation of rockfall material,
- preservation of the memory of older rockfalls in the names of places and local sites as well as in fairy-tales, songs, and legends,
- transportation complications,
- political, cultural, or language boundaries,
- changed appearance of the cultural landscape.

# 6 Examples of rockfalls in the Slovene Alps

## 6.1 Prehistoric rockfalls

Prehistoric rockfalls occurred in the Pleistocene and in the prehistoric period of the Holocene. In the landscape, only the morphology of the surface, the composition of accumulated material at the foot of hillslopes, and various wall forms at trigger sites indicate these older hillslope processes.

The problem of determining whether accumulated material is of moraine or rockfall origin or a combination of the two arises frequently. On the other hand, the combination of moraine and rockfall material makes the dating easier (Melik 1961). Specifically, all the material accumulated in the valleys was moved primarily through rockfalls or other hillslope processes. These processes were very intensive in the period of ice ages, and large quantities of material were triggered in periglacial areas. Some of this material was moved to secondary sites by glaciers (moraine material), and some remained at the original sites (rockfall material). The experts are not unanimous in identifying one or the other, and differences therefore appear in descriptions of the genesis of the same material.

In Slovenia, the majority of such dilemmas appear in the Upper Soča region, because the geomorphology of this part of Slovenia has been intensively studied from the viewpoint of many generations of experts (see Bavec 2001). It is also true that the Upper Soča region was considerably reshaped by glaciers and rockfalls (Melik 1961). Relative to rockfalls, this remains one of the most threatened regions of Slovenia (Komac and Zorn 2002).

In the Upper Soča region, the largest rockfalls were triggered in the Pleistocene and at the beginning of the Holocene during the periglacial morphogenetic reshaping of hillslopes on southern hillslopes or locations exposed to the sun where temperature changes were the greatest. In addition, the deepness of the valleys in the Upper Soča region, the consequence of the nearby erosion base of the Adriatic Sea and of valley glaciers, and the location along the tectonic deformations of the Soča Valley also contribute to the occurrence of rockfalls. Between Most na Soči and Žaga, for example, the Soča Valley runs along the Idrija fault zone.

### 6.1.1 Črča

The accumulation of material at Črča between Kal-Koritnica and Soča exemplifies the problem of explaining the material's origin, since some authors describe it as a terminal moraine (Šifrer and Kunaver 1978, Kunaver 1980) and others as a rockfall (Melik 1961, Bavec 2001, Zorn 2001).

Rock masses tumbled down to the valley from the steep hillslopes of the ridge between Mount Svinjak and Mount Bavški Grintavec. The strata here slope steeply on the south side and are parallel to the hillslope. On the hillslope are visible bare and relatively smooth strips where large segments of strata were triggered and tumbled downwards. This probably occurred numerous times and was not a single event. The rockfall at Črča supposedly dammed the Soča and the lake presumably stretched into the Lepena Valley (Melik 1961). Planina (1954) cites that lake chalk was found and he dates the lake in late glacial time.

In this area, rockfalls were also recorded near the village of Soča (Melik 1961).

### 6.1.2 Kuntri

Lower down the Soča Valley between Srpenica and Kobarid, we come across two similar problems in explaining deposited material. The Kuntri (also known as Gorenji hrib or Hrib) elevation (530 m) between Srpenica and Trnovo ob Soči is the largest known rockfall in the Slovene Alps. Downriver between Trnovo ob Soči and Kobarid, the Molid and Dolenji hrib elevations (6.1.3) are similarly supposed to be the consequence of one of the larger rockfalls in Slovenia.

In both cases, authors are divided regarding the origin of the accumulated material. Among older authors, Winkler (1926) favoured the rockfall origin of the Kuntri elevation and dated the rockfall to the period after the end of glaciation. Some later authors are of a similar opinion (Melik 1961, Bavec 2001, Zorn 2001). On the other hand, the geology of the elevation was also mapped as non-agglutinated moraine (Buser 1986a) or as a mixture of moraine and the rockfall material (Kuščer et al. 1974).

According to some authors (e. g., Grimšičar 1988), the Srpenica Lake, which supposedly stretched into the Bovec Basin (Figure 4), was a consequence of a rockfall in the late Quaternary. Layers of lake chalk more than two hundred meters thick prove the lake's existence (Kuščer et al. 1974).

In the opinion of other authors, the Kuntri rockfall fell onto previously deposited lake chalk and did not cause the formation of Srpenica Lake (Melik 1962, Bavec 2001).

In either case, an accumulation of such size had to cause the damming of the Soča River. The rockfall was probably triggered at the end of the Pleistocene or at the beginning of the Holocene. According to the latest studies, the event could have occurred 12,790 ± 85 years ago (Marjanac et al. 2001).

The Kuntri elevation and its continuation on the left bank of the Soča measure over 200 million cubic meters according to our calculations. Bavec (2001) estimates its volume at 50–100 million cubic meters. The Kuntri rockfall is undoubtedly the largest known rockfall in the Slovene Alps. The greater part of the rockfall material originates in the southern hillslope of Mount Polovnik on which a concave wall formation is clearly visible from where the material was triggered in a single event or in several events. Some of the material also probably originates in the northern hillslope of the ridge between Mount Kobariški Stol and Mount Starijski vrh.

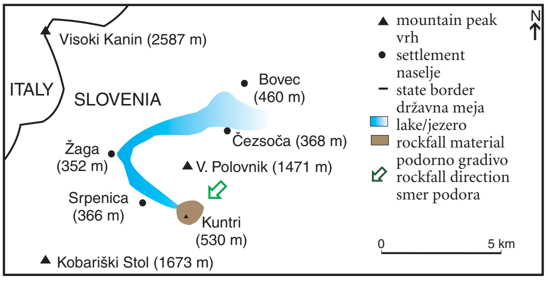



Figure 4: Srpenica Lake (adapted from Grimšičar 1988).
Slika 4: Srpeniško jezero (prirejeno po Grimšičar 1988).

### 6.1.3 Molid and Dolenji hrib

Another problematic case in the section of the Soča Valley between Trnovo ob Soči and Kobarid is the accumulation of material or the rockfall near Magozd.

According to the first explanation, the elevations of Molid (479 m) and Dolenji hrib (482 m) are the consequence of a rockfall (Winkler 1931, Melik 1961, Buser 1978) from the southern hillslope of Mount Polovnik (Buser 1986b), while according to the second, they are predominantly composed of moraine material mixed with rockfall material (Kuščer et al. 1974). The author of a third explanation believes the material was deposited by mass flows that came from the direction of the western hillslope of Mount Krn (Bavec 2001). This material also created a lake (Melik 1961) about two kilometers long, as evident from the deposits of lake chalk on the left bank of the Soča River north of Trnovo ob Soči (Kuščer et al. 1974).

### 6.1.4 Confluence of the Soča and Tolminka rivers

The next major hillslope process and at the same time a source of debate in the Upper Soča region is the layer of carbonate rubble found at the confluence of the Soča and Tolminka rivers. According to Šifrer (1965), this layer is carbonate debris of rockfall origin (Figure 5). In his opinion, the rockfall occurred above Zatolmin, east of Mount Vodel (1,053 m). The accumulation of an enormous quantity of rockfall material that is not of glacial origin occurred later than the Holocene deposits that were left after the retreat of the glaciers. This material also apparently dammed the Soča River.

In the ground, a layer of presumed rockfall material can be traced north all the way to Tolmin and Zatolmin and south to Modrej. The layer is about six kilometers long, and in it we found no thick fluvioglacial gravel. According to Šifrer, this confirms the fact that this was a sudden event. Würmian fluvioglacial terraces

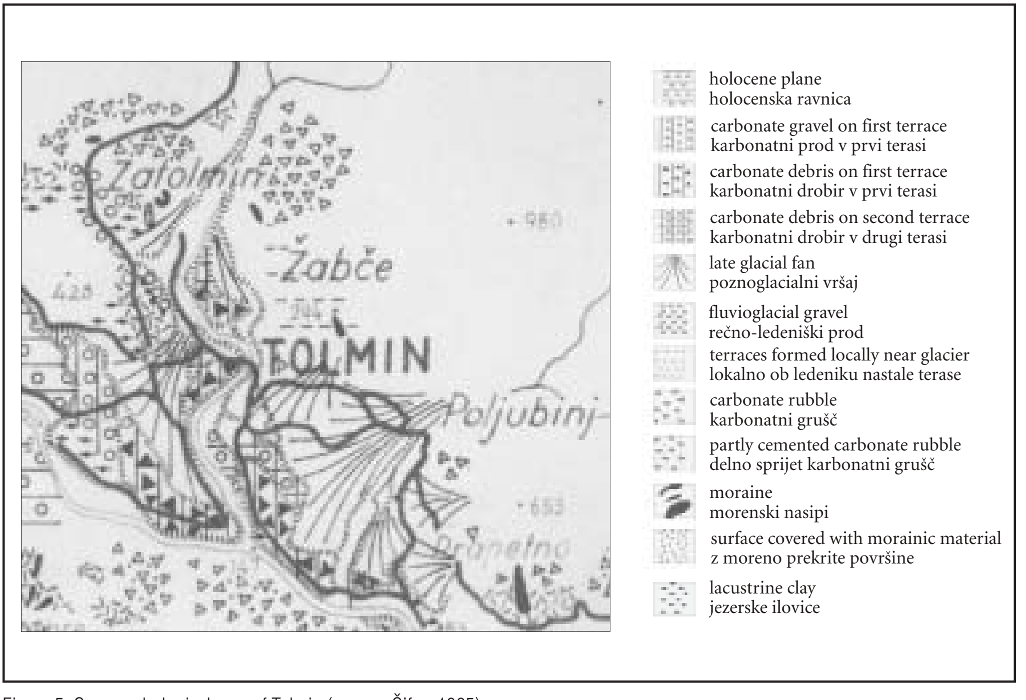



Figure 5: Geomorphological map of Tolmin (source: Šifrer 1965).
Slika 5: Geomorfološka karta Tolmina (vir: Šifrer 1965).

Figure 6: Presumed rockfall layer in the gravel quarry at Prapetno (photography Matija Zorn).
Slika 6: Domnevno podorna plast v peskokopu Prapetno (fotografija Matija Zorn).

are found higher than the deposited material, which means that it was deposited when the riverbed of the Soča was already formed (Zorn 2001).

The layer of rockfall material is clearly visible in the gravel quarry at Prapetno, at the confluence of the Soča and Tolminka rivers, and in Tolmin on the low Čemanova bula elevation. In the gravel quarry at Prapetno, fluvial Holocene river alluvium from the Godič stream (Figure 6) is visible below the presumed rockfall layer.

Geologists who believe the layer is of glacial origin do not agree with Šifrer. In their opinion, the layer is non-agglutinated moraine material (Buser 1986a, Vrabec 1998). Kunaver (1993) also attributes a glacial origin to the material and describes the upper layers in the Čemanova bula elevation as sharp-edged glacial deposits.

In our opinion, the deposited material is the remains of a debris flow that formed following a rockfall somewhere in the Tolminka Valley. Regarding its date of origin, we concur with Šifrer's view that the riverbed of the Soča was already formed, which could not have been earlier than during the prehistoric period of the Holocene.

### 6.1.5 Mount Planski vrh

Elsewhere in the Slovene Alps, we also find many examples of prehistoric rockfalls, but their volume is much smaller. One of the larger such rockfalls lies below Mount Planski vrh (1,299 m) where the town of Jesenice stands today (an area encompassing the railway station (Figure 7 and 8), the old ironworks, Kurja vas, and Podmežakla). From the hillslopes of the Mežakla ridge, more than ten million cubic meters of limestone and dolomite tumbled into the Upper Sava Valley and filled it up to twenty meters high. Behind the rockfall material, a lake formed that stretched to Hrušica. The presence of lake chalk confirms its existence. On the basis of pollen studies, the rockfall and the lake were dated to the Holocene (Grimšičar 1983, 1988).

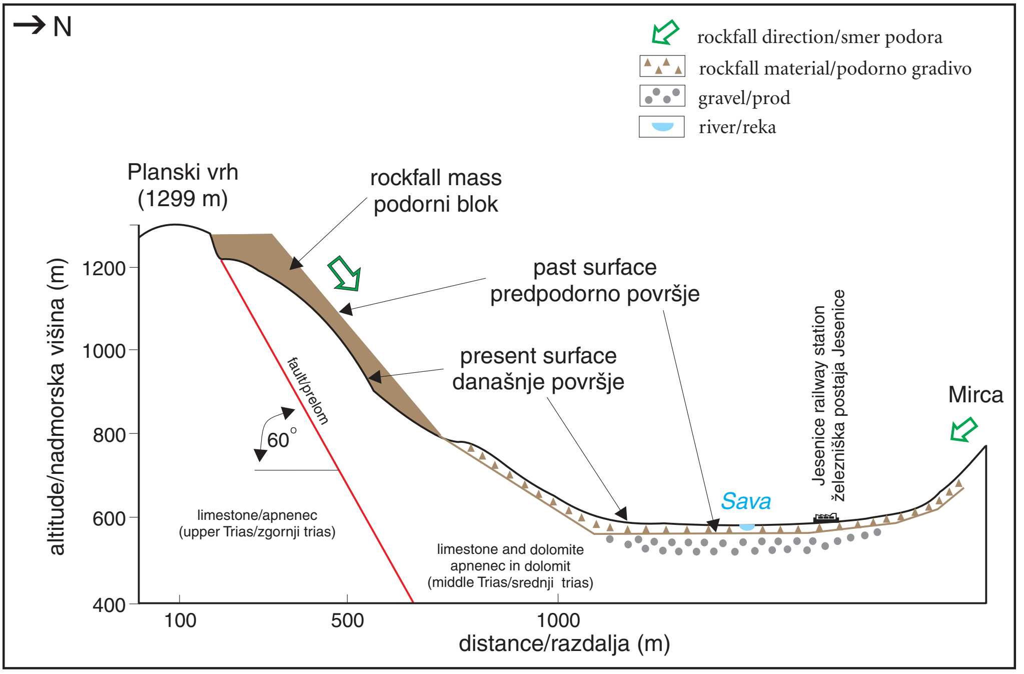



Figure 7: Rockfall below Mount Planski vrh (adapted from Grimšičar 1988).
Slika 7: Podor pod Planskim vrhom (prirejeno po Grimšičar 1988).

On the opposite hillslope at the foot of the Karavanke Mountains, the »twin« Mirca rockfall also occurred in the prehistoric period, coming to rest in the Murova area of Jesenice. From the hillslope of Mount Mirca (1,025 m), just under 100,000 cubic meters of dolomite blocks tumbled down (Grimšičar 1988).

In chapter 6.1, we have described only the larger known prehistoric rockfalls in the Slovene Alps, which in size are much smaller than the largest rockfalls in the Alps or the world. The largest known prehistoric rockfalls in the Eastern Alps were triggered on the southern hillslope of Mount Dobratsch in the Lower Gail Valley (Carinthia, Austria). It is estimated that up to 900 million cubic meters of material was triggered and deposited over an area of almost thirty square kilometers (Zorn 2002).

The largest rockfall in the Alps was triggered in Switzerland near Flims. Its volume was about 12,000 million cubic meters (12 km$^3$), and it covered more than fifty square kilometers (Heim 1932).

## 6.2 Historic rockfalls

The best known historic rockfalls whose descriptions can be found in Slovene professional and other literature occurred during the Villach earthquake on January 25, 1348, in the immediate vicinity of present-day Slovenia on the southern hillslope of Mount Dobratsch (Carinthia, Austria) in Slovene ethnic territory. Six larger rockfalls were triggered with a total volume of up to 150 million cubic meters and covered more than six square kilometers (Zorn 2002).

The historic and prehistoric (6.1) rockfalls on Mount Dobratsch have a total volume of over one cubic kilometer (Zorn 2002).

In Slovenia, there are no known historic rockfalls of such size and so well documented.

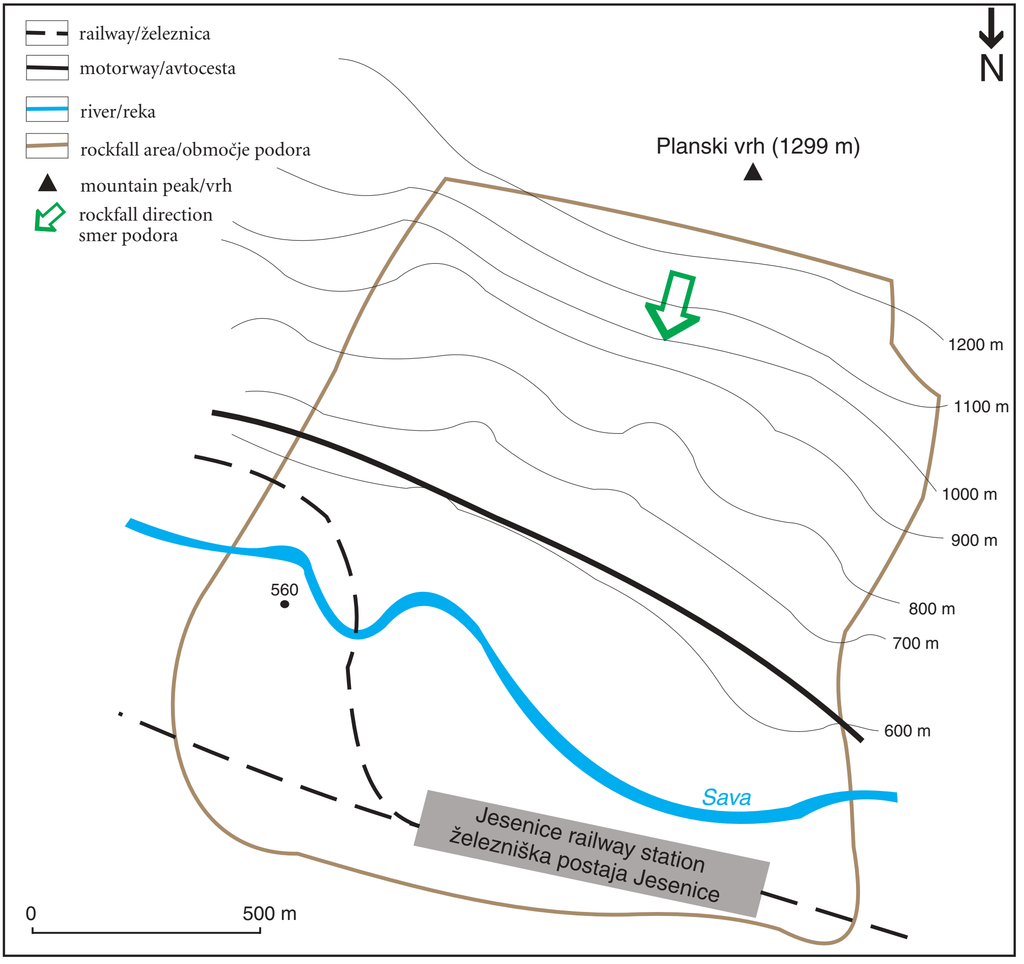



Figure 8: Rockfall relief in Jesenice (adapted from Grimšičar 1988).
Slika 8: Podorni relief na Jesenicah (prirejeno po Grimšičar 1988).

### 6.2.1 Mount Veliki vrh

The largest known rockfall is on Mount Veliki vrh (2,088 m) and was triggered from the southern hillslope of the Košuta ridge in the Karavanke Mountains. It is estimated that between twenty million and one hundred million cubic meters of material tumbled into the valley (Zorn 2001), which we can trace five kilometers down the valley of the Gebnov potok stream all the way to Plaz and Deševno in the Podljubelj area. The 7.5-hectare Košuta rockfall basin and the large talus area called »Birški plaz« remind us of this rockfall.

In this case as well, there are alternative descriptions of the deposited material. Melik (1954) believes that the settlement of Plaz is situated on a terminal moraine, and the authors of the geological map of this area (Buser and Cajhen 1977) hold a similar view, labeling the material deposited in the valley as moraine material.

While we can be satisfied with approximate estimates of the amount of material, the time of such an event in an historic period should be more precisely determined. It is interesting that a specific date for this event

Figure 9: Map of the largest rockfalls in the Alps (adapted from Abele 1972).
Slika 9: Karta največjih podorov v Alpah (prirejeno po Abele 1972).

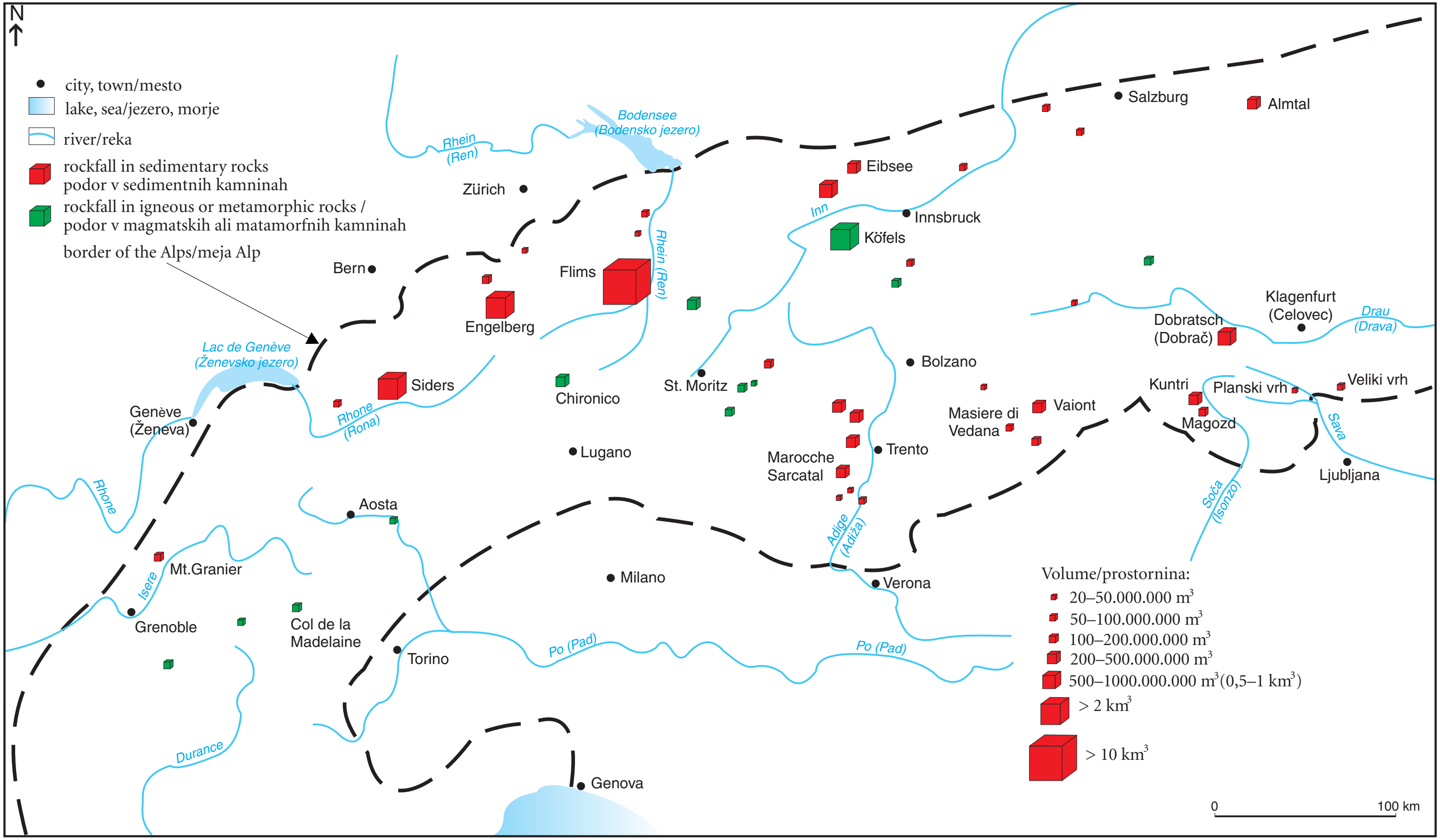


Figure 10: Veliki vrh (photography Matija Zorn).
Slika 10: Veliki vrh (fotografija Matija Zorn).

does not appear in the documentary sources as it does in the case of Mount Dobratsch. The reason may be that there were no similar writers or chroniclers in Carniola during the Middle Ages as there were in Carinthia, or perhaps the reason is that the event did not occur in an area important for transportation, which the lower Gail Valley was at that time. At that time, there was also no larger settlement in the immediate vicinity, whereas Villach was quite near Mount Dobratsch.

In the literature, we found various references to the event. Koblar (1895) and Seidl (1895) believe that the rockfall occurred at the time of the Villach earthquake on January 25, 1348, and the same hypothesis is also proposed by Gruden (1910) and Badjura (1953).

A somewhat different date can be traced in the legend of the foundation of the Church of St. Ana near the Ljubelj Tunnel. The legend states that the bells in the church »still today show the date 1517 as the year of the sad event …« (Kragl 1936).

Hicinger (1845) does not put down a precise year but dates the event in the period before 1399.

The literature frequently mentions that this »landslide« (as the older literature calls it) buried beneath it the original settlement of Tržič. Tržič was presumably established after a Carinthian duke donated the Ljubelj area to the Stična monastery in 1261, which arranged it as a shelter or hospice for travellers. The settlement of »Forum Lvbelino« or the borough of Ljubelj grew up around it. This predecessor of Tržič probably stood near Lajb in the Mošenik Valley, most likely at the spot where the route across pass Preval (1,311 m) through the Draga Valley past Kamen Castle to the Radovljica plain met the road leading from the Tržiška Bistrica Valley (Šoren 1998).

According to folk tradition, however, the borough probably stood somewhat lower or more to the south at Plaz–which translates as »landslide« (Avguštin 1970). It is not known where exactly in the Mošenik Valley the original settlement stood or what happened to it, but it is most probable that the original settlement

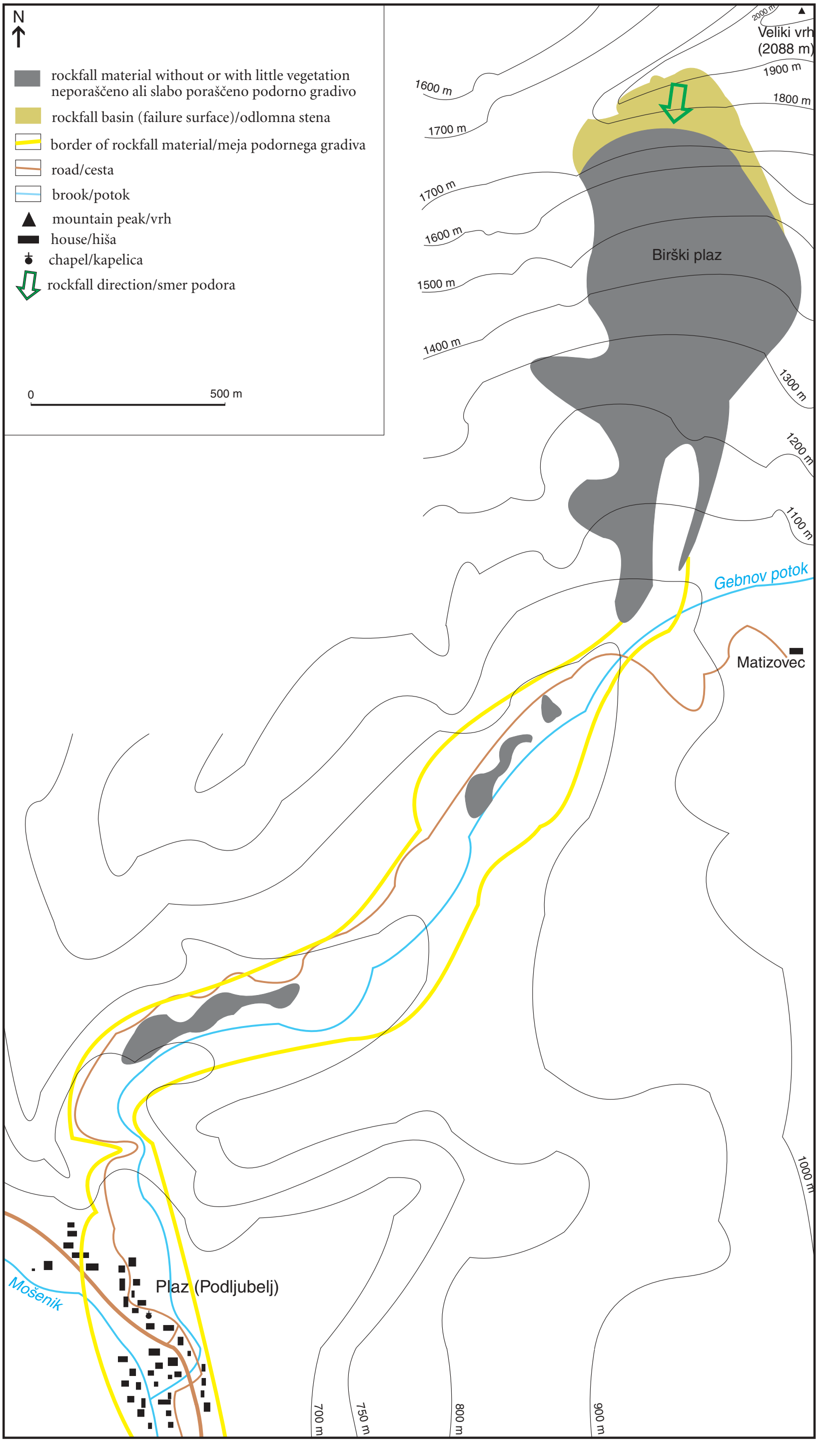



Figure 11: Rockfall on Veliki vrh.
Slika 11: Podor na Velikem vrhu.

was built at the crossroads in Lajb since it could thus fulfill necessary functions (board and accommodation, various skilled tradesmen) for users of the two roads (Šoren 1998).

If the folk tradition that the settlement stood at Plaz holds true, the rockfall is then certainly responsible for the decline of the settlement and must have happened between 1261 when the first hospice was built and 1337 when the first documentation of the existence of »Neymarckhtl« or the new Tržič exists (Janša-Zorn 1999).

## 6.3 Recent rockfalls

We witness recent instability on hillslopes every day. New rocks and rubble accumulate throughout the entire year on the talus in the high mountains. The majority of the newly detached material falls on the talus in the spring when the temperatures rise above the freezing point and fissures start to thaw. However, these are largely minor events.

Larger rockfalls are a different story and are much rarer, although their numbers can still be high during certain events such as stronger earthquakes.

### 6.3.1 Mount Krn and Mount Osojnica

During the earthquake that struck the Upper Soča region on April 12, 1998, with a magnitude of 5.8 on the Richter scale and an intensity of VII to VIII degrees EMS (European Macroseismic Scale), around one hundred rockfalls were recorded (Vidrih and Ribičič 1998). The earthquake shock waves reduced the effect of gravitational pull on the rock at the moment of oscillation and thus slides were triggered in the weakened part of the rock on the plane of the least shear resistance (Ribičič and Vidrih 1998b).

Figure 12: Rockfalls on Mount Krn (photography Matija Zorn).
Slika 12: Podori na Krnu (fotografija Matija Zorn).

Figure 13: Rockfalls on Mount Osojnica (photography Matija Zorn).
Slika 13: Podori na Osojnici (fotografija Matija Zorn).

Figure 14: Wedged-shaped rockslide from the Šija ridge in the Lepena Valley (photography Matija Zorn).
Slika 14: Klinasti zdrs z grebena Šije v dolini Lepene (fotografija Matija Zorn).

During the earthquake, several million cubic meters of material was moved. The belt of greatest damage to nature runs from Bovec along the southwestern ridges above the Lepena Valley across the Krn mountain range (southwestern ridge of Mount Krn and Mount Krnčica) to the source of the Tolminka stream and the Polog mountain pasture area above Tolmin. The greatest amounts of material were triggered on the southwestern wall of Mount Krn (2,244 m) and on Mount Osojnica above the Tolminka Valley. In both cases, more than one million cubic meters of material was triggered. In the first case, there were seven larger rockfalls and an additional several dozen rockfalls of smaller dimensions. Below the southwestern wall of Mount Krn, rockfall material covered an area of about fifteen hectares. In the second case, the rockfalls on Mount Osojnica damaged the mountain's northeastern, eastern, and southeastern slopes and covered an area of more than thirty hectares (Komac and Zorn 2002).

## 6.3.2 Mount Javoršček

There are several older recent rockfalls in the Upper Soča region. Planina (1950, 1952) described a rockslide on Mount Javoršček (1,557 m) in the Bovec basin that was triggered on August 8, 1950. This is a good example of a rockslide along stratification when some 80,000 cubic meters of material was triggered.

Figure 15: Javoršček rockslide (photography Karel Natek).
Slika 15: Podor Javoršček (fotografija Karel Natek).

## 6.3.3 Dvojčka

The best known rockfalls in the Upper Soča region are the »twin« rockfalls (Dvojčka) in the Lower Trenta Valley. Twin rockfalls often appear in narrow alpine valleys with glacially reshaped hillslopes when rockfalls occur on opposite hillslopes. The first rockfall occurred above the Plajer homestead on the left bank of the Soča and was triggered between June 28 and 29, 1989, from the northwestern hillslope of Mount Mala Tičarica (1,797 m). It originated on the site of an older rockfall (Orožen Adamič 1990, Rojšek 1991). About 300,000 cubic meters of material was triggered (Pavšek 1996).

Figure 16: Rockfall above the Plajer homestead in the Lower Trenta Valley (photography Matija Zorn).
Slika 16: Podor nad domačijo Plajer v Spodnji Trenti (fotografija Matija Zorn).

Figure 17: Construction of road gallery below the Berebica rockfall in the Lower Trenta Valley (photography Matija Zorn).
Slika 17: Graditev cestne galerije pod podorom Berebica v Spodnji Trenti (fotografija Matija Zorn).


Figure 18: Road sign warning for the Berebica rockfall (photography Matija Zorn).
Slika 18: Prometni znak, ki je opozarjal na podor Berebica (fotografija Matija Zorn).

Opposite the first rockfall, Berebica rockfall above the Fačer homestead was triggered later. Two rockfalls have occurred here in the last ten years – on December 12, 1993, and July 27, 1998 (Pavšek 1994, Zorn 2001). These rockfalls not only presented a threat to the homestead but also damaged the Bovec-Kranjska Gora regional road in both cases. The unstable hillslope threatened the road and drivers for almost ten years until a 280-meter long gallery was completed in May 2001 (Zorn 2001).

### 6.3.4 Mount Veliki Mangart

Two well-publicized rockfalls occurred on the southwestern wall of Mount Veliki Mangart (2,679 m). The smaller occurred (according to various sources) on October 26 or 27, 1995, and the larger on October 29, 1995 (Rojšek 1995, Hrvatin and Pavšek 1995, Pavšek 1996).

In other areas of Slovenia's alpine world, fewer such events have been recorded recently in the literature. This does not mean they have not occurred, but since they did not present any threat to people, they remained largely unknown. Only reddish or yellowish spots on the walls of the mountains show us they happened (for example, on the north wall of Mount Veliki Draški vrh).

Among the major rockfalls in recent years in the Gorenjska region is the rockfall on Mount Dovški Gamsovec (2,440 m) when part of its western wall collapsed on August 6, 1995 (Golob and Hrvatin 1996). During the earthquake on April 12, 1998, a rockfall occurred in the Radovna Valley near Klemenček when several hundred cubic meters of material fell. On November 2, 2001, a minor rockfall occurred between Mount Zadnja Mojstrovka (2,369 m) and Mount Travnik (2,379 m) above the Tamar Valley. Another rockfall occurred on the western hillslope of Mount Veliki Zvoh (1,971 m) above Roblekov kot at the beginning of April 2002.

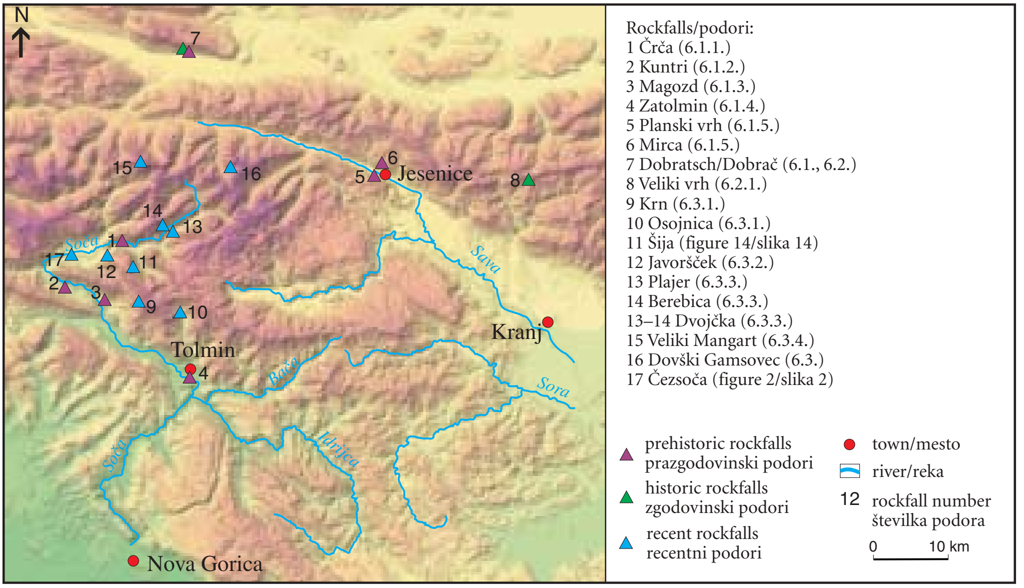



Figure 19: Map of rockfalls presented in the text.
Slika 19: Karta podorov predstavljenih v članku.

# 7 Conclusion

Rockfalls are a constant in Slovenia's alpine world. In this paper, we have traced them from the Pleistocene to the present day through prehistoric, historic, and recent rockfalls. If we had delved more deeply into the origin of the relief, we undoubtedly would also have found the remains of fossil rockfalls from older geological periods.

In spite of numerous proofs that rockfalls reshape mountain relief, it is not possible to claim that mountain relief is solely the consequence of rockfall processes. Mountain relief is a complex system, and its origins can only be explained through a polygenetic approach to the development of the relief in which glaciation, karstification, and other forms of hillslope processes play no less a role.

Rockfalls occur constantly in the mountain world, but we cannot predict where and when the next one will be triggered. We can only state a general rule that applies to the rockfall-threatened areas of the mountain world: »In the rocky mountain world, rockfalls can occur anywhere and at any time.«

We can define more threatened or less threatened areas on the basis of specific factors. However, we can only define the current state and not conditions that may occur in future due to the permanent activity of endogenic and exogenic processes when today's stable areas can become unstable. People living in mountain valleys will never be able to avoid this fact, and therefore the only solution is to accept the fact and adapt to it. People cannot prevent natural disasters of major dimensions. The only course left to them is limited encroachment in mountain areas where rockfalls can be expected. Unfortunately, human memory is short, and within just a few years we unrealistically feel completely safe in areas that were recently still threatened by natural disasters.

In the Pleistocene, hillslopes were additionally reshaped by glacial erosion. The large production of rubble, the consequence of intensive mechanical weathering on unglaciated areas, mostly the peaks that were not covered by glaciers, remind us of rockfall events in the periods of glaciation.

Boulders found with large quantities of moraine material are also a good indicator of rockfalls in the Pleistocene. They fell on a glacier and were subsequently moved.

After the retreat of the glaciers (in the periods between ice ages or at the end of the Pleistocene) hillslopes that were previously covered with ice also began to collapse since glacial erosion destroyed the stability of hillslopes. When the ice retreated and the hillslopes lost their support, their general collapse began. Traces of these processes in the periods between ice ages were removed by the glaciers of younger ice ages.

In the Holocene, rockfall events were not as intensive as they were in the Pleistocene, but it is also true that the Pleistocene lasted two million years and the Holocene only 12,000.

Rockfalls are also known in the youngest geological period of the earth. Prehistoric rockfalls are confirmed with the help of special datation procedures, while historic rockfalls are reflected in numerous sources (from genuine historical documents to fairytales, songs, and legends). And we can confirm the existence of recent rockfalls ourselves by exploring the mountain world where at every step we find extensive talus and large quantities of rubble (from smaller pieces of rock to blocks of great size).

Along with deposited material, concave wall forms remind us of rockfalls since the observer has the feeling that some material is missing in the hillslope. Younger rockfall sites in the limestone or dolomite that predominantly composes our mountains differ from the rest of a wall by their still »fresh« yellowish or reddish colour, the consequence of weathering.

Indirectly, all the rubble and gravel accumulated in valleys and basins reminds us of rockfalls in the mountains. The great majority of this material also started on its way to its current location with a rockfall.

In conclusion, let us once more emphasize the fact that today's mountain relief is the result of complex intertwined effects of endogenic and exogenic processes that act continuously on the earth's surface. Geomorphic activity is something constant, even though it often proceeds relatively slowly and is therefore hidden from the human eye. Geomorphologists can read the signs written in nature and have ways to monitor geomorphic processes. In ordinary life, we only become aware of these processes when a major event occurs that destroys a settlement (debris flow in Log pod Mangartom, November 17, 2000) or buries an important road (Berebica rockfall, 6.3.3). Such »unique« events give people the misconception that they occurred suddenly and without warning.

In this article, we have tried to show that rockfalls are only one developmental stage in the long-term geomorphic changing of the earth's surface.

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# 9 Summary in Slovene – Povzetek

## Podori v slovenskih Alpah

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### 1 Uvod

Ko človek hodi po gorah se včasih zamisli nad tem, kako je vse minljivo, le gore ostajajo večno enake v svoji lepoti. Gore nastanejo, obstajajo dolge milijone let, a vendar počasi izginjajo in končno napravijo prostor novemu. To spreminjanje reliefa, poteka pred našimi očmi, a ga zaradi kratkotrajnosti našega življenja v glavnem ne opazimo (Natek 1985).

Veter, voda v vseh oblikah, temperaturna nihanja in gravitacija stalno, vendar počasi sproščajo, odnašajo gradivo z gora v doline. Občasno se v dolino nenadno odvalijo velike kamninske gmote ali kar cela pobočja, zato se relief v Alpah spreminja relativno hitro.

Slovenske Alpe pri pojavljanju podorov niso nobena izjema. Za številne manjše podore (odlome) pravzaprav nikoli ne izvemo, saj so pogostejši na nenaseljenih in odročnih območjih. Nanje nas opomnijo šele geomorfni procesi večjih razsežnosti, ki povzročijo škodo na stanovanjskih in infrastrukturnih objektih (Pavšek 1994, Komac in Zorn 2002).

Skalni podori so eden vidnejših in hitrejših geomorfnih procesov sploh. Dogajajo se na strmejših pobočjih v gorskem svetu, pa tudi na strmih bregovih rek in klifnih morskih obalah. V tem prispevku bodo obravnavani le nekateri primeri iz slovenskega alpskega sveta.

## 2 Opredelitev podorov

V Sloveniji se s preučevanjem podorov v naravoslovju ukvarjajo strokovnjaki več znanstvenih panog, na primer geologi (Grimšičar 1960, 1983, 1988, Ribičič in Vidrih več citiranih del), gozdarji (Šneberger 1999, Zemljič in Horvat 1999), vodarji (Mikoš 1995, 2000, Mrak 1999), pa tudi geografi (Planina 1951, 1952, Gams 1956, 1989, Orožen Adamič 1990, Pavšek 1994, 1996, Kunaver 1995, Rojšek 1995, Hrvatin in Pavšek 1995, Golob in Hrvatin 1996, Zorn 2001, Komac in Zorn 2002, Zorn in Komac 2002).

Vsaka od omenjenih strok obravnava in definira podore drugače. Geologi jih definirajo kot »… naravne zdrse velikih blokov trdih kamnin v alpskem ali hribovitem terenu, kjer so pobočja nagnjena. Nastajajo ob različnih med seboj sekajočih se sistemih razpok, pri katerih je eden ponavadi blizu navpičnega nagiba …« (Ribičič 1998, Ribičič 1999: 19). V geološki literaturi podore uvrščajo k plazovom, ki jih delijo v zemeljske plazove in skalne podore (Grimšičar 1983).

Podobno tudi vodarji podore oziroma »podorno erozijo« prištevajo k plazovom (Mikoš 2000: 103–104).

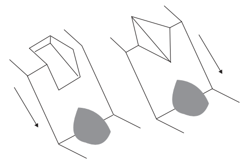
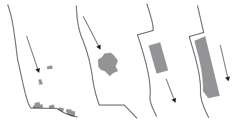
Vse omenjene stroke, tudi geografija, uvrščajo podore k »pobočnim procesom«. S tem izrazom imenujemo »vse pojave premeščanja gradiva, ki nastanejo zaradi vpliva gravitacije« in so pomemben del denudacije površja (Strahler in Strahler 1992: 287). V nasprotju z zgoraj omenjenima strokama, geografi podorov ne uvrščamo med plazove, pri katerih je temeljni način premikanja plazenje, pač pa jih obravnavamo kot posebno kategorijo, kjer premikanje gradiva v pretežni meri poteka v obliki padanja. Pri pobočnih procesih poznamo tri temeljne načine premikanja gradiva: tok, plazenje in padanje (Thomson in Turk 1993, Zorn 2001, Zorn in Komac 2002).

Podore bi najlažje opisali kot pojav, ki »nastane, ko se del trdne kamnine odlepi od strmega pobočja in pade v nižjo lego. Gmota se premika pretežno v obliki prostega padanja, ob tem pa se pojavljata še odbijanje od tal in kotaljenje. Podori so najpogostejši na skoraj vertikalnih pobočjih, kjer je kamnina dobro razpokana. Razpokanost oblikuje bloke kamnine, ki se lahko odlepijo ob pobočja. Te procese lahko pospešijo antropogeni posegi v pobočja« (Easterbrook 1999: 74), na primer cestni useki ali miniranje pobočij.

V tem članku uvrščamo med skalne podore v širšem pomenu besede (glej preglednico 1) vse vrste porušitev trdne kamnine na pobočjih, kjer gradivo prosto pada proti vznožju (način premikanja je »padanje«) ne gleda na količino premaknjenega gradiva. S takšno opredelitvijo zajamemo vse porušitve v trdni kamnini od manjšega krušenja kamnin, ki jim pravimo odlomi, do večjih porušitev, ki jih imenujemo podori (v ožjem pomenu besede). V članku med skalne podore uvrščamo še vse oblike kamnitih zdrsov, pri katerih je začetno gibanje (ob sprožitvi gradiva) »plazenje« in bi jih zato lahko uvrstili tudi med plazove. Toda glede na morfologijo gorskega sveta to gradivo v večini primerov kmalu preide v fazo padanja.

V nadaljevanju članka uporabljamo izraz skalni podor v širšem pomenu besede, razen če ni navedeno drugače.

PREGLEDNICA 1: SKALNI PODORI V ŠIRŠEM POMENU BESEDE (ZORN 2001, ZORN IN KOMAC 2002).

| skalni podori v širšem pomenu besede | način premikanja gradiva | hitrost premikanja | opis | primer | odloženo gradivo | skica |
|---|---|---|---|---|---|---|
| KAMNITI ZDRS | plazenje | zelo počasno do ekstremno hitro | Zdrs trdne kamnine po eni ali več nezveznostih. Pozneje ponavadi zaradi morfologije pobočij preide v padanje. | klinasti zdrs z grebena Šije v dolini Lepene (slika 14); zdrs po plastovitosti na pobočju Javorščka (slika 15) | pobočni grušč, prevrnjeni bloki, melišča |  |
| SKALNI PODOR | padanje | ekstremno hitro | Gradivo prosto pada ali se prevrača po pobočju. | jugozahodna stena Krna (slika 12), Osojnica (slika 13), Čezsoča (slika 2) | |  |

## 3 Vrste podorov

Z določanjem vrst skalnih podorov se je ukvarjalo več avtorjev (Abele 1971, Zemljič in Horvat 1999, Ribičič in Vidrih 1998a, Vidrih in Ribičič 1999, Zorn 2001), ki so podore opredelili glede na:
a) skupno prostornino podornega gradiva,
b) način in obliko sprožitve,
c) starost gradiva.

a)
V nemški geografski literaturi pogosto uporabljajo delitev na *Bergsturz* in *Felssturz* (Abele 1971). *Bergsturz* je podor s prostornino, ki je večja od 0,01 km$^3$ (10 milijonov m$^3$). Če se prostornine ne da določiti, je merilo obseg območja, ki je prekrito s podornim gradivom. Mejna vrednost je 0,5 km$^2$. Pri manjših količinah gradiva govorimo o *Felssturzih*.

Slovenska gozdarska literatura kvantitativno opredeljuje podore, kot kaže preglednica 2. Pomanjkljivost preglednice je, da ni opredeljene kategorije med padanjem skal in skalnim podorom. V preglednici je uporabljena drugačna terminologija kot drugod v članku.

b)
Najbolj značilne vrste skalnih podorov, glede na način in obliko sprožitve gradiva sta v Sloveniji opredelila M. Ribičič in R. Vidrih (1998a, Vidrih in Ribičič 1999), ki ločita (slika 3):
1. »ravninski ali planarni zdrs«, ki nastane, kadar padnica pobočja in padnica usmeritve kakega sistema razpok potekata približno v isti smeri,
2. »klinasti zdrs«, ki nastane, ko je presečišče dveh sistemov razpok usmerjeno v isti smeri kot padnica pobočja in nagnjeno navzdol,
3. »zdrs po različnih sistemih razpok«,
4. »zdrs po plastovitosti ob slučajni zaledni razpoki«,
5. »zdrs v močno razpokani kamnini«, ki nastane izjemoma. To se zgodi, ko je trdna kamnina prepredena s tremi ali več sistemi razpok in pride do krožnega oziroma razpokam prilagojenega drsenja, pri katerem se kamnina obnaša kot gmota preperine,
6. »podor ob strmo nagnjeni leziki«,
7. »podor ob vertikalni razpoki v pobočju, spodjedenem v spodnjem delu«,
8. »zdrs bloka ob poševni razpoki«, ki preide v podor ob navpično nagnjenem pobočju.

Za vrste skalnih podorov 6–8 je značilna šibka, bolj ali manj navpično nagnjena ploskev, ki je približno vzporedna s pobočjem in se pojavi znotraj kamninske gmote v zaledju pobočja.

c)
Glede na starost odloženega gradiva oziroma glede na čas sprožitve, delimo skalne podore na (Abele 1971, Abele 1974, Zorn 2001):

1. *fosilne podore* (nastali so v starejših geoloških obdobjih, njihove sledi so se ohranile v kamninskem zapisu Zemlje, zato jih obravnava sedimentologija in ne geomorfologija),
2. *prazgodovinske podore* (nastali so v pleistocenu in v prazgodovinskem obdobju holocena),
3. *zgodovinske podore* (nastali so v času pisanih zgodovinskih virov) in
4. *recentne podore* (nastali so v zadnjih letih oziroma desetletjih).

## 4 Vzroki in povodi za nastanek podorov

Za razumevanje neprestanega geomorfnega dogajanja, katerega del so podori, je pomembno razlikovanje med vzroki in povodi zanje. Na prvi pogled so podori posledica potresov ali močnejših padavin, toda pri teh gre le za tako imenovane sprožitelje (povode). Delujejo razmeroma kratek čas in odločajo le o času sprožitve gradiva, ne pa tudi o tem, kaj in koliko gradiva se bo sprožilo. O sprožitvi odloča splet dlje časa trajajočih dejavnikov (vzrokov), ki s hitrostjo in intenzivnostjo delovanja vplivajo na to, ali se bo del pobočja tudi resnično premaknil, ko bo nastopil »sprožitelj« (na primer potres), ali pa bo ta potres le še eden izmed vzrokov, ki počasi načenjajo stabilnost pobočja. Nek dogodek je torej povod le v tistem trenutku, ko dejansko pride do sprožitve gradiva, v ostalem času pa je le delček v mozaiku vzrokov, ki pripeljejo do sprožitve (Zorn in Komac 2002).

Dejavniki, ki dlje časa delujejo na potencialno mesto sprožitve in s svojim delovanjem v pobočju krhajo ravnovesje, so torej »vzroki« za nastanek podorov. Tisti dejavnik, ki dokončno podre dinamično ravnovesje, pa je »povod«. Po sprožitvi se na območju sprožitve vzpostavi novo dinamično ravnovesje, ki vztraja toliko časa, dokler novi »vzroki« ne razrahljajo pobočja do te mere, da ga »povod« lahko zopet podre (Zorn in Komac 2002).

Površje je odprt sistem, v katerem se vedno znova vzpostavlja dinamično ravnovesje, tako da vsaki spremembi zunanjih okoliščin sledi niz prilagoditev celotnega sistema, na pobočjih tudi z njihovim podiranjem (Zorn in Komac 2002).

PREGLEDNICA 3: POGLAVITNI VZROKI IN POVODI PODOROV (ZORN 2001).

| poglavitni vzroki podorov | poglavitni povodi podorov |
|---|---|
| 1. potresi, | 1. potresi, |
| 2. vremenska dogajanja, | 2. vremenski dogodki (ekstremne padavine, spomladansko odtaljevanje razpok), |
| 3. preperevanje kamnine (mehansko, kemično, biološko), | 3. človeški posegi v pobočja. |
| 4. erozija (ledeniška, rečna, vetrna), | |
| 5. človeški posegi v pobočja. | |

## 5 Pokrajinski učinki podorov

Podori in drugi pobočni procesi vplivajo na naravo, pa tudi na človeka. Njihove učinke oziroma posledice v pokrajini lahko razdelimo na tri ločena območja delovanja (Mikoš 1995, Zorn 2001, Zorn in Komac 2002):
a) na območje nastanka ali sproščanja (območje odloma),
b) na območje premeščanja ali spreminjanja (območje poti v dolino),
c) na območje odlaganja ali zastajanja (območje akumulacije).

Učinki se med seboj prepletajo in lahko delujejo v vseh ali pa le v enem od naštetih območij.

a)
Na območju nastanka prihaja do:
- sprememb reliefnih oblik na pobočjih (stenske oblike),
- nastanka tenzijskih razpok, ki so vzporede z odlomno ploskvijo,
- poškodb alpinističnih smeri in planinskih poti.

b)
Na območju premeščanja prihaja do:
- reliefnih poškodb,
- poškodb prsti in vegetacije,
- nastanka zračnih udarov,
- poškodb infrastrukturnih objektov,
- poškodb stanovanjskih in drugih objektov,
- poškodb alpinističnih smeri in planinskih poti.

c)
Na območju odlaganja gradiva pa prihaja do:
- sprememb v morfologiji območja (kupi odloženega gradiva),
- spremenjenih hidroloških razmer ali do nastanka podornih jezer in poplav,
- popolnega uničenja prsti in vegetacije,
- mikroklimatskih sprememb,
- zasutja naselij, posameznih stanovanjskih ali infrastrukturnih objektov in poti,
- hidroenergetske izrabe podornih jezer ali neposredne izrabe podornega gradiva v industriji,
- ohranitve spomina na starejše podore v krajevnih in ledinskih imenih, kot tudi v pripovedkah, pesmih in legendah,
- otežene prometne komunikacije,
- političnih, kulturnih ali jezikovnih meja,
- spremenjenega izgleda kulturne pokrajine.

# 6 Primeri podorov v slovenskih Alpah

## 6.1 Prazgodovinski podori

Prazgodovinski podori so nastali v pleistocenu in v prazgodovinskem obdobju holocena. V pokrajini nas na tako stare pobočne procese opozarjajo morfologija površja, sestava odloženega gradiva na vznožju pobočij in različne stenske oblike na mestih sprožitve.

Dostikrat naletimo na težavo, ali je akumulirano gradivo morenskega ali podornega izvora ali pa gre za kombinacijo obojega. Po drugi strani pa pomešanost morenskega in podornega gradiva olajša datiranje (Melik 1961).

Če smo natančni, se je vse gradivo, ki je akumulirano v dolinah, primarno premaknilo s pomočjo podorov ali drugih pobočnih procesov. Ti so bili v času ledenih dob zelo intenzivni in na periglacialnih območjih so se sproščale velike količine gradiva. Del tega gradiva so ledeniki prestavili na sekundarno mesto (morensko gradivo), del pa je ostal na prvotnem mestu (podorno gradivo). Pri razlagi enega in drugega si strokovnjaki niso enotni, zato pri razlagi geneze istega gradiva prihaja do razlik.

Največ tovrstnih dilem je v Sloveniji odprtih v Zgornjem Posočju, kar je posledica dejstva, da je bil ta predel Slovenije intenzivno geomorfološko preučevan s strani več generacij strokovnjakov (glej Bavec 2001). Dejstvo je, da je bilo Zgornje Posočje tako ledeniško kot podorno močno preoblikovano (Melik 1961). Glede slednjega je še vedno eno bolj ogroženih območij Slovenije (Komac in Zorn 2002).

V Zgornjem Posočju so se v pleistocenu in v začetku holocena, v času periglacialnega morfogenetskega preoblikovanja pobočij, največji podori prožili na južnih pobočjih oziroma prisojnih legah, kjer so bile temperaturne spremembe največje. Poleg tega je v Zgornjem Posočju za pojavljanje podorov ugodna poglobljenost dolin, ki je posledica bližnje erozijske baze Jadranskega morja in dolinskih ledenikov, pa tudi položaj ob tektonskih deformacijah. Dolina Soče med Mostom na Soči in Žago na primer poteka po idrijski prelomni coni.

### 6.1.1 Črča

Problem pri razlagi gradiva predstavlja odloženo gradivo pri Črči med krajema Kal-Koritnica in Soča, ki ga nekateri avtorji razlagajo kot čelno moreno (Šifrer in Kunaver 1978, Kunaver 1980), spet drugi pa kot podor (Melik 1961, Bavec 2001, Zorn 2001).

Skalne gmote so zgrmele v dolino s strmih pobočij grebena med Svinjakom in Bavškim Grintavcem. Skladi so tu strmo nagnjeni na južno stran in so vzporedni s pobočjem. V pobočju so vidne gole in dokaj gladke proge, v katerih so se velike zaplate skladov sprožile ter zgrmele navzdol. Verjetno se je to dogajalo večkrat in ni šlo le za enkratni dogodek. Podor pri Črči naj bi zajezil Sočo in jezero naj bi segalo tudi v dolino Lepene (Melik 1961). Planina (1954) navaja, da je bila v dolini najdena jezerska kreda in datira jezero v postglacial.

Na tem območju so večji odlomi zabeleženi tudi pri vasi Soča (Melik 1961).

### 6.1.2 Kuntri

Nižje v dolini Soče med Srpenico in Kobaridom naletimo na podobna problema pri razlagi izvora odloženega gradiva. Vzpetina Kuntri (Gorenji hrib, Hrib; 530 m) med Srpenico in Trnovim ob Soči po našem mnenju predstavlja največji znani podor v slovenskih Alpah. Med Trnovim ob Soči in Kobaridom naj bi bili vzpetini Molid in Dolenji hrib (6.1.3) prav tako posledica enega večjih podorov pri nas.

V obeh primerih so avtorji razdeljeni glede izvora odloženega gradiva. Za podorni izvor vzpetine Kuntri, se je med starejšimi avtorji opredelil že Winkler (1926), ki podor datira v čas po koncu poledenitve. Podobnega mnenja so tudi nekateri kasnejši avtorji (Melik 1961, Bavec 2001, Zorn 2001). Nasprotno pa je bila vzpetina geološko kartirana kot nesprijeta morena (Buser 1986a) oziroma kot mešanica morenskega in podornega gradiva (Kuščer in ostali 1974).

Po navedbah nekaterih avtorjev (na primer Grimšičar 1988), naj bi kot posledica podora Kuntri nastalo mlajšekvartarno tako imenovano Srpeniško jezero, ki naj bi segalo v Bovško kotlino (slika 4). Obstoj jezera dokazujejo prek 200 m debele plasti jezerske krede (Kuščer in ostali 1974).

Po mnenju drugih avtorjev pa je podor Kuntri padel na že prej odloženo jezersko kredo in ni povzročil nastanka Srpeniškega jezera (Melik 1962, Bavec 2001).

Ne glede na to je morala tako velika akumulacija povzročiti zajezitev Soče. Podor se je verjetno sprožil koncem pleistocena ali pa v začetku holocena. Po novejših gledanjih bi do dogodka lahko prišlo 12.790 ± 85 let pred sedanjostjo (Marjanac in ostali 2001).

Vzpetina Kuntri in njeno nadaljevanje na levem bregu Soče po naših ocenah meri preko 200 milijonov $m^3$. Bavec (2001) njeno prostornino ocenjuje na 50–100 milijonov $m^3$. Podor Kuntri je nedvomno največji znan podor v slovenskih Alpah. Največji del podornega gradiva izvira z južnega pobočja Polovnika na katerem je lepo vidna konkavna stenska oblika, od koder se je sprožilo gradivo ob enkratnem ali večkratnih dogodkih. Del gradiva ima verjetno izvor tudi na severnem pobočju med Kobariškim Stolom in Starijskim vrhom.

### 6.1.3 Molid in Dolenji hrib

Drug nejasen primer v delu soške doline med Trnovim ob Soči in Kobaridom je podor oziroma odloženo gradivo pri Magozdu.

Vzpetini Molid (479 m) in Dolenji hrib (482 m) naj bi po prvi razlagi nastali kot posledica podora (Winkler 1931, Melik 1961, Buser 1978) z južnega pobočja Polovnika (Buser 1986b), po drugi pa gre za pretežno morensko gradivo pomešano s podornim (Kuščer in ostali 1974). Avtor tretje razlage meni, da je bilo gradivo odloženo z masnimi tokovi, ki so tekli iz smeri zahodnega pobočja Krna (Bavec 2001). Tudi za tem gradivom je nastalo jezero (Melik 1961), dolgo okrog 2 km, kot kažejo izdanki jezerske krede na levem bregu Soče severno od Trnovega ob Soči (Kuščer in ostali 1974).

### 6.1.4 Sotočje Soče in Tolminke

Naslednji večji pobočni proces in hkrati dilemo v Zgornjem Posočju predstavlja plast karbonatnega drobirja, ki jo najdemo ob sotočju Soče in Tolminke. Po mnenju Šifrerja (1965) gre pri tej plasti za karbonatni drobir podornega izvora (slika 5). Podor naj bi nastal nad Zatolminom vzhodno od vzpetine Vodel (1053 m).

Po Šifrerju naj bi po holocenskih nanosih, ki so nastali po umiku ledenikov, prišlo do odložitve ogromnih količin domnevno podornega gradiva, ki naj ne bi bilo ledeniškega izvora. To gradivo naj bi tudi zajezilo Sočo.

V podlagi lahko plast domnevnega podora spremljamo na severu vse do Tolmina in Zatolmina, na jugu pa do Modreja. Plast je dolga okrog 6 km, v njej pa ne najdemo debelega rečno-ledeniškega proda. To po Šifrerju priča o tem, da je šlo za nek nenaden dogodek. Würmske rečno-ledeniške terase najdemo višje, kot je odloženo to gradivo, kar pomeni, da se je odložilo, ko je že bila izoblikovana struga Soče (Zorn 2001).

Plast podornega gradiva je lepo vidna v peskokopu Prapetno in ob sotočju Soče in Tolminke, pa tudi v samem Tolminu na rahli vzpetini imenovani Čemanova bula. V peskokopu Prapretno je pod domnevno podorno plastjo vidna fluvialna holocenska rečna naplavina potoka Godiča (slika 6).

S Šifrerjem se ne strinjajo geologi, za katere je ta plast ledeniškega izvora. Po njihovem mnenju naj bi šlo za nesprijeto morensko gradivo (Buser 1986a, Vrabec 1998). Ledeniški izvor gradivu pripisuje tudi Kunaver (1993), ki zgornje plasti v Čemanovi buli razlaga kot ostrorobat ledeniški nanos.

Po našem mnenju je odloženo gradivo ostanek vršaja drobirskega toka. Nastal je po podoru nekje v dolini Tolminke. Glede časa nastanka se pridružujemo mnenju Šifrerja, da je takrat že bila izoblikovana struga Soče, kar ni moglo biti prej kot v prazgodovinskem obdobju holocena.

### 6.1.5 Planski vrh

V Posočju, pa tudi drugod v slovenskih Alpah, najdemo še več primerov prazgodovinskih podorov, le njihova prostornina je mnogo manjša. Med večje spada podor pod Planskim vrhom (1299 m), na čigar nanosu stojijo danes Jesenice (območje celotne železniške postaje (slika 7 in 8) in stare železarne, Kurja vas in Podmežakla). S pobočja Mežakle je v Zgornjesavsko dolino zgrmelo prek 10 milijonov $m^3$ apnenca in dolomita in jo zasulo do 20 m visoko. Za podornim gradivom je nastalo jezero, ki je segalo do Hrušice. Obstoj le-tega dokazuje jezerska kreda. Na podlagi pelodnih preiskav so podoru in jezeru določili holocensko starost (Grimšičar 1983, 1988).

Na nasprotnem pobočju, na vznožju Karavank, je prav tako v prazgodovinskem obdobju nastal »podor dvojček« prvemu, podor Mirca, ki se je tudi odložil na območju Jesenic (predel Murova). S pobočja Mirce je zgrmelo nekaj manj kot 100.000 $m^3$ dolomitnih podornih blokov (Grimšičar 1988).

V poglavju 6.1 smo omenili le večje znane prazgodovinske podore v slovenskih Alpah, ki pa so po velikosti veliko manjši od največjih alpskih ali svetovnih podorov. Največji znani prazgodovinski podori v Vzhodnih Alpah so se sprožili na južnem pobočju gore Dobrač v Spodnji Ziljski dolini (Koroška, Avstrija). Ocenjujejo, da se je sprožilo do 900 milijonov $m^3$ gradiva, ki je odložen na okrog 30 $km^2$ velikem območju (Zorn 2002).

Največji podor v Alpah se je sprožil v Švici pri kraju Flims. Njegova prostornina je znašala okrog 12.000 milijonov $m^3$ (12 $km^3$), prekril pa je prek 50 $km^2$ veliko območje (Heim 1932).

## 6.2 Zgodovinski podori

Najbolj znani zgodovinski podori, katerih opise zasledimo v slovenski strokovni in drugi literaturi, so nastali ob beljaškem potresu 25. 1. 1348 v neposredni bližini Slovenije na južnem pobočju gore Dobrač (Koroška, Avstrija), na slovenskem etničnem ozemlju. Takrat se je sprožilo šest večjih podorov s skupno prostornino do 150 milijonov $m^3$, ki so prekrili površino večjo od 6 $km^2$ (Zorn 2002).

Zgodovinski in prazgodovinski (6.1) podori na Dobraču imajo skupno prostornino prek 1 $km^3$ (Zorn 2002).

V Sloveniji ni znanih tako velikih in tako dobro pisno dokumentiranih zgodovinskih podorov.

### 6.2.1 Veliki vrh

Največji znani je podor na Velikem vrhu (2088 m), ki se je sprožil z južnega pobočja Košute v Karavankah. Po ocenah naj bi v dolino zgrmelo med 20 in 100 milijoni $m^3$ gradiva (Zorn 2001), ki mu lahko sledimo 5 km navzdol po dolini Gebnovega potoka vse do Podljubelja (predel Plaz in Deševno). Na pobočju Košute na podor še vedno spominjata oblomna stena velika okrog 7,5 ha in veliko melišče imenovano »Birški plaz« (slika 10 in 11).

Tudi v tem primeru se pojavljajo drugačne razlage za odloženo gradivo. Melik (1954) meni, da se naselje Plaz nahaja na čelni moreni, podobnega mnenja pa sta tudi avtorja geološke karte tega območja (Buser in Cajhen 1977), ki odloženo gradivo v dolini označujeta za morensko gradivo.

Če se pri količini gradiva lahko zadovoljimo s približno oceno, pa bi moral biti čas takega dogodka v zgodovinski dobi natančneje določen. Zanimivo je, da v pisnih virih ni naveden natančen datuma dogodka, kot je v primeru Dobrača. Vzrok je lahko dejstvo, da v srednjem veku na Kranjskem ni bilo takih piscev in kronistov, kot so bili na Koroškem ali pa je razlog ta, da se dogodek ni zgodil v tako prometno pomembnem območju kot je bila Spodnja Ziljska dolina. V tistem času v neposredni bližini tudi ni bilo večjega kraja, kot je pri Dobraču Beljak.

V literaturi smo našli različne navedbe dogodka. Koblar (1895) in Seidl (1895) sta mnenja, da je podor nastal ob beljaškem potresu 25. 1. 1348. Isto domnevo navajata tudi Gruden (1910) in Badjura (1953).

Nekoliko drugačno datacijo zasledimo pri legendi o ustanovitvi cerkvice Svete Ane pod Ljubeljem. Legenda namreč pravi, da zvonovi v cerkvici »še dandanes kažejo letnico 1517 kot leto žalostnega dogodka …« (Kragl 1936).

Hicinger (1845) ne napiše natančne letnice, a datira dogodek v čas pred letom 1399.

Literatura večkrat omenja, da naj bi ta »plaz«, kot ga imenuje starejša literatura, zasul prvotno naselbino Tržiča. Tržič naj bi nastal po tem, ko je leta 1261 koroški vojvoda podaril Ljubelj v posest stiškemu samostanu, ki je tu uredil zavetišče oziroma hospic za popotnike. Okoli tega je nastalo naselje »Forum Lvbelino« oziroma trg Ljubelj. Ta predhodnik Tržiča naj bi stal nekje v dolini Mošenika, najverjetneje na mestu, kjer se je pot čez Preval (1311 m) skozi dolino Drage mimo gradu Kamen na radovljiško ravnino križala s tisto, ki je vodila iz doline Tržiške Bistrice. Ta kraj, se danes imenuje »Lajb« (Šoren 1998).

Po ljudskem izročilu pa naj bi stal trg nekoliko nižje oziroma južneje, na kraju, ki se imenuje »Plaz« (Avguštin 1970). Kje natančno v dolini Mošenika je prvotno naselje stalo in kaj se je z njim zgodilo, ni natančno ugotovljeno. Verjetneje pa je, da je prvotno naselje nastalo na križišču cest, na Lajbu, saj je tako opravljalo funkcije (gostišča, prenočišča, razni obrtniki) za uporabnike obeh cest (Šoren 1998).

Če drži ljudsko izročilo, da je naselje stalo na Plazu, potem je podor zagotovo odgovoren za zaton naselja in se je moral zgoditi med letoma 1261, ko so zgradili prvo zavetišče in letom 1337, ko obstajajo prvi dokazi o obstoju »Neymarckhtl-a« oziroma novega Tržiča (Janša-Zorn 1999).

## 6.3 Recentni podori

Recentnim nestabilnostim na pobočjih smo priča tako rekoč vsakodnevno. Na meliščih se v visokogorju prek celega leta nabirajo nove in nove skale ter grušč. Največ novo odlomljenega gradiva pade na melišča spomladi, ko temperature narastejo nad ledišče in se začne odtaljevanje razpok. Vendar so to večinoma manjši odlomi.

Drugače pa je z večjimi podori, ki so redkejši, a je lahko njihovo število ob določenih dogodkih, kot so močnejši potresi, vseeno veliko.

### 6.3.1 Krn in Osojnica

Ob potresu v Zgornjem Posočju 12. 4. 1998 z magnitudo 5,8 in intenziteto VII.–VIII. stopnje po EMS (Evropska makroseizmična lestvica) je nastalo okrog 100 podorov (Vidrih in Ribičič 1998). Potresno valovanje je v trenutku nihanja povzročilo zmanjšanje delovanja gravitacijskega pospeška na kamnino. Na ta način so se v razrahljanem delu kamnine na ploskvi najmanjšega stižnega odpora sprožili zdrsi (Ribičič in Vidrih 1998b).

Ob potresu je bilo premaknjenega nekaj milijonov m$^3$ gradiva. Pas z največjimi poškodbami v naravi poteka od Bovca po jugozahodnih grebenih nad dolino Lepene, prek Krnskega pogorja (jugozahodni greben Krna in Krnčice), do izvira Tolminke in planine Polog nad Tolminom. Največ gradiva se je sprožilo v jugozahodni steni Krna (2244 m) in na Osojnici nad dolino Tolminke (slika 12 in 13). V obeh primerih se je sprožilo prek milijon m$^3$ gradiva. V prvem primeru gre za sedem večjih podorov, poleg teh pa je še več deset odlomov manjših dimenzij. Podorno gradivo je pod jugozahodno krnsko steno zasulo okrog 15 ha veliko območje. V drugem primeru pa so podori na Osojnici poškodovali severovzhodno, vzhodno in jugovzhodno pobočje gore in zasuli prek 30 ha veliko območje (Komac in Zorn 2002).

### 6.3.2 Javoršček

V Zgornjem Posočju je še nekaj starejših recentnih podorov. Planina (1950, 1952) je opisal podor na Javorščku (1557 m) v Bovški kotlini, ki se je sprožil 8. 8. 1950. Gre za lep primer zdrsa po plastivitosti, ko se je sprožilo okrog 80.000 m$^3$ gradiva (slika 15).

### 6.3.3 Dvojčka

Najbolj znana podora v soški dolini pa sta »podora Dvojčka« v Trenti. V ozkih gorskih dolinah z ledeniško preoblikovanimi pobočji pogosto prihaja do »podorov dvojčkov«, ko nastaneta podora na nasprotnih pobočjih. Prvi je nastal podor nad domačijo Plajer (slika 16) na levem bregu Soče. Sprožil se je med 28. in 29. 6. 1989 s severozahodnega pobočja Male Tičarice (1797 m) v Spodnji Trenti. Nastal je na mestu starejšega podora (Orožen Adamič 1990, Rojšek 1991). Sprožilo se je okrog 300.000 m$^3$ gradiva (Pavšek 1996).

Nasproti prvemu pa se je kasneje sprožil podor Berebica oziroma podor nad domačijo Fačer (slika 17). Pri tem je do večjih odlomov prišlo kar dvakrat v zadnjih desetih letih (12. 12. 1993 in 27. 7. 1998) (Pavšek 1994, Zorn 2001). Podor ni ogrozil le domačije, pač pa je obakrat poškodoval tudi regionalno cesto Bovec-Kranjska Gora. Labilno pobočje je skoraj deset let ogrožalo cesto in voznike, preden so maja 2001 odprli 280 m dolgo cestno galerijo (Zorn 2001).

### 6.3.4 Veliki Mangart

Do dveh medijsko bolj odmevnih podorov je prišlo tudi v jugozahodni steni Velikega Mangarta (2679 m). Manjši je nastal (po različnih virih) 26. oziroma 27. 10. 1995, večji pa 29. 10. 1995 (Rojšek 1995, Hrvatin in Pavšek 1995, Pavšek 1996).

V drugih območjih slovenskega alpskega sveta je bilo v zadnjih letih v literaturi zabeleženih manj tovrstnih dogodkov. To ne pomeni, da jih ni bilo, a ker niso ogrozili človeka, so ostali večinoma neznani. Nanje spominjajo le rdečkaste ali rumenkaste lise na stenah gora (na primer v severni steni Velikega Draškega vrha).

Med večjimi podori v zadnjih letih na Gorenjskem je podor v Dovškem Gamsovcu (2440 m), ko se je 6. 8. 1995 porušil del zahodne stene (Golob in Hrvatin 1996). Ob potresu 12. 4. 1998 je prišlo tudi do odloma v dolini Radovne pri Klemenčku, kjer se je odlomilo nekaj 100 $m^3$ gradiva. 2. 11. 2001 je nastal manjši podor med Zadnjo Mojstrovko (2369 m) in Travnikom (2379 m) nad dolino Tamar. V začetku aprila 2002 pa je nastal še podor na zahodnem pobočju Velikega Zvoha (1971 m) nad Roblekovim kotom.

## 7 Sklep

Podori so v našem alpskem svetu stalnica. V članku smo jim sledili od pleistocena do danes skozi prazgodovinske, zgodovinske in recentne podore. Če bi posegli še globlje v zgodovino nastanka reliefa, bi nedvomno našli tudi ostanke fosilnih podorov iz starejših geoloških obdobij.

Kljub številnim dokazom, da podori preoblikujejo gorski relief, pa je vseeno nemogoče trditi, da je gorski relief posledica le podornih procesov. Gorski relief je namreč zapleten sistem. Njegov nastanek se da razložiti le s poligenetsko razlago razvoja reliefa, v kateri poledenitev, zakrasevanje ali druge oblike pobočnih procesov nimajo nič manjše vloge.

Podori v gorskem svetu nastajajo nenehno, a kje in kdaj se bo sprožil naslednji, ne moremo napovedati. Lahko zapišemo le splošno pravilo, ki velja v podorno ogroženih območjih gorskega sveta, »da se podori v kamnitem gorskem svetu lahko pojavijo kjerkoli in kadarkoli«.

Na podlagi določenih dejstev lahko določimo bolj ogrožena ali manj ogrožena območja. Opredelimo lahko le sedanje stanje, ne pa razmer, ki bodo nastopile v prihodnosti zaradi stalnega delovanja endogenih in eksogenih procesov, ko lahko danes stabilna pobočja postanejo nestabilna. Temu dejstvu se človek, ki živi v gorskih dolinah, ne bo mogel nikoli izogniti, zato je edina rešitev, da se z njim sprijazni oziroma se mu prilagodi. Naravnih nesreč velikih razsežnosti pač ne more preprečiti. Preostane le omejeno poseganje v gorski prostor tam, kjer lahko predvidimo podore. Žal pa je človeški spomin kratkotrajen, tako da se že čez nekaj let počutimo popolnoma varne na območjih, ki so jih še nedavno ogrožale naravne ujme.

V pleistocenu so bila pobočja z ledeniško erozijo dodatno preoblikovana. Na podorna dogajanja v času poledenitev nas opominja velika produkcija grušča, ki je posledica intenzivnega mehanskega preperevanja na nepoledenelih območjih, predvsem na vrhovih, ki jih niso pokrivali ledeniki.

Dober indikator podorov v pleistocenu so tudi balvani skupaj z veliko količino morenskega gradiva. Podrli so se na ledenik in bili sekundarno prestavljeni.

Po umiku ledenikov (v medledenih dobah ali konec pleistocena) so se začela podirati tudi pobočja, ki so bila prej pod ledom. Ledeniško brušenje je porušilo stabilnost pobočij. Ko se je led umaknil in so pobočja izgubila oporo, je prišlo do njihovega vsesplošnega rušenja. Sledove teh procesov v medledenih dobah so odstranili ledeniki mlajših ledenih dob.

V holocenu ni bilo tako intenzivnega podornega dogajanja, kot v pleistocenu. Res pa je, da je pleistocen trajal dva milijona let, holocen pa jih šteje komaj 12.000.

Kakorkoli že, tudi v najmlajšem geološkem obdobju Zemlje poznamo podore. Prazgodovinske dokazujemo s pomočjo posebnih datacijskih postopkov. O zgodovinskih pa pričajo številni viri (od pravih zgodovinskih virov do pripovedk, pesmi in legend). O obstoju sodobnih podorov se lahko prepričamo sami, če se odpravimo v visokogorski svet, kjer nas na vsakem koraku spremlja obilo grušča (od malih kosov kamnine do blokov večjih dimenzij) in obsežna melišča.

Poleg odloženega gradiva na podore v gorskem svetu opominjajo še konkavne stenske oblike. Opazovalcu dajo občutek, da v pobočju nekaj gradiva manjka. Mlajša odlomna mesta v apnencu ali dolomitu, ki v pretežni meri gradita slovenske gore, se od ostale stene ločijo še po »sveži« rumenkasti oziroma rdečkasti barvi, ki sta posledica preperevanja.

Posredno nas na podore v gorah opominja vse gruščnato-prodno gradivo, nakopičeno v dolinah in kotlinah. Tudi to gradivo je svojo pot do današnjega mesta pričelo z odlomom.

Na koncu še enkrat poudarjamo dejstvo, da je današnji gorski relief rezultat kompleksnega součinkovanja endogenih in eksogenih procesov, ki stalno delujejo na zemeljsko površje. Geomorfno dogajanje je nekaj stalnega, pa čeprav dostikrat poteka razmeroma počasi in zato skrito človeškim očem. Geomorfologi znajo brati znake, ki so zapisani v naravi in znajo geomorfne procese spremljati stalno. Teh procesov pa se v običajnem življenju zavemo šele, ko pride do večjega dogodka, ki uniči naselje (drobirski tok v Logu pod Mangartom, 17. 11. 2000) ali pa zasuje pomembno prometno povezavo (podor Berebica, 6.3.3). Taki »enkratni« dogodki dajejo ljudem napačno predstavo, da so nastali naenkrat in brez opozorila.

S člankom smo skušali opozoriti, da so podori le ena razvojna stopnja v dolgotrajnem geomorfnem spreminjanju površja.