DOLOMITE AREAS IN SLOVENIA WITH PARTICULAR CONSIDERATION OF RELIEF AND LAND USE

DOLOMITNE POKRAJINE V SLOVENIJI S POSEBNIM OZIROM NA RELIEF IN RABO TAL

Matej Gabrovec

Dolomite slope dissected by dells at Selo in the Polhov Gradec mountains (photography M. Gabrovec).
Dolomitno pobočje, razčlenjeno z dolci, v Selu v Polhograjskem hribovju (fotografija M. Gabrovec).

Abstract UDC: 911.5:552.54(497.12)

Dolomite Areas in Slovenia with Particular Consideration of Relief and Land Use

More than one tenth of Slovenia is situated on dolomite. It is characterized by a special sort of fluviokarst form, and we have divided it into four basic types according to relief. The largest part of the article is devoted to an analysis of land use in dolomite areas. We determined land use by means of cadastral data and the *Agrokarta* ("Agricultural Map"), and in three test areas we also utilized the Emperor Francis' cadaster (1823) to determine changes in land use over the last two centuries. In comparison with areas situated on other rock, an above-average proportion of meadows and overgrown surfaces is characteristic of dolomite areas.

Izvleček UDC: 911.5:552.54(497.12)

Dolomitne pokrajine v Sloveniji s posebnim ozirom na relief in rabo tal

Dobra desetina slovenskega državnega ozemlja je zgrajena iz dolomita. Zanj je značilna posebna vrsta fluviokrasa, glede na relief pa smo ga razdelili v štiri osnovne tipe. Največji del članka je posvečen analizi rabi tal v dolomitnih pokrajinah. Rabo tal smo ugotavljali s pomočjo katastrskih podatkov in agrokarte, na treh izbranih testnih območjih pa smo uporabili tudi franciscejski kataster in tako ugotavljali spremembe rabe tal v zadnjih dveh stoletjih. Za dolomitne pokrajine je v primerjavi z območji na drugih kamninah značilen nadpovprečen delež travnikov in zaraščojočih se površin.

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1. Introduction

A large part of Slovenia is covered by dolomite rock, and specific relief forms appear here which have not previously been studied systematically. Land use is linked to the relief base in a special way. In general, we notice that dolomite slopes were used much more intensively in the past than they are today. The core of the article is devoted to the analysis of land use in dolomite areas. The first part contains a brief survey of the distribution of dolomite and a description of the basic types of dolomite relief.
The primary aim of this paper was to determine the links between relief and land use. I was able to achieve this aim only by creating a geographical information system. Dolomite areas were digitalized from all the basic 1 : 100,000 scale geological maps, a 100 × 100 meter digital relief model and the Register of Spatial Units (Lipej 1990) were used and finally cadastral data on land use were added. In addition, for the test areas maps of land use in the Emperor Francis' cadaster and the *Agrokarta* were digitalized and a more detailed digital relief model was made by means of digitalizing isohips.
The dolomite areas of Slovenia have not been studied systematically by geographers before. A few survey studies were done by geologists, but unfortunately these studies were never published (Lukacs 1965, Ogorelec 1977, 1978, 1979, 1980, 1980 a). On the occasion of 200th anniversary of Dolomieu, the first to describe dolomite, sedimentologists published an anthology in which numerous authors discussed the characteristics of dolomite and dolomitization (Purser, Tucker, Zenger 1994). In Slovenia, geomorphologists only wrote about the relief forms of dolomite in the context of general geomorphological discussions, for example Gams (1968) and Habič (1968), or studied dolomite relief in a very narrow and limited area, for example Kunaver (1991). The numerous Slovene geographical discussions of land use do not explicitly reveal its links with the bedrock. This article is a section from the author's doctoral thesis, the first attempt at a clearer presentation of dolomite areas in Slovenia (Gabrovec 1994).

2. Distribution of Dolomite Rock in Slovenia

The main source for this survey chapter is the basic 1 : 100.000 scale geological map. Unfortunately, the various authors of individual maps appear to have different opinions on the age of individual rock and different markings of lithological borders. Because I was limited to this single cartographical source, this survey as well can be neither too accurate or too exact. In some disputable cases, where individual geological maps were not in accordance with one another, I made smaller corrections suggested by Dr. Buser. In certain cases I depended on the latest survey 1 : 500,000 scale map of Slovenia published by the Geodetic Institute of Slovenia in 1990.
All the Slovene dolomite areas were digitalized from the basic geological 1 : 100,000 scale maps using the IDRISI and ROOTS programs. I combined the different dolomites into nine groups. On the basis of the geological maps, only a chronological division was possible. Thus from the oldest to the youngest Permian, Scythian, Anisian, Cordevolian, Upper Carnian, Rhaetian-Norian, Bača, Jurassic, and Cretaceous dolomite succeed one another. For the needs of such a study, chronological division is far from ideal; however, one type of dolomite is characteristic of each geological period.
When the digitalization of individual maps was concluded, I compared each map with the adjacent maps and attempted to harmonize them to the greatest possible extent. In the final phase I combined databases in vector form for individual maps into one database for all of Slovenia. This database was transformed by means of the IDRISI computer program into a raster form with a cell size of 100 × 100 m. This final rastered database was the basis for all the following analysis in this work.
In Slovenia, dolomite rock covers a surface area of approximately 2500 km^2, some 12% of the territory of the Republic of Slovenia. This surface area does not include dolomite that alternates with limestone and is not specifically outlined on the geological maps. Gams (1983) ascertained a somewhat larger proportion of dolomite in Slovenia, some 14.4%. The difference is not essential as it occurs in regions where dolomite and limestone alternate frequently over a short distance and an exact division is not possible. Additionally, a difference occurs because of the necessary generalization in cases when we employ maps of smaller scale as a source.

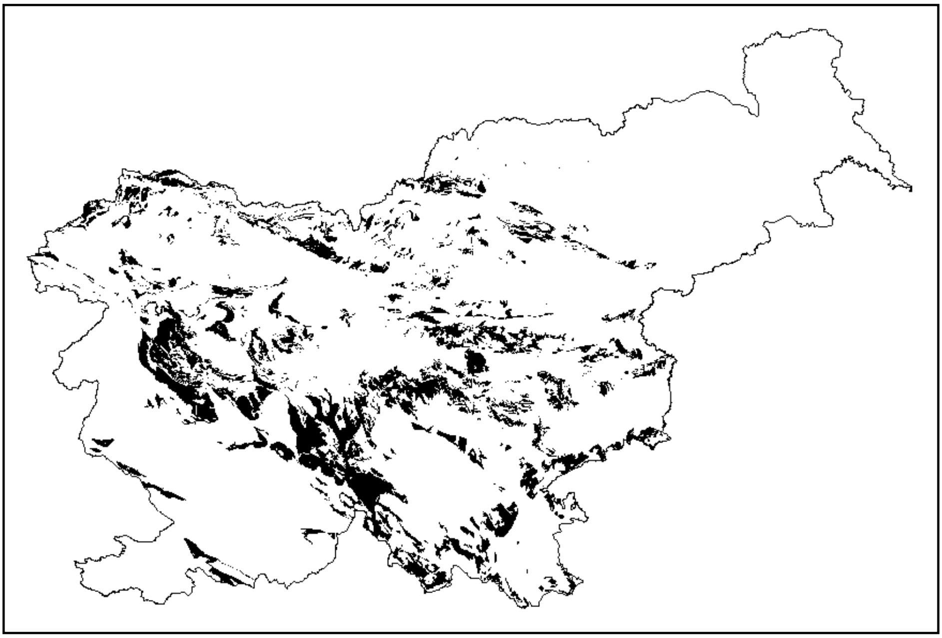

Figure 1: Dolomite areas in Slovenia.

TABLE 1: DISTRIBUTION OF DOLOMITE IN SLOVENIA.

Type of dolomite	Area in km^2	Proportion among dolomite in %	Proportion of area of Slovenia in %
Permian	14	1	0
Scythian	35	1	0
Anisian	306	12	2
Cordevolian	498	20	2
Upper Carnian	36	1	0
Rhaetian-Norian	1146	46	6
Bača	130	5	1
Jurassic	252	10	1
Cretaceous	82	3	0
Total	2499	100	12

The table above shows us the distribution of individual types of dolomite in Slovenia. Upper Triassic Rhaetian-Norian dolomite dominates. Its characteristic is stratification and it appears mostly in the Dinaric regions of southwestern Slovenia. In the alpine and subalpine regions, Anisian and Cordevolian dolomite are more widespread, and massiveness is characteristic of them in great measure. The oldest Permian and Scythian dolomite alternate over short distances with other rock and only rarely cover larger cohesive surfaces.

Upper Carnian stratified dolomite with insertions of mudstone appears to a large extent only in the Idrija–Cerklje highlands of western Slovenia. Stratified Bača dolomite with quartz is typical primarily of western Slovenia where it appears on the southern edge of the Julian Alps. Jurassic dolomite frequently alternates with limestone over short distances and in general is rather bituminous, on average has a smaller proportion of magnesium, and can be found mostly in southern Slovenia. Cretaceous dolomite is also only found in southern Slovenia, while in large cohesive stretches it is only found in the Kras region. (Lukacs 1965, Buser 1986, Pleničar 1970).

In the natural geographical divisions of Slovenia, the proportion of dolomite is quite different. The largest, 20%, is found in the Dinaric karst, 15% is found in the alpine and subalpine highlands, and only 5% occurs in subpannonian and littoral Slovenia.

3. Types of Dolomite Relief in Slovenia

From reading the previous chapter on the distribution of dolomite areas according to individual natural geographical regions of Slovenia, it is obvious that different types of dolomite relief recur to which characteristic land use is linked. Very roughly, all the dolomite areas can be divided into four principal types:

1. brittle walls and slopes in the high mountains,
2. steep slopes dissected by erosion gullies,
3. gentle slopes dissected by dells
4. plateaus with shallow sinkholes.

With some simplifications, I mapped these four types of relief with the help of a geographical information system in which I included the digital relief model, dolomite areas, and natural geographical regions of Slovenia. The borders of the areas are simplified, and in each area other forms may occur along with the one specified. The map presents only survey information, and a more detailed typification would demand more intensive field work across the whole country. Below I describe briefly the characteristics of individual types of dolomite relief and the areas of their occurrence.

3.1. Brittle Walls and Slopes in the High Mountains

In this first type, which comprises 20 km^2, I classified all the dolomite areas in the Julian Alps and the Kamniške and Savinjske Alps. Dolomite walls differ from limestone walls by their greater degree of brittleness, a consequence of which is the extensive scree below them. However, in the high moun-

Figure 2: Dolomite relief – type 1.

tains above the tree line there is little dolomite, and the highest peaks in the central part of both mountain ranges are composed of limestone. A larger quantity of rubble also appears on dolomitized limestone (Šifrer 1963). There are more dolomite areas at lower elevations (the Mala Pišnica valley, Kot, etc.) where the slopes, in Slovene called pečevnate drti (Senegačnik 1980), appear. These are very brittle slopes with numerous torrent ravines. The less dissected and gentler slopes in the Karavanke Mountains could be classified into this type only in individual smaller areas, and for simplification I classified them as a whole in the subsequent type.

3.2. Steep Slopes Dissected by Erosion Gullies

In this group, I classified all dolomite slopes with a gradient greater than 32°. These steepest slopes are usually dissected by numerous erosion gullies often starting at the end of a dell in the upper part of a gentle slope. Rocky outcroppings appear frequently on these slopes, a good example being Iški vintgar. It is typical that numerous Slovene gorges were carved out in dolomite, for example, the valley of the Sava River below Trbovlje, Iški vintgar, Pekel near Borovnica, part of the valley of the Kokra River, the Učja River, the Nadiža River near Robič, etc. They are characteristic primarily of the Karavanke Mountains and subalpine highlands while in the Dinaric region, the most typical examples are Iški vintgar and the slopes above the Kolpa River. To this group also belong the so-called "melci" (Badjura 1953, 157) which are steep, poorly overgrown slopes with numerous erosion gullies in the weathered dolomite. Examples are the Grmada and Tošč peaks in the Polhov Gradec range, the Zasavje Sveta gora and Ostrež, etc. This type of dolomite relief comprises 23 km^2 in Slovenia or a little less than a tenth of all dolomite areas.

3.3. Gentler Slopes Dissected by Dells

Dells are "shallow, several meter deep open dry little valleys, usually oriented in the direction of the greatest gradient of the slope" (Slovene Karst Terminology 1973, 5) and are the most frequently found

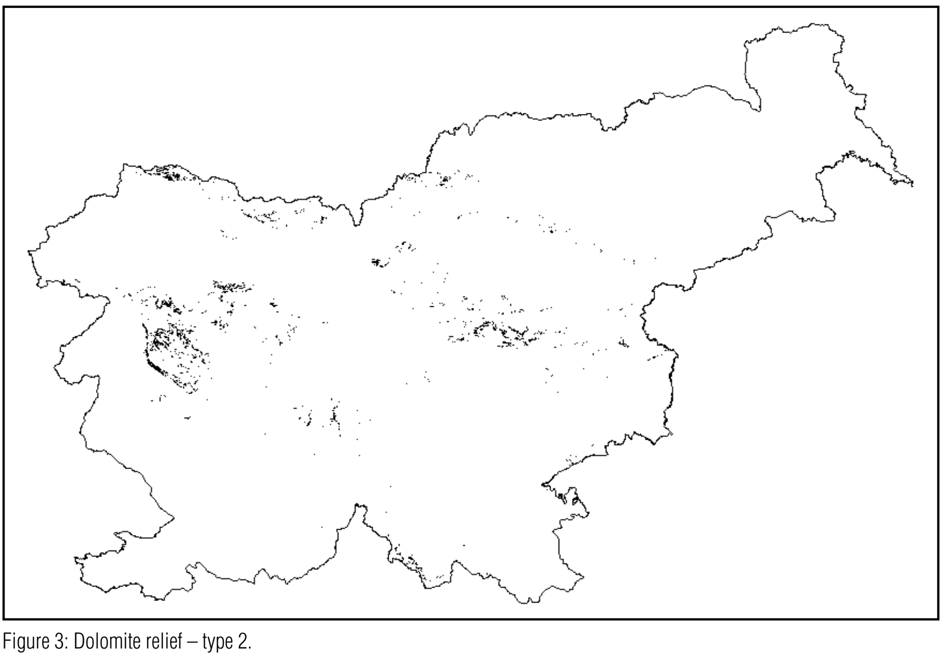

Figure 3: Dolomite relief – type 2.

relief forms on dolomite. They occur on both gentle and steeper slopes. In Selo near Polhov Gradec they appear, for example, on slopes with a gradient of 25 degrees. Such relief occurs everywhere in the subalpine world where the slopes are not too steep. In the Dinaric world, the sinkhole dolomite world is interwoven with smooth slopes and slopes dissected by dells. A typical example of such interweaving is the area around Kurešček which is analyzed in detail below. On all detailed geomorphological maps showing the individual dolomite areas in Slovenia (Gams 1968, Mihevc 1986, Gams, Natek 1981), the great density of dells is clearly evident. This type of dolomite relief in Slovenia is the most frequent and covers 177 km^2.

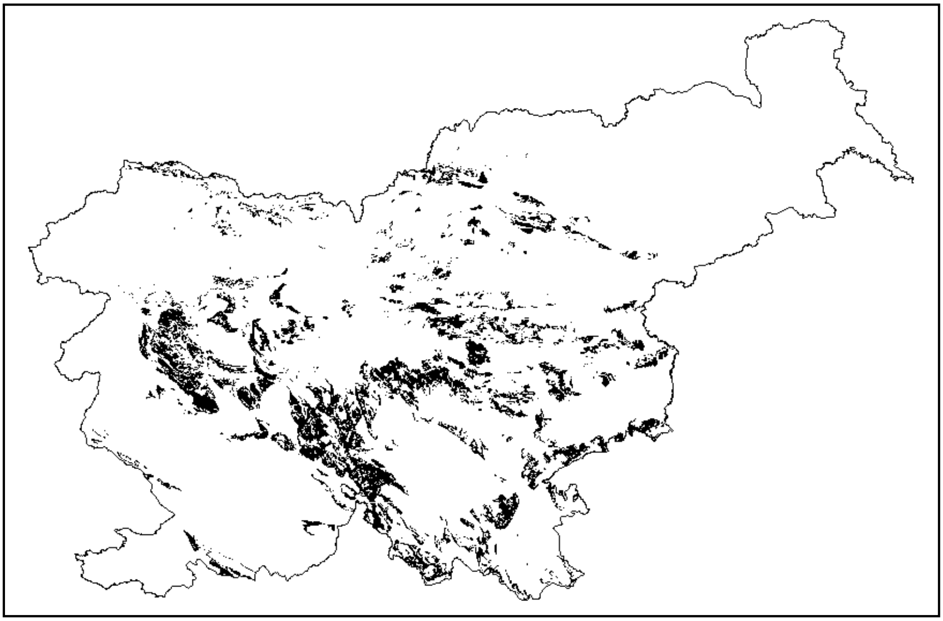

Figure 4: Dolomite relief – type 3.

3.4. Plateaus with Shallow Sinkholes

Sinkholes in dolomite appear on the plateaus of the southern Dinaric part of Slovenia. Sinkholes can be found in the areas composed of Rhaetian-Norian, Jurassic, or Cretaceous dolomite but not in areas of Anisian or Cordevolian dolomite. Sinkholes appear where there is a larger or smaller proportion of $CaCO_3$ in the dolomite and we therefore have limestone dolomite or even dolomitized limestone. The other condition for the appearance of sinkholes is a level plateau area. Such conditions are fulfilled only in south Slovenia on an area of about 35 km^2.

4. Land Use in Dolomite Areas

In this central chapter, I will try to establish two things for the entire territory of Slovenia. Firstly, I will show whether land use in dolomite areas differs essentially from that in areas of other rock. Secondly, I will try to determine whether the processes of the change in land use such as greening and forestation in dolomite areas are as intensive as elsewhere. Field observations, cartographic sources, and literature show that land use on dolomite areas is in many places considerably different than on nondolomite environments. However, these differences in the various Slovene macroregions are reflected in different ways. In the subpannonian world, dolomite areas are more forested than the surrounding

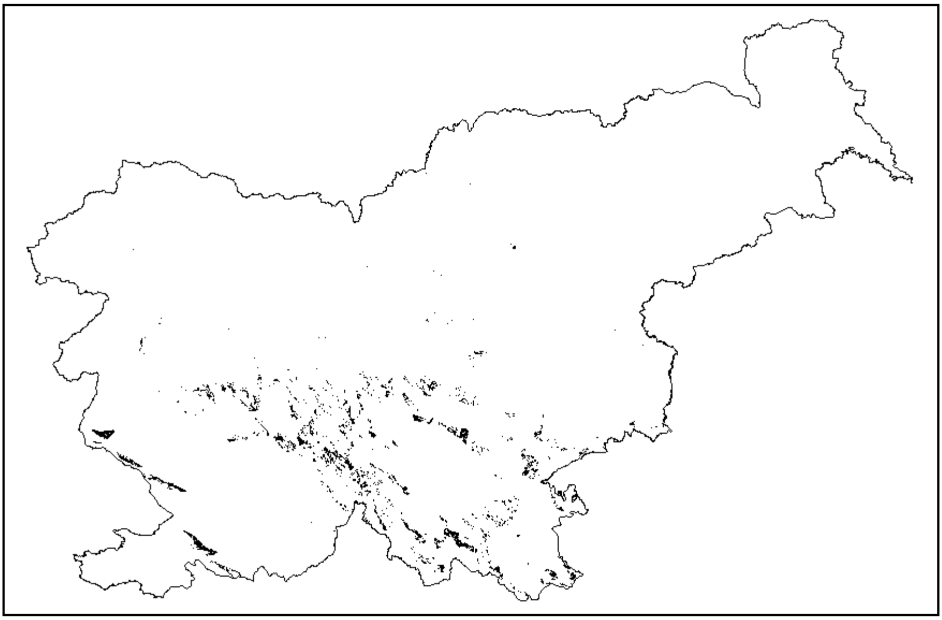

Figure 5: Dolomite relief – type 4.

highlands which are composed of Tertiary rock, while in the Dinaric world dolomite areas stand out for their meadow use while the limestone environment is more forested. In some cases, the averages for all of Slovenia can therefore tell us much less than the averages for individual natural geographical macroregions. In continuing I will therefore consider most of the studies on two levels, first for the entire country and then separately for the subalpine, Dinaric, and subpannonian regions.

Unfortunately, data on the use of land is only available at the level of cadastral districts. These, however, are only rarely homogenous rock areas since cadastral districts include the territory of one or more villages with their associated farm land, and the villages are frequently situated on lithological borders. For all calculations I therefore applied the principle of a two-third majority and only considered cadastral districts where one type of rock composed two thirds of their area. As in the tables in the previous chapter, we divided the rock into three groups, distinguishing only dolomite, limestone, and other (largely noncalcareous) rock. I eliminated from the study those cadastral districts situated mostly on plains or on less diverse highlands. These are districts that have mostly clastic sediments (scree, sand, clay, loam). Only hilly and mountainous areas remained in the analysis, while the plains that have completely different characteristics according to land use were eliminated. The differences in the rock composition are consequently better expressed in the following analysis.

Data on land use according to cadastral districts is not available either in digitalized form or in one place for the entire country. Collecting this data from regional geodetic offices and entering it would be too time-consuming and I therefore depended on data already arranged in digital form for individual periods previously used in various studies. I had data from the years 1953, 1961, 1971, and 1979 (Kladnik 1985) at my disposal from the Ljubljana Institute of Geography and from 1987 which I obtained from the Agricultural Institute of Slovenia.

4.1. Methodology

All the studies were done with the help of a geographical information system, and the basic tool for creating this system and processing data was the IDRISI computer program (Eastman 1992). This is a rastered geographical information system, and the cell size used for all the processing was 100 × 100 m. Digitalized borders of cadastral districts are a constituent part of the Register of Spatial Units which is the property of the Surveying and Mapping Authority of the Republic of Slovenia. We rasterized the borders of cadastral districts that we received in vector form with the help of IDRISI. In this way we were able to link the digital relief model and the lithological data. After this phase of the work, a precise location was defined for every cadastral district, making possible the calculation of average slopes, altitudes, and the proportion of territory of various rock for each cadastral district.

The data on land use presented a major problem. By applying logical checks, I discovered errors in the data I received on diskettes from the Ljubljana Institute of Geography for almost two hundred of the cadastral districts (the sum of individual types of land use was not equal to the surface area of a cadastral district). The mistakes on the diskettes obviously occurred during the transfer of data between various computer systems or possibly the latest corrected version had not been saved. However, since the data in the table in the appendix of the elaboration was accurate everywhere, it was possible to correct these errors. Another problem were the cadastral districts that had had their ciphers changed after 1979. This happened in cases where the territory of a cadastral district was cut by the border of an administrative district. In the material from the Institute of Geography, both parts of the cadastral district had the same cipher and only the cipher of the administrative district was different, while in today's coding these administrative districts have ciphers between 2653 and 2714. For these cadastral districts, it was necessary to unite the old ciphers and the data bases with the help of the 1 : 250.000 scale survey maps of the cadastral districts of Slovenia. In addition, at the Ljubljana Institute of Geography, the data of two or more cadastral districts was summed up and handled under the cipher of one of the previous cadastral districts in cases when the borders between cadastral districts had changed and comparison between different years was no longer possible. In this way, they united 127 cadastral districts into 36 regions where there were 14 cadastral districts at the most. Because in the material, these united regions preserved the cipher of only one of the constituent districts, it was not possible to immediately separate the cases of individual cadastral districts from the areas with larger cadastral districts. It was possible to identify these cases only by comparing the surface areas of the entire cadastral districts in this database, the Register of Spatial Units, and the 1987 database from the Agricultural Institute. In the final phase I harmonized all the data bases in such a way that under the same cipher the same cadastral districts (or a sum of the larger cadastral districts) are to be found that had approximately the same surface area in both 1953 and 1987 (smaller differences appeared because of new surveys of association and the like). However, some cadastral districts were left for which it was not possible to establish exact data for either year. Because searching the archive data for these districts would be too time-consuming and since their proportion of the entire country's surface area could not significantly influence the final results, I used data for these cadastral districts from the closest year for which it was available. These cases are described in the following paragraph.

For 1987, data for the Moravci cadastral district in the district of Ljutomer and for the administrative district of Radlje was missing. In both cases I used data from 1979. Data for all the cadastral districts was available for 1953, but in some cases logical checks (comparison of the entire surface area of the cadastral districts between 1953 and 1987) showed very large differences in the total surface areas. In these cases, it was usually a matter of major changes to the borders of cadastral districts between 1953 and 1961. Since due to territorial changes in the treated period in these cases the results of analysis would not be realistic, I exceptionally used the data from 1961 for these cadastral districts. There are four such examples, namely Ulaka on the Bloke plateau, Borovnica near Ljubljana, Otalež near Cerkno, and Idrijski Log.

A second problem was presented by cadastral districts whose borders were changed in the 1980's. In such cases I employed the same method used in Kladnik's study (Kladnik 1985). I thus united several cadastral districts into larger regions which had the same boundaries in both treated years. This method is not exactly the best because it reduces the number of treated units and increases their size; however, we used it for two reasons. In this way, the data was linked with the database at the Institute of Geography that we used, and therefore it would have made no sense to use several different methods in the same study to solve the same problem. And secondly, this is the only possible method without repeatedly going through the basic data scattered in the regional geodetic offices. Thus, I combined 40 cadastral districts into 9 regions. In northeastern Slovenia the following cadastral districts were united: Gornja Radgona, Spodnji Gris, Mele, Črešnjevci, Police and Hercegovščak; in the Kočevje region: Kumrova vas, Brezje, Koprivnik, Nemška Loka and Knežja Lipa, and Smuka, Rog, Mala Gora, Koblarji, Stara Cerkev, Kočevje, Željne, Rajhenav, Livold and Koče; in Ljubljana: Karlovško predmestje, Prule, and Golovec; in Primorska: Zazid and Podpeč; near Brežice: Cerklje, and Drnovo; near Maribor: Mali Rošpoh and Morski Jarek; in the Idrija–Cerklje highlands: Srednja Kanomlja, Čekovnik, Idrija mesto, and Jelični Vrh.

4.2. Changes in Land Use across Slovenia

Cadastral districts are often naturally heterogeneous. The consequence of this is that 680 cadastral districts comprising 6653 km^2, almost a third of Slovene territory, are situated on heterogeneous rock. In these districts, none of the rock or groups of rock covers the two thirds of the area. In using cadastral data, this third of the territory is lost to our analysis. 3604 km^2 or 18% of Slovenia is covered by cadastral districts lying outside the hilly world in the plains or on less dissected highlands where scree, sand, clay, or loam dominate. For the analysis, therefore, only 9972 km^2 or less than half of Slovene territory is left. This is still a large enough territory for us to expect representative results.
In the territories treated I will compare land use on dolomite, limestone, and the remaining rock. Among the latter belong various metamorphic and volcanic rock as well as sedimentary flysch, marl, sandstone, conglomerate, and mudstone. There are 62 cadastral districts with dominating dolomite with a total surface area of 545 km^2, of which 434 km^2 is on dolomite. This surface area unfortunately represents only good 17% of all dolomite surface areas in Slovenia as the majority of dolomite is found in cadastral districts where other rock dominates. Limestone comprises at least two thirds of the surface area in 341 cadastral districts Of their total surface area of 4844 km^2, limestone comprises 4172 km^2 or 71%. This last proportion shows us that limestone occurs in essentially larger cohesive surface areas than dolomite. Other rock dominates in hilly sections of 749 cadastral districts, comprising 4135 km^2 of the entire surface area of 4583 km^2.

TABLE 2: PROPORTION OF INDIVIDUAL TYPES OF LAND USE IN 1953 AND 1987 IN % AND INDEXES OF CHANGE OF LAND USE BETWEEN 1953 AND 1987 ON DIFFERENT ROCK.

		Dolomite	Limestone	Other
Fields	1953	10	9	15
	1987	8	7	11
	Index	79	73	72
Meadows	1953	26	16	16
	1987	25	15	18
	Index	95	98	116
Pastures	1953	15	22	13
	1987	11	16	9
	Index	70	75	67
Forests	1953	45	44	47
	1987	53	49	52
	Index	117	111	111

From the table above we can quickly see that land use on dolomite differs essentially in some features from that on limestone or other rock. The proportion of fields on dolomite is only a little larger than that on limestone. Regarding the proportion of fields, the essential difference is only between dolomite and limestone on the one hand and other rock on the other. The most significant differences in all land uses on dolomite areas occur with meadows. The proportion of meadows on dolomite is ten percent higher than the proportion on limestone and other rock. There are fewer meadows on limestone due to the greater stoniness that does not facilitate mowing; therefore, there is a sub-

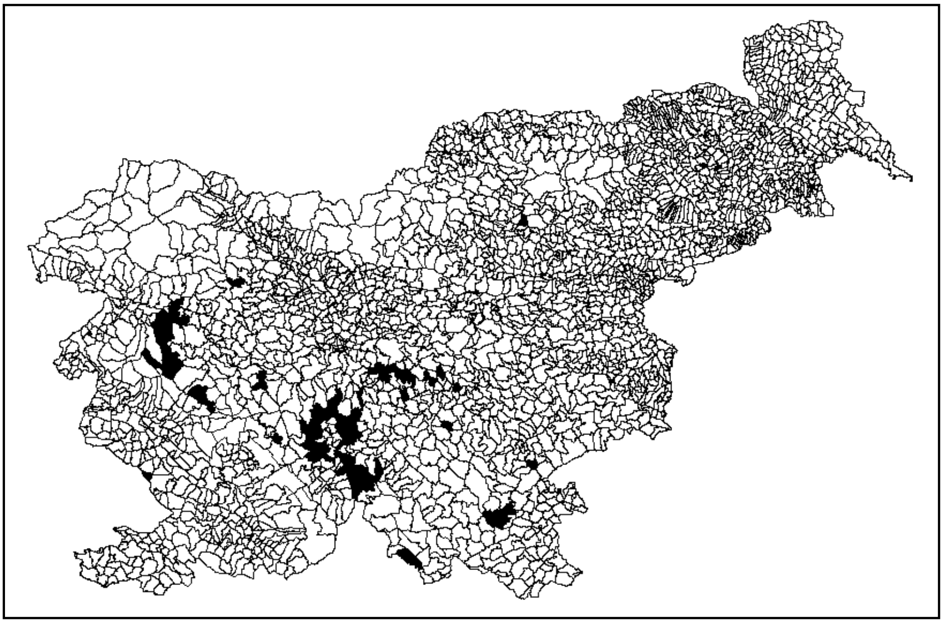

Figure 6: Cadastral districts where dolomite dominates.

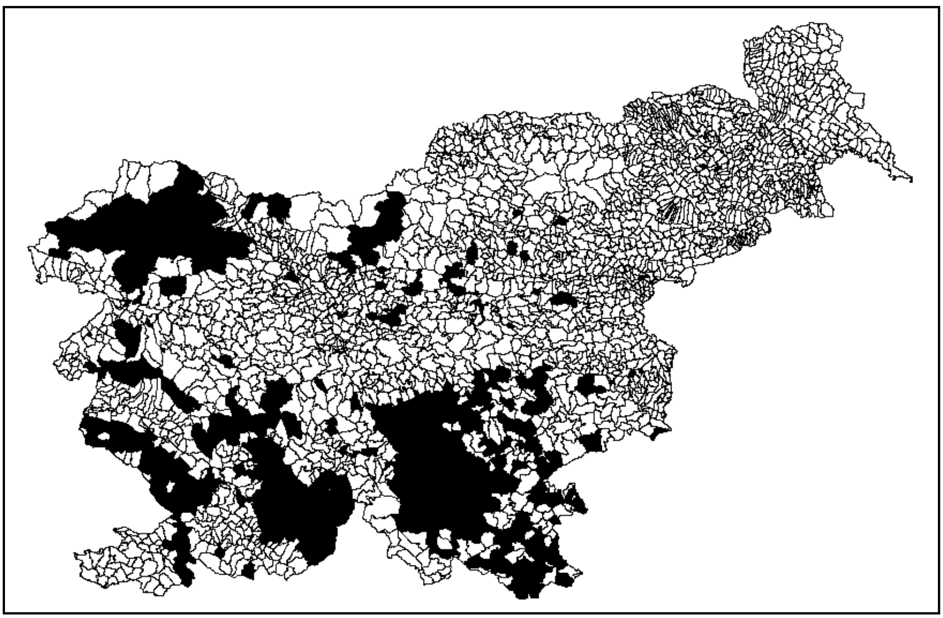

Figure 7: Cadastral districts where limestone dominates.

stantially larger proportion of pasture. On other rock, the smaller proportion of meadows is conditioned by the larger proportion of fields and other cultivated areas (vineyards, orchards). Because very steep meadows less suitable for machine mowing are characteristic on dolomite, the greatest decrease in meadow surfaces is characteristic here. The proportion of meadows here has decreased in spite of the fact that the meadow area on the other hand has increased due to the greening of fields. Therefore, the largest overgrowing of meadow surfaces appears on dolomite, a situation also reflected in the largest increase of forest area between 1953 and 1987. For pastures, the situation is just the opposite as it is for meadows. The largest proportion of pasture land is on limestone because a different type of land use is simply not possible here due to its karst character.

4.3. Land Use on Dolomite Areas in the Subalpine Highlands

I assume that land use on dolomite in Slovenia varies according to individual macroregions. The differences arise primarily from the fact that the surroundings of the dolomite world are different. Dolomite areas are intensively exploited if conditions in the surrounding area are poorer for agriculture and vice versa. For this reason I will show in the same way the land use on different rock in the subalpine world, in the Dinaric karst, and in subpannonian Slovenia.

TABLE 3: PROPORTIONS OF INDIVIDUAL TYPES OF LAND USE IN 1953 AND IN 1987 IN % AND INDEXES OF CHANGE IN LAND USE BETWEEN 1953 AND 1987 ON DIFFERENT ROCK.

		Dolomite	Limestone	Other
Fields	1953	9	16	13
	1987	6	12	9
	Index	66	73	68
Meadows	1953	21	11	14
	1987	21	14	15
	Index	99	124	111
Pastures	1953	18	10	12
	1987	13	8	7
	Index	71	80	63
Forests	1953	48	56	56
	1987	57	59	62
	Index	118	105	111

In analyzing land use in the subalpine highlands, I considered all the cadastral districts whose larger part, at least two thirds, lies in the subalpine highlands. There are 703 such cadastral districts in Slovenia. The great rock diversity of the subalpine highlands is seen in the fact that in some 264 districts, no rock has a two-thirds majority. Dolomite dominates in 19 cadastral districts, limestone in 39, 51 cadastral districts lie on alluvial deposits in the valleys of the subalpine highlands, and other rock dominates in 330 cadastral districts. The subalpine highlands are considered in the broader sense of the word, and transition landscapes (the Celje basin, the Boč–Macelj highlands, the Senovo lowlands, the Mirna valley, the Rovte highlands, and the Lower Soča valley with the Kambreško area) are also included in this analysis.

Comparing Table 3 with Table 2, which deals with the whole of Slovenia, we can observe some essential differences. In dolomite areas we see that the intensity of land use in the subalpine highlands is lower than the intensity for the whole of Slovenia. Thus, the proportion of fields and meadows is smaller than for the entire country, and the proportion of pastures and forests, on the other hand, is greater. This can be explained by the previously mentioned fact that in the subalpine highlands dolomite areas are usually surrounded by areas of impermeable rock which are more suitable for agricultural than dolomite. In addition, dolomite areas in the subalpine highlands are steeper than in the Dinaric world. But the basic characteristic of land use on dolomite remains the above-average proportion of meadow and the above-average increase of forest areas. Most outstanding intensive agricultural use of land in the subalpine highlands is on limestone. This can be explained by the fact that sinkholes usually do not occur on slopes or are at least rare. In contrast to the Dinaric karst region, there is little level plateau world in the subalpine highlands. Exceptions are only the smaller karst plateaus in Zasavje, for example, the Šentlambert plateau above Zagorje. Thus in the subalpine highlands, characteristic karst relief is not developed on limestone. This also means that in limestone areas, there are no especially limiting factors for agriculture. The final consequence of all this is also that in the subalpine highlands, dolomite areas are the least used for fields.

4.4. Land Use on Dolomite Areas of Subpannonian Slovenia

In subpannonian Slovenia, dolomite nowhere comprises larger cohesive surfaces. In subpannonian Slovenia in the narrow sense without transitional landscapes, it never reaches two thirds of the surface area in any cadastral district. It appears only in the Kozjansko highlands, in Bizeljsko, and in the Krško highlands. It is typical especially of the Kozjansko highlands and Bizeljsko that the slopes are much steeper on dolomite than on the surrounding Tertiary highlands and therefore here, in contrast with the surrounding area, forest dominates. A different situation is found in the Krško highlands. Here, calcareous rock dominates and land use depends more on the relief and exposure to the sun than on the lithological foundation.

In the transitional subpannonian-Dinaric world, dolomite dominates in only one cadastral district. This is Težka Voda to the south of Novo mesto, where there is good 77% of dolomite. However, we cannot make serious comparisons on the basis of data from one cadastral district.

4.5. Land Use in the Dinaric Karst Region of Continental Slovenia

In analyzing the Dinaric karst, I only considered this macroregion in the strict sense of the word, therefore only the so-called Lower and Upper Karst regions. It is understandable that in the region of Dinaric karst limestone and dolomite dominate and other rock appears in a more cohesive extent only in the Pivka Basin, in the Velike Lašče region, and in the Kostel region. Thus, impermeable rock dominates in the entire macroregion only in five cadastral districts, that is, in Fara on Kolpa, Kanalski Vrh on the Banjščice plateau, Landol, Zagon, and in Velika Brda in the Pivka Basin. The average data for land use on impermeable rock is therefore not representative.

TABLE 4: PROPORTIONS OF INDIVIDUAL LAND USE IN 1953 AND 1987 IN % AND INDEXES OF CHANGES IN LAND USE BETWEEN 1953 AND 1987 ON DIFFERENT ROCK IN THE DINARIC KARST REGION OF CONTINENTAL SLOVENIA.

		Dolomite	Limestone	Other
Fields	1953	10	9	13
	1987	8	7	7
	Index	87	73	52
Meadows	1953	29	18	45
	1987	27	17	50
	Index	92	92	109
Pastures	1953	13	20	12
	1987	9	12	4
	Index	71	64	33
Forests	1953	44	50	24
	1987	52	53	31
	Index	117	107	132

As mentioned above, the data in the last column is untypical because of the small number of cadastral districts considered. The large proportion of meadow is a consequence of favourable conditions in the slightly undulating Pivka valley, while the large increase in forests originates from the overgrowing of the Banjščice plateau in the Kanalski Vrh cadastral district.
According to land use on dolomite and limestone, the table above strongly resembles Table 2 presenting the whole of Slovenia. It is clearly evident that in agricultural areas meadows dominate on dolomite and pastures on limestone. In field areas there are no essential differences between dolomite and limestone. However, the strong overgrowth of dolomite areas is shown in a high index for forests.

4.6. Determining Land Use by Means of The *Agrokarta*

With the help of cadastral data it was possible to establish the main characteristics of land use according to individual natural and geographical macroregions. However, cadastral data has some fundamental shortcomings. The data in the cadastral records is obsolete because the landowners do not regularly report changes in land use. In addition, one third of the cadastral districts are lithologically heterogeneous and therefore cannot be used for analysis of land use according to different rock.
Data collected in the framework of the *Agrokarta* project overcomes these shortcomings. "The *Agrokarta* provides a professional basis for the preparation of plans and other important documents for agriculture in which the productivity of agricultural land, other important assets for agricultural, and possible long-term orientation of agricultural land use in the district are determined" (Germek et al. 1987). In 1987 and partly in the following years, 1 : 5000 scale maps were created. The source of data for these maps was photographs from a three-year-cycle of aerial photography in the period 1985 to 1987. Surface areas of individual types of land use were planimetered. The smallest territorial unit for which data on land use is gathered in the table and partly available in digital form, is the so-called "estimation unit." "As a rule, this is a region of like categories of agricultural land, and if major differences occur in the productivity within a category, it must be separately marked." For each estimation unit in the tables, the cipher of cadastral district, the category of agricultural land, the pedosequence, and the areas of individual land use are stated singly by state and private ownership (Germek et al. 1987). Data on pedosequence (a "genetic series of soil on the same or similar bedrock") enables us to calculate land use on different rock foundations inside the cadastral district. Unfortunately, dolomite and limestone belong in the framework of the same pedosequence on "hard calcareous rock." However, we can establish land use on dolomite in cadastral districts where in addition to dolomite, other rock appears among which there is no limestone.
Because the category of land among other things is defined by gradient, with the help of this data we can separate more or less steep slopes on territory of the same rock. In this way I separately showed land use in the fifth and sixth categories where by definition cultivation is not possible due to the unsuitable relief but where the use of mowing machines is still partly possible and the gradient exceeds 20%. As a contrast, land use is shown in the first three categories that are still suitable for field use (Stritar 1974).
However, the *Agrokarta* has its weaknesses. The first is that in the framework of this project, only agricultural land is tabled, without forests. We cannot therefore calculate proportions of land use for the entire surface area of a cadastral district or natural region but only according to the surface area of all the agricultural land in a cadastral district or region. A second problem is that different categories are used than in the cadasters. Itemized in the tables are fields, grassland, permanent plantations, overgrown land, agricultural land temporarily out of agricultural use, and other agricultural land, and undeveloped building land. Overgrown land is separated into regions of more or less intensive growth. The regions of more intensive growth actually represent forests that were included in the category of agricultural land. Among other agricultural land, the estimators classified surface areas that were defined as grassland on the basis of the photographs but were actually reedy areas or ponds.
Given the limited amount of data available in digital form, I will elaborate one example each from the subalpine highlands and the Dinaric world. The example from the subalpine highlands will be the former district of Idrija (today the districts of Idrija and Cerkno) and from the Dinaric world,

the district of Cerknica (today the districts of Cerknica and Loška dolina). Both districts are characterized by an above-average proportion of dolomite. In all the following tables, the proportions are calculated according to the total agricultural surface area, which in both cases is the sum of surface areas of fields, grassland, permanent plantations, and less intensively overgrown agricultural land. Because the land of more intensive overgrowth is actually forest, it is not reasonable to separate it from the rest of the forests and classify it as agricultural land. In the tables, I counted as dolomite areas all those evaluation units which according to the *Agrokarta* are on solid calcareous rock and simultaneously lie in cadastral districts where dolomite covers two thirds of the surface area or occurs at least twice as much as limestone. Limestone areas were defined in the same manner. The remaining evaluation units on solid calcareous ground were excluded from the study. For comparison, land use on pedosequences on soft calcareous and noncalcareous rock is given in the tables.

4.6.1. Land Use in the Idrija District

The Idrija district includes the Idrija–Cerklje highlands to a great extent. These highlands are one of the geographical regions with the largest proportion of dolomite which comprises some 48% of the entire surface area.

TABLE 5: LAND USE IN THE IDRIJA DISTRICT (PROPORTION OF ALL AGRICULTURAL AREAS, SOURCE *AGROKARTA*).

	Type of Rock			
	Dolomite	Limestone	Soft calcareous	Noncalcareous
Fields	4	2	5	6
Grassland	89	94	90	92
Overgrown	7	3	5	1
1st–3rd cat.				
Fields	7	4	10	10
Grassland	90	93	88	89
Overgrown	2	2	1	0
5th–6th cat.				
Fields	2	1	1	3
Grassland	88	93	90	94
Overgrown	10	4	7	2

In the Idrija district, the classification of a vast territory in pedosequence on soft calcareous rock is questionable. These pedosequences supposedly appeared in two series. To the first series should belong marl and calcareous sandstone in eastern Slovenia, and to the second, flysch in western Slovenia (Stritar 1974). In the Idrija district we have neither, however Triassic Scythian layers where dolomite alternates with sandstone, marl, marl limestone and oolite have obviously been classified into this category. In the areas where limestone and dolomite appear in the framework of these layers, land use is the same as usual on this rock. Therefore a relatively high proportion of overgrown land is typical for the soft calcareous rock here, similar as for dolomite and partly for limestone. The proportion of grassland inside agricultural surfaces does not tell much in the case of Idrija where there are practically no orchards or vineyards. The proportion is higher where there are fewer fields and overgrown areas. However, a larger proportion of fields on noncalcareous rock and proportion of overgrown surfaces is evident on steep dolomite slopes.

4.6.2. Land Use in the Cerknica District

The Cerknica district spreads over four natural and geographical regions that are a constituent part of the Dinaric karst of continental Slovenia. These regions are Bloke and Loški potok, the Krim–Mokrec highlands with the Menišija region, the Notranjska lowlands, and Snežnik and Javorniki. The first two have the largest proportion of dolomite among the natural and geographical regions, Bloke and Loški potok with 62% and the Krim–Mokrec highlands with the Menišija region with 58%. Together with the Idrija district, we thus managed with the help of the *Agrokarta* to at least partly analyze all the natural and geographical regions in Slovenia where the proportion of dolomite exceeds 40%.

TABLE 6: LAND USE IN THE CERKNICA DISTRICT (PROPORTION OF ALL AGRICULTURAL AREAS, SOURCE *AGROKARTA*).

	Type of Rock		
	Dolomite	Limestone	Noncalcareous
Fields	12	9	17
Grassland	65	50	69
Overgrown	23	41	14
1st–3rd cat.			
Fields	29	30	30
Grassland	68	67	65
Overgrown	4	3	4
5th–6th cat.			
Fields	1	0	2
Grassland	63	43	72
Overgrown	36	56	26

In the Cerknica district, only Scythian layers which contain marl and micalike sandstone along with various limestone and dolomite are classified in the pedosequence on noncalcareous rock. In this case, therefore, it is not as a whole a matter of noncalcareous rock. In the Idrija district, the same rock is classified on the *Agrokarta* among soft calcareous rock. Other noncalcareous rock, if we exclude Quaternary sediments belonging to the second pedosequence and not included in the analysis, does not exist in the district.

On the whole, a substantially higher proportion of overgrown areas is more characteristic of the Cerknica district than of the Idrija district. However, it is interesting that here the proportion of fields is also larger, which can be explained by extensive level areas. The largest proportion of overgrown areas is on limestone. These areas on limestone and on dolomite appear in more than 90% of cases on land in the 5th and 6th categories. However, this land is classified in these two categories because of steep slopes or because of sinkholes and rocky surfaces. Overgrown areas on dolomite where there are fewer sinkholes are therefore largely linked with steep slopes, and on limestone to a large extent with sinkholes. Unfortunately, the data offered by the *Agrokarta* cannot be used to compare only steep slopes on different rock, but it is obvious that in the areas composed of Scythian layers, the proportion of overgrown areas is much smaller.

5. Land use and Relief on Selected Test Areas

Test areas were selected with the intention of checking general finds valid for all of Slovenia. At the same time, in these areas we were able to include data that cannot be gathered for the entire country. To get a perspective on traditional land use, we copied and digitalized the Emperor Francis' cadastral records. For comparison, we also digitalized land use according to the *Agrokarta*. Thus we got a comparison for the period 1823 to 1987, and not on the cadastral district level where the relief is often too heterogeneous for such analysis. At the same time, these small test areas made possible an analysis of land use according to relief forms. Therefore, for each of these areas, a simple geomorphological sketch was made. These are not intended to explain the genesis of the relief but only to show the most typical forms such as dells, sinkholes, dry valleys, erosion gullies, etc. The intention of these sketches is only to enable the analysis of different land use in dells and their adjacent slopes. The 100 × 100 m digital relief model does not enable analysis of the dissected karst relief. Forms such as dells and sinkholes can be neither shown nor analyzed with this model. Therefore, in all three test areas we digitalized the isohips from 1 : 10.000 scale maps and made a new 10 × 10 m digital relief model by means of interpolation. Several interpolation methods are possible (Rihtaršič, Fras 1991), and in our case, we employed the *Intercon* subprogram which is a constituent part of IDRISI. It uses modified CONSURF algorithm developed by David Douglas at the University of Ottawa in Canada (Eastman 1992). In our case, the procedure of making the digital relief model was as follows. In the first phase we rastered the vector database of isohips containing individual altitude points on 2 × 2 m cells. Using the *Intercon* subprogram we then calculated values for intermediate 2 × 2 m cells. Finally we condensed this data to a level of precision of 10 × 10 m, calculating the average from twenty-five 2 × 2 m cells. We calculated the gradient of each 10 × 10 m cell with the help of the altitude data.

We performed all the analysis of land use and its changes in the period from 1823 to 1987 according to relief on examples from three test areas. The first lies in the Polhov Gradec highlands in the area of Selo and Tošč, and the other two are the Krim–Mokrec highlands. The first of these two areas is on Kureščček and lies entirely on Rhaetian-Norian dolomite, and the second is on Dolenje Kališče where Cordevolian dolomite dominates. All three areas lie entirely on dolomite.

5.1. Test Area One – Selo Above Polhov Gradec

This test area lies in the northern section of the Polhov Gradec highlands in the Selo cadastral district. In the north it is bordered by the Tošč ridge while in the south it reaches Jevski graben and a little more to the south of Gabrše and Široka dolina. More precisely, its western border is defined by coordinate 5446000, its eastern border by 5448250, its northern border by the boundary between the Škofja Loka district and the Dobrova–Horjul–Polhov Gradec district, and its southern border is coordinate 5105500. However, in the southwestern section, its border rises toward the north to the lithological border between dolomite and Permian and carbonate rock. The area within this slightly complicated border lies entirely on dolomite. On the basic geological map this dolomite is marked as unstratified and belonging to Anisian and Ladin.

The treated area has an average altitude of 762 m and the heights range between 579 m at Jevski graben and 1021 m at Tošč, the highest peak in these highlands. The slopes are very steep, averaging a good 26° gradient. As much as one quarter of the entire area is covered by slopes with more than 32° gradient. In some places stronger erosion foci occur, bare dolomite slopes covered only with sporadic pine trees and dissected by numerous erosion gullies. One large such area is on the south slopes of Veliki vrh, and there is a smaller one on the southwestern slope of Planinca, a ridge descending from Tošč toward the northwest. Areas suitable for agricultural, that is, with less than 12° or 20% gradient, comprise barely 6% of the total area. These occur mostly in the dry Široka dolina valley east of Gabrše and in a larger dell south of the Zalipa valley and the St. Jedert church. The treated area is cut by two larger valleys running east–west. The first is Zalipa, separating Tošč from Veliki vrh and Špiklj, and the second is Jevski graben, continuing further up into Široka dolina. On the south slopes in the vicinity of the St. Jedert church is a group of very beautiful dells used for meadows in spite of the 25° gradient of their bottoms.

Unfavourable relief conditions are linked with land use. Abandoned fields and strong overgrowth is typical. The area of field has shrunk by sixteen times since 1823: of the previous nine hectares, only a good half hectare remains.

TABLE 7: SELO – LAND USE IN 1823 AND IN 1987.

	1823		1987	
	area in hectares	slope in °	area in hectares	slope in °
Fields	9	16	1	16
Grassland	107	28	19	20
Forest pasture	19	29	–	–
Less overgrown	–	–	6	30
More overgrown	–	–	8	23
Forest	63	25	165	27

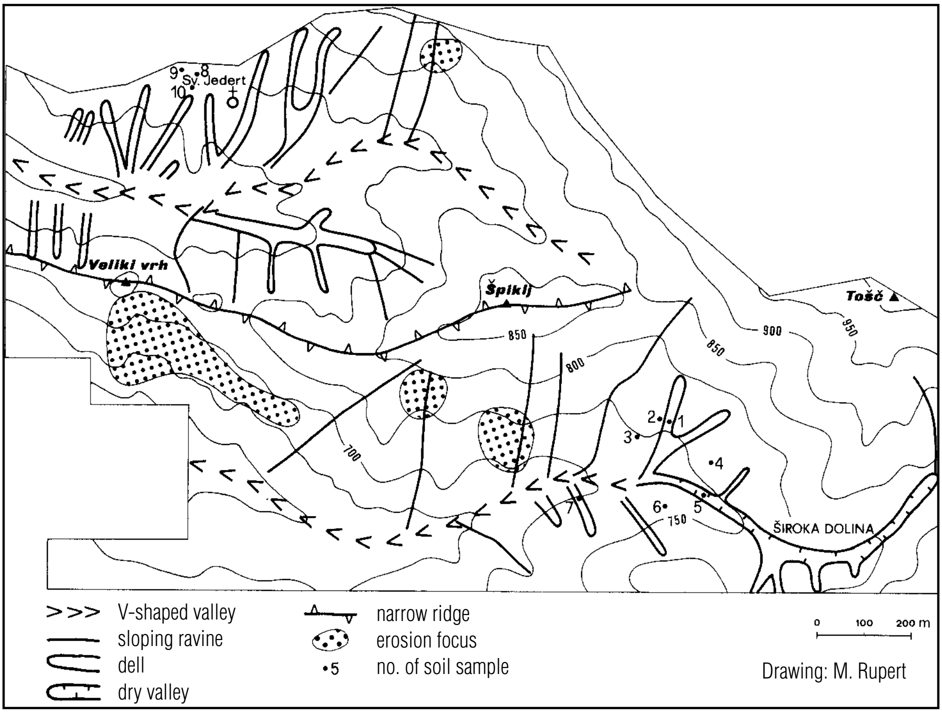

Figure 8: Selo – geomorphological sketch.

Unfortunately, the categories of land use in the two sources, the Emperor Francis' cadaster and the *Agrokarta*, are not identical. In the *Agrokarta*, meadows are not separated from pastures but are treated together as grassland. I therefore combined these two categories in the Emperor Francis' cadaster. Here, of 107 hectares of grassland, pastures dominate with 79 hectares. In the forest pasture category we included those areas where the Emperor Francis' cadaster denoted trees on pasture areas. From the table, major changes in land use are evident as the area of meadow and pasture has shrunk

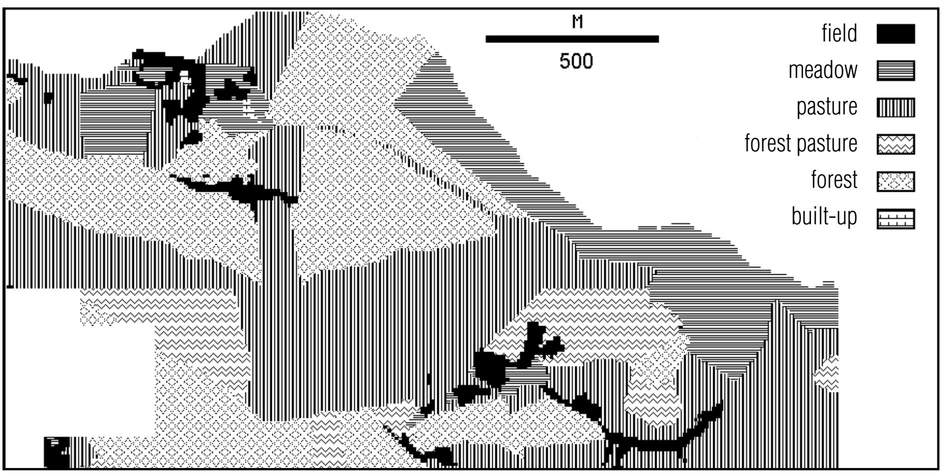

Figure 9: Selo – land use in 1823.

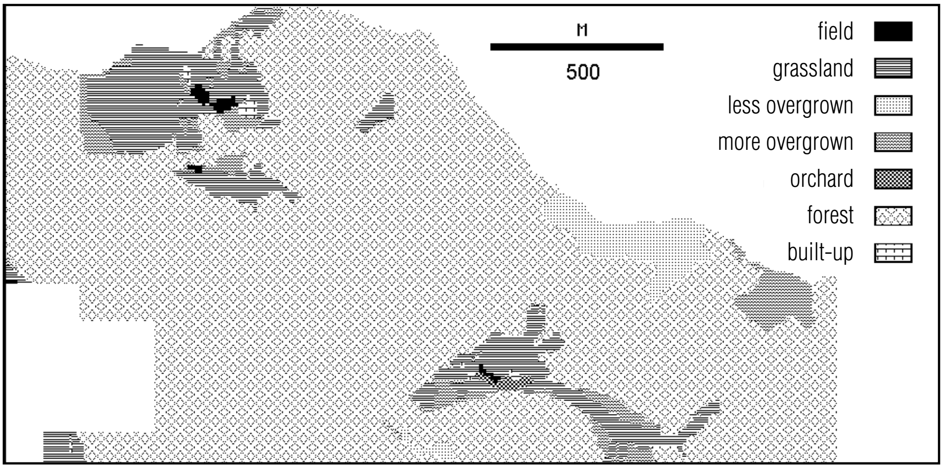

Figure 10: Selo – land use in 1987.

to less than one fifth, meaning that the majority of former pastures and the steeper and more remote meadows were overgrown. Today meadows are where fields used to be. Forests have spread by two and a half times, nor are overgrown areas insignificant.

For a more detailed illustration of the change in land use we made a contingency table of land use in 1823 and 1987. We located all the combinations of land use appearing in at least 250 cells or 2.5 hectares. Thus we first established the area that an individual change in land use comprised and then what proportion of this surface area occurred in dells and on the gentlest and steepest slopes.

TABLE 8: SELO: TYPES OF CHANGES IN LAND USE BETWEEN 1823 AND 1987.

Type of change				proportion of area in %		
1823	1987	area in ares	average gradient	in dells	with gradient to 12°	with gradient over 32°
field	grassland	737	16	43	29	–
meadow	grassland	475	22	16	8	7
meadow	less overgrown	508	31	–	1	12
meadow	more overgrown	369	25	10	14	23
meadow	forest	1381	28	0	2	21
pasture	grassland	497	21	13	7	7
pasture	more overgrown	275	23	8	9	16
pasture	forest	7114	29	1	2	39
forest pasture	forest	1845	30	1	2	39
forest	forest	6047	25	2	7	17

From this table it is very clear that all of today's areas where there were once meadows and pastures are on the steepest slopes and outside dells. The average gradient of today's meadows is obviously lower than the average gradient of more or less overgrown areas. Mostly those meadows and pastures lying outside dells are overgrown. Today, there are practically no fields, former fields are now meadows, and half of all the former fields were in dells. There are no examples of intense agricultural land use or clearing of forest areas in the treated test area.

The two tables above show the characteristics of areas with different types of land use. The concluding tables, however, were done inversely and show the structure of land use according to relief. From these, the difference in land use between dells and the rest of the areas will be clearer.

TABLE 9: SELO – LAND USE ACCORDING TO RELIEF IN 1823.

	Dells	Other
Proportion of field in %	42	3
Proportion of meadow in %	17	14
Proportion of pasture in %	25	51
Proportion of forest in %	16	32

TABLE 10: SELO – LAND USE ACCORDING TO RELIEF IN 1987.

	Dells	Other
Proportion of field in %	2	0
Proportion of grassland in %	58	7
Proportion of less overgrown area in %	0	3
Proportion of more overgrown area in %	10	4
Proportion of forest in %	30	85

5.2. Test Area Two – Dolenje Kališče

The second test area lies in the Dinaric karst in the Krim–Mokrec highlands at the extreme southeastern section of the Rutarska planota plateau. In the middle of the area at the juncture of several broad ridges lies the village of Dolenje Kališče. This 2.25 km^2 area is bordered on the south by the Karlovica–Bloke road, in the west by the Kozarščica creek, in the east by the Mišja dolina valley, and in the north it reaches to Gorenje Kališče. More precisely, the area is bounded by coordinate 5075000 in the north, 5073500 in the south, 5467500 in the west, and 5469000 in the east. The western section of the area is composed of "white to light grey, sugar-like granulated" Cordevolian dolomite, and its eastern section is composed of Scythian dolomite alternating with "grey, reddish, and violet micalike sandstone, siltstone, and marl." In the northeast, there is a small patch of Rhaetian-Norian dolomite on Ostri vrh (Buser 1974).

This test area lies at the altitude between 530 and 820 m, with an average altitude of 683 m. Relative to the first test area in the subalpine highlands, these slopes are gentler on average, with an average gradient of 23° and 16% of the slopes with a gradient above 32°. The most suitable surface areas for agricultural are around the village of Dolenje Kališče, where numerous dells are found between individual rounded peaks. South and east of the village are wooded slopes cut by large ravines. The Kališarjev potok stream and its left tributary run down valleys with approximately 50 m wide bottoms before flowing into the Kozmanjka River at Podžaga.

TABLE 11: KALIŠČE – LAND USE IN 1823 AND 1987.

	1823		1987	
	area in ha	gradient in °	area in ha	gradient in °
Fields	15	14	1	8
Grassland	48	18	27	17
Forest pasture	93	24	–	–
less overgrown	–	–	2	17
More overgrown	–	–	14	19
Forest	68	26	178	24

As in Selo, strong forestation and greening is also characteristic of Kališče. Here too, practically all the fields have been abandoned and forest areas have increased by 162%. The "forest pasture" category includes all grassy areas with drawn trees, that is, meadows and pastures. Meadows dominate with 79 hectares, while there are 14 hectares of pasture. In the early 19th century, practically all the

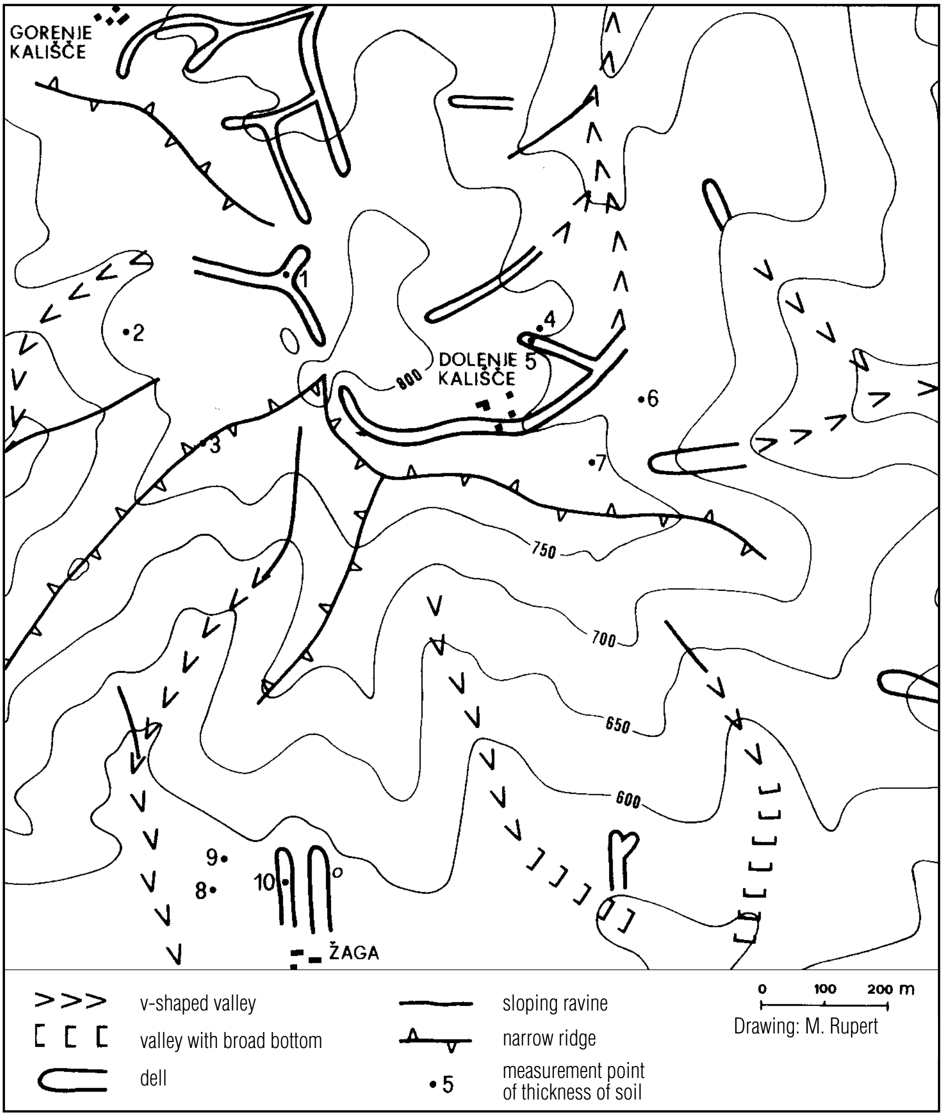

Figure 11: Kališče – geomorphological sketch.

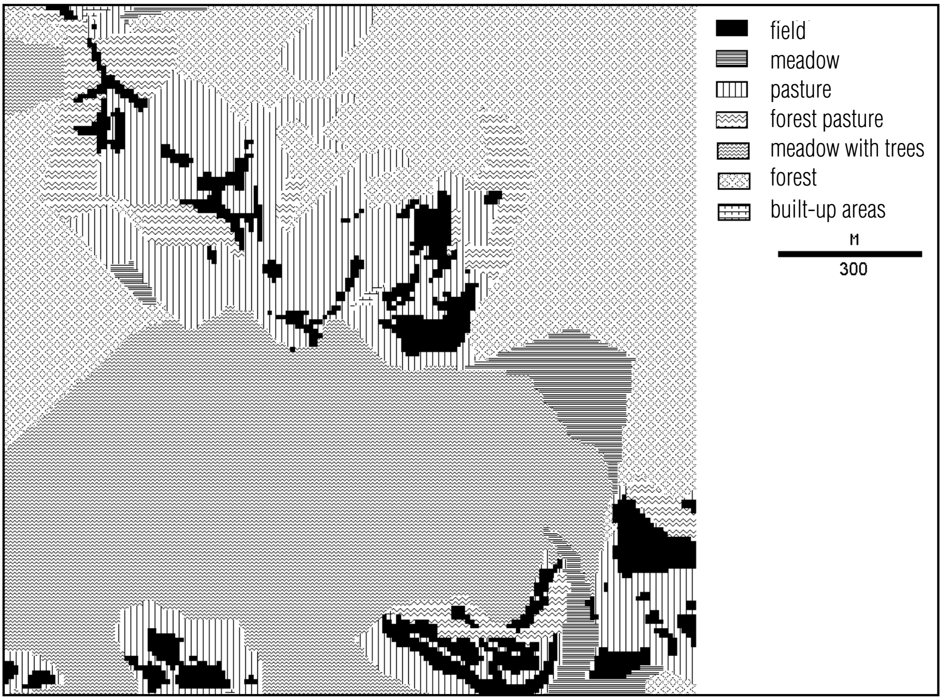

Figure 48: Kališče – land use in 1823.

forests were on northern slopes, while extensive meadows and pastures were on the steeper southern slopes. These are today completely overgrown with forests.

TABLE 12: KALIŠČE – TYPES OF CHANGES IN LAND USE IN THE PERIOD 1823 AND 1987.

Type of change				proportion of area in %		
1823	1987	area in ares	average gradient	in dells	with gradient to 12°	with gradient over 32°
field	grassland	1045	15	4	35	5
meadow	grassland	225	21	1	6	2
meadow	forest	512	25	–	5	28
forest meadow	forest	7724	25	0	4	17
pasture	grassland	888	16	6	34	3
pasture	more overgrown	794	19	9	16	4
pasture	forest	2036	17	3	25	4
forest pasture	grassland	380	19	10	17	8
forest pasture	more overgrown	282	18	–	25	12
forest pasture	forest	698	18	4	29	8
forest	forest	6677	26	2	5	26

In the table above, as in the first test area, we did not take into consideration types of change in land use that did not exceed two hectares. In the test area treated there are numerous dells in sunless areas where there is therefore a smaller proportion of fields and meadows and more forest. It is clearly evident that meadows are maintained where relief conditions are better and slopes are gentler and where fields used to be. It is interesting that in 1823 meadows were on steeper slopes than pastures. In the early 19th century, forests covered only less suitable steep and sunless slopes while today even gentler southern slopes are overgrown.

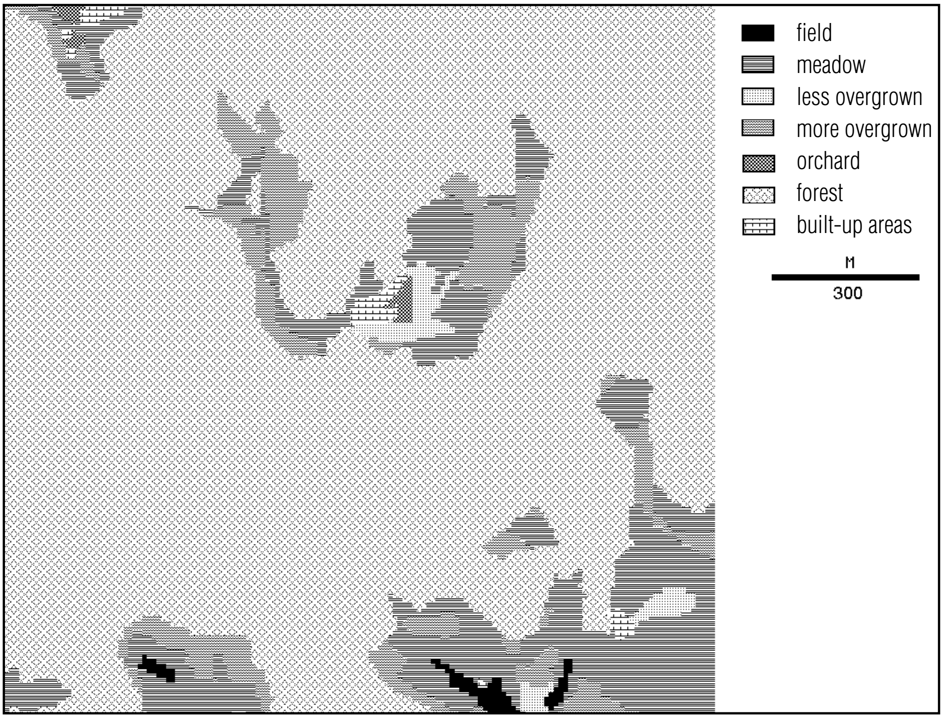

Figure 13: Kališče – land use in 1987.

TABLE 13: KALIŠČE – LAND USE ACCORDING TO RELIEF IN 1823.

	Dells	Wide Valleys	Other
Proportion of field in %	16	45	6
Proportion of meadow in %	1	28	40
Proportion of pasture in %	55	27	23
Proportion of forest in %	27	–	31

TABLE 14: KALIŠČE – LAND USE ACCORDING TO RELIEF IN 1987.

	Dells	Wide Valleys	Other
Proportion of field in %	–	21	0
Proportion of meadow in %	28	55	11
Proportion of less overgrown area in %	6	–	1
Proportion of more overgrown area in %	18	10	6
Proportion of forest in %	45	13	81

In comparison with Selo in the subalpine highlands, heavy overgrowth also occurred in the treated test area on areas favourable for agricultural because of the strong depopulation, and a quarter of all areas in dells is more or less overgrown and there are no more fields at all. Intensive agricultural land use is evident in both wide valleys with alluvial bottoms.

5.3. Test Area Three – Kureščèk

The third test area also lies in the Krim–Mokrec highlands, but in contrast to the second test area, it lies entirely on Rhaetian-Norian dolomite. It is characteristic of this area that among surface relief forms sinkholes often appear in addition to dells. The reason for this is in the lesser purity of the dolomite or larger proportions of $CaCO_3$ (Kranjc 1981). In contrast with the other two areas, this area has a plateau character. Like the second area, the third also measures 2.25 km^2. It was defined with the Kureščèk peak in the middle, and the village of Zapotok is already outside the area at its south-east corner. Its northern border is defined by coordinate 5083000, the southern with coordinate 50815000, and the western and eastern borders by coordinates 5465500 and 5467000 respectively. According to type of relief, the area can be divided into four units. At the center is the rounded Kureščèk peak with smooth slopes, west of the Ig–Rob road is a dissected plateau, the plateau world of Šprikl-

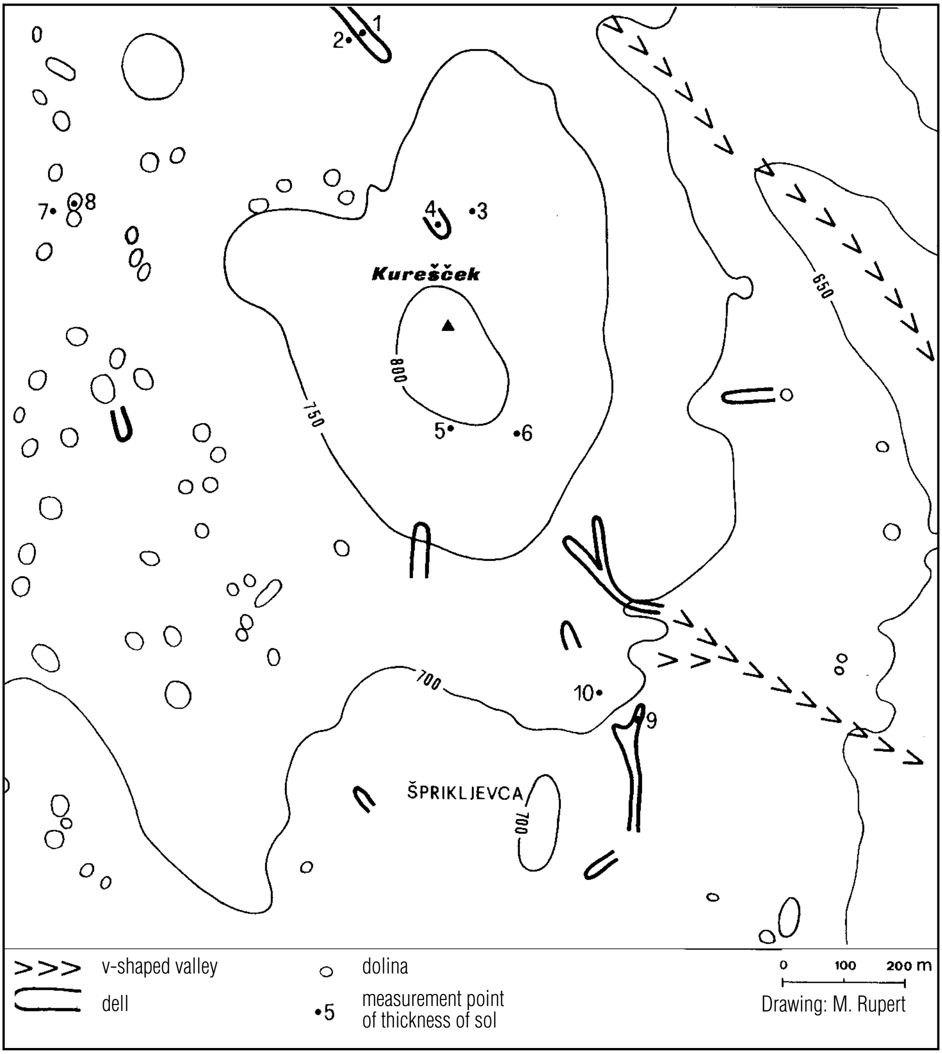

Figure 14: Kureščèk – geomorphological sketch.

jevec is dissected only by shallow dells, and in the northeast is the catchment area of Ščurkova grapa. As a whole, gradients as well as relative altitudes in the third area are substantially smaller than in the first two areas. Altitudes are between 610 and 823 m, the average gradient is only 11°, 65% of the territory is composed of gentle slopes with gradients up to 12°, and only a good one percent of the area is steeper than 32°.

TABLE 15: KUREŠČEK – LAND USE IN 1823 AND 1987.

	1823		1987	
	area in ha	gradient in °	area in ha	gradient in °
Fields	9	7	0	0
Grassland	26	9	39	9
Forest pasture	93	9	–	–
Less overgrown	–	–	7	11
More overgrown	–	–	65	10
Forest	95	14	109	13

The treated test area differs from the first two in the fact that the changes of land use do not depend to such a degree on the gradients. Because of the gentle slopes, the gradient here is not the main limiting factor. The main limitation to more intensive agricultural land use is presented by the sinkhole relief in the western section of the area. In the 19th century, pastures here were partly overgrown with trees, but today, some sections are completely overgrown by forest. In the table above, these areas are denoted as more overgrown but are actually already forest areas which still lead as agricultural areas in the cadaster.

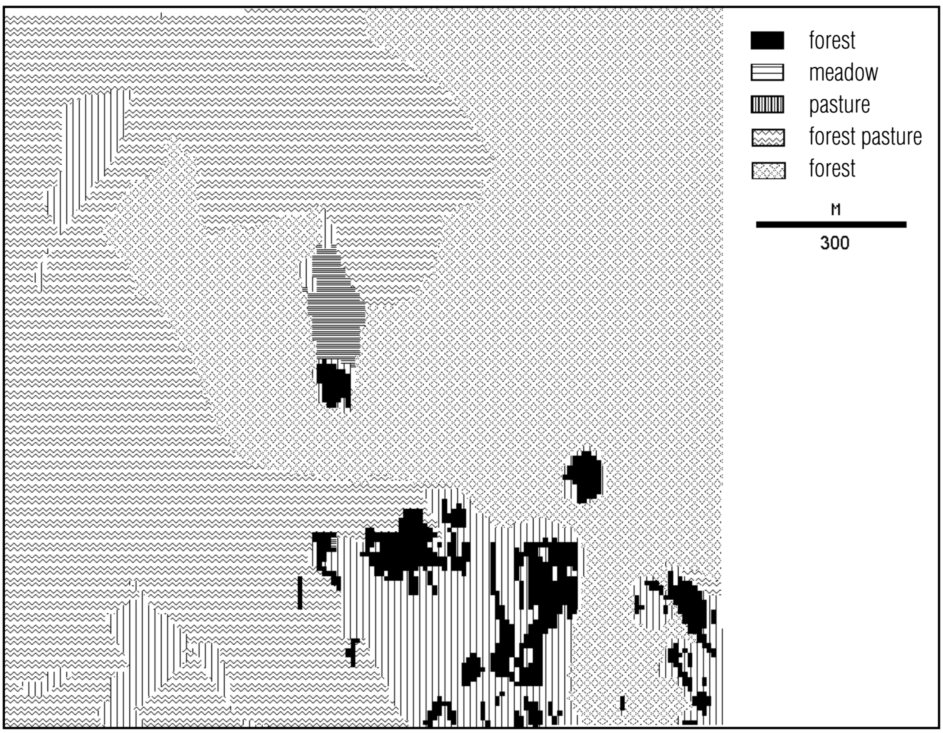

Figure 15: Kurešček – land use in 1823.

TABLE 16: CHANGES IN LAND USE BETWEEN 1823 AND 1987.

Type of change 1823	1987	area in ares	average gradient	proportion of area in % in dells	with gradient to 12°	with gradient above 32°
field	grassland	702	7	3	100	0
meadow	grassland	951	8	1	81	0
pasture	more overgrown	1148	9	1	81	0
forest pasture	grassland	2000	9	1	77	0
forest pasture	more overgrown	520	10	0	78	0
forest pasture	forest	4945	10	0	72	0
forest pasture	forest	1813	7	0	90	0
forest	more overgrown	297	11	0	62	0
forest	forest	8916	15	1	46	3

Dells comprise only a small proportion of the surface of the Kureščček test area. With this is connected the smaller proportion of fields and meadows, as fields and meadows are normally found in dells bottoms. The average gradients are similar with different types of land use. However, it is obvious that in the early 19th century there was less forest on the gentler slopes. As in the other two test areas, more extensive land use is also characteristic for the Kureščček area.

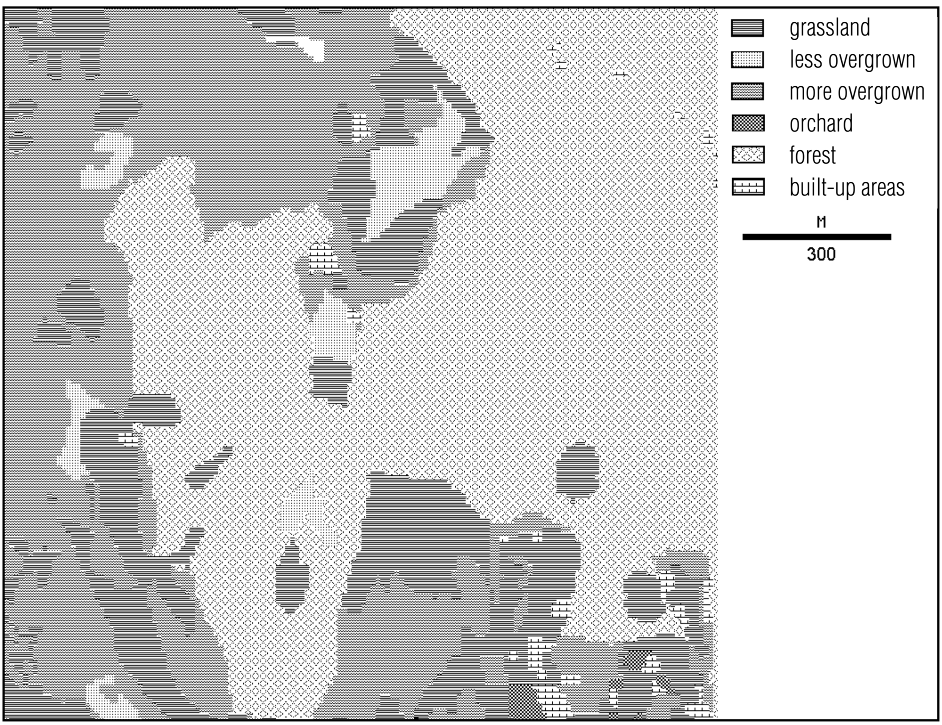

Figure 16: Kureščček – land use in 1987.

In the sinkhole areas that resemble limestone areas in relief, land use also has “karst” characteristics. These are shown in the above-average proportion of pasture areas that have become overgrown lately. Intensive agricultural land use is evident in the dells.

TABLE 17: LAND USE ACCORDING TO RELIEF IN 1823.

	Dells	Wide Valleys	Other
Proportion of field in %	17	1	4
Proportion of meadow in %	1	–	–
Proportion of pasture in %	40	89	52
Proportion of forest in %	41	10	43

TABLE 18: LAND USE ACCORDING TO RELIEF IN 1987.

	Dells	Wide Valleys	Other
Proportion of field in %	0	0	0
Proportion of meadow in %	31	27	17
Proportion of less overgrown area in %	0	2	3
Proportion of more overgrown area in %	26	53	29
Proportion of forest in %	42	16	49

5.4. Links Between Soil, Relief, and Land Use in Test Areas

In our analysis so far, we have shown the link between relief and land use. However, relief does not influence the land use only directly with the gradient but also to a great extent indirectly through soil. In the test area in the Polhov Gradec highlands, we examined the connection between thickness of soil and relief. The results showed that the most important link is between relief position and thickness of soil. The thinnest soil is on the upper convex parts of a slope and the thickest is the alluvial soil on the lower concave parts of a slope and on terraces. In this area rendzina on dolomite were only half as deep as soils on neighbouring noncalcareous rock and marl limestone (Gabrovec 1990).

5.4.1. Methodology

We decided to do two types of soil analysis. In all three test areas we measured the thickness of soil at various relief positions. We thus hoped to verify and augment the results of a previous study in the Polhov Gradec highlands (Gabrovec 1990). We therefore used the same method of measuring with a pedological probe as in the previous studies. At each point we took ten measurements over a 4 m^2 area, ruled out the two extreme results, and calculated the average value from the remaining eight.

In the Selo test area, in addition to the thickness of the soil, we also measured momentary moisture and retention capacity. We proceeded from the assumption that dryness is one of the main limiting factors in land use on dolomite rendzina because of their shallowness and sandiness.

According to Gračanin, retention capacity is the ability of the soil to retain water through the action of molecular adhesion, hydration, molecular forces, and surface tension. Retention capacity represents the quantity of water that soil can retain. This property shows us the impermeability of a particular soil (Resulović 1971, Lovrenčak 1979). In the Polhov Gradec test area, soil samples were taken by means of 100 cc tubes at 14 points. The soil samples were taken to a depth of 10 to 20 cm; only at three points in the bottom of dells where the soil was thicker than half a meter did I take additional samples to a depth of 30 to 40 cm. Ten points lie on dolomite while the remaining four are on Permian-Carboniferous sandstone and Scythian marl limestone. The points on dolomite were chosen in various relief positions, gradients, and exposures.

The laboratory analysis was done by Špela Špilar at the physical geography laboratory of the University of Ljubljana Department of Geography. The analysis procedure is as follows. The tube with the soil is placed in a dish on a stand with filter paper which is in water. In this way, the soil absorbs the water through the filter paper. Water rises through capillary action and moistens the surface area of the soil in the tube. At this moment, the water is found in the capillary pores, the soil is saturated to its retention capacity, and air is found in the macropores. The tube is removed from the moist filter paper and placed on a dry paper, left for half an hour to drain superfluous water from the net, wiped dry, and weighed. In this way we obtain the weight of the tube and the soil saturated to its retention capacity. When the soil sample is dried and weighed again, we get the weight of the tube and the dry soil. With these two figures we can calculate the retention capacity in volume percents (Lovrenčak 1979). The tubes with the soil were also weighed immediately after the samples were brought to the laboratory in order to calculate the momentary moistness of the soil.

5.4.2. Links between thickness of soil, relief, and land use

I measured the thickness of the soil in all three test areas, each time taking the measurements at ten points. These were selected in various gradients, exposures, and positions.

TABLE 19: THICKNESS OF SOIL – SELO ABOVE POLHOV GRADEC.

Sequence number	Thickness of soil in cm	Gradient in °	Exposure	Position	Land use
1	> 50	12	S	bottom of dell	meadow
2	20	28	E	rim of dell	overgrown
3	14	30	S	slope	meadow
4	27	16	S	slope	meadow
5	> 50	12	NW	dry valley	meadow
6	35	32	N	slope	forest
7	> 50	20	N	dell	overgrown
8	12	5	–	ridge	meadow
9	10	0	–	ridge	field
10	12	20	S	slope	meadow

TABLE 20: THICKNESS OF SOIL – KALIŠČE.

Sequence number	Thickness of soil in cm	Gradient in °	Exposure	Position	Land use
1	> 80	2	–	bottom of dell	meadow
2	24	16	W	slope	forest
3	11	0	–	ridge	forest
4	18	25	SW	rim of dell	meadow
5	> 60	10	SE	dry valley	field
6	25	5	NE	atrificial terace	field
7	29	2	NE	atrificial terace	field
8	> 60	10	SE	ridge	meadow
9	16	20	SE	ridge	overgrown
10	> 60	13	S	bottom of dell	meadow

As we had previously determined in studying the soil in the Polhov Gradec highlands (Gabrovec 1990, 59), we also found here that the thickness of the soil depends primarily on position. The thickest soil, usually measuring more than half a meter, is found at the bottoms of dells, sinkholes, and dry valleys. Fields lie to a large extent at the bottoms of dells where the soil is the thickest but also on flattened ridges where the thickness of the soil is barely 10 cm. While it is obvious that fields are usually found in areas with thick soil (dells, dry valleys, alluvial soil at the foot of slopes), they also occur on other level areas even though the soil is thin.

TABLE 21: THICKNESS OF SOIL – KUREŠČEK.

Sequence number	Thickness of soil in cm	Gradient in °	Exposure	Position	Land use
1	> 80	13	NW	bottom of dell	meadow
2	13	23	SE	slope	overgrown
3	16	2	–	ridge	meadow
4	> 50	10	NW	bottom of dell	meadow
5	16	16	S	slope	meadow
6	20	22	E	slope	forest
7	15	0	–	plateau	overgrown
8	> 50	0	–	bottom of dolina	overgrown
9	> 50	12	S	bottom of dell	meadow
10	40	8	S	slope	meadow

5.4.3. Moisture of Soil and Land Use

TABLE 22: MOMENTARY MOISTURE (21.4.1994) AND RETENTION CAPACITY IN THE POLHOV GRADEC HIGHLANDS (SELO) IN VOLUME PERCENTS.

Sequence number	Momentary moisture	Retention capacity	
1	41**	40	medium
1*	24	37	medium
2	49	51	large
3	30	50	large
4	37	40	medium
5	40	43	medium
5*	37	39	medium
6	39	53	large
7	44	51	large
7*	43	53	large
8	25	39	medium
9	31	50	large
10	30	39	medium
11	43	46	large
12	35	49	large
13	28	36	medium
14	26	34	small

*sample taken at a depth of 30 cm
**probable error in laboratory analysis

Samples under sequence numbers 1 to 10 were taken in the same places where the thickness of the soil was measured. The lithological bedrock of this soil is dolomite, and its relief position is described in Table 19. The bedrock of samples 11 and 12 is Permian sandstone; sample 11 was taken from a meadow and sample 12 from a forest, both in a western position in the vicinity of the Peklaj farm. Sample 13 is from a meadow on an eastern slope over Scythian limestone. Sample 14 is from a meadow along the Selo–Hrastnica road on a slope over Permian-Carboniferous sandstone. In the last column of the table, the values of retention capacity are classified into categories according to Gračanin (Lovrenčak 1979).

In spite of the contrary expectation, from the table we see that retention capacities on dolomite are relatively high since they are medium or large on all profiles. The average retention capacity of all samples on dolomite is 45. This value is on the border between medium and large retention capacities. Retention capacity is no larger in dells than on slopes: on average, it is even a little smaller. Larger differences appear in momentary moisture than in retention capacity. In spite of the fact that the measurements were taken after a longer period of rainy weather, the moisture of the soil was substantially smaller on southern exposures and on the sunny tops of ridges than on more shaded positions. Samples 1,3,4,8,9, and 10 thus show smaller momentary moisture than the rest. Retention capacity on Permian sandstone (samples 11 and 12) is somewhat higher than the average on dolomite, but on Permian-Carboniferous sandstone and Scythian limestone it is even lower. The number of samples taken outside the dolomite areas was too small to allow us to make any serious conclusions on this basis. However, from these results we can conclude that retention capacity is not a property of soil that conditions different land use on different rock. For soil moisture and with it dryness in the highland world, exposure is more important than retention capacity which depends mostly on the texture and structure of the soil. However, dryness is less on thicker soils as these take longer to dry due to the larger absolute quantity of moisture in them. On the other hand, retention capacity measured in volume percents is similar for both thick and shallow soils.

From the above we can conclude that neither soil thickness nor retention capacity expressed in volume percents show very significant links to land use. However, at least from the point of view of dryness, the combination of these two factors or rather their product is more important. We thus obtain the quantity of moisture in the soil expressed in mm or l/m^2, and this data can be paralleled with evaporation.

Comparisons of this kind will not be done for each measurement point separately. We will choose only three typical positions that differ according to thickness of soil and retention capacity. In the first group belongs soil on dolomite omitting that in dells and alluvial soil. In the second group belongs soil in dolomite dells, and in the third soil on slopes composed of impermeable rock. The averages for the first two groups are calculated on the basis of measurements in the third test area at Selo. Because we did not carry out a larger representative number of measurements on impermeable rock, we used the data from the previous study in the Polhov Gradec highlands (Gabrovec 1990). From this source we calculated the average thickness of soil on slopes composed of impermeable rock, and for retention capacity we took into consideration the two measurements on Permian-Carboniferous sandstone in the third test area.

TABLE 23: AVERAGE THICKNESS OF SOIL AND RETENTION CAPACITY IN DIFFERENT POSITIONS.

	Average thickness in cm	Retention capacity in %	Retention capacity in l/m^2 or mm
Dolomite slopes	19	46	86
Dolomite dells	60	44	264
Impermeable slopes	27	48	129

When we calculated the retention capacity of the soil for water in absolute quantity in l/m^2 or mm (we obtained the number by multiplying the thickness of the soil by the retention capacity of the soil in volume percents), we discovered the essential differences between areas on different rock and relief forms: the capacity of the sopil for water in dells is three times as large as that on slopes, and dolomite slopes have a water capacity one third smaller than slopes on impermeable rock.

By comparing the data on water retention capacity on the one hand and evaporation and the length of periods without precipitation on the other, we can estimate on which areas aridity will occur. Plants cannot use the all the water in the soil, but the water capacity needed for plants amounts to between one half and three quarters of the retention capacity (Rowell 1993, Matajc 1991, Gams 1986). For the following calculations we assumed that the available water capacity for plants amounts to two thirds of the retention capacity. The water capacity available for plants would therefore total 58 mm on dolomite slopes, 177 mm in dolomite dells, and 86 mm on slopes composed of impermeable rock.

Measurements of actual evaporation in the Ljubljana region showed that the average daily evaporation on a meadow in the warmest months (May to September) is about 4 mm a day (Matičič 1977). If we compare daily evaporation with the available water capacity, we find that on dolomite slopes, a water shortage will begin to appear in 14 days, in dells in 44 days, and on slopes composed of impermeable rock in 21 days. In the Ljubljana region the maximum drought period is 36 days (Furlan 1960). Fields and meadows in dells should therefore not be affected by drought even in the worst case. On dolomite slopes, however, we can predict that drought conditions will appear a week earlier than on neighbouring slopes of impermeable rock. In the summer drought of 1988, the drought period lasted between twenty and thirty days in central and eastern Slovenia. Such dry periods are common phenomena that we record at least every other year (Kolbezen, Zupančič 1988). In a twenty-day dry period, water shortages would appear only on dolomite slopes while slopes on impermeable rock would not yet be affected. A more detailed determination of the frequency of drought on dolomite slopes would demand an analysis of daily precipitation over a longer period, which is not the aim of this study. Analysis of the average monthly precipitation offers no results since the evaporation measured in Ljubljana (Matičič 1977) does not substantially exceed the average amount of precipitation in any of the months.

The calculation above represents only a very rough evaluation of actual conditions. In nature, numerous other factors that can differ considerably by location influence the quantity of moisture in the soil. However, the results do show some basic characteristics of soil on different rock and relief forms and partly explain the more extensive use of land on dolomite compared with land use on impermeable rock.

As an example, we calculated a soil balance sheet for the drought year of 1993. We used a decade of data on precipitation and potential evaporation for the Ljubljana–Bežigrad meteorological station that we obtained from the Agrometeorological Department of the Hydrometeorology Institute in Ljubljana and the calculated retention capacity of soil on dolomite slopes and dells. Such theoretical calculations, shown in the graph below, reveal that in 1993 dolomite slopes with shallow rendzina twice suffered a shortage of water, in late May and early June and in late July and August. The shortage occurred in these periods in spite of lower precipitation the amount of which was smaller than the evaporation. In contrast to this, the shortage of water first appeared in dells only in mid August.

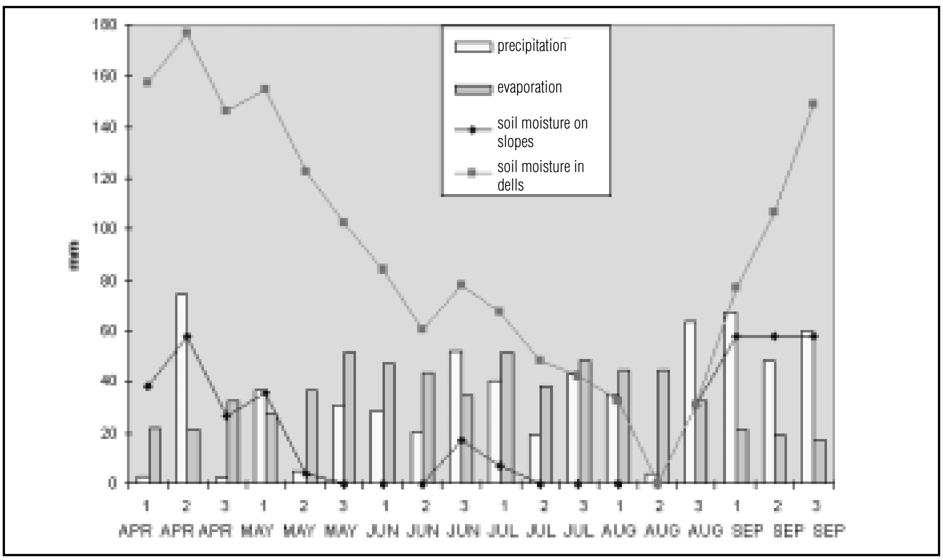

Figure 17: Ground water balance sheet on dolomite areas in 1993.

6. Conclusions

In Slovenia, dolomite covers 2500 km^2 or 12% of the country's area. The majority (86%) is Triassic dolomite, only one percent is older Permian dolomite, and 13% is younger Jurassic and Cretaceous dolomite., One half of the areas of Triassic dolomite are composed of Upper Triassic stratified Rhaetian-Norian dolomite, which covers the largest areas in the Dinaric world of southern Slovenia. In the subalpine highlands, massive Cordevolian dolomite is more characteristic, occupying 500 km^2. According to the natural and geographical macroregions of Slovenia, dolomite represents a significant proportion of all surfaces in the high-mountain Alps (15%), the subalpine highlands (15%), and the Dinaric world of continental Slovenia (20%).

In describing of individual natural and geographical regions, the extent, average gradient, and basic relief characteristics linked to land use are shown according to individual types of dolomite. Given the basic source of data, that is, the basic geological 1 : 100,000 scale maps, the only possible classification was chronostratigraphic, although we are aware of all the weaknesses of such classification. Among Scythian layers, for example, there are at least two different layers of dolomite, Anisian dolomite can be either massive or stratified, and so on. In spite of this, a rough analysis already showed certain differences in the relief on different types of dolomite. In the majority of regions, the largest gradients appear on Cordevolian dolomite, and the smallest on Rhaetian-Norian dolomite. Sinkholes appear on dolomite almost exclusively in areas of Upper Triassic Rhaetian-Norian dolomite.

On dolomite, incomplete carbonate karst has developed that may also be considered a special type of fluviokarst. On dolomite bedrock, an almost normal fluvial relief has developed with a network of surface rivers. The karst characteristics of the relief are reflected in tiny wrinkled surfaces, characteristic dry valleys, and occasional shallow sinkholes and uvalas (Habič 1982). In Slovenia, we defined four types of dolomite relief using a geographical information system into which a digital relief model, lithological data, and natural and geographical regionalization were included:

- brittle walls and slopes in the high mountains,
- steep slopes dissected by erosion gullies,
- gentle slopes dissected by dells,
- plateaus with shallow sinkholes.

In the various natural and geographical macroregions of Slovenia, different types of dolomite relief occur, and there are major differences in land use on dolomite areas with different relief.

In the high mountain world, the largest proportion of dolomite occurs in the Karavanke Mountains and in the Kamniško–Savinjske Alps. Dolomite slopes and walls stand out with greater brittleness, a greater density of torrential ravines, and numerous erosion foci. Similar characteristics are also found on dolomitized limestone which is not treated in the study. Because of the smaller mechanical resistance of dolomite, some gaps or saddles occur in the crests in dolomite areas across which important roads lead. Examples are the Vršič and Predel passes.

In the subalpine highlands, dolomite is most frequent in the western part of Slovenia where it covers 48% of all surface areas in the Idrija–Cerklje highlands. From the viewpoint of land use, the most important relief form in subalpine dolomite areas is the dell (in some places these are smaller dry valleys) which often continues downward into a sloping ravine. In land use in subalpine dolomite areas, meadows and pastures stand out and occur much more frequently in comparison with neighbouring limestone areas and areas composed of other rock. Meadow and pasture areas cover 34% of all areas on dolomite and only 22% on other rock. There are fewer fields on dolomite, and these are almost exclusively limited to the bottoms of dells. In 1953, forests were also fewer on dolomite than on other rock. However, because dolomite slopes characteristically have the greatest degree of overgrowth, a fact confirmed by data from the *Agrokarta*, the proportion of forests today almost equals the proportion on other rock. Thus, the area of forest increased by some 18% between 1953 and 1987 while the area of pasture decreased by 29% over the same period. The intensity of land use on dolomite areas of the subalpine highlands is smaller than the average for all the dolomite areas in Slovenia. Thus, the proportion of fields and meadows is also smaller than for the entire country while in contrast the proportion of pastures and forest is larger. This can be explained by the fact that dolomite areas in the subalpine highlands are largely surrounded by areas of impermeable rock which are more suitable for agricultural land use than dolomite. In addition, dolomite areas in the subalpine highlands are steeper than in the Dinaric karst.

The largest proportion of dolomite is found in the Dinaric karst region of continental Slovenia. Among these areas, the Bloke and Loški potok region with 62% and the Krim–Mokrec highlands with 58% stand out. Substantially smaller average gradients are more characteristic of dolomite areas in this part of Slovenia than in the subalpine highlands since the average gradients in individual dolomite areas range around 12° while in the subalpine highlands they usually exceed 20°. However, here too, we encounter typical steep forested slopes with rocky outcroppings, for example, Iški vintgar and the slopes above the Kolpa River between Fara and Osilnica. In the Dinaric world, shallow sinkholes frequently occur, primarily on Rhaetian-Norian dolomite, while they are rare in the dolomite areas of Slovenia's subalpine highlands. Comparison of land use between dolomite and limestone areas reveals some different relationships than in the subalpine world. Here too, a larger proportion of meadows stands out on dolomite, while the proportion of pastures is substantially smaller than on limestone. Due to lesser overgrowing and the more rapid mechanical weathering of dolomite, dolomite slopes are smoother than limestone slopes, the latter being unsuitable for mowing because of their rockiness. Pastures are therefore characteristic of limestone while meadows dominate on dolomite. In 1987, 27% of meadows were on dolomite and only 17% on limestone, while 9% of the pastures were on dolomite and 12 % on limestone.

In subpannonian and littoral Slovenia, dolomite covers only 5% of the area. In subpannonian Slovenia, dolomite areas stand out with steeper slopes and their degree of forestation. In littoral Slovenia, only Cretaceous dolomite occurs in the Kras region, but the dolomite areas here do not differ essentially from surrounding areas in either relief or land use.

Dolomite in Slovenia occurs mainly in the highland world. Only in the Dinaric region of Slovenia does it occur at the bottoms of certain karst poljes and other depressions. The results of the study are therefore valid only for the dolomite highland world and not for the few flat areas on dolomite. In highland positions we chose three test areas in order to study the links between land use and relief in detail. The first was in the subalpine highlands in the village of Selo above Polhov Gradec, while the second and third test areas were in the Dinaric world in the Krim–Mokrec highlands at Dolenje Kališče and on Kurešček. Here, we also compared modern land use with that of the early nineteenth century and analyzed land use separately for various relief forms. Everywhere, more extensive land use has shown. Overgrown meadows and pastures are characteristic mostly for slopes with gradients above 32°, former fields and today's better meadows are to a great extent tied to the bottoms of dells and dry valleys. In the test area in the Polhov Gradec highlands, for example, 42% of all the areas at the bottoms of dells and dry valleys were under fields in 1823. Today, these fields are almost entirely abandoned, their area having decreased from thirty-three hectares to barely two hectares. The area of meadows in the test areas has decreased by over half, from 181 hectares to 85 hectares. Very strong greening is therefore characteristic of the bottoms of dells, and forestation of the rest of the areas.

The abandoning of meadows on dolomite slopes can be explained by more serious conditions such as aridity and not simply by their gradients. The twenty-day dry period that occurs in central Slovenia almost every other year affects meadows on dolomite slopes with shallow rendzina that has a small water retention capacity but does not affect meadows and fields in dells or on slopes of impermeable rock.

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8. Povzetek – Summary

Dolomitne pokrajine v Sloveniji s posebnim ozirom na relief in rabo tal

Matej Gabrovec

V Sloveniji dolomit prekriva 2500 km^2 ozemlja ali 12 % državne površine. Večina dolomita (86 %) je triasne starosti, le en procent je starejšega permskega, 13 % pa je mlajšega jurskega in krednega dolomita. Med triasnimi dolomiti zavzema polovico površine zgornjetriasni plastovit glavni dolomit, ki zavzema največje površine v južni Sloveniji, v dinarskem svetu. Za predalpsko hribovje pa je značilnejši masiven cordevolski dolomit, ki leži na 500 km^2. Po naravnogeografskih makroregijah Slovenije predstavlja dolomit pomembnejši delež vseh površin v Visokogorskih Alpah (15 %), Predalpskem hribovju (15 %) in Dinarskem svetu celinske Slovenije (20 %).

Pri opisu posameznih naravnogeografskih regij so razprostranjenost, povprečen naklon ter osnovne reliefne značilnosti v povezavi z rabo tal prikazane po posameznih vrstah dolomita. Glede na osnovni vir podatkov, to je osnovna geološka karta v merilu 1 : 100000, je bila edina možna klasifikacija kronostratigrafska. Zavedamo se vseh slabosti take razdelitve. Med skitskimi plastmi sta na primer vsaj dve različni vrsti dolomita, anizijski dolomit je lahko masiven ali plastovit in tako naprej. Kljub temu pa je že groba analiza pokazala nekatere razlike v reliefu na različnih vrstah dolomita. V večini regij se največji nakloni pojavljajo na cordevolskem dolomitu, najmanjši pa na glavnem. Vrtače se na dolomitu pojavljajo praktično samo na območjih zgornjetriasnega glavnega dolomita. Na dolomitih je razvit nepopoln karbonatni kras, ki ga lahko označimo tudi kot poseben tip fluviokrasa. Na dolomitni podlagi je razvit skoraj normalen dolinast relief s površinsko rečno mrežo. Kraške značilnosti reliefa se odražajo v drobnem grbinastem površju, značilnih suhih dolinah ter redkih plitvih vrtačah in uvalah (Habič 1982). V Sloveniji smo s pomočjo geografskega informacijskega sistema, v katerega so bili vključen digitalni model reliefa, litološki podatki in naravnogeografska regionalizacija, določili štiri tipe dolomitnega reliefa, in sicer:

- krušljive stene in pečevnate drti v visokogorju,
- strma pobočja, razčlenjena z erozijskimi jarki,
- položnejša pobočja, razčlenjena z dolci,
- planote s plitvimi vrtačami.

V različnih naravnogeografskih makroregijah Slovenije se pojavljajo različni tipi dolomitnega reliefa, prav tako pa so med njimi tudi velike razlike v rabi tal na dolomitnih območjih.

V visokogorskem svetu je največji delež dolomita v Karavankah in Kamniško–Savinjskih Alpah. Dolomitna pobočja in stene izstopajo z večjo krušljivostjo, večjo gostoto hudourniških grap in s številnimi erozijskimi žarišči. Podobne značilnosti najdemo tudi na dolomitiziranih apnencih, ki pa jih v raziskavi nismo obravnavali. Zaradi manjše mehanske odpornosti dolomita so prav na območju dolomita nekatera vrzeli v grebenih – sedla, prek katerih vodijo pomembne poti. Taka primera sta Vršič in Predel.

V predalpskem hribovju je dolomita največ v zahodnem delu, v Idrijsko–Cerkljanskem hribovju, kjer prekriva kar 48 % vseh površin. Z vidika rabe tal je najpomembnejša reliefna oblika na predalpskih dolomitnih območjih dolec (ponekod gre že za manjše suhe doline), ki se navzdol pogosto nadaljuje v pobočno grapo. V rabi tal na predalpskih dolomitnih območjih izstopajo travniki in pašniki, teh je v primerjavi s sosednjimi apnenčastimi območji in območji, zgrajenimi iz ostalih kamnin, bistveno več. Travniških in pašniških površin je na dolomitu po podatkih katastra 34 % vseh površin, na drugih kamninah pa le 22 %. Njiv je na dolomitu najmanj, vezane so praktično le na dna dolcev. Tudi gozdov je bilo leta 1953 na dolomitu še manj kot na drugih kamninah. Ker pa je za dolomitna pobočja značilna največja stopnja zaraščanja, kar nam potrjujejo tudi podatki iz agrokarte, je danes delež gozdov že skoraj izenačen z deležem na ostalih kamninah. Tako se je površina gozdov med leti 1953 in 1987 povečala kar za 18 %, medtem ko se je površina pašnikov v istem razdobju zmanj-

šala kar za 29 %. Intenzivnost rabe tal na dolomitnih območjih predalpskega hribovja je manjša od povprečja za dolomitna območja celotne Slovenije. Tako je delež njiv in travnikov manjši kot v celotni državi, delež pašnikov in gozdov pa nasprotno večji. To si lahko razlagamo z dejstvom, da v predalpskem hribovju dolomitna območja obdajajo povečini območja neprepustnih kamnin, ki so za kmetijsko rabo primernejša kot dolomitna. Poleg tega so dolomitna območja v predalpskem hribovju strmejša kot na dinarskem krasu.

Največji delež dolomita je na Dinarskem krasu celinske Slovenije. Med regijami tu izstopajo Bloke in Loški potok z 62 % ter Krimsko–Mokrško hribovje z 58 %. Za dolomitna območja v tem delu Slovenije so značilne bistveno manjše povprečne strmine kot v predalpskem hribovju, povprečni nakloni po posameznih regijah se tu gibljejo okoli 12°, medtem ko v predalpskem hribovju navadno presegajo 20°. Vendar pa tudi tu naletimo na tipična strma gozdna pobočja s skalnimi osamelci, tak primer so Iški vintgar ter pobočja nad Kolpo med Faro in Osilnico. V dinarskem svetu se predvsem na glavnem dolomitu pogosto pojavljajo tudi plitve vrtače, te so na dolomitih predalpske Slovenije velika redkost. Primerjava rabe tal med dolomitnimi in apnenčastimi območji nam pokaže nekaj drugačna razmerja kot v predalpskem svetu. Tudi tu na dolomitu izstopa večji delež travnikov, vendar pa je delež pašnikov bistveno manjši kot na apnencu. Dolomitna pobočja so namreč zaradi manjše zakraselosti in hitrejšega mehaničnega razpadanja dolomita mnogo bolj gladka kot apnenčasta, slednja zaradi kamnitosti niso primerna za košnjo. Za apnence so zato značilni pašniki, medtem ko na dolomitih prevladujejo travniki. Travnikov je bilo leta 1987 na dolomitu 27 %, na apnencu pa le 17 %, medtem ko je bilo pašnikov na dolomitu 9 %, na apnencu pa 12 %.

V subpanonski in primorski Sloveniji je dolomita le po 5 %. V subpanonski Sloveniji dolomitna območja izstopajo z večjimi strminami in gozdnatostjo. V Primorju je le kredni dolomit na Krasu, vendar pa se tukajšnja dolomitna območja od okolice ne ločijo bistveno niti po reliefu niti po rabi tal. Dolomit se v Sloveniji pojavlja predvsem v hribovitem svetu. Le v dinarskem delu Slovenije se pojavlja tudi v posameznih podoljih in v dnu nekaterih kraških polj. Rezultati naloge veljajo zato za dolomitni hribovski svet, ne pa za redkejše uravnave v dolomitu. V hribovitih legah smo tudi izbrali tri testna območja, da bi še podrobneje proučili zvezo med rabo tal in reliefom. Prvo je v predalpskem hribovju, v vasi Selo nad Polhovim Gradcem, drugo in tretje pa sta v dinarskem svetu na Krimsko–Mokrškem višavju, v Dolenjem Kališču in na Kureščku. Tu smo tudi primerjali današnjo rabo tal s tisto v začetku devetnajstega stoletja, rabo tal pa smo ločeno analizirali na različnih reliefnih oblikah. Povsod se je pokazala močna ekstenzifikacija rabe tal. Zaraščanje travnikov in pašnikov je značilno predvsem za pobočja z naklonom nad 32°, nekdanje njive in današnji boljši travniki so v veliki meri vezani na dna dolcev in suhih dolin. Na testnem območju v Polhograjskem hribovju je bilo na primer leta 1823 kar 42 % vseh površin v dnu dolcev in suhih dolin pod njivami. Do danes so te njive skoraj v celoti opustili, saj se je njihova površina zmanjšala s 33 ha na komaj 2 ha. Površina travnikov se je v testnih območjih zmanjšala za več kot polovico, s 181 ha na 85 ha. Za dna dolcev je torej značilno zelo močno ozelenjevanje, za vse ostale površine pa močno ogozdovanje.

Opuščanje travnikov na dolomitnih pobočjih pa lahko tolmačimo tudi s slabšimi razmerami zaradi sušnosti, ne le s strmino. Dvajsetdnevno sušno razdobje, ki se v osrednji Sloveniji pojavlja vsaj vsako drugo leto, že prizadene travnike na dolomitnih pobočjih s plitvo rendzino, ki ima majhno retencijsko kapaciteto za vodo, ne prizadene pa še travnikov in njiv v dolcih ali na pobočjih iz vododržnih kamnin.