GEOLOGIJA *48/1,* 117–126, Ljubljana 2005

Statistics of the Geological Map of Slovenia at scale 1 : 250.000

Statistika Geološke karte Slovenije 1 : 250.000

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Key words: geology, geological map, geological cover, statistics, Slovenia
Ključne besede: geologija, geološka karta, pokrovnost, statistika, Slovenija

Abstract

The paper gives the analytical results of the abundance of spatial and linear elements found on Geological Map of Slovenia at scale 1 : 250.000. Six types of rocks, based on the genesis, and 17 classes of geological ages, were analysed for the area proportions. Linear elements (faults, thrusts and other elements) were analysed for their distance according to the spreading direction. Almost one half of Slovenia is consisted of clastic rocks and 40 % of carbonate rocks. Kenozoic and Mesozoic rocks cover roughly 90 % of Slovenian territory, with 44 % and 45 % respectively. Analytical results for structural elements suggest that the main spreading directions are in Dinaric and W – E directions.

Izvleček

V prispevku so prikazani rezultati analiz površinskih in linijskih elementov Geološke karte Slovenije v merilu 1 : 250.000. Po pogostosti pojavljanja je bilo prikazanih šest tipov kamnin, glede na nastanek, ter 17 razredov kamnin, glede na geološko starost. Analizirana je bila tudi pogostost pojavljanja prelomov, narivov in ostalih strukturnih elementov na karti glede na usmerjenost. Klastične kamnine obsegajo skoraj polovico, karbonatne pa 40 % slovenskega ozemlja. Devet desetin Slovenije je pokritih s kenozojskimi im mezozoijskimi kamninami. Prve zasedajo 44 % in druge 45 % ozemlja. Analize strukturnih elementov kažejo na dve glavni smeri razprostiranja, v dinarski smeri SZ – JV in v smeri V – Z.

Introduction

The importation of the data from Geological Map of Slovenia at scale 1 : 250.000 into the GIS enabled for the first time an exact assessment of proportions of different geological spatial features in the area of Slovenia. The analytical results are useful for the general overview of geological properties of Slovenian territory and for a general estimation of numerous natural resources that depend on geological properties.

Data used

The Geological Map of Slovenia at scale 1 : 250.000 (Buser, in print) (Figure 1) is a result of a over 15 years of field work and several years of GIS data preparation. The map was compiled form the "Basic Geological Map at scale 1 : 100.000" data and later updated and completed (Buser & Komac, 2002). 114 different lithostratigraphic units were individualized. Beside the geological boundaries six different structural elements

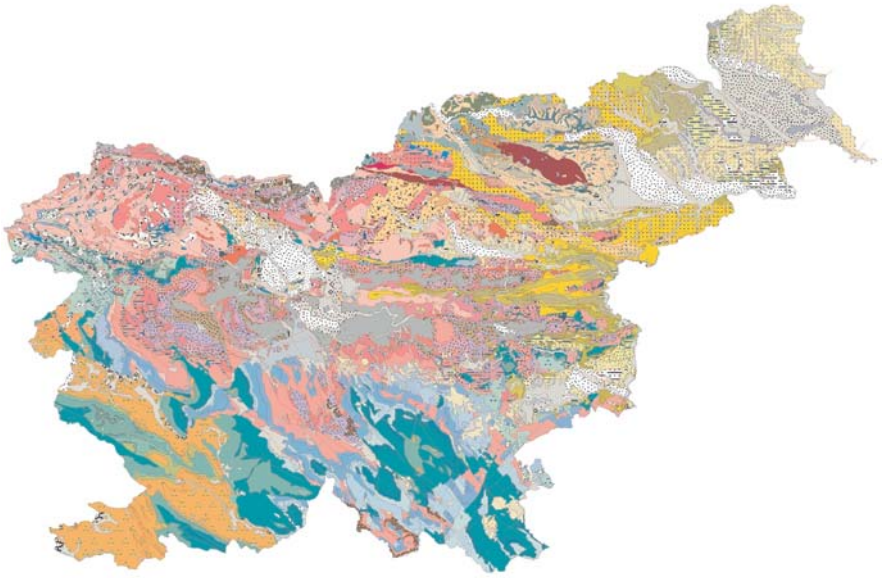

Figure 1. Geological Map of Slovenia at scale 1 : 250.000 in its final phase before the cartographic phase (after Buser, in print).

Slika 1. Geološka karta Slovenije 1 : 250.000 v končni obliki pred pripravo za kartografsko obdelavo (po Buserju, v tisku).

are shown on the map. Slovenian territory is divided into 4550 polygons and nearly 8700 km of structural elements, not counting the geological boundaries.

Methods

For the purpose of basic statistical description assessment of geological features of Slovenia, simple statistical analyses were conducted. Area and area proportions of lithostratigraphic units based on six rock types, based on their genesis, were defined. The rock types were: clastic rocks, carbonate rocks, clastic-carbonate rocks, pyroclastic rocks, metamorphic rocks, and igneous rocks. The same analysis was done for the age parameter of lithostratigraphic units. The geological age was divided to: Quaternary (Q), Tertiary – Quaternary (Tc,Q), Tertiary (Tc), Cretaceous-Tertiary (K,Tc), Cretaceous (K), Jurassic- Cretaceous (J,K), Jurassic (J), Triassic-Jurassic (T,J), Triassic (T), Permian (P), Lower Permian-Upper Carboniferous (P,C), Carboniferous (C), Devonian (D), Devonian-Silurian (D-S), Silurian-Ordovician (S-O), Cambrian (Є), and Precambrian (PC). Major linear element classes were analysed for their distance according to the orientation (N-S, NE-SW, E-W, and NW-SE). These analyses were conducted for faults, thrusts and other elements (anticlines, synclines, domes, and basins).

Results and discussion

Statistical results for spatial elements

Divided by the lithological type the 49,25 % of Slovenian territory is composed by clastic rocks, carbonate rocks cover 39,31 % of the territory, and the mixture of the two cover 4,27 % of the terrain. The smallest area is occupied by igneous rocks (1,49 %), little more by pyroclastic rocks (1,78 %), and metamorphic rocks compose 3,9 % of Slovenian territory. Figure 2 and Figure 3 represent the spatial distribution of rock types in Slovenia.

The division of lithostratigraphic units by geologic times is a little more extensive, due to the 17 different age classes. Quaternary rocks spread over 20,02 % of the terri-

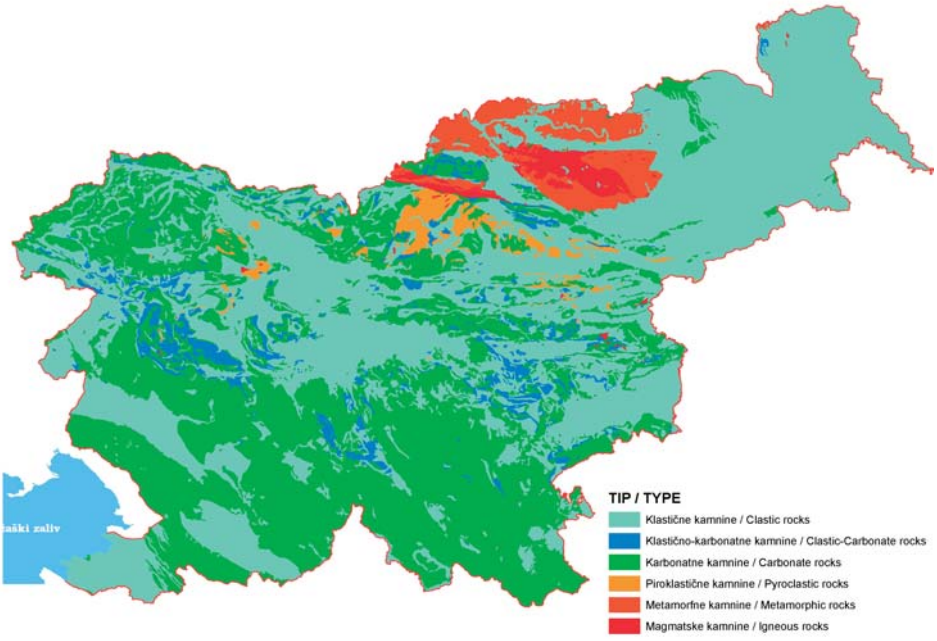

Figure 2. Spatial distribution of rock types in Slovenia (after Buser, in print).
Slika 2. Kamninska sestava Slovenije glede na tip kamnin (po Buserju, v tisku).

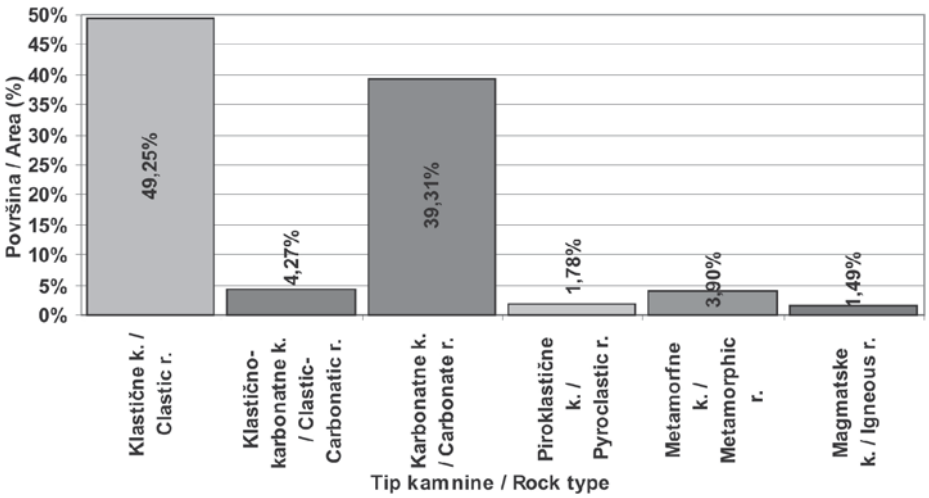

Figure 3. Proportions of surfaces comprised by individual rock types in Slovenia.
Slika 3. Porazdelitev površine Slovenije glede na tip kamnin.

tory, Tertiary – Quaternary rocks only over 2,1 %, and Tertiary rocks over one fifth of the territory (22,1 %). Only 0,64 % of the terrain is covered by Cretaceous-Tertiary rocks, 13,98 % by Cretaceous rocks, and really a small portion is covered by Jurassic-Cretaceous rocks (0,17 %). Jurassic rocks occupy 8,22 %, Triassic-Jurassic rocks 0,07 %, and Triassic rocks 23,14 % of Slovenian territory. Upper Permian rocks

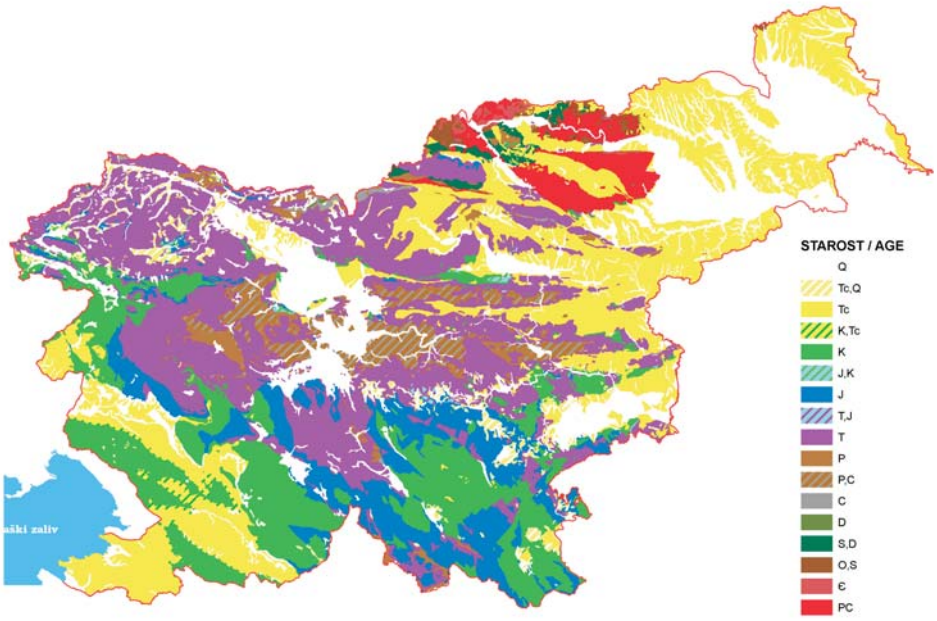

Figure 4. Spatial distribution of rocks of individual geologic times in Slovenia (after Buser, in print).
Slika 4. Pojavljanje kamnin glede na starost v Sloveniji (po Buserju, v tisku).

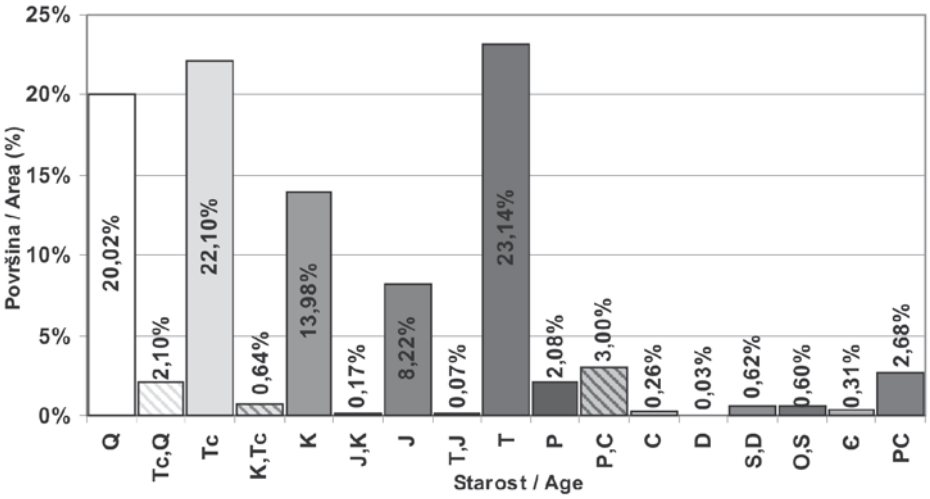

Figure 5. Proportions of surfaces comprised by rocks of individual geologic times in Slovenia.
Slika 5. Porazdelitev površine Slovenije glede na starost kamnin.

constitute 2,08 %, lower Permian-upper Carboniferous rocks 3 %, and lower Carboniferous rocks 0,26 % of the territory. Except for Precambrian rocks that cover 2,68 % of Slovenian territory, Devonian, Devonian-Silurian, Silurian-Ordovician, and Cambrian rocks represent small portions of the territory. They represent 0,03 %, 0,62 %, 0,6 %, and 0,31 % of the area respectively. Figure 4 and Figure 5 represent the spatial distribution of rocks of individual geologic times in Slovenia.

When combining the age and rock type, the most abundant lithostratigraphical type is quaternary clastic rocks (20 %), followed by tertiary clastic rocks (16,8 %), Triassic carbonate rocks (16,7 %), Cretaceous carbonate rocks (10,6 %) and Jurassic carbonate rocks (8,1 %). Proportions of the rest are shown in Table 1.

Table 1. Proportions of surfaces comprised by rock types for individual geologic times in Slovenia.
Tabela 1.Porazdelitev površine Slovenije glede na presek tipa in starosti kamnin.

Age	Klst/Clst	Klst-krb/Clst-Crb	Krb/Crb	Pirok/Pyroc	Metam	Magm/Igneous
Q	20,02 %	0 %	0 %	0 %	0 %	0 %
Tc,Q	2,10 %	0 %	0 %	0 %	0 %	0 %
Tc	16,80 %	0,17 %	2,85 %	1,27 %	0 %	1,02 %
K,Tc	0 %	0,08 %	0,55 %	0 %	0 %	0 %
K	2,63 %	0,74 %	10,59 %	0 %	0,01 %	0 %
J,K	0 %	0 %	0,17 %	0 %	0 %	0 %
J	0 %	0,16 %	8,06 %	0 %	0 %	0 %
T,J	0 %	0 %	0,07 %	0 %	0 %	0 %
T	2,76 %	3,12 %	16,66 %	0,52 %	0 %	0,07 %
P	1,68 %	0 %	0,32 %	0 %	0 %	0,08 %
P,C	3,00 %	0 %	0 %	0 %	0 %	0 %
C	0,26 %	0 %	0 %	0 %	0 %	0 %
D	0 %	0 %	0,03 %	0 %	0 %	0 %
S,D	0 %	0 %	0 %	0 %	0,60 %	0,02 %
O,S	0 %	0 %	0 %	0 %	0,60 %	0 %
Є	0 %	0 %	0 %	0 %	0,31 %	0 %
PC	0 %	0 %	0 %	0 %	2,38 %	0,29 %

Legenda / Legend: Klst/Clst – klastične k. / Clastic r.; Klst-krb/Clst-Crb – klastično-karbonatne k. / Clastic-Carbonate r.; Krb/Crb – karbonatne k. / Carbonate r.; Pirok/Pyroc – piroklastične k. / Pyroclastic r.; Metam – metamorfne k. / Metamorphic r.; Magm/Igneous – magmatske k. / Igneous r.

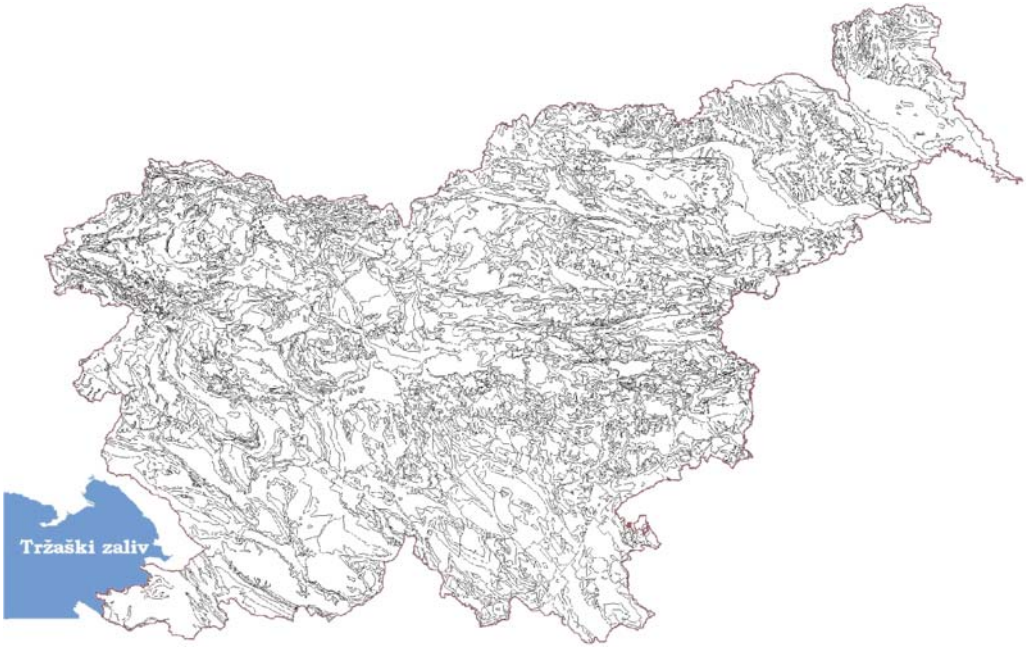

Figure 6. Spatial distribution of geological boundaries of the Geological Map of Slovenia at scale 1 : 250.000 (after Buser, in print).

Slika 6. Pojavljanje geoloških mej na Geološki karti Slovenije 1 : 250.000 (po Buserju, v tisku).

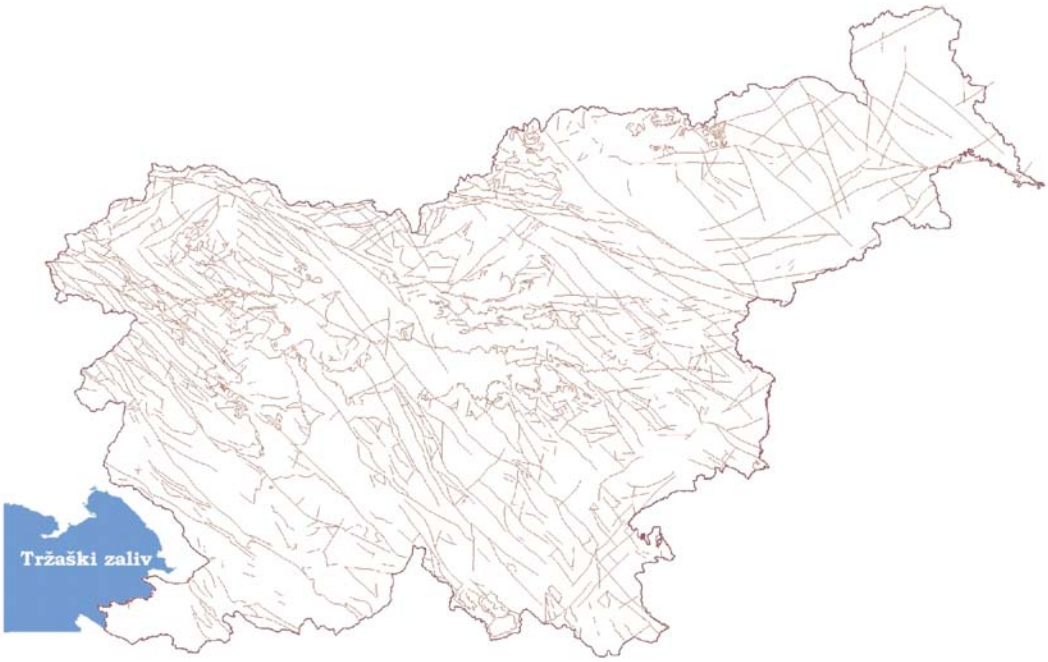

Figure 7. Spatial distribution of structural elements of the Geological Map of Slovenia at scale 1 : 250.000 (after Buser, in print).

Slika 7. Pojavljanje strukturnih elementov na Geološki karti Slovenije 1 : 250.000 (po Buserju, v tisku).

Statistical results for linear elements

Figure 6 represents the distribution of geological boundaries and Figure 7 represents the distribution of structural elements found on the Geological Map of Slovenia at scale 1 : 250.000.

The total length of faults found in the Geological Map of Slovenia at scale 1 : 250.000 is 6733,843 km. The dominant direction of faults is NW – SE (47,35 %), followed by the W – E direction (26,11 %). 15,86 % of fault length spreads in the NE – SW direction, and the rest (10,68 %) in the N – S direction (Figure 8).

The prevailing direction of thrusts is W – E (36,98 %), followed by thrusts in the NW – SE direction (25,04 %), those that spread in the NE – SW direction (20,04 %), and the least common direction for thrusts is N – S (17,96 %). The total length of thrusts is 1644,07 km (Figure 9).

Among the rest of the structural elements, analysed for their direction occurrence, synclines are most common (58,95 %), followed by anticlines (36,2 %), domes (3,95 %) and basins (0,91 %). Considering only synclines, the dominant directions are W – E (43,45 %) and NW – SE (34,47 %). 11,91 % of synclines spread in the NE – SW direction and the rest, 10,17 % in the N – S direction. The distribution of anticlines is similar to syncline distribution, with the change in the first two places. Almost half of anticlines spread in the NW – SE direction, 37,53 % in the W – E direction, 9,21 % in the NE – SW direction, and the rest in the N – S direction(3,58 %). Distribution of all structural elements, excluding faults and thrusts, is due to the proportion of synclines and anticlines, dominated by the two directions, W – E (41,1 %) and NW – SE (38,7 %). The total length of structural elements is 319,7 km. The distribution according to directions is shown in Figure 10.

Conclusions

The analytical results of Geological Map of Slovenia at scale 1 : 250.000 have been assessed in detail for the first time sho-

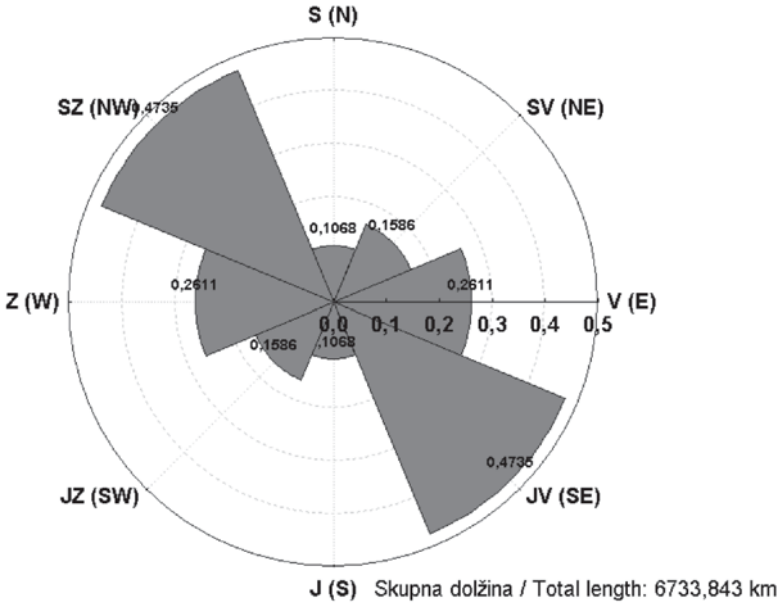

Figure 8. Faults distribution according to directions in Slovenia (length proportions).
Slika 8. Porazdelitev usmerjenosti prelomnih struktur na območju Slovenije (deleži dolžin).

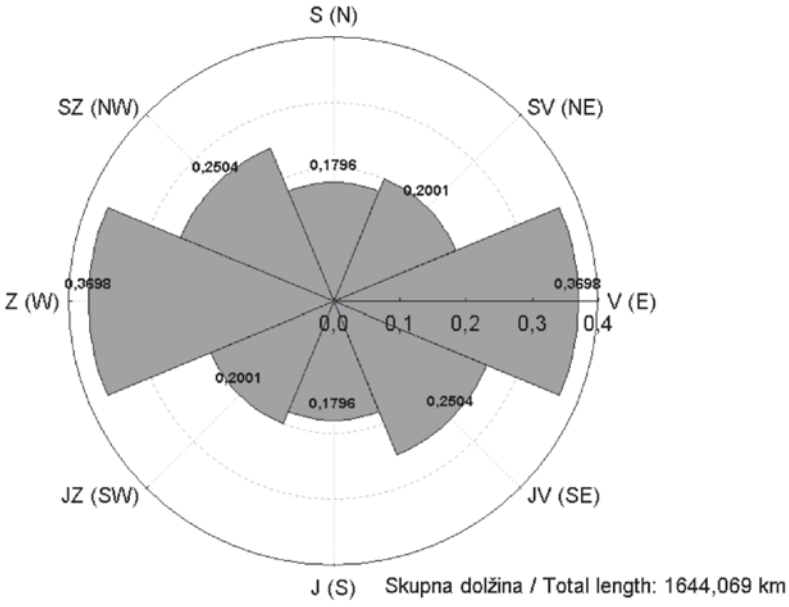

Figure 9. Thrusts distribution according to directions in Slovenia (length proportions).
Slika 9. Porazdelitev usmerjenosti narivnih struktur na območju Slovenije (deleži dolžin).

wing the proportions of linear and spatial geological elements. Almost one half of Slovenia is consisted of clastic rocks and 40 % of carbonate rocks. Kenozoic and Mesozoic rocks cover roughly 90 % of Slovenian territory, with 44 % and 45 % respectively. Analytical results for structural elements suggest that the main spreading directions are in Dinaric and W –E directions.

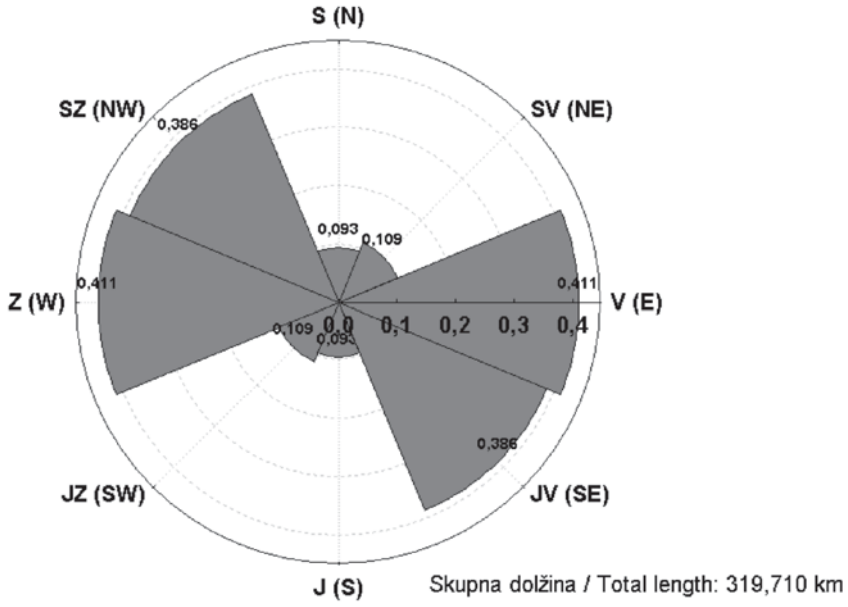

Figure 10. Structural elements distribution according to directions in Slovenia (length proportions). Faults and thrusts are excluded.

Slika 10. Porazdelitev usmerjenosti sinklinal, antiklinal, dom in bazenov na območju Slovenije (deleži dolžin).

Acknowledgements

This work was supported by the Geological Survey of Slovenia. Author would also like to thank Prof. dr. Stanko Buser for the permission to publish the analyses data. Author would like to apologise to the reader for the errors in the results (Figure 9), presented at the 17th Meeting of Slovenian Geologists, held in Ljubljana in April 2005 (Komac, 2005). The errors have been corrected and presented in this paper.

Statistika Geološke karte Slovenije 1 : 250.000

Uvod

Zaradi zajema podatkov v GIS je prvič do sedaj možen natančen izračun deležev posameznih enot, tipov kamnin, enot po starosti ter izračun deležev dolžin usmerjenosti strukturnih elementov. Rezultati analiz so uporabni za pregled splošnih geoloških lastnosti Slovenije in za grobo oceno številnih naravnih danosti, pogojenih z geološkimi lastnostmi.

Uporabljeni podatki

Geološka karta Slovenije 1 : 250.000 (Buser, v tisku) (Slika 1) je plod 15-letnega znanstvenega in strokovnega dela na področju geologije in nekajletnega dela priprave in zajema podatkov s karte v GIS. Karta je bila izdelana na podlagi podatkov Osnovne geološke karte 1 : 100.000 in njihove reambulacije (Buser & Komac, 2002). Obsega 114 litostratigrafskih enot, ter poleg geoloških mej še 6 tipov strukturnih elementov. Območje Slovenije pokriva 4550 posameznih poligonov 114-ih litostratigrafskih enot in skoraj 8700 km strukturnih elementov neupoštevaje geoloških mej.

Metode

Za namen pridobitve osnovnih statističnih podatkov o geologiji Slovenije so bile uporabljene enostavne statistične opisne metode. Ugotovljene so bile površine in deleži površin litostratigrafskih členov glede na šest tipov kamnin, razdeljenih na način nastanka; na klastične, karbonatne, metamorf-

ne in magmatske kamnine, na piroklastite ter na menjavanje klastičnih in karbonatnih kamnin. Po enakem principu je bilo analizirano pojavljanje litostratigrafskih členov glede na njihovo starost (kamnine kvartarne (Q), tercirano-kvartarne (Tc,Q), terciarne (Tc), kredno-terciarne (K,Tc), kredne (K), jursko-kredne (J,K), jurske (J), triasno-jurske (T,J), triasne (T), permske starosti (P), spodnje permsko-zgornje karbonske (P,C), karbonske (C), devonske (D), devonsko-silurske (D,S), silursko-ordovicijske (S,O), kambrijske (Є) ter kamnine predkambrijske starosti (PC)). Glavni razredi linijskih elementov na Geološki karti Slovenije 1 : 250.000 so bili analizirani glede na dolžino pojavljanja in njihovo usmerjenost v smeri osmih glavnih smeri neba. Tako so bile opravljene analize pojavljanja za prelome, narive in ostale strukturne elemente (sinklinale, antiklinale, dome in bazeni).

Rezultati in razprava

Statistika površinskih elementov

Razdeljeno po tipu kamnine pokrivajo klastične kamnine 49,25 % površine Slovenije, karbonatne kamnine pokrivajo 39,31 % in enote, v katerih se ta dva tipa menjavata pokrivajo 4,27 % Slovenije. Piroklastiti tvorijo 1,78 % kamnite podlage Slovenije, metamorfne kamnine 3,9 % in magmatske kamnine 1,49 % podlage Slovenije. Sliki 2 in 3 predstavljata sestavo Slovenije glede na tip kamnin.

Starostna razdelitev je nekoliko obširnejša, saj obsega 17 razredov. Kamnine kvartarne starosti sestavljajo 20,02 %, tercirano-kvartarne starosti 2,1 %, terciarne starosti 22,1 %, kredno-terciarne starosti 0,64 %, kredne starosti 13,98 %, jursko-kredne starosti 0,17 %, jurske starosti 8,22 %, triasno-jurske starosti 0,07 %, triasne starosti 23,14 %, zgornje permske starosti 2,08 %, spodnje permsko-zgornje karbonske starosti 3 %, spodnje karbonske starosti 0,26 %, devonske starosti 0,03 %, devonsko-silurske starosti 0,62 %, silursko-ordovicijske starosti 0,6 %, kambrijske starosti 0,31 % in kamnine predkambrijske starosti 2,68 % površine Slovenije (Sliki 4 in 5).

Analiza preseka tipa in straosti kamnin je pokazala, da so v Sloveniji najpogostejše klastične kamnine kvartarne starosti (20 %), po pogostosti pojavljanja pa jim sledijo klastične kamnine terciarne starosti (16,8 %), karbonatne kamnine triasne (16,7 %), kredne (10,6 %) in jurske starosti (8,1 %). Deleži pojavljanj ostalih kamnin po starosti so podani v tabeli 1.

Statistika linijskih elementov

Slika 6 prikazuje pojavljanje geoloških mej, slika 7 pa pojavljanje strukturnih elementov, prikazanih na Geološki karti Slovenije 1 : 250.000.

Med prelomi s skupno dolžino 6733,843 km prevladuje usmerjenost v smeri SZ – JV (17,91 %), 12,52 % prelomov se razteza v smeri S – J, 10,52 % v smeri V – Z in 9,04 % prelomov v smeri SV – JZ (Slika 8).

Največji delež narivov (17,26 %) poteka v smeri S – J, sledijo narivi v smeri V – Z (13,62 %), narivi v smeri SZ – JV (12,1 %) in narivi v smeri SV – JZ (7,03 %). Skupna dolžina narivov je 1644,07 km (Slika 9).

Med ostalimi strukturnimi elementi (sinklinale, antiklinale, dome in bazeni), katerih skupna dolžina znaša 319,71 km, prevladujejo sinklinale (58,95 %), sledijo jim antiklinale (36,2 %), dome (3,95 %) in bazeni (0,91 %). Osi sniklinal večinoma potekajo v smeri V – Z (43,45 %) in SZ – JV (34,47 %). 11,91 % jih poteka v smeri SV – JZ in 10,17 % v smeri S – J. Skoraj polovica osi antiklinal (49,67 %) leži v smeri SZ – JV, 37,53 % v smeri V – Z, 9,21 % v smeri SV – JZ in 3,58 % S – J. Slika 10 prikazuje porazdelitev usmerjenosti vseh strukturnih elementov, razen prelomov in narivov. Glede na deleže antiklinal in sinklinal sta temu primerno opazni dve prevladujoči smeri, V – Z (41,1 %) in SZ – JV (38,7 %)

Sklepi

Rezultati analiz geološke sestave slovenskega prostora, predstavljeni v tem prispevku, prvič natančno podajajo deleže tipov kamnin in njihove starosti ter deleže linijskih elementov glede na njihovo usmerjenost. Klastične kamnine obsegajo skoraj polovico, karbonatne pa 40 % slovenskega ozemlja. Devet desetin Slovenije je pokritih s kenozojskimi im mezozoijskimi kamninami.

Prve zasedajo 44 % in druge 45 % ozemlja. Analize strukturnih elementov kažejo na dve glavni smeri razprostiranja, v dinarski smeri SZ – JV in v smeri V – Z.

Zahvale

Izvedbo tega dela je omogočil Geološki zavod Slovenije. Avtor se zahvaljuje prof. dr. Stanku Buserju za dovoljenje za objavo rezultatov analiz. Pri predstavitvi analiz na 17. posvetovanju slovenskih geologov, aprila 2005 v Ljubljani (Komac, 2005), je prišlo do napake v prikazu rezultatov usmerjenosti linijskih elementov (Slika 9). Za neljubo napako, ki jo v tem prispevku popravlja, se avtor opravičuje bralcem.

References - Viri

Buser, S.: Geološka karta Slovenije 1 : 250.000 = Geological Map of Slovenia at scale 1 : 250.000.- v tisku (in print).

Buser, S. & Komac, M. 2002: Geološka karta Slovenije 1: 250.000. - *Geologija*, *45/2*, 335-340, Ljubljana.

Komac, M. 2005: Statistika geološke karte Slovenije 1: 250.000. V: HORVAT, Aleksander (ur.). *17. posvetovanje slovenskih geologov*, (Geološki zbornik, 18). Ljubljana: Univerza v Ljubljani, Naravoslovnotehniška fakulteta, Oddelek za geologijo, 2005, str. 61-62.