GEOGRAPHICAL CHARACTERISTICS OF EARTHQUAKES IN THE SOČA RIVER REGION

GEOGRAFSKE ZNAČILNOSTI POTRESOV V POSOČJU

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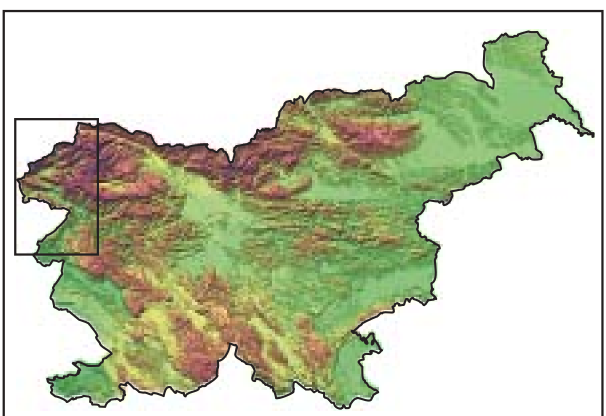
Small chapel in Bovec, Mala vas (photography Miha Pavšek).
Kapelica v Bovcu, Mala vas (fotografija Miha Pavšek).



Abstract

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Geographical characteristics of earthquakes in the Soča River Region

KEY WORDS: nature disasters, earthquake, Soča River Region, Slovenia

In the last few decades, Slovenia has fortunately not been struck by natural disasters that judged according to the extent of damage or the number of casualties can be ranked among catastrophes of world dimensions. However, this is not true of natural disasters on the immediate margins of Slovene ethnic territory. During the Friuli earthquake in Italy in 1976, more than one thousand people lost their lives. That earthquake also caused major damage in Slovenia, although we had no casualties. However, in Slovenia we must still consider seriously the possibility of many casualties in a large-scale earthquake such as occurred in 1511.

The upper Soča River region is among the most picturesque Slovene landscapes. The upper valley of the Soča River has none of the larger plains or basins that characterize other parts of Slovenia. Somewhat larger widenings occur only near Bovec, Kobarid, and Tolmin, with a side spur into the Nadiža Valley. It appears that tectonic and several other characteristics of this region contributed heavily to this morphological formation of the upper Soča region. There is no doubt that upper Soča area ranks among Slovenia's most threatened regions. In the span of only twenty-two years, two devastating series of earthquakes have struck, in 1976 and 1998. These two earthquakes were different in their nature and effect. The first earthquake in 1976 was undoubtedly stronger than the one in 1998. Luckily for Slovenia, the epicenter of that earthquake was in neighbouring Italy, about twenty-five kilometers from the border.

As we did in 1976, we undertook field studies of the 1998 earthquake activity in the upper Soča region. The consequences caused by natural disasters in a particular region always have multi-layer dimensions. It is therefore no coincidence that very diverse groups of researchers participated in these studies. The work of research groups in the »Effects of the Earthquake of April 12, 1998, in the Bovec Region on the Buildings, People, and Environment« project was coordinated by the Civil Engineering Institute ZRMK. Also participating in this project was the Anton Melik Geographical Institute from the Scientific Research Centre of the Slovenian Academy of Sciences and Arts and the Department of Psychology of the Faculty of Philosophy of the University in Ljubljana. In this paper, only a few geographical dimensions of the consequences of the last two major earthquakes in the upper Soča region are presented.

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Geografske značilnosti potresov v Posočju

KLJUČNE BESEDE: naravne nesreče, potres, Posočje, Slovenija

V zadnjih nekaj desetletjih k sreči naših krajev niso prizadele naravne nesreče, ki bi jih po obsegu škode ali številu žrtev lahko uvrstili med katastrofe svetovnih razsežnosti. To pa ne velja za naravne nesreče z neposrednega obrobja našega etničnega ozemlja. V furlanskem potresu leta 1976 je v Italiji izgubilo življenje več kot tisoč ljudi. Ta potres je povzročil veliko škode tudi v Sloveniji, čeprav nismo imeli smrtnih žrtev. V Sloveniji pa moramo resno upoštevati možnost, da bi zlasti ob večjem potresu lahko imeli tudi veliko smrtnih žrtev, kot je bilo leta 1511.

Zgornje Posočje spada med najbolj razgibane slovenske pokrajine. Zgornja dolina Soče nima večjih in obsežnejših uravnav ali kotlin, ki so značilne za preostali del Slovenije. Nekaj večje razširitve so le pri Bovcu, Kobaridu in Tolminu s stransko vejo proti Nadiži. Videti je, da so k taki morfološki izoblikovanosti Posočja močno prispevale tektonske in nekatere druge značilnosti te pokrajine. Ni dvoma, da sodi Zgornje Posočje med naše najbolj ogrožene pokrajine. Samo v razmaku 22 let sta ga prizadeli kar dve uničujoči seriji potresov, leta 1976 in 1998. Ti potresni dogajanji sta bili različni po svoji naravi in učinkih. Prvi potres leta 1976 je bil nedvomno močnejši od tistega v letu 1998. K sreči je bilo pri prvem žarišče v sosednji Italiji, približno 25 km oddaljeno od meje.

Leta 1998 smo se kakor že leta 1976 lotili terenskega raziskovanja potresnega dogajanja v Zgornjem Posočju. Posledice, ki jih v določenem območju povzročijo naravne nesreče, imajo vedno večplastne razsežnosti. Zato ni slučaj, da so tudi pri tem raziskovanju sodelovale zelo različne skupine raziskovalcev. Delo raziskovalnih skupin pri projektu Vpliv potresa 12. 4. 1998 na Bovškem na stavbe, ljudi in okolje je koordiniral Zavod za gradbeništvo Slovenije. Sodelovala pa sta Znanstvenoraziskovalni center Slovenske akademije znanosti in umetnosti z Geografskim inštitutom Antona Melika ter Univerza v Ljubljani s Filozofsko fakulteto, Oddelkom za psihologijo. V tem prispevku so le pregledno prikazane nekatere geografske razsežnosti posledic zadnjih dveh velikih potresov v Posočju.

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Contents – Vsebina

1. Introduction

While no lives were lost in Slovenia during the earthquakes in the upper Soča region in 1976, around 13,000 people suddenly found themselves without roofs over their heads. Abroad, the term »homeless person« is often applied. A study of the consequences of the 1976 earthquake in Italy's Resia region ten years after the event revealed that earthquakes can have extensive social, economic, and cultural dimensions. Here, it undoubtedly meant a great leap from the traditional agrarian or »Resian« society to a completely new society and a new social structure. This process shook Resia and its people to the core, and Resia as we knew it before the earthquake no longer exists. To a great extent, this is also true of the upper Soča region. Similarly, many people believe that Ljubljana only began to grow into a modern city and acquire the basis of its modern appearance following the 1895 earthquake.

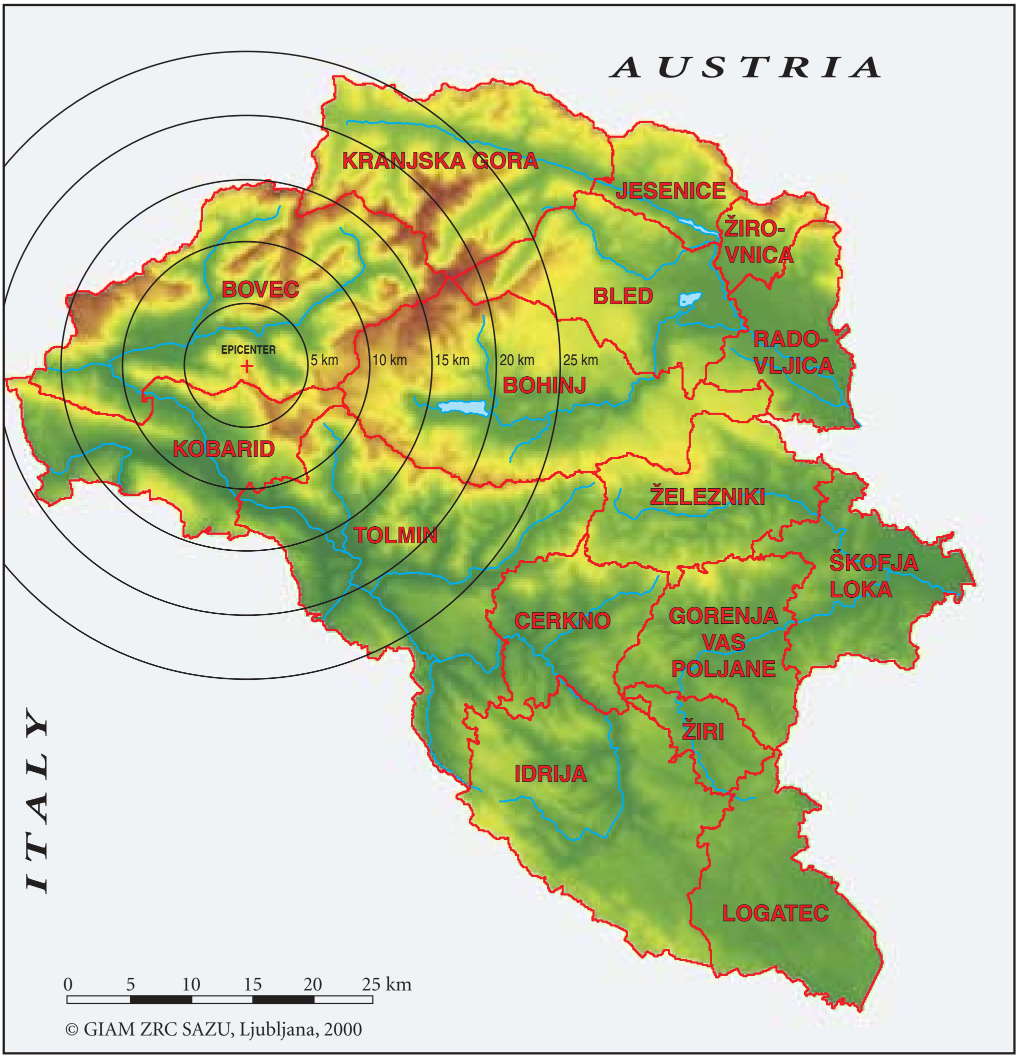

Figure 1: Map of 16 municipalities in northwest of Slovenia affected by 1998 earthquake.
Slika 1: Ob potresih leta 1998 prizadetih 16 občin severozahodne Slovenije.

The majority of the older rural residential and farm buildings in Slovenia are built of stone with lime mortar. The quality of construction is usually poorer than in the more important urban buildings. Walls are usually constructed of two layers of uncut or partly cut stone with the space between filled with stone gravel mixed with poor lime mortar. The majority of the houses were built in this fashion in the Kozjansko region where the 1974 earthquake caused considerable damage. Following the 1976 earthquake in the upper Soča region, when many old buildings had to be demolished or repaired, houses built before 1945 were relatively few (1,919 or 32.6%). In the Tolmin region, there were few homes built in the period between 1945 and 1970, only 19.3%, as there was a low rate of construction in that period. The proportion of homes built after 1970, which is the consequence of restoring housing after the 1976 earthquake, is well above the average (44.7%).

2. Geological and other features of the Upper Soča Region

Earthquake activity in this part of Europe is determined by the African and Eurasian plates, and the overall activity is further complicated by the smaller Adriatic plate which lies between them. The undeformed section of the Adriatic plate encompasses almost the entire Adriatic Basin and is surrounded by mountain chains (Hellenides, Dinarides, Alps, Apennines) elevated due to the influence of the plates. Research indicates that the Adriatic plate is revolving in northeast direction, which causes folding and thrusting on the eastern and northern side of the plate and partly on the northwest side as its southwest edge stretches and moves away from the European plate. The greater part of Slovenia (its southern and western parts) lies on the northern part of the Adriatic plate, which is very deformed and overlaps the central less deformed part of the Adriatic plate.

Geotectonically, this region is classified in the Dinarides, which are further divided into the Southern Alps and the Outer Dinarides. For this section of the Southern Alps, regional thrusts from north to south are characteristic (e. g., the thrust of the Julian Alps). The Outer Dinarides encompass the southwest part of Slovenia. Faults run from northwest to southeast (the so-called »Dinaric« orientation), and the thrusts run from north to south. Faults of the Dinaric orientation continue into Friuli-Venezia Giulia in Italy where they are covered by thrusts.

Triassic limestone and partly dolomite strongly dominate the upper Soča region. From the Bovec basin south, primarily in lower locations, Jurassic and Cretaceous impermeable hilly formations appear with sandstone and flysch. In the bottoms of the valleys, gravel Quaternary sediments occur in larger quantities accompanied by numerous alluvial fans of permanent creeks and torrents and scree. In some places, for example, at Breginjski kot, the remains of glaciation are very distinct.

After the earthquakes that shook the region in 1976, major differences in the amount of damage caused by the earthquakes were evident within small distances (Orožen Adamič, 1979). The same phenomenon was determined during a detailed survey of the consequences of the earthquakes in Resia (Rezija) and the Torre Valley (Terska dolina). To a great extent, this is explained by differences in the micro and macro geological conditions. Even the initial survey of the extent of the damage showed that the greatest damage occurred in settlements located over non-compact ground such as gravel, particularly where the groundwater is close to the surface. A more detailed survey of the consequences of the 1976 earthquake in Podbela showed that the lesser depth of the water table in the southern and southwestern parts of the settlement additionally contributed to the extent of the damage. In general, there was significantly less damage in settlements located on flysch, for example, in Drežnica, which lies in the immediate vicinity of Ladra and Smast where there was very great damage. Overall, the earthquakes in the upper Soča region were best survived by settlements situated on carbonate stone. The northeastern part of Kobarid was less damaged than the rest of the town that lies on Quaternary sediments. Regarding the effects of earthquakes relative to the predominant geological bedrock, the upper Soča region can be divided into three units:
1. Quaternary sediments,
2. predominantly impermeable hilly formations, and
3. hard Carbonate stone.

Quaternary sediments are mostly composed of more or less cemented fluvioglacial material, slope rubble, and the like. These are favourable regions for settlements and agricultural use. They include the lower parts of valleys and in many places indent like tongues into steeper slopes. Due of the nature of the bedrock, the great differences in altitude, and the heavy precipitation in the upper Soča region, this is a quite unstable ground. In the lower parts of the valleys, the groundwater is often very close to the surface, and in some places flooding is relatively frequent. Settlements in the upper Soča region are mostly situated on the fringes of Quaternary sediments and at the contact of different impermeable or carbonate rock. A location at the contact of different natural geographical or geo-ecological units is typical of rural settlements. Permanent reservoirs of groundwater in the upper Soča region are not large because there are no suitable orographical conditions for them. The valleys are relatively narrow and offer no possibility for large accumulations of groundwater in Quaternary sediments. Finally, it is also significant that many settlements are located on slopes, on alluvial fans, and on scree where the composition of the earth and the gradient of the slope intensify the instability of the ground. Thus, for example, the village of Ladra lies on gravel deposited by the Soča River and a smaller tributary where the groundwater is close to the surface due to the proximity of the river. Borjana, Potoki, Stanovišče, Homec, and many other settlements are situated on scree. Breginj and some other places in the upper Soča region are mostly situated on uncemented slope rubble and partly on the remains of glacial moraines.

Along with these factors, it must be particularly emphasized that flysch occurs in greater or lesser depths covered by Quaternary sediments under many of these settlements, which additionally makes direct comparisons impossible. Similar and even greater landscape diversity is characteristic of the majority of Slovenia's regions, not just the upper Soča region. Experience in the upper Soča region teaches us that this diversity must be fully taken into account in areas distinctly threatened by earthquakes.

The influences of ground and topographical factors are interrelated and are interwoven with substantial variations in the soil on the bedrock. In practice, these factors are very difficult to evaluate or assess quantitatively. Furthermore, there are several factors, for example, the depth of the groundwater, that are changeable and unstable.

Microseismic regionalization, usually done for the most threatened regions, is an attempt to find at least partial answers to these questions.

The epicenter region is composed mainly of limestones and dolomites originating in various geological periods of the Mesozoic, which from the seismic and geological viewpoint is very good ground; however, it must be emphasized that the majority of the settlements stand on the deposits of the Soča River and its tributaries or on rubble slopes, which are essentially less favourable sites. Numerous joints intersect the rock, which further weakens the strength of the rock.

3. Seismic maps

The history of the origin of seismic maps in the former Yugoslavia began in 1950 when J. Mihailović made the Seismological Map of Yugoslavia, which in 1964 was appended to the first technical regulations for the construction of buildings in seismic regions. In 1982, in the framework of the Office of Seismology of Yugoslavia, which united the seismological institutes and observatories of the various republics, the first Provisional Seismological Map of Yugoslavia was published. It was based on a statistical analysis of known earthquakes that had struck the territory of Yugoslavia in the past. This seismological data is, of course, not sufficient for making modern seismological maps. Work therefore began on a new map based on complex seismological, geological, and geophysical studies that was published in 1987. This map has a prognostic character since it offers an assessment of the probability of the occurrence of an expected earthquake in the future. The first phase of elaborating the map presented the focus zones of possible earthquakes with their maximum magnitudes, and the second phase presented the magnitudes of expected earthquakes for various regions and various return periods. Maximum magnitudes are calculated for the longest period, 10,000 years. For the construction of buildings, parameters had to be calculated and maps made for shorter periods of 50, 100, 200, 500, and 1,000 years. Isolines were created on the maps by connecting points of equal values of individual magnitudes. Isolines delineate areas with the same levels of predicted magnitudes of earthquakes. Errors in the isolines can be up to (5 kilometers. Places that are situated on isolines fall within areas of greater magnitude. The map for the return period of 10,000 years shows the maximum possible magnitudes that could strike an individual region. For regions where an intensity of $I \geq 7$ MSK ($I \geq 7^{th}$ degree on the EMS scale) is possible, additional seismological studies and the microregionalization of the terrain must be undertaken in accordance with the technical regulations for construction in seismic areas. A revision of the map is required every five years or after stronger earthquakes affecting individual areas that can change the previous information about them. Seismological maps are intended for the needs of the statutes on technical norms for the construction of buildings in seismic areas as well as for the requirements of spatial and urban planning and projecting (Explanation of the Seismological Map of Yugoslavia, Belgrade, April 1987).

4. Maps of detailed earthquake regionalization

At the initiative of the Republic Civil Defense Headquarters, an analysis was done at the Seismological Institute of the Republic of Slovenia (currently the Office of Geophysics of the Republic of Slovenia) at the beginning of 1991 entitled Earthquake Threat to Slovenia that covered the municipalities of Brežice, Idrija, Krško, Ljubljana, and Tolmin. Maps of anticipated earthquake effects were drawn for civil defense use (earthquake microregionalization). This was not the regular microregionalization but a more detailed earthquake regionalization. The maps were made exclusively on the basis of seismological data and the geological structure of the terrain and were therefore not intended for planning construction. To make maps of use to construction planning, much deeper studies and more detailed geological (engineering geological and hydrogeological) mapping should be done, the joints in the terrain should be determined, and various on-site geophysical measurements should be taken. Perhaps the earthquake in the upper Soča region will spur the creation of such maps for the most threatened regions of Slovenia (Vidrih, 1998).

The greatest expected earthquake magnitudes appear on part of the map of a more detailed earthquake regionalization of the Tolmin municipality (see Figure 7). The map of the municipality is divided into areas with the highest expected magnitudes of 8 and 9 on the MSK scale, which correspond to magnitudes 8 and 9 on the EMS scale, and is derived from the national map of earthquake magnitudes. These areas are further divided relative to three different bases: index 1 – better ground, index 2 – medium ground, and index 3 – poorer ground.

The main earthquake at 12:55:32 p.m. (local time) on April 12, 1998, was followed by around four hundred aftershocks in the first twenty hours, and by May 8, 1998, several thousand weaker aftershocks had been recorded. Five of the aftershocks exceeded a magnitude of 3.0. Another powerful aftershock occurred on May 6^{th} at 4:53 a.m.

The epicenter of the 1998 earthquake occurred in a region where according to the applicable national map of earthquakes, magnitudes can reach 8 on the MSK scale, which corresponds to 8 on the EMS scale (Statute on Technical Norms for the Construction of Tall Buildings in Seismic Regions, Official Gazette of SFRY, No. 31/87, and Statute on the Changes and Supplements of the Statues on Technical Norms for the Construction of Tall Buildings in Seismic Regions, Official Gazette of SFRY, No. 52/90). The distribution of the greatest effects during the last earthquake was also correctly estimated as the greatest damage occurred in the areas marked with index of 3, meaning poor ground. The epicenter area is composed primarily of carbonate rock (limestones and dolomites), which in some places changes into marl. From the seismological viewpoint, carbonate rock is favourable ground while marl is somewhat poorer. Deposits of rivers and streams and rubble slopes offer the poorest base. The deposits of the Soča River and its tributaries form terraces composed of gravel, sand, and rarely conglomerate. Rubble slopes are also dangerous. The damage in Mala vas, Bovec, Kal-Koritnica, the Lepena Valley, Spodnje Drežniške Ravne, Magozd, Jezerca, Krn, and so forth was the consequences of shock waves amplified due to the poor geological foundation.

All the places where the greatest damage occurred lie on poor ground. According to preliminary assessments, the earthquake nowhere exceeded a magnitude between 7 and the 8 on the EMS scale, which corresponds to the national map of earthquake magnitudes (Vidrih, 1998).

TABLE 1: AFTERSHOCKS WHOSE MAGNITUDES EXCEEDED 2.5 (OFFICE OF RS FOR GEOPHYSICS, 1998).
PREGLEDNICA 1: PREGLED POPOTRESNIH SUNKOV, KATERIH MAGNITUDA JE PRESEGLA 2,5 (UPRAVA RS ZA GEOFIZIKO, 1998).

Date	Time (UTC)	Local time	M
12.04.1998	10.56	12.56	5.5
12.04.1998	11.13	13.13	2.7
12.04.1998	11.50	13.50	2.7
12.04.1998	12.44	14.44	2.7
12.04.1998	13.35	15.35	3.2
12.04.1998	14.24	15.24	2.5
12.04.1998	16.15	18.15	3.0
12.04.1998	20.54	22.54	2.8
12.04.1998	22.14	00.14	3.2
13.04.1998	03.23	05.23	2.7
13.04.1998	04.58	06.58	2.7
15.04.1998	19.40	21.40	3.4
15.04.1998	22.42	00.42	3.1
16.04.1998	17.21	19.21	2.9
21.04.1998	10.50	12.50	2.5
22.04.1998	06.56	08.56	2.8
06.05.1998	02.53	04.53	4.0
08.05.1998	10.11	12.11	2.8
12.05.1998	11.31	13.31	3.3
13.05.1998	01.59	03.59	3.1
13.05.1998	21.37	23.37	2.6
15.05.1998	13.38	15.38	2.7
20.05.1998	06.40	08.40	2.6
24.05.1998	17.45	19.45	2.6

UTC: the time of an earthquake is usually stated in terms of Coordinated Universal Time, which differs by one hour from our local time or two hours during Daylight Saving Time in summer.
UTC, čas potresa se navadno prikazuje po koordinatah univerzalnega časa. Ta je za eno uro različen od našega lokalnega časa oziroma dve uri v polenem času.

The 1998 earthquake was felt throughout the territory of Slovenia. It was also felt in Croatia, Bosnia and Herzegovina, Hungary, Slovakia, the Czech Republic, Germany, Austria, Switzerland, and Italy. This earthquake was the most powerful earthquake with an epicenter in the territory of present-day Slovenia since 1917.

The earthquake triggered numerous rockfalls and landslides, particularly in the Krn mountain chain. The largest rockfalls and landslides included the rockfall below Mount Lemež in the Lepena Valley, the rockfall on the southwestern slope of Mount Krn, the rockfall on the alpine meadow area of Polog above Tolmin, and the rockfall at the source of the Tolminka River. Landslides near Grahovo and Kneža and five other larger rockfalls and landslides in the Lepena Valley became active again. The earthquake damaged several dams and waterworks and caused a change in groundwater levels resulting in interruptions and disorder in the supply of drinking water. Numerous local and several regional roads were temporarily impassable due to rockfalls, landslides, and damage to roadbeds and bridges.

5. Consequences of the 1976 earthquakes

The main and the most powerful shock of the 1976 earthquakes occurred at 21:00:12.5 on May 6th, with its epicenter in the area of Mount San Simeone in northern Friuli. Ribarič (1980) states a focus depth of 11.8 kilometers and a magnitude of 6.5 ± 0.2 on the Richter scale and a maximum magnitude of 9 to 10 on the MCS scale.

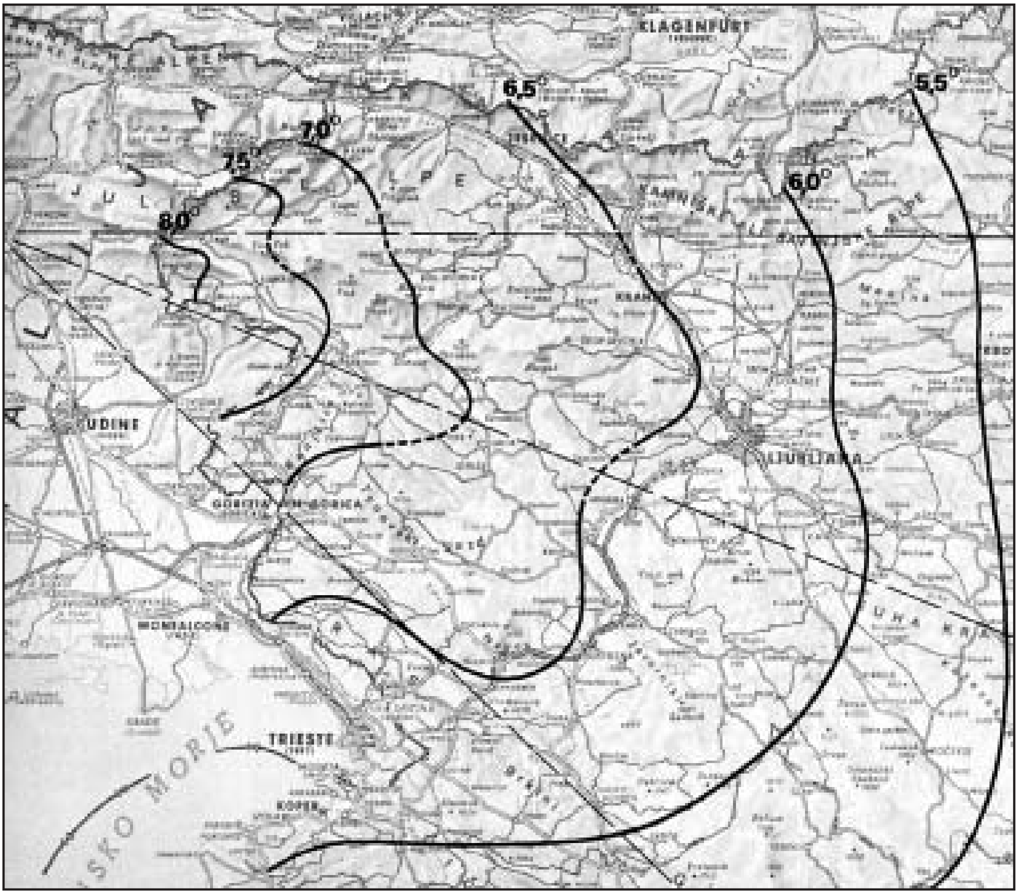

Figure 2: A sector of the map of isoseismal lines based on the MCS scale in Slovenia for the earthquake on May 6, 1976, which had its epicenter in Friuli (Astronomical and Geophysical Observatory of the University of Ljubljana).
Slika 2: Izsek iz karte izoseist po MCS lestvici v Sloveniji za potres z dne 6. 5. 1976, ki je imel epicenter v Furlaniji (Astronomskogeofizikalni observatorij Univerze v Ljubljani).

Newer buildings constructed according to safety regulations on seismically more stable terrain in the upper Soča region withstood the earthquake only with minor damage. The major damage was to buildings located on flysch and Quaternary bedrock and where the groundwater is very close to the surface. Such bedrock conditions are characteristic of the following settlements and their parts: Breginj, Podbela, Ladra, Kamno, Volarje, etc. Due to the solid rock beneath it, Tolmin suffered relatively little damage. In Kobarid, there was considerably less damage to buildings on the north side of Gregorčič street, which stand directly above Triassic rock, than to buildings above Quaternary sediments in other parts of the town.

After May 6, especially strong aftershocks occurred on May 9th and 11th, and then the aftershocks gradually subsided. A second series of stronger earthquakes followed on September 11, 1976. The renewed earthquake activity reached magnitudes of 8 and 9 on the MSC scale, only a half to one degree less than the initial earthquakes on May 6, 1976. On September 15th, there were six earthquakes with magnitudes of 6 or higher on the MCS scale.

In Breginjski kot the strength of the earthquakes reached about one to one and a half magnitudes lower on the MCS scale than at the epicenter area in Italy. In Slovenia, earthquakes of magnitude 8 occurred twice, of magnitude 7 five times, of magnitude 6 seven times, and of magnitudes between 5 and 6 as many as twenty-four times. Such a large number of earthquakes in the two periods caused considerable damage. The gradual increasing of the original damage must be particularly emphasized.

Another important factor is that there were relatively few new buildings strengthened with reinforced concrete at that time in the upper Soča region; old houses built largely from stone with lime mortar and with wooden ceilings dominated. Note that we state the data according to areas of the existing municipalities (60). The figures from the 1971 census of population and housing (Census … 1971) show that the percentage of housing built before 1918 was 50.4% in the Idrija municipality, 46.6% in the Tolmin municipality (which can be attributed to the consequences of World War I), and only 22.4% in the Nova Gorica municipality. The percentage of housing built between 1918 and 1945 and still usable was 30.5% in the Tolmin municipality and 7.7% in the Idrija municipality. Housing built between 1946 and 1960 accounted for 9.7% in the Tolmin municipality, 17.4% in the Idrija municipality, and 18.5% in the Nova Gorica municipality. There are also large differences in the amount of housing built in the period between 1960 and 1971: 12.3% in Tolmin, 21.9 in Nova Gorica, and 23.4% in Idrija. Almost half of the housing in the Tolmin and Idrija municipalities was more than fifty years old at the time of the earthquake. This was housing in which reinforced concrete or other modern materials were rarely used. Reinforced concrete sheets and other similar construction elements only came into use to a greater extent after 1946. Before the earthquake, about 80% of the housing in the Tolmin municipality was built in the traditional fashion without the use of concrete, iron, brick, or and similar materials. There were understandably substantial differences between individual settlements, which reflect the level of urbanization. The percentage of housing built before 1918 in Borjana was 79.2%, in Breginj 86.9%, in Podbela 100%, and in Volarje 94.3%. In Borjana, the proportion of housing built before 1918 was a little lower than in neighbouring less urbanized settlements due to the avalanche on February 14, 1952, swept away part of the village. A completely different picture appears in the more urbanized settlements, where there is substantially less housing built before 1918. In 1971, such housing amounted to 53.5% in Kobarid and only 12.8% in Tolmin.

Figure 3: After the first strong earthquake shocks on May 6, 1976, numerous buildings in the upper Soča region were heavily damaged. The photograph shows an example of damage to a typical, traditionally-built house in Podbela, which at the beginning of the earthquake activity was already the most damaged settlement. The picture was taken on May 7th when the first series of earthquakes had not yet ended. This building was later demolished because repair was no longer economically justifiable (photography Milan Orožen Adamič).

Slika 3: Že po prvih močnih potresnih sunkih 6. maja 1976 so bile v Posočju močno poškodovane številne stavbe. Na fotografiji je primer poškodb na hiši v Podbeli, ki je bila že ob začetku potresne aktivnosti najbolj prizadeto naselje. Fotografija je bila posneta 7. maja, ko še ni bila zaključena prva serija potresov. To stavbo so kasneje porušili, ker popravilo ni bilo več ekonomsko opravičljivo (fotografija Milan Orožen Adamič).

In some other places, other factors are important as well; for example, 95.8% of the homes in Stanovišče were rebuilt after 1946 because the village was razed during the war. In restoring Stanovišče in 1946, the majority of the original floor plans were maintained and advantage was taken of existing ruins to the fullest extent possible, and thus the quality of the buildings was not substantially improved. The same applies for Žaga, which was destroyed in World War I and suffered much in World War II as well.

No major landslides, rockfalls, or similar occurrences were recorded in Slovenia due to the 1976 earthquake. Some water sources were muddy for a short while. For safety reasons, the quality of water had to be checked in numerous catchments and the use of water limited, but there were no major difficulties. Minor rockfalls occurred on the slopes of the right bank of the Natisone/Nadiža River on the Italian side from Stupizza/Štupica downriver. Minor road repairs were necessary in a few places near Žaga and Idrsko.

However, if we consider extensive consequences of the earthquake in the upper Soča region, the specific problems of this region, and the consequences in the Venetian Slovenia (Beneška Slovenija), Resia, and Goriško regions, the 1976 catastrophe was undoubtedly one of the greatest natural disasters to strike Slovenes in the 20th century.

The majority of those left homeless-some only temporarily until repairs were made while others lost their homes forever-were from local communities in the Tolmin municipality (Figure 5), which appear in Group 1 on the appended map. In four of this municipality's local communities (LC), more than 80% of the population was left homeless: Breginj (80.28%), Ladra-Smast (80.67%), Srpenica (81.48%), and Trnovo (84.62%). Particularly interesting is the very high number of homeless people in LC Trnovo whose homes were classified exclusively in Category 2, temporarily unusable but repairable housing. The largest num-

Figure 4. This photograph from Podbela clearly shows how the wall of a house was built. The rocks are arranged so that the wall is flat on the outside and the inside and held together with limestone mortar and plaster. This traditional method of building is very poor from the construction point of view and the consequences were therefore catastrophic (photography Milan Orožen Adamič).
Slika 4: Na tem posnetku iz Podbele je lepo vidno, kako je bil zgrajen zid hiše. Kamni zidov so bili zloženi tako, da je bila s tem ravna z zunanje in notranje strani, vezani z apnenim vezivom in ometom. Tak način tradicionalne gradnje je statično zelo slab in zato so bile tudi poškodbe tako katastrofalne (fotografija Milan Orožen Adamič).

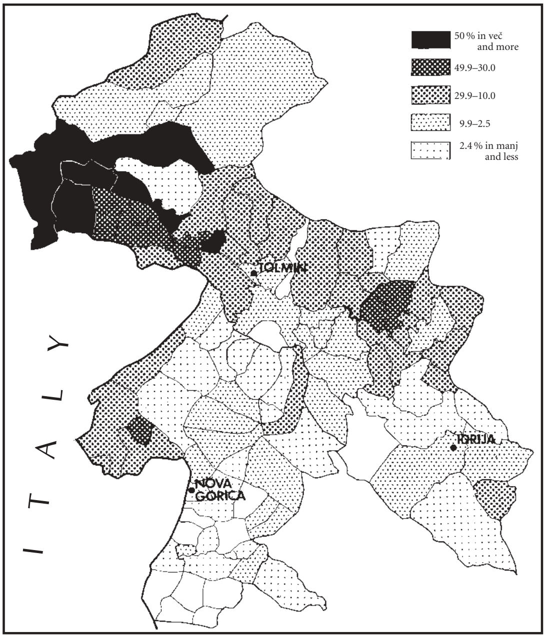

Figure 5: Proportion of the population without safe housing due to the consequences of the 1976 earthquakes according to existing local communities in the municipalities of Tolmin, Nova Gorica, and Idrija.
Slika 5: Delež prebivalstva brez varnih bivališč zaradi posledic potresov leta 1976 po takratnih krajevnih skupnostih v občinah Tolmin, Nova Gorica in Idrija.

bers of people with homes in Category 3, permanently unusable housing, were from LC Breginj (31.33%), Borjana (23.14%), Ladra-Smast (21.78%), and Srpenica (15.64%). Between 50% and 80% of the population in the local communities of Čezsoča (68.78%), Žaga (66.14% Volarje (59.16%), and Borjana (52.34%) was left homeless. In LC Žaga, the proportion of the homeless population increased greatly following the series of earthquakes in September, and the final situation can be compared with Breginj. The same applies for LC Borjana where the village of Podbela was without doubt the most damaged site in the upper Soča region. The situation in LC Volarje was similar to that in LC Ladra-Smast.

We placed local communities where 30% to 50% of the population found themselves homeless due to the earthquakes in Group 2. In the Tolmin municipality, the following local communities belong in this group: LC Idrsko (46.68%), LC Kred (40.41%), LC Kobarid (37.72%), and LC Kamno (36.22%). In the Idrija municipality, the major damage was caused in LC Orehek (44.89%) and Bukovo (33.73%). In the Nova Gorica municipality, only LC Kojsko (32.05%) in Goriška Brda belongs in this group. The Tolmin municipality is characterized by local communities with the most affected areas. After the series of earthquakes in September, the level of damage here increased greatly, and we estimate that more than 50% of the population in these places was without regular housing.

Venetian Slovenia (Beneška Slovenija) and Resia were heavily struck, and according to our classification many areas here fall largely in Category 3 with permanently unusable housing. According to the figures in the Poročilo o opravljenem delu pri odpravi posledic potresov v Posočju (Report on the Work Performed in the Removal of Consequences of the Earthquakes in the Upper Soča Region) for 1976, 1,609 houses were demolished in thirteen villages or settlements in Venetian Slovenia due to the earthquakes. Of all the regions where Slovenes live, Venetian Slovenia was the most heavily struck, which further intensified its already quite major problems.

Medium affected areas (Group 3) included those where 10% to 30% of the population lost their regular housing due to earthquakes. The cumulative effect of the earthquakes on these places is estimated at approximately magnitude 7 on the MCS scale. In the category of less affected areas (Group 4), we ranked places where 2.5% to 10% of the population lost their homes. We classified areas where less than 2.5% of the population of local communities was left without safe housing in Group 5.

We do not have such detailed figures for other municipalities in Slovenia. In the Radovljica municipality, the most damage was caused in LC Bohinjska Bistrica in the Bohinj region, which could be ranked in Group 5. The same applies to the Škofja Loka municipality, where twenty-six buildings suffered Category 2 damage and ten suffered Category 3 damage. In the Ajdovščina municipality, most of the damage occurred in the Vipava Valley with local communities mostly in Group 5 and some in Group 4. In the Postojna municipality, no major damage was recorded. In the Jesenice municipality, the major damage occurred in Rateče, Podkoren, and Kranjska Gora (Group 6). The damage in LC Stara Ljubljana can also be classed in Group 6. There were no records of any major damage in Slovenia's coastal municipalities.

In the Tolmin municipality, as much as 21.03% of the population lived in buildings suffering Category 2 and Category 3 earthquake damage, and a good fifth of the population of this municipality was forced to live in temporary housing. In the Idrija municipality, this population percentage was 8.22%, and in Nova Gorica 4.6%. As a result of this earthquake, about 0.5% of Slovenia's population was forced to spend a shorter or longer period of time in temporary housing.

6. A detailed survey of the consequences of the 1998 earthquake

The earthquake that struck the upper Soča region in 1998 differed in many ways from the one in 1976 since its epicenter was located in Slovenia. The epicenter region is composed mainly of limestones and dolomites originating in various geological periods of the Mesozoic, which from the seismic and geological viewpoint is very good ground; however, it must be emphasized that the majority of the settlements stand on the deposits of the Soča River and its tributaries or on rubble slopes, which are essentially less favourable sites. Numerous joints intersect the rock, which further weakens the strength of the rock.

After surveying the terrain, we determined that the magnitude of the earthquake reached its highest levels in Magozd, Drežniške Ravne, Lepena, and Tolminske Ravne. The area where the earthquake reached or exceeded a magnitude of 7 on the EMS scale (the more modern version of the EMS scale of earthquake magnitudes is not essentially different from the older MCS scale that was in use during the 1976 earthquake) has a diameter of about twenty-two kilometers. Because there was no widespread destruction of buildings, the earthquake only took one life in Slovenia and only three people in Lepena were more seriously injured. During the cleanup immediately following the earthquake, two firemen received minor injuries.

There was major material damage to residential, industrial, and commercial premises as well as to the infrastructure and to cultural heritage sites. The greatest damage occurred in Bovec, Soča, Kal-Koritnica, Lepena,

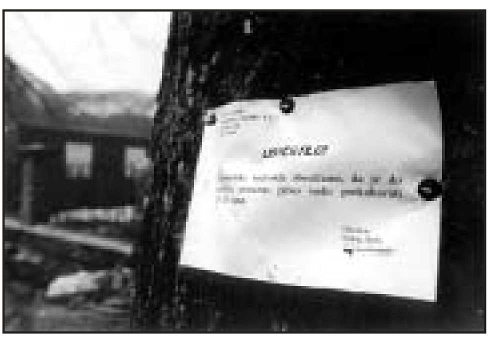

Figure 6: A notice posted in Bovec-Mala vas that water must be boiled for fifteen to thirty minutes before use (photography Milan Orožen Adamič).
Slika 6: Obvestilo v Bovcu – Mala vas, da je treba vodo pred uporabo prekuhavati od 15 do 30 minut (fotografija Milan Orožen Adamič).

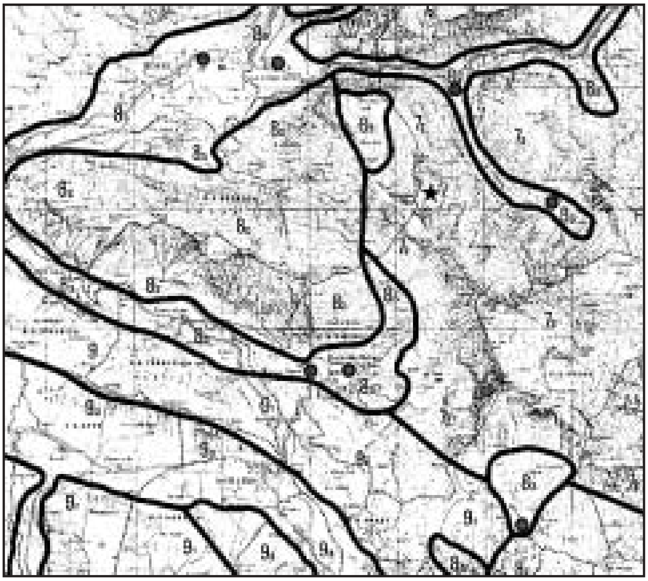

Figure 7: Part of the map of detailed earthquake regionalization in the municipality of Tolmin made in 1991 for civil defense use. A star marks the epicenter of the earthquake on April 12, 1998, and small circles denote places where the earthquake reached its greatest destructive power (Seizmološki zavod RS, 1991).
Slika 7: Del karte podrobnejše potresne rajonizacije občine Tolmin, ki je bila narejena leta 1991 in je namenjena za uporabo v civilni zaščiti. Z zvezdico je označeno nadžarišče (epicenter) potresa 12. aprila 1998, s krogci pa so označeni kraji, kjer je potres dosegel največjo razdiralno moč (Seizmološki zavod RS 1991).

Log pod Mangartom, Drežniške Ravne, Magozd, Koseč, Jezerce, Krn, Tolminske Ravne, and Čadrg. In Gorenjska, mainly private houses were damaged by the earthquake (toppled or otherwise damaged chimneys) along with several hotels in the municipalities of Bohinj and Jesenice.

7. Rockfalls

Rockfalls and landslides occur very frequently during earthquakes in hilly and mountainous regions. It is interesting that in 1976 when the epicenter of a much stronger earthquake was relatively distant, there were much fewer occurrences of these phenomena in the upper Soča region than in 1998. The largest rock-

Figure 8. Rockfalls in the area of the Tolminka watershed greatly changed the previous appearance of the landscape. The asymmetrical form of the slopes on both sides of the valley is even more pronounced (photography Borut Peršolja).
Slika 8: Podori so v povirju Tolminke močno spremenili prejšnjo podobo pokrajine. Asimetričnost pobočij na obeh straneh doline, je s tem še posebej poudarjena (fotografija Borut Peršolja).

Figure 9: The rockfalls from the wall of Mount Osojnica were surprising due to the size of the breaks in the wall and the quantity of rubble that greatly transformed the previously forested slopes. On the site of the rubble, the forest was stripped bare and tongues of larger rocks forced their way toward the Tolminka River (photography Borut Peršolja).
Slika 9: Podori v ostenju Osojnice presenečajo tako zaradi velikosti odlomov v steni, kot tudi zaradi količine nasutega gradiva, ki je močno preoblikovalo prej poraščena pobočja. Na mestu odpada je gozd uničen ploskovno, večje skale pa so si pot proti Tolminki utrle v obliki jezikov (fotografija Borut Peršolja).

falls and landslides included the rockfall below Mount Lemež in the Lepena Valley, the rockfall on the southwestern slope of Mount Krn, the rockfall on the alpine meadow area of Polog above Tolmin, and the rockfall at the source of the Tolminka River. Landslides near Grahovo and Kneža and five other larger rockfalls and landslides in the Lepena Valley became active again. The earthquake damaged several dams and waterworks and caused a change in groundwater levels resulting in interruptions and disorder in the supply of drinking water.

In many places the earthquake greatly accelerated processes that are otherwise normal in nature.

8. The source of the Tolminka was blocked with rock

The valley of the Tolminka River is one of the most charming alpine valleys in the upper Soča region, not only because of the picturesque little World War I chapel in Javorca but also because of its priceless natural assets. It lies in the central part of Triglav National Park. The destructive earthquake wave was exceptionally strong here (Luskovec, 1998), and the earthquake compressed natural processes that otherwise take thousands of years into a few seconds. The nature here suffered by far the most damage. The karst source of the alpine Tolminka River, which before was blanketed in moss and lush greenery, is now buried beneath the material that came tumbling down from Mount Osojnica during the earthquake. Hundreds of tons of rock fell, burying the lush greenery below the mountain and partially covering the road leading to the head of the valley. Crevices appeared in the ground along the mountain trail leading from the alpine meadows at Polog to the source of the Tolminka. The forests on the neighbouring slopes were literally decimated by the falling rocks. Some stands of trees were completely smashed, and individual trunks and branches still lie beneath the fallen rocks. Wherever one looks, the consequences of the earthquake are evident. Gigantic rocks lie scattered everywhere, making one think of the fate of anyone caught here during the earthquake. Such extensive transformations of nature are rare and are usually limited to just the most affected areas.

There were no reports of major material damage from neighbouring Italy. In comparison to the 1976 earthquake, this one was considerably weaker. The former had a greatest magnitude of 6.5 (0.2, while during the 1998 earthquake, a still relatively very high magnitude of 5.5 on the Richter scale was recorded. Another important difference between these two earthquakes was in the size of the area affected. The 1998 earthquake struck a substantially smaller area than the previous one. Its epicenter was approximately twenty-five kilometers due east of the 1976 earthquake (azimuth approximately 84°).

The earthquake caused substantial damage to the architectural and ethnological cultural heritage of the region. The still traditional appearance of the landscape prior to the 1976 earthquake has been further changed by the 1998 earthquake.

Damage was also recorded in the following ten municipalities: Cerkno, Gorenja vas-Poljane, Idrija, Jesenice, Logatec, Radovljica, Škofja Loka, Železniki, Žiri, and Žirovnica. Sixteen of Slovenia's 192 municipalities with a combined area of 3067.8 km^2 were affected, a good 15% of Slovenia.

According to its natural and geographical characteristics, this part of Slovenia is ranked in the alpine world. This is the highest region in Slovenia, and Triglav National Park is situated at its center. The area is relatively scarcely settled as altogether only 157,906 people-just over 8% of the population of Slovenia-live in 516 settlements in 40,473 houses. The average population density is fifty-one inhabitants per square kilometer, about half of the national average. Data on the damage by settlements and effected municipalities was provided by the Ministry of the Environment and Spatial Planning in October 1999.

The map in Figure 10 shows the areas most affected during the 1998 earthquake. Some of the settlements mentioned frequently in this article are identified. The size of the circles reflects the number of buildings in individual settlements. In the entire area studied, there are 516 settlements in sixteen municipalities. Damage was recorded in 224 settlements. There are altogether 40,473 house numbers registered in these municipalities (8.6% of all house numbers in Slovenia) and 26,499 house numbers registered in the affected settlements (5.6% of all house numbers in Slovenia). A total of 2,543 buildings were damaged in the earthquake.

The map in Figure 11 shows affected settlements by municipalities according to the cost of damage. The size and colour of the circle indicate the amount of damage in individual settlements. It is easily apparent from the map that the damage was by far the greatest in Bovec, where the cost totaled substantially more than one billion tolars (1,579,816,953 SIT[1]). Damage was also quite high in Jesenice (117,103,592 SIT) and in the area of Ukanc near Lake Bohinj (217,800,838 SIT), even though these two settlements are quite distant from the most affected area in the upper Soča region. It is clear from the map that the damage in settlements close to these two places was considerably less. This apparent anomaly can be attributed to the fact that Jesenice is a relatively large town and therefore the total cost of all the damage here was high. The damage was high in the Ukanc area because several tourist facilities in the area (Hotel Zlatorog in Ukanc, Ski Hotel on Mount Vogel, and the mountain lodges at the Savica waterfall and the Triglav lakes) were heavily damaged.

It is also clear from the graph in Figure 12 that the damage was by far the greatest in the Bovec municipality. With something more than half the damage suffered by Bovec, the municipalities of Kobarid and Tolmin are in the second group. At the time of the 1976 earthquake, these three municipalities were united in the single municipality of Tolmin. In the third group fall the substantially less affected municipalities of Gorenja vas-Poljane, Bohinj, and Cerkno. In the municipalities of Jesenice and Železniki, the total damage was still smaller, around 100,000,000 tolars in each. In the remaining municipalities, the damage was

[1] SIT (slovene tolar), 1 EUR = 223 SIT = 0,8744 USD

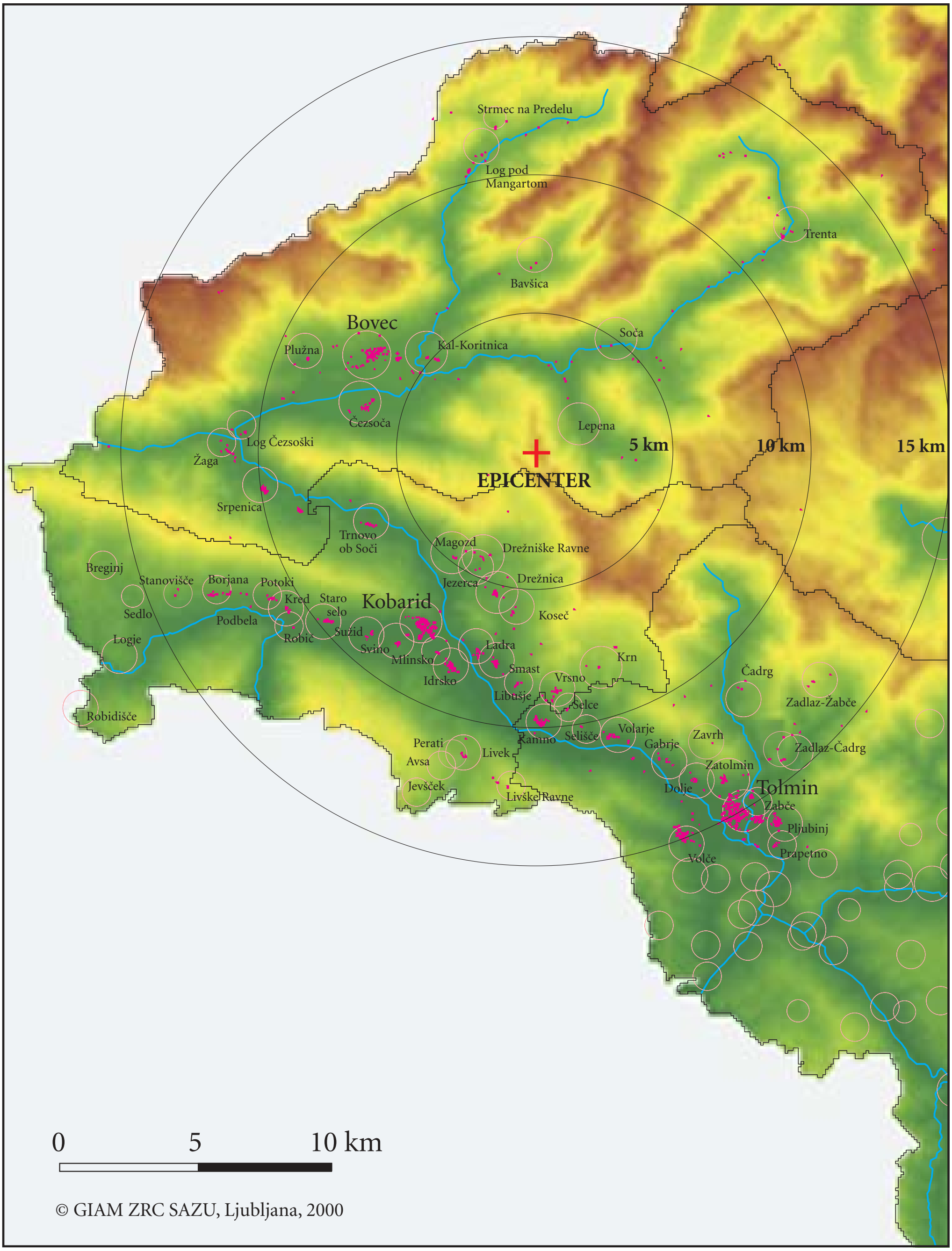

Figure 10: Most affected area, buildings, and settlements (source: EHIŠ, GURS 1998).
Slika 10: Najbolj prizadeto območje, objekti in naselja (vir: EHIŠ, GURS 1998).

substantially smaller in comparison with the most affected area. In spite of the very diverse relief and the resulting uneven distribution of settlements, the degree to which settlements were affected drops rapidly with the distance from the most affected epicenter area.

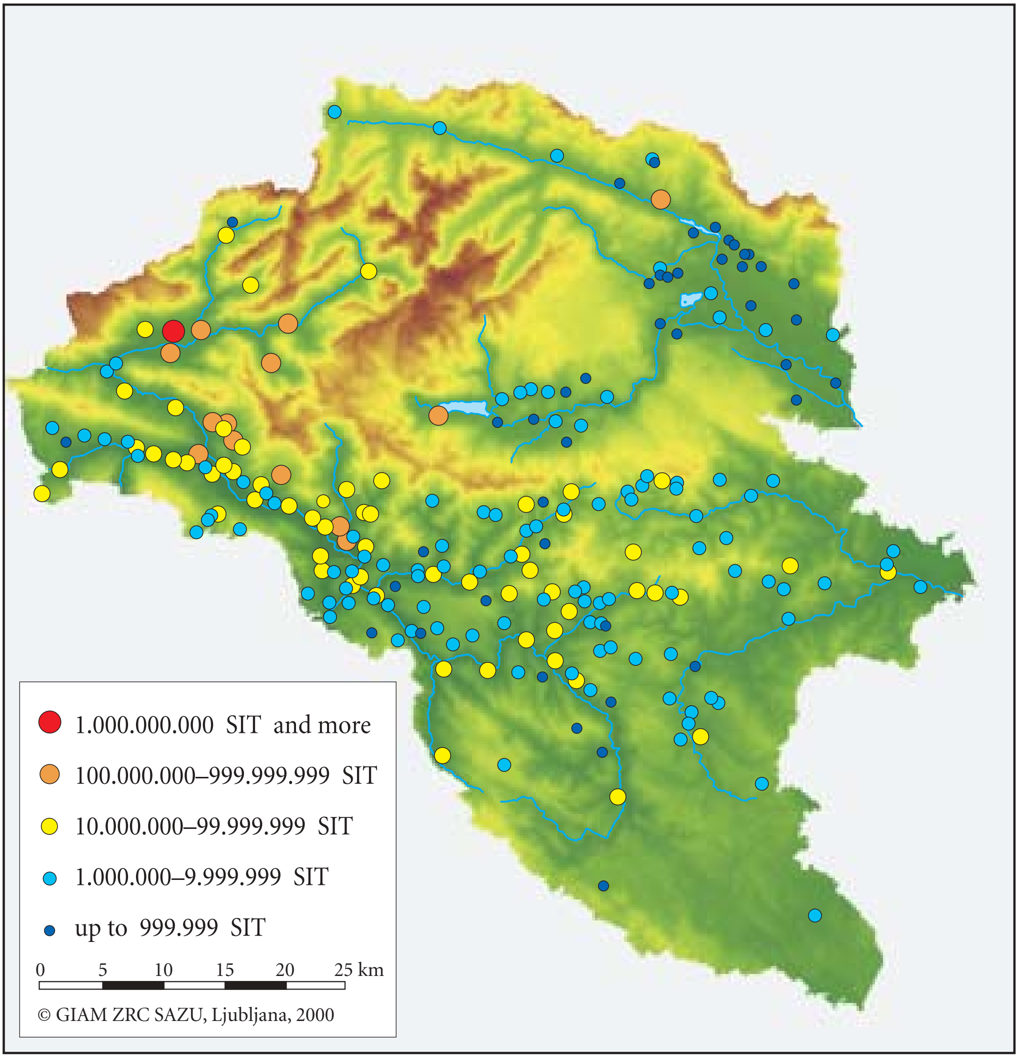

Figure 11: Cost of damage in the region struck by the 1998 earthquake, shown according to settlements (MOP 1999).
Slika 11: Višina škode na območju, prizadetem ob potresu leta 1998, prikazana po naseljih (MOP 1999).

The graph in Figure 12 shows the cost of damage calculated per individual inhabitant in the affected settlements according to municipalities. The columns are arranged in descending order. By far the highest is the Bovec municipality where the average damage per inhabitant reaches almost 800,000 SIT (774,111). The Kobarid municipality follows, in which damage per inhabitant is already about 2.5 times smaller (297,857 SIT). The municipalities of Tolmin, Gorenja vas-Poljane, Bohinj, and Cerkno follow with less than 100,000 SIT and more than 50,000 SIT of damage per inhabitant, and substantial damage per inhabitant also occurred in the Železniki municipality (20,155 SIT). In the remaining affected municipalities, the damage per inhabitant of the affected settlements in the municipality was considerably smaller, the highest damage being 5,554 SIT per inhabitant in Jesenice. Figure 13 shows this data according to individual settlements. The map clearly depicts the relative impact on individual settlements. Robidišče stands out distinctly because damage here, in spite of its being comparatively less affected than other areas, was relatively high because of the small number of inhabitants. Two other settlements in Železniki municipality, Zabrdo and Torka, stand out. Only five people live in the former settlement and only three in the

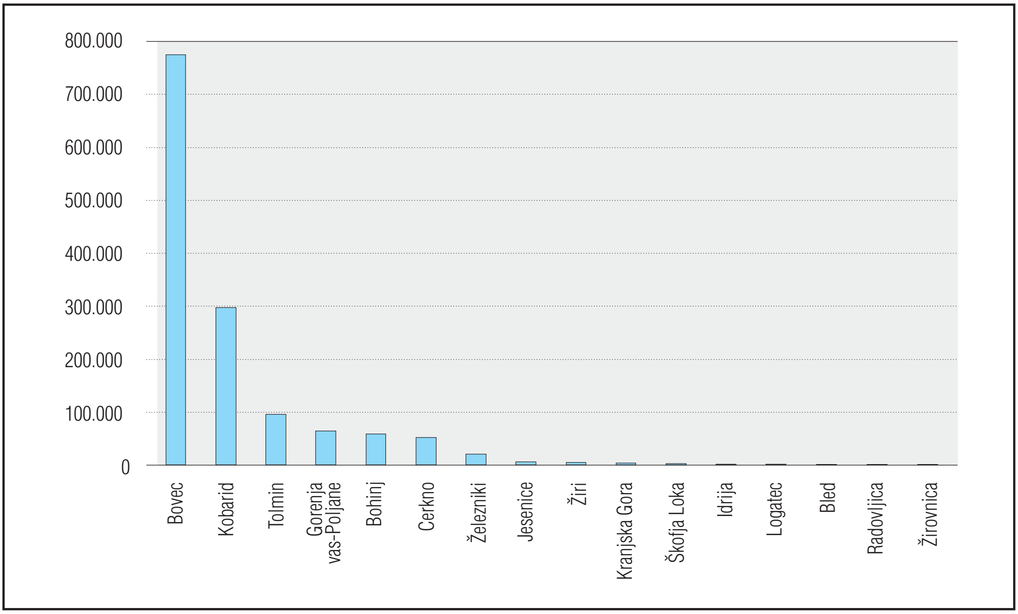

Figure 12: Cost of damage from the 1998 earthquake according to municipalities, calculated in SIT per inhabitant (MOP, 1999, population data from 1991 census).
Slika 12: Škoda po potresu 1998 po občinah, preračunana v SIT na prebivalca (MOP 1999, podatki o prebivalstvu po popisu 1991).

latter. The total damage in Zabrdo was assessed at almost fourteen million tolars, and in Torka, a little over five million tolars. Overall, the cost of damage was higher than one million tolars per inhabitant in thirteen settlements. Damage totaled between 500,000 SIT and one million tolars per inhabitant in nine settlements, between 100,000 SIT and 500,000 SIT in sixty-five settlements, and between 50,000 SIT and 100,000 SIT in twenty-four settlements. In more than one half of the settlements (112), the damage per inhabitant was less than 50,000 SIT. This indicates the extraordinary differences among places relative to damage. On the map, the Bovec municipality with the Bavšica and Trenta valleys stands out distinctly; followed by Drežniški kot and Vrsno in the Kobarid municipality; Tolminske Ravne, Čadrg, and Zadlaz-Žabče in the Tolmin municipality; and finally the previously mentioned settlements of Zabrdo and Torka in the Železniki municipality.

The map in Figure 13 clearly reflects the difficulties faced by the population in the affected areas following the earthquake because it considers the number of people by individual settlements. We would have an even better picture of the impact on settlements if we had been able to analyze the survey data on damage in view of the overall economic level of the population affected by the earthquake. Because of outdated information, particularly the lack of current and economy-related cadastral data, our attempt at such an analysis did not provide any usable information. We hope that with the upgrading and more ongoing maintenance of cadastral data and with the additional use of other tax data, it will be possible to establish the relative impact of natural disasters on individual areas or places in a more quantitative way in future. There is no doubt that this question is important for the distribution of funds for rebuilding from the government and other sources of aid following natural disasters and for the planning of long-term reconstruction.

The problem of reconstruction is well illustrated by the surprising discovery that of the 173 demolished buildings (5^{th} degree damage), seventy-six had been previously rebuilt. Even more eloquent is the fact that twenty-six buildings were destroyed that had been rebuilt immediately following the 1976 Friuli earthquake in the period between 1976 and 1980 (Godec, Vidrih, Ribičič 2000). It is obvious that too little attention was paid to strengthening the buildings during the reconstruction work. For this reason, the decision of the Ministry that all reconstruction work be carried out somewhat more slowly but consistently and thor-

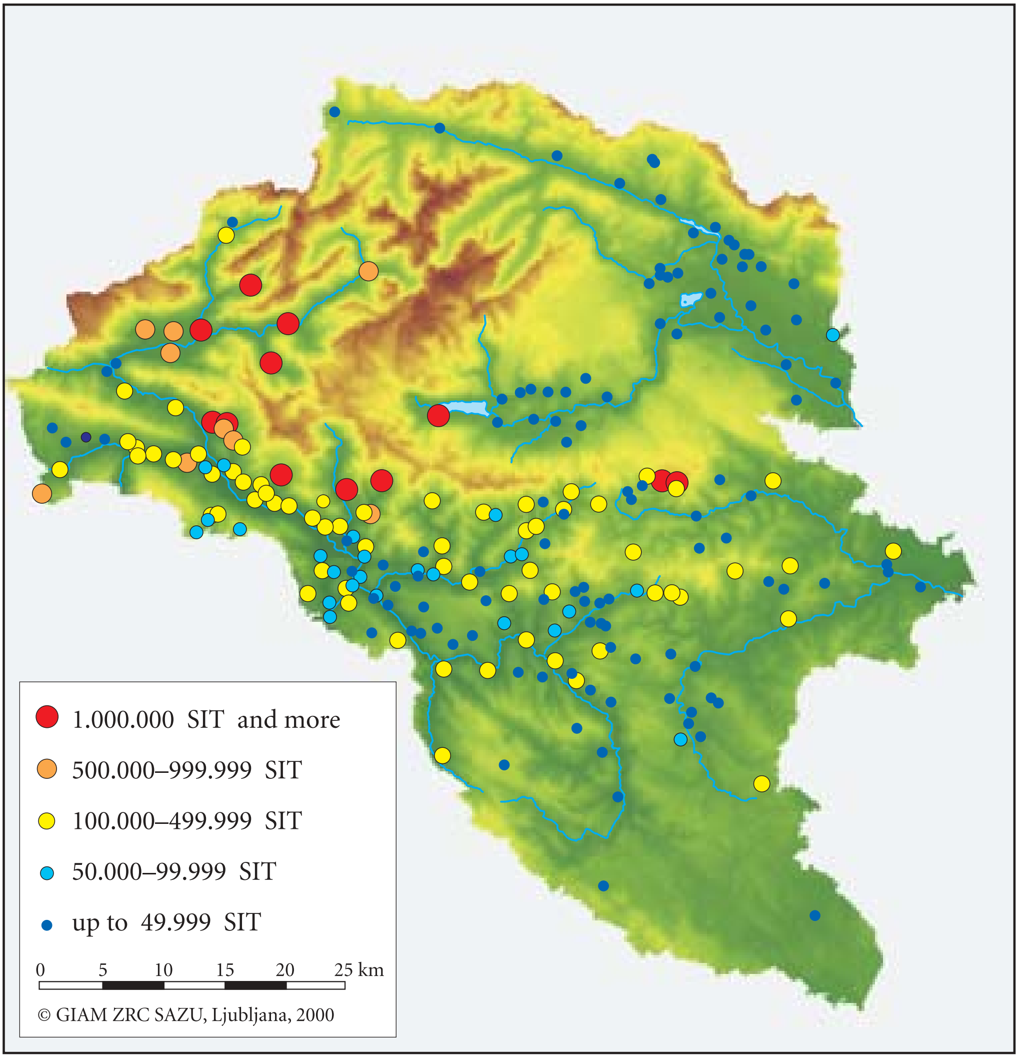

Figure 13: Cost of damage from the 1998 earthquake according to settlement, calculated in SIT per inhabitant (MOP 1999)
Slika 13: Višina škode po prizadetih naseljih, preračunana na prebivalca v naselju (MOP 1999).

oughly is so much more appropriate. This is the only way to reduce the possibility of worse damage occurring during a future earthquake.

9. Reconstruction

Experience with the reconstruction following the 1976 earthquake, which encompassed almost the same region, proves that the problem must be dealt with more thoroughly. Reconstruction following the 1976 earthquake was not carried out well enough everywhere, even though people invested much money and energy in rebuilding. Of the 3,390 buildings surveyed in 1998, 1,769 had undergone previous reconstruction work.

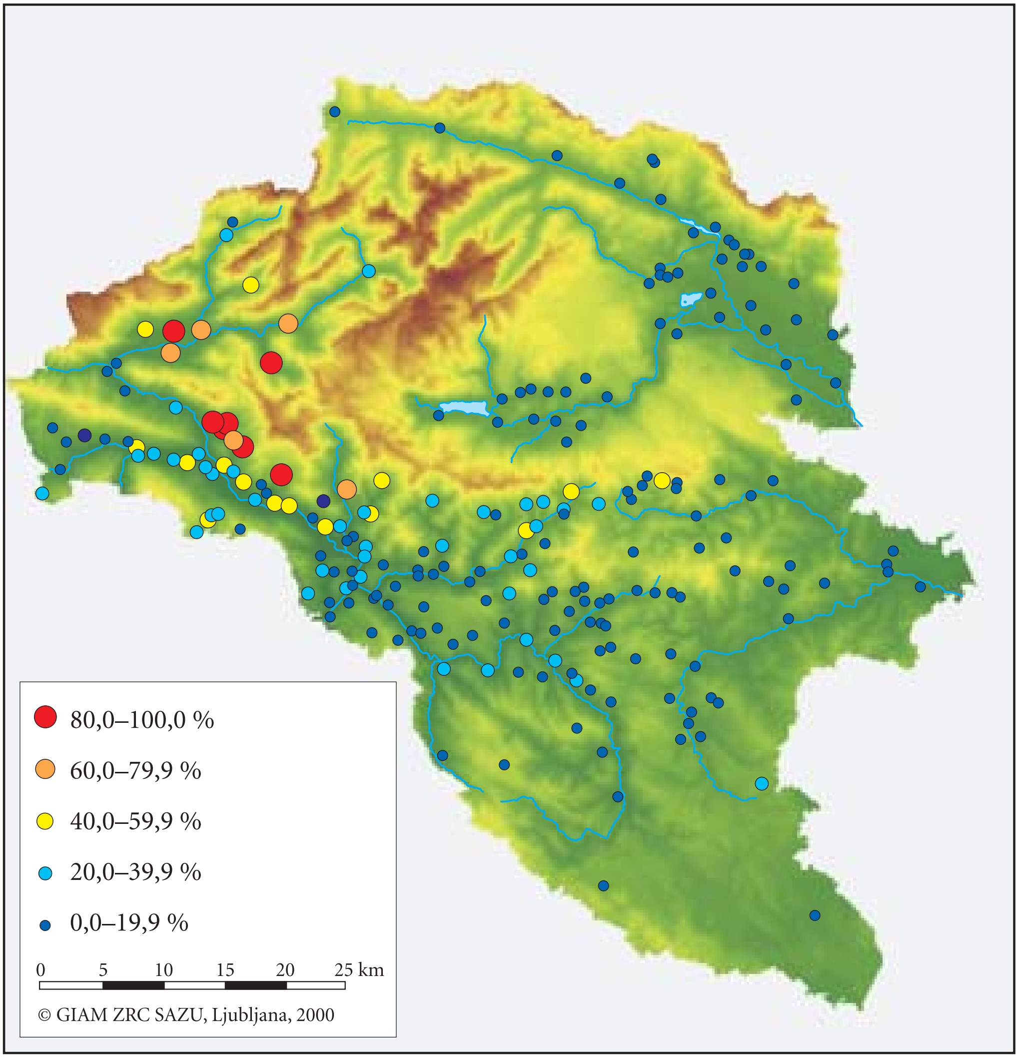

Figure 14: Proportion of damaged houses in affected settlements (MOP 1999).
Slika 14: Delež poškodovanih hiš v prizadetem naselju (Register prostorskih enot, MOP 1999).

Special attention must be devoted to increasing the earthquake safety of older buildings. Among the buildings surveyed, almost four fifths were built before 1964 when the legislation on earthquake-safe construction was adopted. This does not mean, however, that all older buildings are particularly vulnerable to earthquakes, but the earthquake resistance of all buildings should constantly be improved. For the moment, the most urgent task is to reconstruct and earthquake-reinforce buildings in the upper Soča region, but the number of earthquake vulnerable buildings elsewhere in Slovenia should also be reduced by the systematic reinforcement of the buildings.

There are eighty-five settlements in the groups with estimated damage costs between ten and one hundred million tolars. In addition to those in the upper Soča region, there are many such settlements in the Bohinj and in Cerkljansko regions, as well as in the municipalities of Kranjska Gora, Jesenice, Železniki, and Škofja Loka. The estimated damage did not exceed ten million tolars in ninety-one settlements, and it was lower than one million tolars in twenty-two settlements.

The best picture of the consequences of the earthquake is given by the map in Figure 14, which shows the proportion of damaged houses in the affected settlements. In two settlements, Drežniške Ravne and Jezerca, all the houses were damaged (100%), followed by Magozd (96%), Krn (93%), Koseč (91%), Lepena (90%), and Bovec (81%). These catastrophically affected places are shown in red on the map. As a rule, the second group of above-average affected settlements where the earthquake damaged from 60% to 80% of the houses is distributed around them (orange circles). These settlements are Kal-Koritnica (79%), Drežnica (77%), Čezsoča (66%), Soča (62%), and Čadrg (62%). The third group of very affected settlements includes fifteen settlements where 40% to 60% of the houses were damaged: Libušnje, Tolminske Ravne, Svino, Dolje, Zabrdo, Plužna, Bavšica, Bača pri Podbrdu, Selišče, Zadlaz-Žabče, Kred, Avsa, Znojile, Ladra, and Volarje. In thirty-nine settlements, 20% to 40% of the houses suffered damage (light blue circles), and in the remaining 137 settlements, less than 20% of the houses were damaged. In eighteen settlements, damage was only evident to the infrastructure network or elsewhere.

Reconstruction is always a long-term and complicated process and it is still not finished. In our study, we only dealt with it partially from the geographical viewpoint. It is treated more detail in other parts of this project. Table 2 shows buildings according to the level of damage following the 1998 earthquake. In this table, there are several methodological differences from the data of the Ministry of the Environment and Spatial Planning (1999), which was the starting point for our analysis, since it shows the number of all the surveyed buildings regardless of house numbers.

TABLE 2: BUILDINGS SURVEYED IN THE UPPER SOČA REGION AND ASSESSMENT OF THE LEVEL OF DAMAGE (MOP, 1999).
PREGLEDNICA 2: PREGLEDANI OBJEKTI V ZGORNJEM POSOČJU IN OCENE GLEDE NA GRADBENOTEHNIČNO STOPNJO POŠKODB (MOP 1999).

	Level of damage to buildings						
	No damage	1	2	3	4	5	Total
Buildings	462	1,810	509	304	132	173	3,390
Renovated by 1998	125	1,040	285	182	61	76	1,769
Not renovated by 1998	337	770	224	122	71	97	1,621
Renovated after 1976	99	755	201	124	50	53	1,282
Renovated 1976–1980	48	381	92	38	18	16	593
Renovated after 1980	51	374	109	86	32	37	689
Inhabitants	798	3,806	803	497	157	158	6,219
Households	396	1,904	316	188	61	67	2,932

The problem of reconstruction is well illustrated by the surprising discovery that seventy-six of the 173 demolished buildings (5^{th} degree damage) had been previously rebuilt. Even more eloquent is the fact that twenty-six buildings were destroyed that had been rebuilt immediately following the 1976 Friuli earthquake in the period between 1976 and 1980 (Godec, Vidrih, Ribičič 2000). It is obvious that too little attention was paid to strengthening the buildings during the reconstruction work. For this reason, the decision of the Ministry that all reconstruction work be carried out somewhat more slowly but consistently and thoroughly is so much more appropriate. This is the only way to reduce the possibility of worse damage occurring during a future earthquake.

Experience with the reconstruction following the 1976 earthquake, which encompassed almost the same region, proves that the problem must be dealt with more thoroughly. Reconstruction following the 1976 earthquake was not carried out well enough everywhere, even though people invested much money and energy in rebuilding. Of the 3,390 buildings surveyed in 1998, 1,769 had undergone previous reconstruction work.

Dealing with the consequences of the earthquake in the upper Soča region showed that special attention must be devoted to increasing the earthquake safety of older buildings. Among the buildings surveyed, almost four fifths were built before 1964 when the legislation on earthquake-safe construction was adopted. This does not mean, however, that all older buildings are particularly vulnerable to earthquakes, but the earthquake resistance of all buildings should constantly be improved. For the moment, the most urgent task is to reconstruct and earthquake-reinforce buildings in the upper Soča region, but the number of earthquake vulnerable buildings elsewhere in Slovenia should also be reduced by the systematic reinforcement of the buildings.

The highest reconstruction costs by far were assessed in Bovec (1,329,741,558 SIT). In neighbouring Čezsoča, which ranked second according to damage, the damage was less than one third of this amount (425,307,590 SIT). A group of ten very affected settlements where the cost of reconstruction was estimated from one hundred million tolars to a just over 250 million tolars follows: Soča (254,048,870 SIT), Tolmin (235,209,960), Kobarid (211,565,600), Dolenja Trebuša (184,199,700), Drežniške Ravne (180,325,784), Krn (143,438,000), Zatolmin (140,356,000), Magozd (129,972,300), Kal-Koritnica (124,315,180), and Poljubinj (103,291,500 SIT). The cost of reconstruction was estimated at just under one hundred million tolars in Drežnica (97,399,000 SIT) and Trenta (95,131,000 SIT). The geographical distribution of

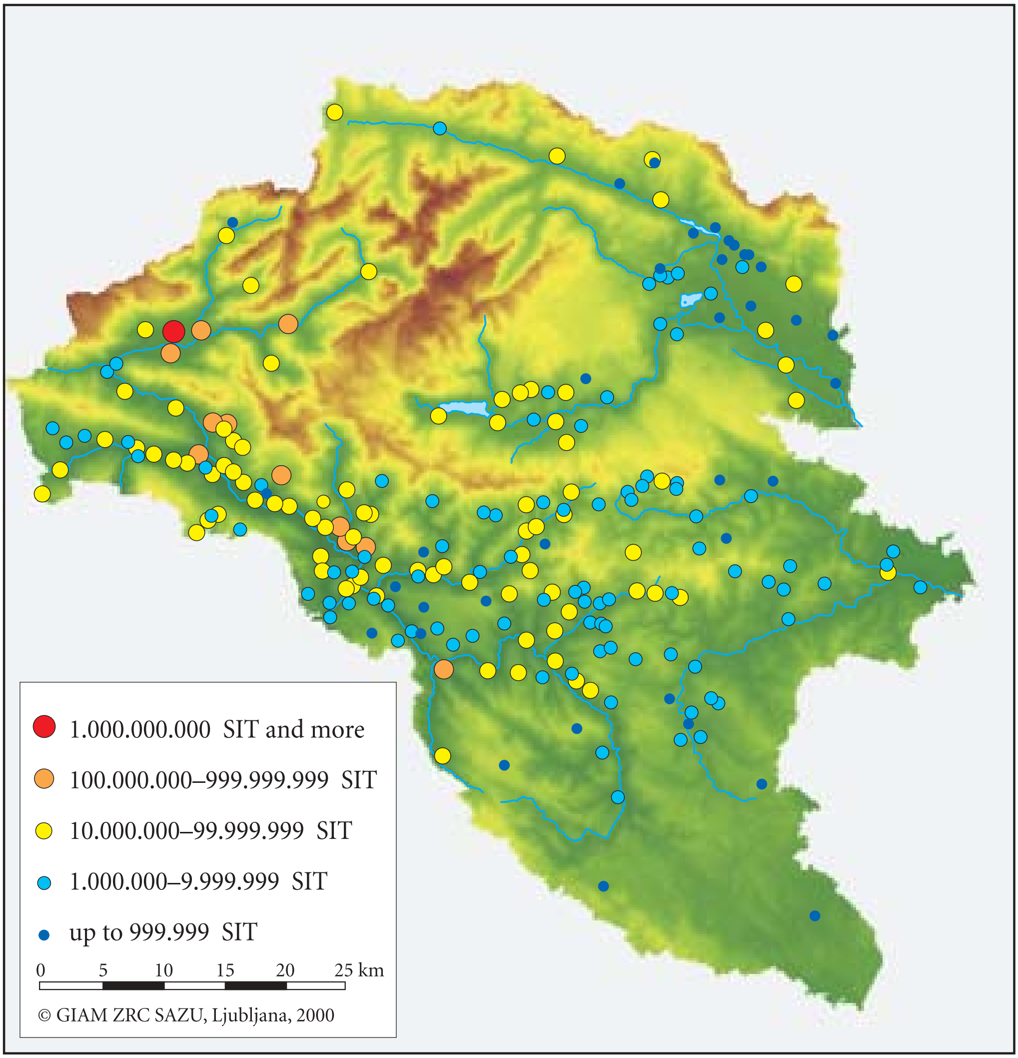

Figure 15: Costs of reconstruction according to individual settlements (MOP 1999).
Slika 15: Stroški sanacije po posameznih naseljih (MOP 1999).

these settlements is clearly evident on the map (Figure 15). The larger settlements in the Bovec, Drežniški kot, and Tolmin areas stand out, and all are located in the three upper Soča region municipalities of Bovec, Kobarid, and Tolmin.

The number of settlements in the group with estimated costs between ten million and one hundred million tolars is quite large, eighty-five altogether. In addition to those in the upper Soča region, there are many such settlements in the Bohinj and Cerkljansko regions as well as in the municipalities of Kranjska Gora, Jesenice, Železniki, and Škofja Loka. In ninety-one settlements, the estimated cost of reconstruction does not exceed ten million tolars, and in twenty-two settlements, it is below one million tolars.

In fifteen affected settlements, there is no anticipated expenditure of government funds for the reconstruction of damaged buildings because the extent of damage was too small to fulfill the conditions for aid and for

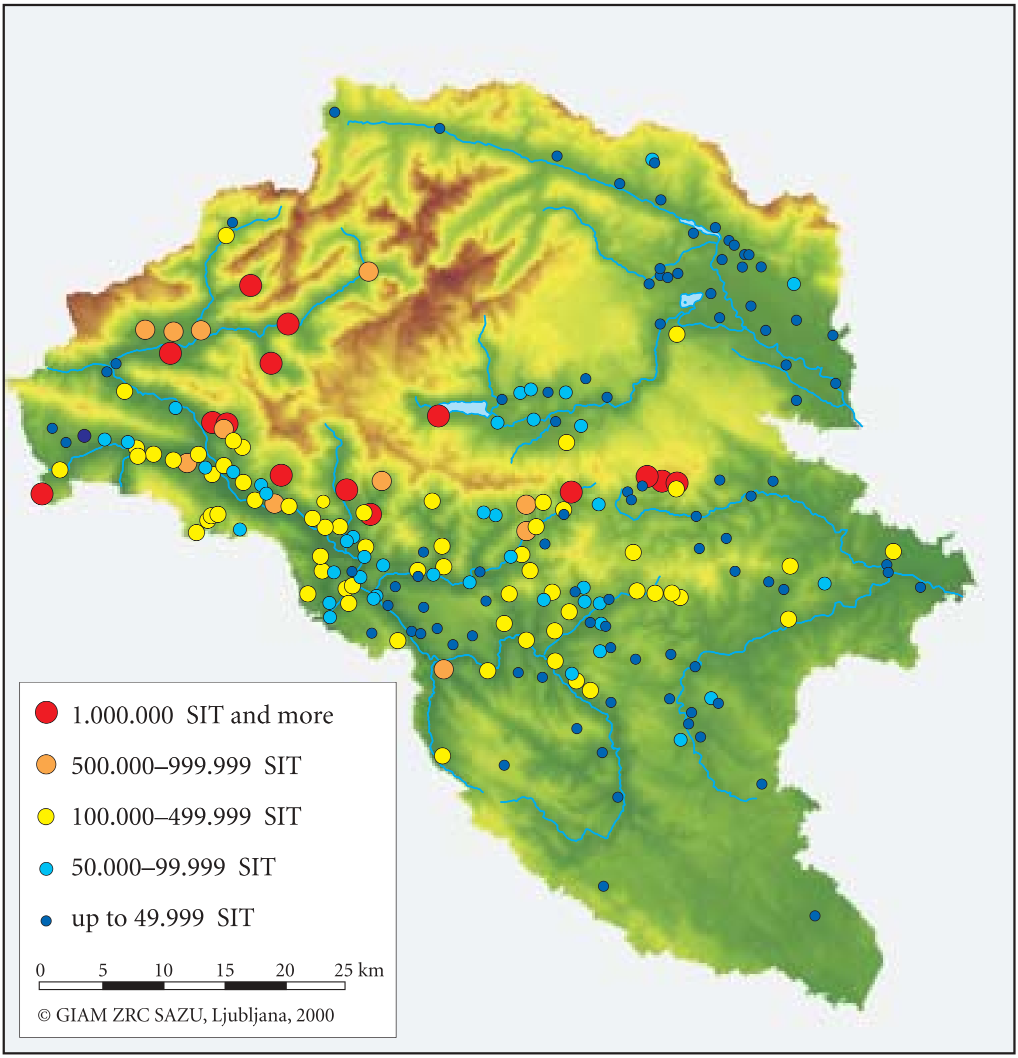

Figure 16. Costs of reconstruction calculated per inhabitant by affected settlements (based on 1991 population and housing census figures, MOP 1999).
Slika 16: Stroški sanacije preračunani na prebivalca po prizadetih naseljih (Popis prebivalstva in stanovanj … 1991, MOP 1999).

other reasons: Breznica, Bukovski Vrh, Hrušica, Kališe, Kanalski Lom, Lesce, Logaršče, Logatec, Peračica, Porezen, Roče, Sela nad Podmelcem, Smokuč, Vrh Sv. Treh Kraljev, and Zabreznica (MOP, 1999).

The graph in Figure 14 shows the costs of reconstruction calculated per settlements. Like the graph in Figure 14 showing the damage calculated per inhabitant, this map clearly illustrates the problems of the local population. Costs of reconstruction in remote and less developed settlements are an especially great problem, particularly in the fifteen settlements of Zabrdo (4,352,000 SIT), Bavšica (3,974,417), Krn (2,988,292), Magozd (2,096,327), Ukanc (2,003,956), Lepena (1,868,507), Torka (1,713,333), Zgornje Danje (1,703,333), Čadrg (1,702,335), Robidišče (1,597,412), Soča (1,403,585), Bača at Podbrdo (1,314,444), Čezsoča (1,288,811), Drežniške Ravne (1,099,547), and Zadlaz-Žabče (1,043,319). There are eleven settlements in the second group with reconstruction costs between 500,000 and one million tolars. It is interesting that Bovec is included in this group of settlements with 796,252 SIT per inhabitant, but only in twentieth place.

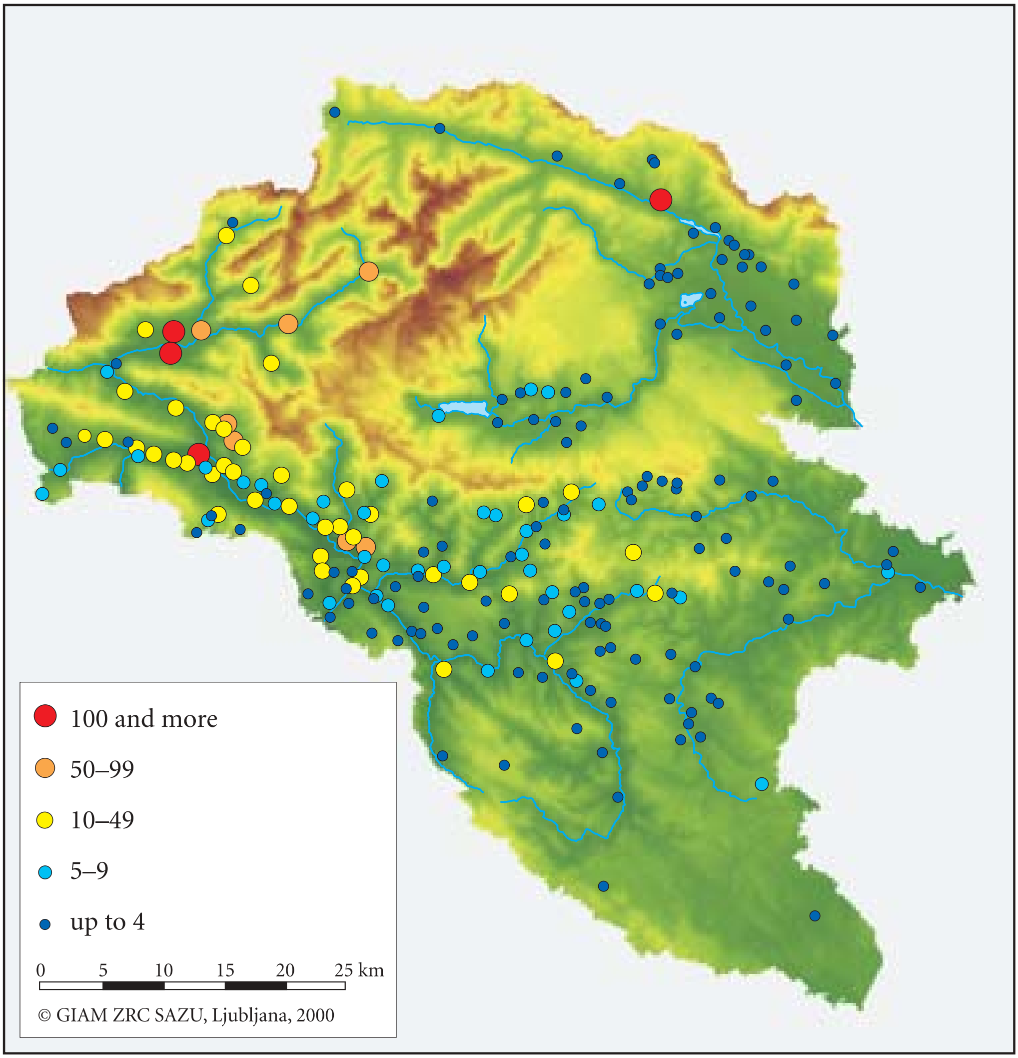

Figure 17: Number of damaged houses according to settlements in the affected region (MOP 1999).
Slika 17: Število poškodovanih hiš po naseljih prizadetega območja (MOP 1999).

There are sixty-one settlements in the next group with reconstruction costs between 100,000 SIT and 500,000 SIT per inhabitant, followed by a group of forty-one settlements with anticipated costs of reconstruction per inhabitant between 50,000 SIT and 100,000 SIT. In seventy-eight settlements the calculated cost of reconstruction per inhabitant is lower than 50,000 SIT. And in fifteen settlements, no government funds for reconstruction are anticipated. Thus, varying amounts will go to 209 of 224 settlements to cover the costs of reconstruction.

On the map showing the number of damaged houses according to settlements of the affected area (Figure 17), all 2,543 houses are illustrated. By far the largest number are in Bovec (473), followed by Čezsoča (108), Kobarid (107), Jesenice (103), Soča (96), Tolmin (80), Drežnica (63), Kal-Koritnica (56), Trenta (53), Drežniške Ravne (51), and Poljubinj (51). In thirty-eight settlements, between ten and fifty houses were damaged. It is understandable due to the large number of small settlements, the number of settlements in which less than ten houses were damaged is the highest (155).

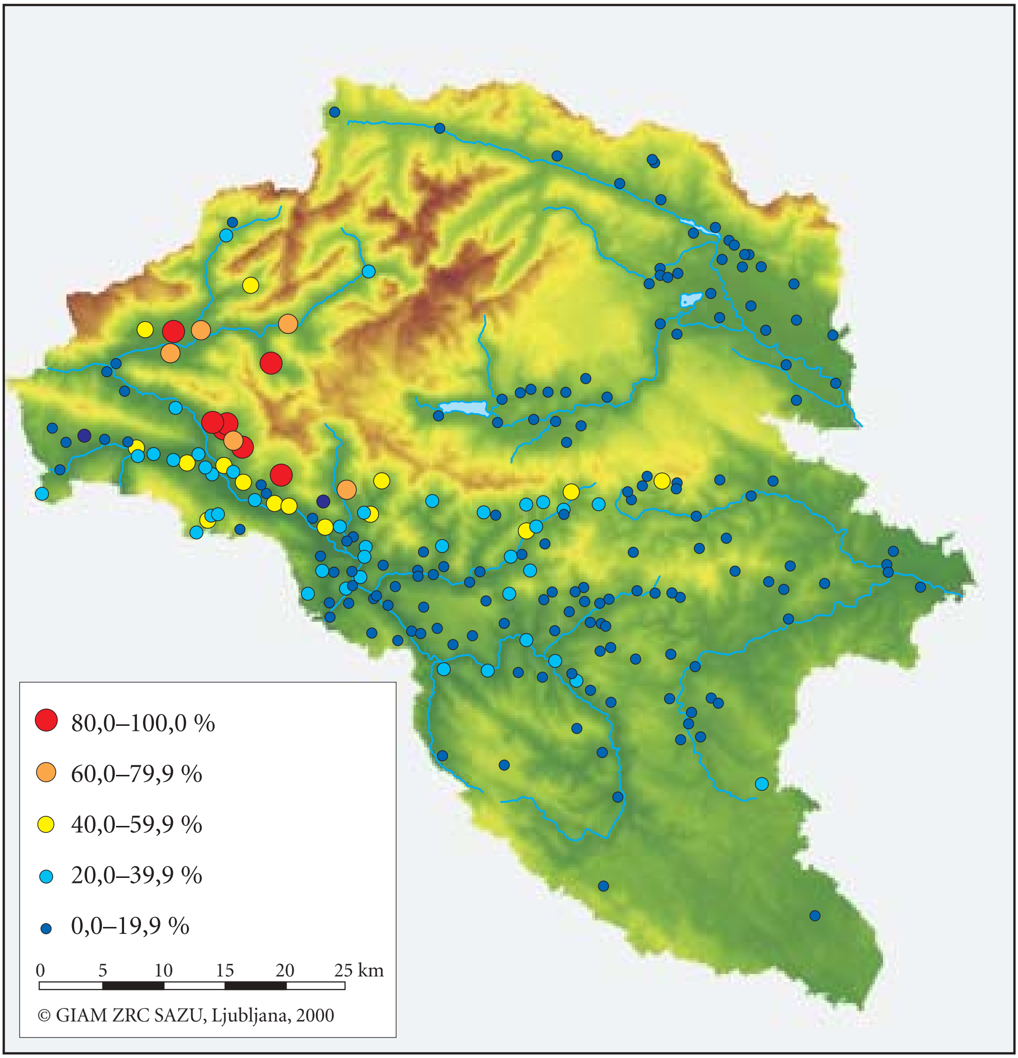

Figure 18: Proportion of damaged houses in affected settlements (MOP 1999).
Slika 18: Delež poškodovanih hiš v prizadetem naselju (Register prostorskih enot, MOP 1999).

The best picture of the consequences of the earthquake is perhaps given by the map in Figure 18, which shows the proportion of damaged houses in the affected settlements. In two settlements, Drežniške Ravne and Jezerca, all the houses were damaged (100%), followed by Magozd (96%), Krn (93%), Koseč (91%), Lepena (90%), and Bovec (81%). These catastrophically affected places are shown in red on the map. As a rule, the second group of above-average affected settlements where the earthquake damaged from 60% to 80% of the houses is distributed around them (orange circles). These settlements are Kal-Koritnica (79%), Drežnica (77%), Čezsoča (66%), Soča (62%), and Čadrg (62%). The third group of very affected settlements includes fifteen settlements where 40% to 60% of the houses were damaged: Libušnje, Tolminske Ravne, Svino, Dolje, Zabrdo, Plužna, Bavšica, Bača pri Podbrdu, Selišče, Zadlaz-Žabče, Kred, Avsa, Znojile, Ladra, and Volarje. In thirty-nine settlements, 20% to 40% of the houses suffered damage (light blue circles), and in the remaining 137 settlements, less than 20% of the houses were damaged. In eighteen settlements, damage was only evident to the infrastructure network or elsewhere.

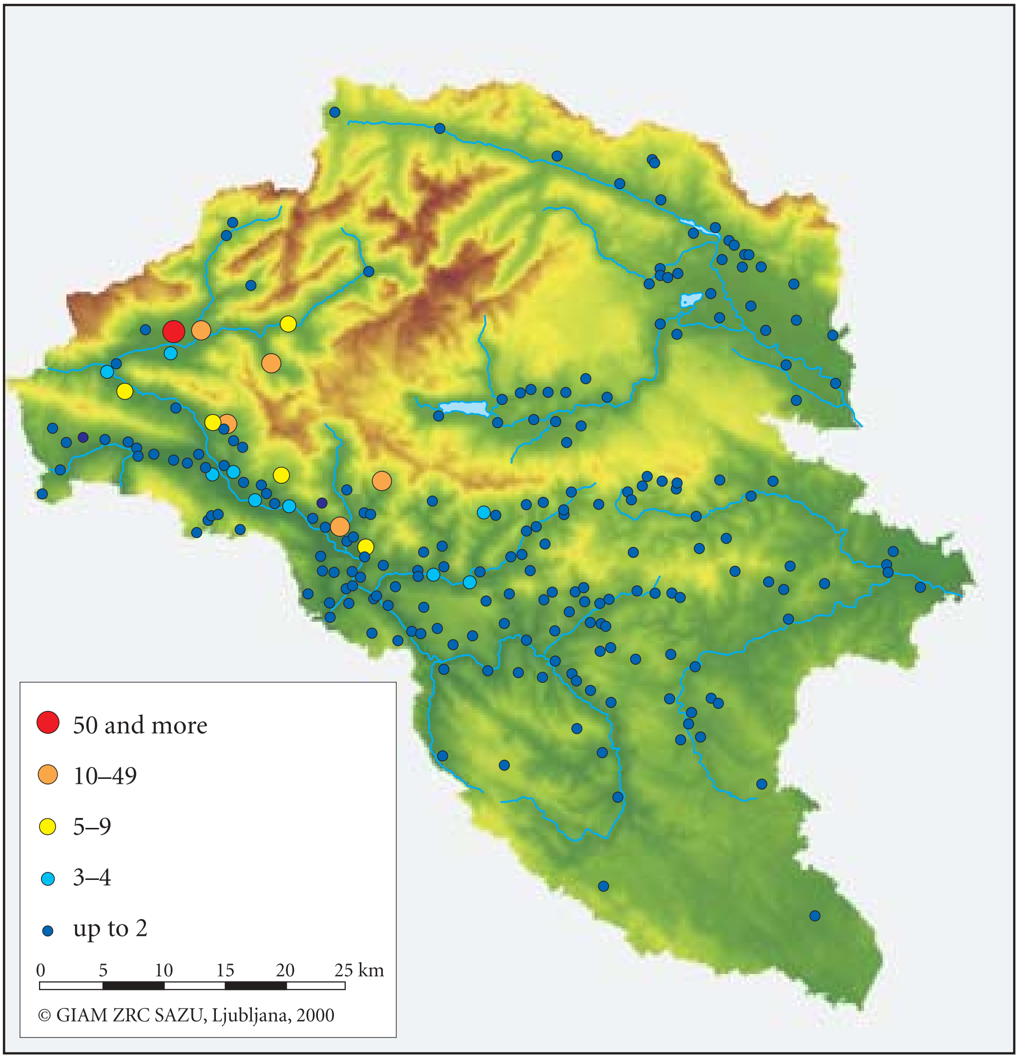

Figure 19: Anticipated number of newly built houses (MOP, 1999).
Slika 19: Predvideno število novogradenj (MOP 1999).

In all, 222 new houses must be built, whose distribution according to settlements is presented in Figure 19. The majority of the new houses will be built in Bovec (53), Drežniške Ravne (25), Lepena (15), Zatolmin (14), Tolminske Ravne (11), Kal-Koritnica (10), Magozd (8), Poljubinj (6), Krn (5), Soča (5), and Srpenica (5). The map clearly indicates concentrations of construction interventions with red, orange, and yellow circles.

10. Conclusion

In terms of magnitude and the extent of the area affected, the 1998 earthquake was smaller than the Friuli earthquakes in 1976. The epicenter area of the 1998 earthquake was in Slovenia about twenty-five kilometers due east of the 1976 earthquakes. Since the magnitude of the 1998 earthquake was considerably smaller, the consequences were also smaller. The 1976 earthquakes claimed around one thousand lives in Italy. To a large extent, the same area in Slovenia was affected during both earthquakes. After the second series of earthquakes in September 1976, about 12,000 buildings were damaged, the majority in the municipalities of Tolmin, Idrija, and Nova Gorica. Around 4,200 buildings of various types were temporarily or permanently unusable, while the remaining buildings suffered minor damage and could still their original functions. In the 1998 earthquake, 2,543 buildings were damaged in Slovenia, five to six times fewer than in 1976, and no major damage was recorded in neighbouring Italy. The consequences of the earthquake were also smaller compared to previous such events within the territory of present-day Slovenia. More inauspicious is the fact that the region was struck by two destructive earthquakes in the relatively short period of twenty-two years.

With all this in mind, we must emphasize that this is a tectonically active area with specific problems. Generally speaking, the complex geographical problems of this region are huge, and natural disasters further deepen and complicate them.

It is worth considering systems of more long-term forms of economic aid and increased endeavours toward the overall development of the affected region. We should make a step forward from simply the immediate mitigation of the consequences of natural disasters.

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12. Summary in Slovene – Povzetek

Geografske značilnosti potresov v Posočju

Milan Orožen Adamič, Mauro Hrvatin

1. Uvod

Ob posledicah potresov v Posočju leta 1976 se je pokazalo, da v Sloveniji sicer nismo imeli človeških žrtev, bilo pa je v trenutku približno 13.000 ljudi brez varne strehe nad glavo. V tujini se pogosto uporablja termin »homeless person«. Preučevanje posledic potresa v Reziji (Italija) je deset let po dogodku (leta 1986) pokazalo, da ima potres lahko tudi širše družbenogeografske razsežnosti. Tam je nedvomno pomenil preskok iz tradicionalne agrarne oziroma »rezijanske« družbe v povsem novo družbo in nove družbene odnose. Ta proces je Rezijo in njene prebivalce pretresel do korenin. Rezije, kakršno smo poznali pred potresom, ni več. To v veliki meri velja tudi za Zgornje Posočje. Tudi za Ljubljano mnogi menijo, da je šele po potresu leta 1895 začela rasti v moderno mesto in dobila zasnovo podobe, ki jo ima danes.

Večina starejših podeželskih stanovanjskih in kmetijskogospodarskih objektov je v Sloveniji grajenih iz kamna v apneni malti. Kakovost gradnje je navadno slabša kot pri pomembnejših mestnih stavbah. Zidovi so običajno narejeni iz dveh plasti neobdelanega ali delno obdelanega kamna, prostor med zunanjima plastema pa je zapolnjen s kamnitim drobirjem, vse v slabi apneni malti. Tako je bila grajena večina hiš na Kozjanskem, kjer je potres leta 1974 povzročil precej škode. Po potresu v Posočju, ko so morali porušiti ali obnoviti veliko starih stavb, je bilo stanovanj, ki so bila zgrajena pred letom 1945, razmeroma malo (1919 ali 32,6 %). Na Tolminskem je bilo malo stanovanj, zgrajenih v obdobju med letoma 1945 in 1970, le 19,3 %. Vzrok je skromna zidava v tem obdobju. Močno nadpovprečen (44,7 %) pa je bil delež stanovanj, zgrajenih po letu 1970, kar je posledica obnove stanovanj po potresu.

2. Geološke in nekatere druge posebnosti Zgornjega Posočja

Potresno dogajanje v tem delu Evrope oblikujeta Afriška in Evrazijska plošča, celotno dogajanje pa zapleta še manjša Jadranska plošča, ki leži med obema. Nedeformiran del Jadranske plošče obsega približno območje celotnega Jadranskega morja, obdajajo pa ga večje gorske verige, ki so vzdignjene zaradi vpliva med ploščami (Helenidi, Dinaridi, Alpe, Apenini). Raziskave kažejo, da se Jadranska plošča vrti v smeri proti severovzhodu, kar povzroča gubanje in narivanje na vzhodni in severni strani plošče ter deloma na severozahodni strani, medtem ko se njen jugozahodni rob razteza in odmika od Evropske plošče. Večji del Slovenije (njen južni in zahodni del) predstavlja severni del Jadranske plošče, ki je zelo deformiran in narinjen na osrednji, manj deformiran del Jadranske plošče.

Geotektonsko uvrščajo geologi to območje v Dinaride, ki so razdeljeni na Južne Alpe, Notranje Dinaride in Zunanje Dinaride. Za Južne Alpe so na tem delu značilni regionalni narivi (nariv Julijskih Alp) od severa proti jugu. Zunanji Dinaridi obsegajo jugozahodni del Slovenije. Prelomi potekajo v smeri severozahod–jugovzhod (t. i. dinarska smer), narivi pa so narinjeni v smeri od severovzhoda proti jugozahodu. Prelomi dinarske smeri se nadaljujejo v Furlanijo, kjer so prekriti z narivi v smeri vzhod–zahod s smerjo narivanja proti jugu.

V Zgornjem Posočju močno prevladujejo triasne apneniške ter deloma tudi dolomitne kamnine. Od Bovške kotline navzdol so predvsem v nižjih legah močno zastopane tudi jurske in kredne vododržne hribine s peščenjaki in flišem. V dnu dolin so v večjih množinah prodni kvartarni sedimenti, ki jih ob pobočjih spremljajo številni vršaji stalnih potokov in hudournikov ter melišča. Ponekod, na primer v Breginjskem kotu, so zelo izraziti tudi ostanki poledenitve.

Po potresih, ki so leta 1976 stresli to pokrajino, so bile marsikje že na majhnih razdaljah opazne velike razlike v škodi, ki so jo povzročili potresi (Orožen Adamič 1979). Isto smo ugotovili tudi ob podrobnem pregledovanju posledic tega potresa v Reziji in Terski dolini. To si v veliki meri razlagamo z razlikami v mikro in makro geoloških razmerah. Že prvi pregled obsega škode je pokazal, da je bilo največ škode v naseljih na nekompaktnih tleh, kot je na primer prod, in to še posebej tam, kjer je talna voda blizu površja. Natančnejši pregled posledic potresa leta 1976 v Podbeli je pokazal, da je prav manjša globina talne vode v južnem in jugozahodnem delu naselja dodatno vplivala na obseg nastale škode. Na splošno je bilo znatno manj škode v naseljih, ki so na flišu, kot na primer Drežnica. Ta leži v neposredni bližini Ladre in Smasta, kjer je bila škoda izredno velika. V celoti so v Posočju potrese najbolje prestala naselja na karbonatnih kamninah. Severovzhodni del Kobarida je bil manj poškodovan od ostalega dela naselja, ki leži na kvartarnih sedimentih. Glede na učinke potresov v odvisnosti od prevladujoče geološke podlage lahko Zgornje Posočje razdelimo na tri enote:

1. kvartarni sedimenti,
2. pretežno vododržne hribine in
3. trde karbonatne kamnine.

Kvartarne sedimente večinoma sestavlja bolj ali manj sprijeto rečno-ledeniško gradivo, pobočni grušč in podobno. To so ugodna območja za naselitev in agrarno izkoriščanje. Obsegajo nižje dele dolin in se marsikje kot jeziki zajedajo v strmejša pobočja. Zaradi narave talne osnove, velikih višinskih razlik in velike namočenosti Posočja so to precej nestabilna tla. V danjih delih dolin je talna voda pogosto zelo blizu površja in tudi poplave so ponekod razmeroma pogoste. Naselja v Zgornjem Posočju so večinoma postavljena na obrobju kvartarnih sedimentov, na stiku z vododržnimi ali karbonatnimi kamninami. Za agrarna naselja je značilna lega na stiku različnih naravnogeografskih ali geoekoloških enot. Stalni rezervoarji podtalnice v Zgornjem Posočju niso veliki, ker za to ni ustreznih orografskih razmer. Doline so razmeroma ozke in ni možnosti za večje akumulacije talne vode v kvartarnih sedimentih. Ne nazadnje je pomembno tudi to, da so mnoga naselja v pobočjih, na vršajih ali meliščih, kjer sestava tal in nagnjenost površja stopnjujeta nestabilnost tal. Tako na primer leži vas Ladra na prodnih nanosih Soče in manjših stranskih pritokov, kjer je zaradi bližine reke tudi talna voda blizu površja. Borjana, Potoki, Stanovišče, Homec in še mnoga druga naselja so na meliščih. Breginj in še nekateri drugi kraji v Zgornjem Posočju so večinoma postavljeni na nesprijetem pobočnem grušču in deloma na ostankih ledeniških moren.

Ob tem je treba posebej opozoriti, da se v mnogih od teh naselij v večji ali manjši globini nahaja fliš, prekrit s kvartarnimi sedimenti, kar dodatno onemogoča neposredne medsebojne primerjave. Taka in še večja pokrajinska pestrost je značilna za večino slovenskih pokrajin, ne le za Posočje. Posoška izkušnja nas uči, da jo kaže na potresno izrazito ogroženih območjih kar najbolj upoštevati.

Vplivi zemljišča in topografski vplivi se med seboj sestavljajo in se prepletajo s temeljnim nihanjem tal na osnovni kamnini. V praksi je to zelo težko kvantitativno ovrednotiti ali oceniti. Poleg tega so nekateri dejavniki, kot na primer globina podtalnice, spremenljivi, nestalni.

Na ta vprašanja poskušajo vsaj deloma odgovoriti tako imenovane mikroseizmične rajonizacije, ki se navadno izdelujejo za najbolj ogrožena območja.

Nadžariščno območje prekrivajo predvsem apnenci in dolomiti, nastali v različnih geoloških obdobjih mezozoika, ki so v seizmogeološkem pogledu sicer zelo dobra tla, vendar je treba poudariti, da večina naselij stoji na naplavinah reke Soče in njenih pritokov ter na pobočnih gruščih, ki so bistveno manj ugodni. Kamnine sekajo številni prelomi, kar še zmanjšuje kamninsko odpornost.

3. Seizmične karte

Zgodovina nastajanja seizmičnih kart v nekdanji Jugoslaviji se je začela leta 1950, ko je J. Mihajlovič izdelal Seizmološko karto Jugoslavije, ki je bila leta 1964 priložena prvim tehničnim predpisom za zgraditev objektov na seizmičnih območjih. Leta 1982 je v okviru Zajednice za seizmologiju SFRJ, ki je združevala takratne republiške seizmološke zavode in observatorije, izšla Privremena seizmološka karta SFRJ. Narejena je bila na statistični analizi znanih potresov, ki so v preteklosti prizadeli območje Jugoslavije. Ti seizmološki podatki pa seveda niso dovolj za izdelavo sodobnih seizmoloških kart. Zato so kmalu začeli izdelavo nove karte, ki temelji na kompleksnih seizmoloških, geoloških in geofizikalnih raziskavah. Izšla je leta 1987. Ta karta ima prognozni značaj, ker daje oceno verjetnosti pojava pričakovanega potresa v prihodnosti. Prva faza izdelave karte predstavlja žariščne cone možnih potresov z njihovimi maksimalnimi magnitudami, druga faza pa predstavlja intenzitete pričakovanih potresov za različna območja in različne povratne dobe. Maksimalne intenzitete so izračunane za najdaljše obdobje, to je 10.000 let. Za graditev objektov je bilo treba izračunati parametre in izdelati karte za krajša časovna obdobja, za 50, 100, 200, 500 in 1000 let. Izolinije na kartah so nastale s povezovanjem točk enakih vrednosti posameznih intenzitet. Izolinije omejujejo območja enakih stopenj predvidenih intenzitet potresov. Napake pri izolinijah so lahko do ± 5 km. Kraji, ki ležijo na izolinijah, pripadajo območju z večjo intenziteto. Karta za povratno dobo 10.000 let predstavlja maksimalne možne intenzitete, ki bi lahko prizadele posamezno območje. Za območja, kjer je možna intenziteta $I \geq 7$ MSK (to ustreza $I \geq 7$. stopnji po EMS lestvici), je treba opraviti dodatne seizmološke raziskave in mikrorajonizacijo terena v skladu s tehničnimi predpisi za graditev na seizmičnih območjih. Revizija karte je potrebna vsakih pet let ali pa po močnejših potresih, ki prizadenejo posamezno območje in lahko spremenijo dosedanje vedenje o njem. Seizmološke karte so namenjene potrebam pravilnika o tehničnih normativih za graditev objektov na seizmičnih območjih, pa tudi za potrebe prostorskega in urbanističnega planiranja in projektiranja (Tumač seizmološke karte SFR Jugoslavije, Beograd, april 1987).

4. Karte podrobnejše potresne rajonizacije

Na pobudo Republiškega štaba za civilno zaščito so na Seizmološkem zavodu Republike Slovenije (danes Uprava RS za geofiziko) v začetku leta 1991 izdelali elaborat Potresna ogroženost Slovenije (občin Brežice, Idrija, Krško, Ljubljana in Tolmin). Za uporabo v civilni zaščiti so bile izrisane karte pričakovanih potresnih učinkov (potresna mikrorajonizacija). To ni prava mikrorajonizacija, ampak podrobnejša potresna rajonizacija. Karte so bile namreč narejene izključno na podlagi seizmoloških podatkov in geološke zgradbe terena, zato niso namenjene projektiranju. Za izdelavo kart, ki bi lahko rabile projektantom, bi morali opraviti mnogo bolj poglobljene študije, detajlno geološko (inženirsko geološko in hidrogeološko) kartiranje, določiti prelome na terenu ter opraviti razne terenske geofizikalne meritve. Mogoče bo potres v Posočju pripomogel k izdelavi tovrstnih kart za najbolj ogrožena območja Slovenije (Vidrih, 1998).

Na delu karte podrobnejše potresne rajonizacije občine Tolmin (slika 7) so prikazane največje pričakovane potresne intenzitete. Občinska karta je razdeljena na območja z največjimi pričakovanimi intenzitetami 8. in 9. stopnje MSK lestvice, kar ustreza 8. in 9. stopnji po EMS lestvici, in je povzeta po državni karti potresnih intenzitet. Obe območji sta nadalje razdeljeni še glede na tri različne podlage: indeks 1 – boljša tla, indeks 2 – srednja tla in indeks 3 – slabša tla.

Glavnemu potresu (12. 4. 1998) je v prvih 20 urah sledilo okoli 400 popotresnih sunkov, do 8. maja 1998 pa je bilo zabeleženih še več tisoč šibkejših popotresnih sunkov. Pet sunkov je preseglo magnitudo 3,0. Močan potresni sunek je bil še 6. maja ob 4. uri in 53 minut.

UTC, čas potresa se navadno prikazuje po koordinatah univerzalnega časa. Ta je za eno uro različen od našega lokalnega časa oziroma dve uri v poletnem času.

Žarišče potresa leta 1998 je nastalo na območju, kjer so po veljavni državni karti potresnih intenzitet največji pričakovani potresi do 8. stopnje po MSK lestvici, kar ustreza 8. stopnji po EMS lestvici (Pravilnik o tehničnih normativih za graditev objektov visoke gradnje na seizmičnih območjih, Uradni list SFRJ št. 31/87 in Pravilnik o spremembah in dopolnitvah pravilnika o tehničnih normativih za graditev objektov visoke gradnje na seizmičnih območjih, Uradni list SFRJ št. 52/90). Tudi razpored največjih učinkov ob zadnjem potresu je bil pravilno ocenjen, saj so nastale največje poškodbe prav na območjih, ki so označena z indeksom 3, to pomeni slaba tla. Nadžariščno območje gradijo predvsem karbonatne kamnine (apnenci in dolomiti), ki ponekod prehajajo v laporje. Karbonatne kamnine so v seizmogeološkem pomenu ugodna tla, laporji pa nekoliko slabša. Najslabšo podlago predstavljajo nanosi rek in potokov ter pobočni grušči. Nanosi reke Soče in pritokov gradijo terase, ki jih sestavljajo prod, pesek in redkeje konglomerat. Nevarni so tudi pobočni grušči. Poškodbe v Mali vasi v Bovcu, v Kalu-Koritnici, v dolini Lepene, v Spodnjih Drežniških Ravnah, Magozdu, Jezercih, Krnu itd. so posledica ojačenja potresnih valov zaradi slabe geološke podlage. Vsi kraji, kjer je nastalo največ poškodb, ležijo na slabi podlagi. Po predhodni oceni potres nikjer ni presegel učinkov med 7. in 8. stopnjo po EMS lestvici, to pa je v skladu z državno karto potresnih intenzitet (Vidrih, 1998).

Potres leta 1998 je bilo čutiti na celotnem območju Slovenije. Čutili so ga tudi na Hrvaškem, v Bosni in Hercegovini, na Madžarskem, Slovaškem, Češkem, v Nemčiji, Avstriji, Švici in Italiji. Ta potres je bil po letu 1917 najmočnejši potres, ki je imel epicenter na območju današnje Slovenije.

Potres je sprožil številne skalne podore in zemeljske plazove, zlasti v Krnskem pogorju. Med največjimi podori in plazovi so skalni podor pod Lemežem v Lepeni, podor na jugozahodnem pobočju Krna, podor na planini Polog nad Tolminom in skalni podor pri izviru Tolminke. Spet sta bila dejavna zemeljska plazova pri Grahovem in Kneži ter pet drugih večjih podorov in plazov v Lepeni. Potres je poškodoval nekatera vodna zajetja in vodovode ter povzročil spremembe podzemnih voda. Zaradi tega je prišlo do prekinitev in motenj v oskrbi s pitno vodo. Številne lokalne in tudi nekatere regionalne ceste so bile začasno neprevozne zaradi skalnih podorov, zemeljskih plazov, poškodb cestišča in mostov.

5. Posledice potresa leta 1976

Glavni in najmočnejši sunek potresov leta 1976 je bil 6. maja ob 21. uri 0 minut in 12,5 sekunde z žariščem na območju Mt. San Simeone v severni Furlaniji. Ribarič (1980) navaja žariščno globino 11,8 km in magnitudo 6,5 (0,2 po Richterju in maksimalno intenziteto od 9 do 10 po MCS).

Po varnostnih predpisih zgrajene novejše stavbe na seizmično stabilnejšem terenu v Posočju so prestale potres le z manjšimi poškodbami. Največ škode je bilo na objektih na flišnih in kvartarnih osnovah in tam, kjer je talna voda prav blizu površja. Taka talna osnova je značilna za naslednja naselja ali njihove dele: Breginj, Podbelo, Ladro, Kamno, Volarje itd. Tolmin je bil zaradi trde skale v osnovi razmeroma malo poškodovan. V Kobaridu so bile znatno manj poškodovane stavbe na severni strani Gregorčičeve ulice, ki stoje neposredno na triadnih kamninah, kakor objekti na kvartarnih sedimentih v ostalem delu mesta.

Po 6. maju so bili še posebej močni sunki 9. in 11. maja, potem so se tla postopno umirjala. Druga serija močnejših potresov je sledila 11. septembra 1976. Obnovljena potresna aktivnost je dosegla 8. do 9. stopnjo po MCS-lestvici, kar je bilo le pol do ene stopnje manj kot ob začetku potresov 6. maja 1976. 15. septembra je bilo kar šest potresov 6. ali višje stopnje po MCS-lestvici.

V Breginjskem kotu je bila moč potresov približno eno do eno in pol stopnje po MCS-lestvici nižja kot v nadžariščnem območju v Italiji. V naših krajih so bili potresi 8. stopnje po MCS dvakrat, 7. stopnje petkrat, 6. stopnje sedemkrat ter 5.–6. stopnje kar štiriindvajsetkrat. Toliko ponovitev potresov v dveh obdobjih je povzročilo znatno škodo. Posebej je treba poudariti postopno povečevanje prvotne škode.

Pomembno je bilo tudi to, da je bilo takrat v Posočju razmeroma malo novejših, z armiranim betonom utrjenih stavb; prevladovale so stare hiše, zgrajene večinoma iz kamna z apneno malto ter z lesenimi stropi. Opozarjamo, da navajamo podatke po območjih takratnih občin (60). Po podatkih popisa prebivalstva in stanovanj leta 1971 (Popis … 1972) je razvidno, da je bilo stanovanj, zgrajenih pred letom 1918, v občini Idrija 50,4 %, v občini Tolmin 46,6 %, kar lahko pripišemo posledicam prve svetovne vojne, v občini Nova Gorica pa le 22,4 % stanovanj. V obdobju 1918–1945 zgrajenih in še uporabnih je bilo v tolminski občini 30,5 %, v idrijski pa 7,7 % stanovanj. V skupini stanovanj, zgrajenih med leti 1946 in 1960, jih je v občini Tolmin 9,7 %, v občini Idrija 17,4 % in v občini Nova Gorica 18,5 %. Velika razlika med občinami je tudi v številu stanovanj, zgrajenih v obdobju 1960–1971; v Tolminu jih je 12,3 %, v Novi Gorici 21,9 % in v Idriji 23,4 %. Približna polovica stanovanj v občinah Tolmin in Idrija je bila pred potresom starejša od 50 let. To so stanovanja, kjer je le izjemoma uporabljen armirani beton ali drugo sodobnejše gradivo. Armiranobetonske plošče in druge podobne konstrukcijske elemente so v večjem obsegu začeli uporabljati po letu 1946. Pred potresom je bilo približno 80 % stanovanj v občini Tolmin zgrajenih na tradicionalni način, brez uporabe betona, železa, opeke in podobnega gradiva. Po posameznih krajih so bile razumljivo znatne razlike, ki kažejo na stopnjo urbanizacije. Pred letom 1918 je bilo v Borjani zgrajenih 79,2 %, v Breginju 86,9 %, v Podbeli 100 %, v Volarjih 94,3 % stanovanj. V Borjani je delež stanovanj, starejših od leta 1918, nekoliko nižji kot v sosednjih manj urbaniziranih krajih, kjer jih je od 85 do 100 %, ker je 14. februarja 1952 snežni plaz odnesel del vasi. Povsem drugačna slika je v bolj urbaniziranih krajih, kjer je znatno manj stanovanj, ki so bila zgrajena pred letom 1918. V Kobaridu je bilo 1971. leta še 53,7 % takih stanovanj, v Tolminu le 12,8 %. V nekaterih krajih so pomembni tudi drugi faktorji, v Stanovišču je bilo npr. 95,8 % stanovanj obnovljenih po letu 1946, ker je bila vas med vojno požgana. V obnovi Stanovišča leta 1946 so se večinoma držali prvotnih tlorisov, v največji možni meri izkoristili obstoječe ruševine ter niso bistveno izboljšali kakovosti stavb. Podobno velja za Žago, ki je bila v prvi svetovni vojni vsa razdejana in je tudi v drugi vojni močno trpela.

V Sloveniji leta 1976 zaradi potresa ni bilo zabeleženih večjih zemeljskih plazov, podorov in podobnega. Nekateri vodni izviri so bili krajši čas kalni. Zaradi varnosti je bilo treba preveriti kakovost vode v številnih zajetjih, začasno je bila omejena poraba vode, vendar večjih težav ni bilo. Manjši podori so bili na pobočjih desnega brega Nadiže na italijanski strani od Štupice (Stupizza) navzdol. Na nekaj mestih pri Žagi in Idrskem so bila potrebna manjša popravila ceste.

Če pa upoštevamo obsežne posledice potresa v Posočju, specifične probleme te pokrajine, posledice v Beneški Sloveniji, Reziji in na Goriškem, je bila katastrofa iz leta 1976 nedvomno ena največjih naravnih nesreč, ki je prizadela Slovence v 20. stoletju.

Največ ljudi, ki so zaradi potresov ostali brez bivališč, nekateri le začasno do obnove, drugi pa so svoj dom izgubili za vedno, je bilo v občini Tolmin (slika 5). V štirih krajevnih skupnostih (v nadaljevanju KS) te občine je več kot 80 % prebivalstva ostalo brez bivališča: Breginj – 80,28 %, Ladra-Smast – 60,67 %, Srpenica – 81,48 % in Trnovo – 84,62 %. Zanimiv je zelo visok delež takšnega prebivalstva v KS Trnovo, ki pa gre izključno v okvir 2. kategorije – začasno neuporabnih stanovanj. V 3. kategoriji so bile najbolj prizadete KS Breginj – 31,33 %, Borjana – 23,14 %, Ladra-Smast – 21,78 % in Srpenica – 15,64 %. Od 50 do 80 % prebivalstva brez bivališča je bilo v KS Čezsoča – 68,78 %, Žaga – 66,14 % Volarje – 59,16 %, Borjana – 52,34 %. V KS Žaga je delež prebivalstva brez strehe močno porasel po septembrski seriji potresov in lahko končno stanje primerjamo z Breginjem. Podobno velja za KS Borjana, kjer je bila Podbela nedvomno najbolj poškodovani kraj v Posočju. V KS Volarje je bilo stanje zelo podobno kot v KS Ladra-Smast.

V drugo skupino smo uvrstili krajevne skupnosti, kjer je bilo zaradi potresa 30 do 50 % prebivalstva brez prebivališča. V občini Tolmin sodijo v to skupino KS Idrsko s 46,68 %, KS Kred s 40,41 %, KS Kobarid s 37,72 %, in KS Kamno s 36,22 %. V občini Idrija je bilo največ škode v krajevnih skupnostih Orehek – 44,89 % in Bukovo – 33,73 %. V novogoriški občini sodi sem le KS Kojsko v Goriških brdih s 32,05 %. V občini Tolmin je značilno sosedstvo teh krajev z najbolj prizadetim območjem. Po septembrski seriji potresov je škoda močno narasla; ocenjujemo, da je bilo v teh krajih brez stalnega bivališča nad 50 % prebivalstva.

Beneška Slovenija in Rezija sta bili močno poškodovani, po naši klasifikaciji sodita večinoma v 1. kategorijo zelo močno poškodovanih krajev. V Beneški Sloveniji je bilo zaradi potresov po podatkih v Poročilu o opravljenem delu pri odpravi posledic potresov v Posočju za leto 1976 porušenih 1609 hiš v 13 vaseh oziroma zaselkih. Od vseh pokrajin, kjer živе Slovenci, je bila Beneška Slovenija najtežje prizadeta, kar je še stopnjevalo njene že tako pereče probleme.

Srednje prizadeta območja so bila tista, kjer je bilo zaradi potresov ob stalna bivališča 10–30 % prebivalstva. Skupni učinek potresov je v teh krajih ovrednoten s približno 7. stopnjo po MCS. V kategorijo manj prizadetih območij smo uvrstili kraje, kjer je bilo ob bivališča 2,5–10 % prebivalstva. V zadnjo skupino smo uvrstili kraje, kjer je bilo v krajevni skupnosti manj kot 2,5 % prebivalstva brez varnega bivališča.

Za druge občine v Sloveniji nimamo tako podrobnih podatkov. V občini Radovljica je bilo največ škode v Bohinju v KS Bohinjska Bistrica, ki bi jo lahko uvrstili v 5. skupino. Podobno je bilo tudi v občini Škofja Loka, kjer je bilo 26 objektov v 2. kategoriji in 10 v 3. kategoriji poškodovanosti. V občini Ajdovščina je bilo največ škode v Vipavski dolini, ti kraji sodijo večinoma v 5. ali ponekod celo v 4. skupino. V občini Postojna niso zabeležili večjih poškodb. V občini Jesenice je bilo največ škode v Ratečah, Podkorenu in Kranjski Gori (6. skupina). Škodo v KS Stara Ljubljana lahko uvrstimo v 6. skupino. V slovenskih obmorskih občinah niso zabeležili večjih poškodb.

V občini Tolmin je kar 21,03 % prebivalstva prebivalo v objektih 2. in 3. kategorije potresne poškodovanosti. Začasno je bila dobra petina prebivalcev te občine prisiljena prebivati v zasilnih bivališčih. V občini Idrija je bilo takega prebivalstva 8,22 % in v Novi Gorici 4,60 %. Zaradi posledic tega potresa je bilo približno 0,5 % prebivalcev Slovenije prisiljenih, da so krajši ali daljši čas prebivali v zasilnih bivališčih.

6. Podrobnejši pregled posledic potresa leta 1998

Potres, ki je leta 1998 prizadel Zgornje Posočje, je bil v marsičem drugačen od tistega v letu 1976. Nadžariščno območje tega potresa je bilo v Sloveniji. Prekrivajo ga predvsem apnenci in dolomiti, nastali v različnih geoloških obdobjih mezozoika, ki so v seizmogeološkem pogledu sicer zelo dobra tla. Vendar je treba poudariti, da večina naselij stoji na naplavinah reke Soče in njenih pritokov ter na pobočnih gruščih, ki so bistveno manj ugodni. Kamnine sekajo številni prelomi, kar še zmanjšuje kamninsko odpornost.

Po ogledu terena je bilo ugotovljeno, da je intenziteta potresa dosegla največje učinke v krajih Magozd, Drežniške Ravne, Lepena in Tolminske Ravne. Območje, na katerem je intenziteta dosegla ali presegla učinke 7. stopnje po EMS (sodobnejša EMS-lestvica intenzitete potresnih učinkov se bistveno ne razlikuje od starejše MCS-lestvice, ki je bila v rabi ob prvem potresu), ima premer približno 22 km. Ker ni prišlo do obsežnega fizičnega rušenja objektov, je potres posredno k sreči zahteval le eno smrtno žrtev, trije prebivalci v Lepeni pa so bili poškodovani. Pri neposrednem odpravljanju posledic potresa pa sta bila lažje poškodovana dva gasilca.

Povzročena je bila velika materialna škoda na stanovanjskih, proizvodnih in drugih gospodarskih objektih ter na infrastrukturi in kulturni dediščini. Največ škode je bilo v naseljih: Bovec, Soča, Kal-Koritnica, Lepena, Log pod Mangartom, Drežniške Ravne, Magozd, Koseč, Jezerce, Krn, Tolminske Ravne in Čadrg. Na Gorenjskem so bile zaradi potresa poškodovane predvsem stanovanjske hiše (porušitve in poškodbe dimnikov) in nekateri hoteli v občinah Bohinj in Jesenice.

7. Podori

Ob potresih v hribovitem in goratem svetu zelo pogosto pride do podorov ali zemeljskih plazov. Zanimivo je, da je bilo leta 1976, ko je bil epicenter sicer veliko močnejšega potresa razmeroma oddaljen, teh pojavov v Zgornjem Posočju veliko manj kot leta 1998. Med največjimi podori in plazovi so skalni podor pod Lemežem v Lepeni, podor na jugozahodnem pobočju Krna, podor na planini Polog nad Tolminom in skalni podor pri izviru Tolminke. Spet sta bila dejavna zemeljska plazova pri Grahovem in Kneži ter pet drugih večjih podorov in plazov v Lepeni. Potres je poškodoval nekatera vodna zajetja in vodovode ter povzročil spremembe podzemnih voda. Zaradi tega je prišlo do prekinitev in motenj v oskrbi s pitno vodo.

Potres je marsikje močno pospešil v naravi sicer običajne procese.

8. Izvir Tolminke so zasule skale

Dolina Tolminke je ena izmed najbolj očarljivih alpskih dolin v Zgornjem Posočju. To ni samo zaradi slikovite cerkvice iz prve svetovne vojne na Javorščku, temveč tudi zaradi neprecenljivih naravnih danosti. Leži v osrednjem delu Triglavskega narodnega parka. Rušilni potresni val je bil tukaj izredno močan (Luskovec, 1998). Potres je naravne procese, ki sicer trajajo tisoče let, skrajšal na nekaj sekund. Narava je tukaj utrpela daleč največ škode. Kraški izvir alpske reke Tolminke, ki je bil prej odet v mah in bujno zelenje, je zdaj zasut z gradivom, ki je ob potresu zgrmel z Osojnice. Padlo je na stotine ton skal, ki so dobesedno pokopale bujno zelenje pod goro in deloma zasule cesto, ki vodi v dolinski zatrep. Ob planinski poti, ki vodi s planine Polog k izviru Tolminke, so se v tleh pojavile razpoke. Gozdovi na okoliških pobočjih so zaradi padajočih skal dobesedno zdesetkani. Nekateri sestoji so povsem polomljeni. Posamezna debla in veje še vedno ležijo po tleh med podornim kamenjem. Kamor koli seže pogled, so vidne posledice potresa. Povsod naokoli so posejane velikanske skale, ki napeljejo na misel, kako bi jo odnesel človek, če bi se tu mudil med potresom. Tako obsežna preoblikovanja pokrajine so redka, navadno pa so omejena le na najbolj prizadeto območje.

Iz sosednje Italije ni bilo poročil o večji materialni škodi. Za razliko od potresa leta 1976 je bil ta znatno šibkejši. Prvi je imel največjo magnitudo 6,5 (0,2, za potres leta 1998 pa je bila ocenjena še vedno razmeroma zelo visoka magnituda 5,5 po Richterju). Pomembna razlika med tema potresoma je bila zato tudi v površini prizadetega območja. Potres iz leta 1998 je prizadel bistveno manjše območje kot prvi. Nadžariščno območje je bilo približno 25 km zračne razdalje vzhodno od tistega iz leta 1976 (azimut približno 84 stopinj).

Potres je povzročil precejšnjo škodo na nepremični kulturni dediščini in na spomenikih etnološke dediščine. Pred potresom leta 1976 še tradicionalna podoba pokrajine se bo s posledicami tega potresa še dodatno spremenila.

Škoda je bila zabeležena še v naslednjih desetih občinah: Cerkno, Gorenja vas – Poljane, Idrija, Jesenice, Logatec, Radovljica, Škofja Loka, Železniki, Žiri in Žirovnica. Prizadetih je bilo 16 od 192 slovenskih občin s skupno površino 3067,8 km^2, kar je dobrih 15 % Slovenije.

Ta del Slovenije po svojih naravnogeografskih značilnostih uvrščamo v alpski svet. To je najvišje vzpet del Slovenije in v njegovem osrednjem delu je Triglavski narodni park. Območje je razmeroma redko poseljeno, saj je v skupno 516 naseljih in 40.473 hišah živelo le 157.906 ljudi, kar je le malo več od 8 % prebivalstva Slovenije. Povprečna gostota poselitve je z 51 prebivalci/km^2 približno pol manjša od državnega povprečja. Ministrstvo za okolje in prostor Republike Slovenije nam je v oktobru 1999 posredovalo podatke o škodi po naseljih in prizadetih občinah.

Na karti (slika 10) je prikazano najbolj prizadeto območje ob potresu leta 1998. Vrisana in vpisana so nekatera v besedilu večkrat omenjena naselja. Velikost krogcev ponazarja število objektov v posameznem naselju. Na celotnem obravnavanem območju je v 16 občinah skupaj 516 naselij. Škodo so zabeležili v 224 naseljih. V teh občinah je skupaj 40.473 hišnih številk (8,6 % vseh v Sloveniji), v prizadetih naseljih pa je 26.499 hišnih številk (5,6 % vseh v Sloveniji). Ob potresu jih je bilo skupaj poškodovanih 2543.

Na karti (slika 11) so po občinah prikazana prizadeta naselja glede na višino škode. Velikost in barva krogca prikazujeta višino škode v posameznem naselju. Iz karte je lepo vidno, da je bila škoda daleč največja v Bovcu, kjer je bila znatno večja od milijarde tolarjev (1.579.816.953 SIT). Zelo velika je bila tudi škoda na Jesenicah (117.103.592 SIT) in v Ukancu v Bohinju (217.800.838 SIT). Ti dve naselji sta sicer že precej oddaljeni od najbolj prizadetega območja v Zgornjem Posočju. Iz karte je razvidno, da je bila škoda v naseljih okoli teh dveh krajev precej manjša. Ta navidezni anahronizem razlagamo s tem, da so Jesenice razmeroma veliko naselje in je bil zato seštevek vse škode visok.

V Ukancu je bila škoda velika zato, ker so bili v tem kraju močno poškodovani nekateri turistični objekti (hotela Zlatorog v Ukancu in Ski hotel na Voglu ter planinski koči pri slapu Savica in Triglavskih jezerih).

Iz grafikona na sliki 11 je lepo vidno, da je bila škoda daleč največja v občini Bovec. V drugi skupini, vendar že z več kot pol manjšo škodo, sta bili občini Kobarid in Tolmin. Vse tri občine skupaj so v času potresa leta 1976 sestavljale enotno občino Tolmin. V tretjo skupino že bistveno manj prizadetih občin sodijo občine Gorenja vas – Poljane, Bohinj in Cerkno. Na Jesenicah in v Železnikih je bila skupna škoda še manjša, okrog 100.000.000 tolarjev. V ostalih občinah je bila v primerjavi z najbolj prizadetim območjem škoda že bistveno manjša. Kljub zelo razgibanemu površju in zato tudi zelo neenakomerni poselitvi se stopnja prizadetosti naselij hitro zmanjšuje z oddaljenostjo od najbolj prizadetega nadžariščnega območja.

Grafikon na sliki 11 prikazuje škodo, preračunano na posameznega prebivalca v prizadetih naseljih po občinah. Stolpci so urejeni v padajočem zaporedju. Daleč pred vsemi je občina Bovec, v kateri povprečna škoda na prebivalca dosega skoraj 800.000 SIT (774.111 SIT). Sledi občina Kobarid, v kateri je škoda na prebivalca že približno 2,5-krat manjša (297.857 SIT). Z manj kot 100.000 in več kot 50.000 SIT škode na prebivalca sledijo občine Tolmin, Gorenja vas – Poljane, Bohinj in Cerkno. Znatna je bila tudi škoda na prebivalca v občini Železniki – 20.155 SIT. V ostalih prizadetih občinah je bila škoda na prebivalca prizadetih naselij v občini že bistveno manjša, še največja s 5554 SIT na prebivalca je bila na Jesenicah. Kartogram na sliki 12 prikazuje ta podatek po posameznih naseljih. Karta lepo odslikava relativno prizadetost posameznega naselja. Izrazito izstopa Robidišče, ker je bila škoda v njem kljub razmeroma malo prizadetemu naselju v primerjavi s sosedstvom razmeroma velika zaradi majhnega števila prebivalcev. Izstopata še dve naselji v občini Železniki, Zabrdo in Torka. V prvem živi le še pet v drugem pa trije prebivalci. Skupna škoda v Zabrdu je bila ocenjena na skoraj 14 milijonov, v Torki pa na nekaj več kot 5 milijonov tolarjev. Sicer pa je kar 13 naselij takih, da je bila v njih škoda višja od milijon tolarjev na prebivalca. V 9 naseljih je bila škoda od pol do milijon tolarjev na prebivalca. V 65 naseljih je bila škoda od 100.000 do pol milijona tolarjev na prebivalca, 24 naselij pa je takih, v katerih je bila škoda na prebivalca manjša od 100.000 SIT, vendar večja od 50.000 SIT. V več kot polovici naselij (112) je bila škoda na prebivalca manjša od 50.000 SIT. To nas opozarja na izredno velike krajevne razlike v škodi. Na karti je lepo vidno izrazito izstopanje Bovškega z Bavščico in Trento, nadalje Drežniškega kota in Vrsnega, ki je še v občini Kobarid, ter Tolminskih

Raven in Čadrga z Zadlazom – Žabčami v občini Tolmin in končno že prej omenjeni naselji Zabrdo in Torka v občini Železniki.

Karta na sliki 12 dobro odslikava stisko prebivalstva ob potresu prizadetega območja, ker upošteva število ljudi po posameznih naseljih. Še boljšo podobo prizadetosti naselij bi dobili, če bi lahko popisne podatke o škodi ovrednotili s celotno gospodarsko močjo v potresu prizadetega prebivalstva. Zaradi neažurnosti, zlasti pa ne dovolj sodobno in ekonomsko naravnanih katastrskih podatkov nam poskus take analize ni dal uporabnih primerljivih rezultatov. Upamo, da bo z dopolnitvijo in bolj tekočim vodenjem katastrskih podatkov ter z dodatno uporabo drugih davčnih informacij v prihodnje mogoče bolj kvantitativno določiti relativno prizadetost posameznih območij oziroma krajev ob naravnih nesrečah. Ni dvoma, da je to vprašanje pomembno za dodeljevanje sredstev za obnovo iz državnih in drugih virov pomoči ob naravnih nesrečah ter za načrtovanje dolgoročne obnove.

Problem obnove dobro osvetljuje presenetljiva ugotovitev, da je bilo med 173 porušenimi objekti (poškodbe 5. stopnje) kar 76 takih, ki so bili kadarkoli obnovljeni. Še zgovornejši je podatek, da je bilo porušenih 26 objektov, ki so bili obnovljeni takoj po furlanskem potresu (1976) v obdobju 1976–80 (Godec, Vidrih, Ribičič 2000). Očitno je bilo pri obnovitvenih delih premalo pozornosti namenjene ojačevanju objektov. Zato je toliko bolj umestna odločitev ministrstva, da se vsi posegi na objektih izvajajo resda malo počasneje, a zato dosledno in popolno. Le tako bo verjetnost nastanka hujših poškodb ob morebitnem novem potresu manjša.

9. Sanacija

Izkušnje z obnovo po potresu leta 1976, ki je zajela skoraj isto območje, so pokazale, da se je treba problema lotiti temeljito. Sanacija po potresu leta 1976 ni bila povsod izvedena dovolj kakovostno. Ljudje so v obnavljanje objektov vložili mnogo sredstev in energije. Med pregledanimi 3390 objekti je bilo kar 1769 takih, kjer so bila opravljena obnovitvena dela.

Posebno je treba pozornost posvetiti povečanju potresne varnosti starejših objektov. Med pregledanimi objekti so bile kar štiri petine zgrajene pred letom 1964, ko je bil sprejet predpis o potresno varni graditvi. To še ne pomeni, da so vsi starejši objekti potresno nevarni, seveda pa bi bilo treba stalno izboljševati potresno odpornost zgradb. Zdaj je najnujneje obnavljati in potresno ojačevati objekte v Posočju, vendar bo tudi drugod v Sloveniji s sistematičnim ojačevanjem objektov treba zmanjšati število potresno nevarnih objektov.

V skupini naselij z ocenjenimi stroški od 10 do 100 milijonov je kar 85 krajev. Ob Zgornjem Posočju je veliko takih krajev v Bohinju in na Cerkljanskem, pa tudi v občinah Kranjska Gora, Jesenice, Železniki in Škofja Loka. V 91 naseljih ocenjena škoda ni večja od 10 milijonov tolarjev, v 22 naseljih pa je manjša od milijona tolarjev.

Najboljšo sliko posledic potresa nam prikazuje karta na sliki 7, ki kaže delež poškodovanih hiš v prizadetem naselju. V dveh naseljih, Drežniške Ravne in Jezerca, so bile poškodovane prav vse hiše (100 %), sledijo Magozd s 96 %, Krn s 93 %, Koseč z 91 %, Lepena z 90 % in Bovec z 81 %. Ti katastrofalno prizadeti kraji so na karti obarvani rdeče. Praviloma je okrog njih razporejena druga skupina nadpovprečno prizadetih naselij (oranžni krogci), v katerih je potres poškodoval od 60 do 80 % hiš. To so naselja: Kal-Koritnica (79 %), Drežnica (77 %), Čezsoča (66 %), Soča (62 %) in Čadrg (62 %). V tretji skupini zelo prizadetih naselij so naselja, v katerih je od 40 do 60 % poškodovanih hiš. Takih naselij je 14: Libušnje, Tolminske Ravne, Svino, Dolje, Zabrdo, Plužna, Bavšica, Bača pri Podbrdu, Selišče, Zadlaz-Žabče, Kred, Avsa, Znojile, Ladra in Volarje. V 39 naseljih je bilo poškodovanih od 20 do 40 % hiš (svetlomodri krogci), v ostalih 137 naseljih pa je bilo poškodovanih manj kot 20 % hiš. V 18 naseljih je bila povzročena škoda le na infrastrukturi ali drugje.

Sanacija je vedno dolgotrajen in zapleten proces ter še vedno ni zaključen. V naši raziskavi smo se jo lotili le deloma in to v geografski luči. V podrobnostih je obravnavana v drugih delih tega projekta. V preglednici 2 so navedeni objekti glede na stopnjo poškodb ob potresu leta 1998. V tej preglednici je nekaj metodoloških razlik od podatkov Ministrstva za okolje in prostor (1999), ki so bili izhodišče našim analizam, ker prikazuje število vseh pregledanih objektov ne glede na hišno številko.

Daleč največji stroški sanacije so bili ocenjeni v Bovcu (1.329.741.558 SIT). V bližnji Čezsoči, kraju, ki je bil po škodi na drugem mestu, je bila že več kot eno tretjino manjša (425.307.590 SIT). Sledi skupina desetih zelo prizadetih krajev, v katerih je bila ocenjena sanacija od 100 do nekaj več kot 250 milijonov SIT. To so naselja: Soča (254.048.870 SIT), Tolmin (235.209.960 SIT), Kobarid (211.565.600 SIT), Dolenja Trebuša (184.199.700 SIT), Drežniške Ravne (180.325.784 SIT), Krn (143.438.000 SIT), Zatolmin (140.356.000 SIT), Magozd (129.972.300 SIT), Kal-Koritnica (124.315.180 SIT) in Poljubinj (103.291.500 SIT). V Drežnici (97.399.000 SIT) in Trenti (95.131.000 SIT) je bila ocenjena sanacija le za malenkost manjša od 100 milijonov tolarjev. Geografska razporeditev teh naselij je lepo vidna na karti (slika 14). Izstopajo večja naselja na Bovškem, v Drežniškem koti in na ožjem Tolminskem. Vsa ta naselja so v treh Zgornje Posoških občinah Bovec, Kobarid in Tolmin.

V skupini naselij z ocenjenimi stroški od 10 do 100 milijonov je zelo veliko, kar 85 krajev. Ob Zgornjem Posočju je veliko takih krajev v Bohinju in na Cerkljanskem, pa tudi v občinah Kranjska Gora, Jesenice, Železniki in Škofja Loka. V 91 naseljih ocenjena škoda sanacije ni večja od 10 milijonov tolarjev, v 22 naseljih pa je manjša od milijona tolarjev.

Kar 15 naselij je takih, da v njih ni predvidenih izdatkov iz državnih virov za sanacijo poškodovanih objektov. Razlog za to je v premajhnem obsegu škode in zato v neizpolnjevanju pogojev pomoči ali drugih razlogov. To so naselja: Breznica, Bukovski Vrh, Hrušica, Kališe, Kanalski Lom, Lesce, Logaršče, Logatec, Peračica, Porezen, Roče, Sela nad Podmelcem, Smokuč, Vrh Sv. Treh Kraljev in Zabreznica (MOP 1999).

Kartogram na sliki 14 prikazuje stroške sanacije preračunane po posameznem prizadetem naselju. Podobno kot kartogram na sliki 15, ki prikazuje škodo preračunano na prebivalca, ta karta dobro osvetljuje problem lokalnega prebivalstva. Stroški sanacije v odročnih in manj razvitih naseljih so še posebno velik problem. Zelo izstopa naslednjih 15 naselij: Zabrdo (4.352.000 SIT), Bavšica (3.974.417 SIT), Krn (2.988.292 SIT), Magozd (2.096.327 SIT), Ukanc (2.003.956 SIT), Lepena (1.868.507 SIT), Torka (1.713.333 SIT), Zgornje Danje (1.703.333 SIT), Čadrg (1.702.335 SIT), Robidišče (1.597.412 SIT), Soča (1.403.585 SIT), Bača pri Podbrdu (1.314.444 SIT), Čezsoča (1.288.811 SIT), Drežniške Ravne (1.099.547 SIT) in Zadlaz-Žabče (1.043.319 SIT). V drugi skupini naselij z razponom sanacije od 500.000 SIT do milijona tolarjev je 11 naselij. Zanimivo je, da je v tej skupini naselij tudi Bovec s 796.252 SIT na prebivalca, sicer pa šele na 20. mestu.

V naslednji skupini s stroški predvidene sanacije od 100.000 do 500.000 SIT na prebivalca je 61 naselij. Sledi skupina 41 naselij v katerih so predvideni stroški sanacije na prebivalca ocenjeni od 50.000 do 100.000 SIT. V 78 krajih je sanacija preračunana na prebivalca manjša od 50.000 SIT. Za 15 naselij se ne predvideva nobenih državnih sredstev za sanacijo. Tako bodo v različni višini sanacijska sredstva šla v 209 od 224 naselij.

V karti, ki prikazuje število poškodovanih hiš po naseljih prizadetega območja (slika) je prikazano vseh 2543 hiš. Daleč največ jih je v Bovcu (473), sledijo naselja Čezsoča (108), Kobarid (107), Jesenice (103), Soča (96), Tolmin (80), Drežnica (63), Kal-Koritnica (56), Trenta (53), Drežniške Ravne (51) in Poljubinj (51). V 38 naseljih je bilo poškodovanih od 10 do 50 hiš. Razumljivo je, da je zaradi velikega števila majhnih naselij največ takih (155), v katerih je bilo poškodovanih manj kot 10 hiš.

V celoti je predvidenih 222 novogradenj, razporeditev po naseljih pa je prikazana v sliki 18. Največ novih hiš bo zgrajenih v Bovcu (53), Drežniških Ravnah (25), Lepeni (15), Zatolminu (14), Tolminskih Ravnah (11), Kalu-Koritnici (10), Magozdu (8), Poljubinju (6), Krnu (5), Soči (5) in Srpenici (5). Karta lepo prikazuje koncentracijo gradbenih posegov s krogci v rdeči, oranžni in rumeni barvi.

10. Sklepne misli

Potres leta 1998 je bil po moči in obsegu prizadetega območja manjši od t. i. furlanskega potresa iz leta 1976. Nadžariščno območje potresov je bilo leta 1998 v Sloveniji in oddaljeno približno 25 km zračne razdalje vzhodno od potresov leta 1976. Ker je bila magnituda potresov leta 1998 precej manjša, so bile tudi posledice manjše. V Italiji je bilo takrat zaradi potresov približno 1000 žrtev. V Sloveniji je bilo v veliki meri prizadeto isto območje. Po drugi seriji potresov v septembru leta 1976 je bilo v Sloveniji poškodovanih približno 12.000 stavb, največ v občinah Tolmin, Idrija in Nova Gorica. Od tega je bilo začasno ali povsem neuporabnih približno 4200 najrazličnejših stavb, ostali objekti so utrpeli manjše poškodbe in so še lahko služili prvotnemu namenu. Ob potresu leta 1998 je bilo v Sloveniji poškodovanih 2543 objektov, to je pet do šestkrat manj kot leta 1976. V sosednji Italiji ni bila zabeležena kakšna posebna škoda. Manjše so bile tudi potresne posledice, če primerjamo zgolj dogajanje znotraj ozemlja današnje Slovenije. Neugodno pa je to, da sta v razmeroma kratkem obdobju 22 let pokrajino prizadela dva rušilna potresa.

Ob vsem tem je treba posebej poudariti, da je to obmejno območje s svojskimi problemi. V celoti vzeto so kompleksni geografski problemi te pokrajine veliki. Naravne nesreče jih še dodatno poglabljajo in zapletajo.

Razmisliti velja o sistemih dolgoročnejših oblik gospodarske pomoči in poglobiti prizadevanja za vsesplošni razvoj prizadete pokrajine. Velja napraviti korak naprej od »zgolj« neposrednega odpravljanja posledic naravne nesreče.