

BASIS RELIEF STRUCTURES IN SANA DRAINAGE BASIN

Emir Temimović

Univerzitet u Sarajevu, Prirodno-matematički fakultet Odsjek za geografiju,
Zmaja od Bosne 33-35, Sarajevo, Bosna i Hercegovina
emirtemimovic@yahoo.com

Applying scientific classification, the differentiation of basic relief structure in the basin drainage area (sub-basin drainage of Una) is made. Thus, in the examined area the most representative morphostructural relief members include: central mountain massifs, karst poljes and plateaus in the karst, pediments, foothills and alluvium, which are further divided into smaller relief subcategories.

Defined relief structures are associated with specific landscape units in the basin drainage area. As a separate unit, complex composite valley of the river Sana is distinguished. Morphostructural types of relief, its areal distribution in the basin drainage of the river Sana and correspondence with tectonic units of Bosnia and Herzegovina are subject of research in this article.

Key words: *Sana drainage basin, morphostructural regionalization, types of relief*

INTRODUCTION

Morphostructural regionalization and determining the basic relief of Sana drainage basin, contribute typological regionalisation of Bosnia and Herzegovina. Morphostructural regionalization relies on tectonic regionalisation, by which Sana's drainage basin is situated in middle Dinarids, which are made of: Paleozoic elastics, mezozoic carbonates, jurassic-creataceous flysh and neogene molasses. Their formation is influenced by pre-orogenic and oro-tectonic processes, which alternated from tertiary.

After Alps orogenic phase, Sana drainage basin with other complexes of territories in northern Bosnian, was tectonically modified by young-styrian tectonic phase in which Pre-Tetis has penetrated until Uzlo mac and Kozara. In Moldovan and attric tectonic phases, in period of Tortorian and Sarmatian, sedimentation in marine shallow-water has taken place and continued raise of Dinarids. Tectonic fluctuations in old ronic, from middle and upper Miocene and young Slavonic from Pliocene geological period, caused raise of mountain morphostructures, those isolated horst mountains on North as well as those which orographically close Sana drainage basin from South, South-East (Spahić, 2000). This orographic tectonics definitely interrupted marine and limnic effect of sedimentation in northern Bosnia, as well as in lowland morphostructures, in which Sana drainage basin is situated. That was a period of intense egzodynamic, which creates separated relief forms and belong to domain of morphostructural components, what are actually object of study in this paper.

Most representative morphostructural relief forms in Sana'a basin include: central massifs, basins and plateaus in the karst, pediments, foothills and river alluvions.

OBJECT OF STUDY

Sana drainage basin is situated in Western and South-Western part of Bosnia and Herzegovina. Area of drainage basin in hydrological watershed covers around 4.520 km² or 8% of Bosnia and Herzegovina and together with Una, which hydrographically belongs to, are incorporated in unique areas of our country, with extremely high levels of natural diversity. Area of Sana drainage basin bounded by orographic watershed covers around 3.740 km².

The biggest disparity of watersheds is in Southern and South-Western investigated parts, in those catchment areas which are constructed mostly from carbonates with underground runoff precipitation. In this part of drainage basin, common underground catchment of Sana and Pliva is isolated and its area is around 320 km². Glamočko polje in its North-West part has this phenomena as well, on are around 175 km², in which underground water bifurcates to springs of Sana and Ribnik. Drainage basins in Bravsko polje as well as in Petrovačko polje, location Drinić, together covers area of 285 km² separates water in underground to springs of Sana, Korčanica and Dabar.

Drainage basin of Sana is in contact with two totally divergent morphological structures: Panonic basin on north and Dinarids on north. Tectonic differentiation is followed by relief dynamic whose morphostructural expressional elements have extreme morphogenetic features. Further, Una-Sana drainage basin represent meso-morphological region, which by its down drainage basin belongs to more balanced relief set, and upper subregion to bila and polja. This last sub-morphological regional form is represented by linear mountain ranges and ridges between which, parallel to orographic directorates, basins and fields are situated separately or grouped in series. The most know are: massif Grmeč with polje in karst Jelašinovci and plateau in karst Krasulje or series of mountain ridges Snetica, Crna gora and Kurozeb with belonging high mountain ravine in-between. On them, morphological components, which are treated by this paper are found.

Methodology of morphostructural researches conceptually relies on complex relief studies, firstly mutual relations of tectonic and relief. Since relief is result of geological structure, tectonic activities and egsodynamic processes than it is same primary study in Sana drainage basin morphostructure. Correlation of all those named elements in relief genesis it is possible to give situation of recent structures (Burbank, Anderson, 2001). Paper is based text analyses method, cartography analyses, aerophotogrammetric analyses, fieldwork prospection and cabinet work.

DISCUSSION

In most recognizable morphostructural relief structures, which are forming base of structure, in Sana drainage basin next are included: central massifs, basins and plateau in karst, foreland steps, foothills and river alluvions.

Central mountain massifs

This relief type in Sana drainage basin of antiform structure, in which most recognizable are: anticline, anticlinorium, horst-anticlinorium, horst-syncline, complex types of covers and tectonic shells. Based on tectonic, litological, genetic and morphological features inside of researched area, it is possible to identify next relief subtypes:

1. Central massif of Alp orogen zone complex tectogenesis
2. Wrinkled-faulted and covering mountain masses alp orogen phase
3. Wrinkled-covered and shelled mountain masses ophiolitic melange

Central massif of Alp orogenic zone complex tectogenesis remobilized mountain massifs, which are based on their tectonic position related to eugeosyncline zone (middle zone) alp orogen. Those are polycyclic complex tectonic structure (massif), raised mostly during neotectonic phase of development, on what indicate erosive-tectonic remains younger covering structures (Bognar, 1980.).

To this relief type in Sana drainage basin belong mountain Majdan (Gojidižnik, 619m), on left valley side of Sana and massif Lisina (627m) and Strmec (Travnik, 689m), on right valley side of Sana. Mountain Majdan is lower mountain range which lies in direction WSW-ENE around 23 km. In central part of mountain Majdan, on road communication Stari Majdan-Budimlić Japra, is situated saddle Barišić (302m), which divides this area on two parts: South-Eastern, with highest peak Gojidižnik (619m), length 10 km North-East, with highest peak Raljaš (498m), length 14 km. Mountain Majdan is composed of Paleozoic sediments and mesozoic limestones. Raised during neotectonic stage of development identified three not matching structures in geological chronology: formation of old structural level at the turn from Eocene to Oligocene, formation of Sana's cover and other Dinaric structures, during the Oligocen and cross faulting Dinaric structures at the end of Oligocene (Jurić, 1977). On other, right side of Sana valley hills Lisina and Strmec are continued on mountain Majdan. They are also composed of Paleozoic sediments and Mesozoic limestones. Together with Manjača massife those hills have developed foreland levels to basin Prijedor-Omarska field. Lisina (672m) is lower hill direction NW-SE, long around 12 km and wide 5 km. Strmac continues on East. Bigger is and has Dinaric direction, long around 8 km and approximate wideness around 4 km.

Wrinkled-faulted and covering mountain masses of Alp orogen in wider sence is categorized in younger morphostructural types Alp orogen. Classification of morphostructural complexes is based on morphostructure analyse. Clasification is based on correlation of contemporary relief with geological structure respecting morphometric, morphographic and lithostratigraphic features. Inside of wrinkled-faulted zone and covering mountain massifs of Alp orogen which effects central and whole upper drainage basin parts, it is possible to identify four levels of mountain ridges and massif which are hypsometrically highest peaks of researched area.

1. Range Klekovača (V. Klekovača, 1962 m) – Lunjevača (Tisov vrh, 1707 m) – Tisova kosa (1227 m) – Javorova kosa (1339 m) – Crna gora (Gola kosa, 1651 m) – Ovčara (Ovčara, 1576 m) – Rosana (1627m) – Smrčeva kosa (1378 m) – Kurozeb (1604 m) – Čardak (1452 m). North border of this range is making reverse fault Uvala-Jasikovac, while South border is outside of researched area (Drvar, Glamoč). Northern from this range is next mountain range which together with range before belongs to zone of High karst.
2. Range Javornjača (1480 m) - Grmeč (Crni vrh, 1604 m) - Sretica (Miljakuša, 1378 m) - Šiša gora (Razvršje, 1388 m) - Bobija (Bobijski vrh, 1465 m) - Lisina (Lisina, 1376 m) - Osoje (1031 m). North border of range is represented by dislocation, cover Ključ. This area is constructed of carbonate complex, and they are represented with folds which are expressed by kilometric dimension. Northern, in the zone of Mesozoic

limestones and Paleozoic sediments, two smaller ranges are identified. They are represented by hills and mountain ranges and massifs.

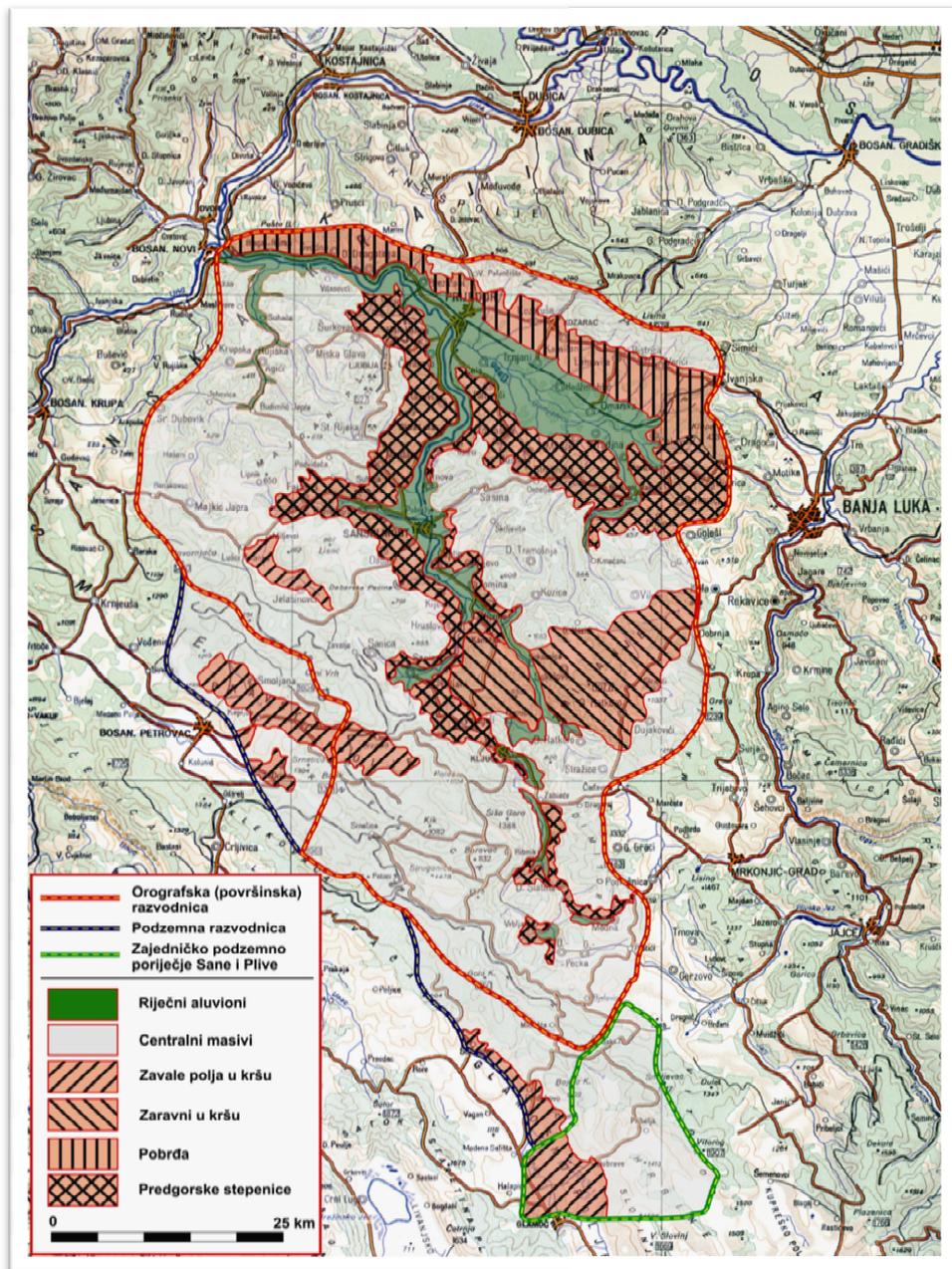


Fig.1. Basis relief structures in Sana drainage basin

3. Range Kalaura (578 m) - Paunovac (779 m) - Palež (473 m) - Kršina (415 m) – range of peak massifs Dimitora (Runjevica (616 m) - Rust (1033 m) - Javorak (1331 m) - Šljeme (1259 m) - Kik (1331 m) - Mali Dimitor (1483 m)). South-west border is made of cover Ključ, in which covers of this range are drawn over tectonic complex High karsts. North-eastern continues last range of hills and mountain ranges and massifs which belong to wrinkled-faulted and covering mountain masses of Alp orogen.
4. Range Gradina (Rudo brdo, 779 m) - Mrežnica (Oštrej, 791 m) - Čelić kosa (Lokveni vrh, 916 m) - Ošljak (666 m) - Breščica (527 m) - Ljubinska mountain (Ljubinski vrh, 833 m) - Cikelj (909 m) - Kik (1091 m) – range of peak massifs Manjače (Tiričevica (1022 m) - Skutarov vrh (1123 m) - V. Manjača (1236 m) - Uzlomac (1082 m) - Lunjevac (1045 m)). South border is represented by fault Sanica-Ključ-Medna, and northern border is border of Sana-Una Paleozoic.

Wrinkled-covering and shelled mountains masses ophiolitic Dinaric zone in geotectonic belong to eurodinariid, or inside Dinaridi tectonic zone. This zone is indicated by complex horsts tectonic structure, horst-anticline, anticline, synclinorium, covers and shells (Bognar, 1980.). To this zone belongs Southern part of Sana drainage basin in which dominates ridge-anticline of Kozara.

Almost though all reef of Kozara watershed is passing, between Sana drainage basin from South part and Una drainage basin and direct Sava drainage basin from Northern side. Kozara lies in WNW-ESE direction with length 45 km, and maximal width 12 km. On West, on Kozara continues Kozara's hills, foothills type of relief which extends total length to 70 km. Approximate border between Kozara and Kozara's hills is located on saddle Madžari (286 m) on road communication Prijedor-Bosanska Dubica. Watershed of drainage basin extends from saddle Madžari (286m) over highest peak of Kozara (Mrakovica (806 m) – Lisina (976 m) till Kamenito brdo (Guganova glava (841 m)) which are situated northern from settlement Ivanjska. On that place watershed is suddenly turning to South and over quaternary depression of Ivanjska is going up (climbing) to hill Piskavica. Length of watershed from Madžari – Guganova glava is around 44km. On main Kozara's reef above settlement Kozarac is situated saddle Mrakovica (770 m), next to same named peak and memorial home, on road communication of local importance Kozarac - Bosanska Dubica. This saddle divides Kozara on two parts: Western with highest peak Mrakovica (804 m) length around 23 km and Eastern part with highest peak Lisina (976 m) length in drainage basin 21 km. Kozara is on North covered with Neogene sediments complex, and South with fault direction NW-SE Božići – Strigova is separated from basin Prijedor-Omarska. Kozara is situated in central ophiolitic zone, and with faults is separated from others components (on North huge Kozara's fault, and on South fault Božić-Strigova). It belongs to same named tectonic component (Jovanović, Magaš, 1986.) which is divided on:

1. Kozara's anticline and it is placed Northern from Gola planina and Lisina and has parallel direction of extend in comparison to Kozar's reef. This anticline is eroded and made of upper Cretaceous sediments. From other structural components is separated by fault, and also range of transversal faults is visible.
2. Kozara's wrinkles cover most area on Kozara. This component is distinguished with small switched wrinkle whose axial surfaces are sinking to North-East. From orographic point of view Kozara has clearly determinate central reef on which continue numerous transversal diagonal hills in parallel ranges. Those diagonal hills are separating deeply incised stream valleys such as: Puharska, Tociluša, Botuša,

Repušnica, Urmovac, Kotlovača, Zofik, Barice, Lušice and Bistrica. Erosion-denudated processes effected large articulation of terrain on Southern Kozara. In this area numerous gullies and ravines are noticed and they are deeply incised in Neogene sediments. Spate streams which are coming from upper parts of Kozara are depositing flooding material, which accumulate in areas of slopes forming flooding cones.

The karst poljes

Karst poljes are specific type of relief structures in Sana drainage basin. Great effect on their forming had: tectonic, fluvial erosion and accumulation. Certainly, in extension of karst poljes corrosion had great, but not crucial, importance in their forming. Accumulation and destruction effects of limnic, fluvial, glacial and slope morphologic processes were significant shaping element of karst poljes. Karst poljes are placed on edges of drainage basins, and some of them partly belong to Sana drainage basin. That is part of drainage basins of Glamočkog, Bravskog i Jelašinovačkog polja which belongs to tectonic structure Outer Dinarids.

Glamočko polje is typical karst polje in West-Southwest Bosnia. It has Dinaric direction, length 40 km and wide from 2 to 10 km. For this area characteristic is range of disturbed wrinkles with dinaric orientation. Wrinkles are with anticline characteristics and upper drawn over synclinal longitudinal reverse faults. Wrinkle structures are high mountains and syncline spacious depressions which are morphologically marked as the karst poles. On terrain of Glamočko polje watershed between Black sea and Adriatic drainage basin is placed, but surface watershed does not match with underground watershed, because of geological structure. With coloring it is found out that sinkholes in North-West area of Glamočko polje runoff to springs of Pliva and Sana (Uzunović, 1958.). Bottom of Glamočko polje is situated at altitudes from 885 till 902 m. In relief it is possible to divide North-West or Gornje polje and South-East or Donje Polje. North-Western part of Glamočko polje has area 62 km², it is wider, in relief more complex, with own hydrological system which is, as it is mentioned, connected with springs of Sana and Pliva.

Bravsko polje is continuing on Petrovačko polje on East, it also has dinaric direction. East part of polje is under researched territory, and whole polje drains to Sana drainage basin. In Bravsko polje with coloring method underground hydrological connections with springs Sanica, Korčanica, Ribnik and catchment of Okašnica, upstream from Ključ, are found out. Altitude of polje is from 580 till 850 m, length around 25 km and wide from 3 to 5 km. Frame of polje makes uphills: Gremč (Crni vrh, 1604 M), on North and Srentica (Miljakuša, 1378 m), on South. Bavarsko polje is formed in lower Cretaceous carbonates, elongated form, it is poen trough faulted line which is cutting central part of polje (fault Bravsko-Gornji Ribnik). Surface is shaped with numerous vrtače healed in vegetation (grass, shrubbery and lower trees) so Bravsko polje represent great example of green pockmarked karst.

Jelašinovačko polje is situated on South-West edge of drainage basin. As well as other karst poljes it is elongated in dinaric direction with length 12 km, wideness is varies from 2 to 3 km. On bottom of polje underground stream Jezrnica is curving, which is sinking in a few smaller sinkholes. With coloring method hydrological connection is found out between those sinkholes and springs of Dabar and Zdena close to Sanki Most (Jurić, 1977.). Bottom of polje is at altitudes from 370 m to 420 m, central and South-East parts of polje are periodically flooded in which are deposited limnic-swamp sediments. Frame of filed are

making uphill: Grmeč (Crni vrh, 1604 m) from South, Javornjača (1480 m) from South-West, Čelić kosa (916 m) from South-East and Gradina (816) from North. Frame of polje is covered with tick proluvial sediments from surrounding uphill.

The karst plateaus

These are specific form of reliefpolygenetic origin which is its origin related to the carbonate bedrock. They represent spacious, more kilometers length and width, karst plateaus on which are shaped thicker or thinner network of sinkholes and dry valleys. Their genesis is linked to corrosion and fluvio- karst processes. Corrosion genesis of forming a karst plateau excludes the possibility of influencing the rivers, but dominance boundary corrosion in appropriate climatic conditions, while fluvio- karst genesis is based on the existence of dry valleys and traces of fluvial sedimentation which presupposes initially assumed lateral erosion expansion and adjusting in the second phase of karstification. (Bognar, 1980.). In Sana drainage basin, the most significant are two karst plateaus: Zmijanje i Krasulje.

Zmijanje, the karst plateau is located in southeast area of drainage basin. It is oval shaped, elongated in dinaric direction, length about 20 kilometers, width max 15 kilometers. Plateaus is constructed by the Lower Triassic sandstone and marl, limestone and dolomite, volcanogenic sedimentary deposits unanalyzed Middle and Upper Triassic, dolomites and limestones of the Upper Triassic and Liassic limestone. In structural terms whole plateau is wrinkled and represents slightly corrugated plate. On the surface it is created dense network of sinkholes and dry valleys, specially in central part.

Plateaus Zmijanje from the north it borders with valley of Kozica river, from the west valley of Banjica, from the south Podrašničko polje, and on east it supplements on northwest slopes of Manjača which makes the structure unit. To the neighboring units, there are observed sharp fractures in the field. Karst plateau Krasulje has smaller surface than Zmijanje, and it is located in central area of drainage basin in direction between Ključ and Sanski Most. It has dinaric direction on the length of about 12 kilometers and width max 5 kilometers. In structural term Zmijanje is wrinkled and wavy plateau. On its surface is formed a dense network of sinkhole and dry valleys. Plateau is from the north and east bordered with valley of Sana river, from the west with valley of Sanica, and from the south a series Golaja- Ošljak- Breščica.

Pediments

Pediments are mild slopes at the base of the hill which is formed by parallel precession of the mountain facade under the influence of slope processes. These morphological forms are bind to the hills and mountains ridges of Kozara (Lisina, 976 m), Šiša gore (1387 m), hills and mountains massifs of Grmeč (Crni vrh, 1603 m), Crna gora (Gola kosa, 1651 m), Dimitor (1483 m) and Manjača with Zmijanje (1236 m). Pediments are ribbed with a characteristic shift of parallel ribs and stream valleys. The top parts of the ribs have different relief structure. Some of them are level to slightly slanted, but mostly marked with shift of head and saddle passes. Heads are usually remains of former complete slightly inclined levels, and saddles are always created at places of erosion or derasion activity of two opposing stream valleys, two gullies or derasion valleys (Bognar, 1980). Big influence on recent geomorphological development of pediments have anthropogenic destructive

impacts (farming, illegal and inappropriate construction, uncontrolled logging) which stimulate development of landslides, flushing and dredging. In Sana drainage basin the biggest pediments are these on the sides of Kozara, Grmeč-Šiša gore, Dimitor, and pediments Manjača-Zmijanje with lower surrounding terrain.

Kozara southwest pediment is developed with whole mountain. Of the Kozara's final crest according to the valley of Sana river and Gomjenica, it is developed pediment with proper ribbed structure, intersected with numerous gullies and hanging valleys in length of about 25 kilometers, and width from the reef to the Sana and Gomjenice of about 6 kilometers (Lamovita- Bistrica) to 2-4 kilometers (Kozaruša- Veliko Palančište). Pediment is slightly tilted, ribs are elongated and general direction of providing is NE-SW, and the peak areas has sometimes flat surface. Numerous elongated and narrow stream valleys are incised in pediments. Most important (the longest) watercourses are Bistrica, Krivaja, Lamovički potok, Kozaračka rijeka, Kozaruša and Garevača. Parallel type of network watercourse is characteristic for this area. Pediment is more relief energetic in its wider western part of the foot of the highest peak of Kozara (Lisina, 976 m).

South of Kozara, there are developed series of pediments of mountain massif Grmeč and mountain ridge Šiša gore which make up one compact unit. Series of pediments Grmeč-Šiša gora are one of the biggest in the Sana drainage basin and general in External Dinarids. They have dinaric direction of stretching. Series of pediments are stretching from valley of Bliha in the northwest, to the Velagići pediment in the southeast. Length is about 35 kilometers, and width about 6 kilometers in the wider area of Sanski Most, decreasing upstream to 2 kilometers, and then again expanding in area of Ključ and Sanica (Velagići) to 5-6 kilometers. These pediments are characterized by the ribbed structure with proper shift ribs and large river valleys, tributaries of Sana (Bliha and tributaries, Zdena, Dabar and Sanica with tributaries: Sanička rijeka, Korčanica, Biljanska rijeka and Trebunj).

In the final spring area of Sana drainage basin originated one small pediment of mountain ridge Crna gora. This is Vrbljana pediment, length about 8 kilometers, and width about 1 kilometer. There is observed ribbed structure with direction NW-SE, rarely west-east. Slope of pediment is more pronounced (4-5°), while the mountain frame with peaks over 1500 meters and slope over 33°.

On the right valley of Sana river side, on direction Prevljaka- Rastoka. Velijašnica-Gornja Slatina stands out pediment Dimitor mountain massif the length of about 12 kilometers, and width about 0,5 to 2 kilometers. Slopes are more pronounced, and on the east side of frame there are located elevations over 1000 meters. Ribbed structure of relief is conditioned on the waterproof layers of Permian-Triassic, with east- west direction. In pediment are carved narrow stream valleys from massif Dimitor. They are slip fault genesis and they have general east-west direction. The biggest watercourses are: Stanička rijeka, Rastoka, Velijašnica, Gušovac and Zamršten. Manjača- Zmijanje pediment is located in central and east side of Sana drainage basin. It length is about 30 km, and width from 3 km to 5 km. Slopes are a little milder about 1 to 3°. Ribs are elongated and with general direction south- north from Bronzani Majdan, in the north they are with dinaric direction. Numerous elongated and narrow stream valleys cut by themselves in the foreland step. The longest watercourse are Gomjenica (57 km) and its tributaries: Melinska rijeka, Stratinska rijeka, Subotica, Brkolosa, Slatina and Stupnica. Network stream is highly branched, provided that the waterproof layers of Sana-Una Paleozoic. The devastation of forest complex and iron ore mines (Omarska and Tomašica) encouraged a revival in this area-real creep slope processes, leaching and dredging.

Foothills

Foothills in its appearance made category of hilly relief types. They are characterized by considerably greater maturity and relief dynamics than pediments. It is necessary to add a more pronounced tectonic impact on their morphological development. That generally gives them a trait of more pronounced relief individualization, especially in terms of independent foothills. By morphological structure and location, there are different types of foothills: type of foothill characteristics and independent type of foothill. Type of foothill characteristics includes foothills related to mountains, on their shape and genesis had a tectonic impact of neighboring mountains. Extracting independent type of foothills is based, primarily, on their structural and relief individuality. They are mostly limited with strong fault zones from neighboring morphostructures (Bognar, 1980). In Sana drainage basin, type with foothill characteristic is located in the far north and it is border area, watershed according to the Una drainage basin. Independent type of foothill - Piskavica is located in the northeast, in the part of drainage basin, which makes watershed according to the Vrbas drainage basin.

In the north part of Sana drainage basin, on an area from Veliko Palančište - Marini - Kriva glava (448 m) stands out (southern part) foothill type of foothill characteristics. This foothill is associated in the west with continuation of the Kozara mountain ridge, which according to the south-southwest slowly reduces to the prominent peak Kriva glava (448 m). Foothill is fractured with tectonic fault and has a direction and slopes gently to the south part of valley of Sana, and in the north to valley of Una. Foothill is intersected by deep stream valleys, tributary of Sana river, in direction north-south and NNE-SSW (Puharska, Kapelska rijeka, Prljugovac, Skakavac, Svodna). Foothill length is about 25 km, and width increases from west (Kriva glava (448 m) to the east; in Svodna it is the widest (4 km), on the stretch Brežičani-Veliko Palančište width is up to 2 km. Considering that this foothill is related to Kozara mountain ridge, it could be termed Kozaričko foothill. By its characteristics it is closely related to the Kozara evolution and it can not be considered as independent type of foothill. Foothill Piskavica, as independent type of foothill, is located partly in Sana drainage basin, which includes northern and southwestern slopes towards Prijedorско-omarsko polje. Tectonically it is a horst-anticline elongated in direction northwest-southeast, length about 10 km. Foothill is clearly separated by fault of the ridge of Kozara. Foothill is symmetric, highest peak is Klupe (433 m) and whole foothill has steep contact with neighboring units. To the north it is stream valley of Prijeka, and to the southwest stream valley of Bistrica and Piskavička rijeka. Generally, whole foothill is characterized by foothill type of relief with radial and wide network of stream (Konaci, Tarašica, Vrelo, Ivanovac, Luke, Duboki potok, etc) and derasion valley, with minor hills between them. Southern border of foothill Piskavica is bounded by fault Šehitluk, one of the most important first order faults in this part of Bosnia and Herzegovina (Mojićević, 1976).

Alluvium in the valley of Sana river

This type of relief is the most common in north and central area of Sana drainage basin, and it is presented with plateau of Prijedorско-omarsko polje and significantly expanded ravine of Sanski Most. Dominant accumulation processes with often appearance fluvial accumulation forms are characteristics of these areas.

Alluvial plain by their genesis are related to the wide valley with reduced falls and to plains. They are occurring with water mechanism of middle and lower flow, with predominant accumulation very important role has lateral erosion. Alluviums are related to accumulation processes. The older layers are out of the reach of high water and they are often referred the accumulation river terraces. Alluviums are most common plain type of relief and they are most prominent in the lower flow of Sana river and Gomjenica, in basin of Prijedorsko-omarsko polje and in ravine of Sana river.

Basin of Prijedorsko- omarsko polje is the biggest in Sana drainage basin. It is length about 30 km, and max weidth is up to 8 km. It is the lowest in the northwest part, around Prijedor, where alluvial plain of Sana and Gomjenica are merging. According to the extreme humidity it is obvius that very important impact on the recent formation have neotectonic subsidence movements. The intensity of the descent is slightly higher than the intensity of accumulation and therefore alluvial plain, especially its southern part, is characterized by an active formation of wetlands. In this area there are organogenic and swamp sediments (Marička and Busnova) and lake sediments (pond Saničani), and in alluvial deposits there are pebbles, which correspond to the geological Paleozoic complex Kozara. The bottom of the ravine of Sanski Most is located in the central part of the drainage basin, stretches from south to north along the flow of Sana river on the length of about 10 km and a width of up to 3 km. It was generated at the point where Sana comes out from Kamičak- Vrhpolje gorge of Sana river.

Complex composit valley of Sana river is the special morphological unit, which in approximately meridian north-south direction grooves all listed morfostructural units. Valley of Sana is one of the largest composite-complex valley in Bosnia and Herzegovina, and its length is about 146 km. It is polygenetic and polyphase river valley with very complex polymetric.

Sana river arises from three springs in the northern foot of the mountain ridge Crna Gora (1651 m). Spring zone is located at an altitude about 440 m and it is formed in the fractured zone of the Lower Cretaceous limestones (Temimović, 2009.). Spring zone is faulted and there are three strong and several small springs in it. The complex of lithological relations on longitudinal profile at many places make a step with many trapped meanders. In area from spring zone to the firth of the Una river near Bosanski Novi (116 m) can be subdivided following valley areas: spring zone, canyon- gorges valley of upper flow of Sana river, ravine Vrbljani, gorge Prizrengrad, Ribnik ravine, gorge Durmišovica, ravine Dubočani- Velečevo, ravine of Ključ, Sklop gorge, ravine of Zgon-Humići, gorge of Banjica - Kamičak, Vrhpolje-Tomina ravine, gorge Čaplje, ravine Sana, Usoračka gorge, basin fo Prijedorsko- omarsko polje, gorge of Blagaj and ravine of Bosanski Novi.

Valley of Sana river is asimetric because of heterogeneous lithologic composition, tectonic fault and exposure. These complex elements are in valley of Sana river in its upper course. It is mostly longitudinal, except in shorter sections when it is cross, on what influenced different geological layers. Near Bosanski Novi, valley of Sana river is combined with the wide valley of the Una.

CONCLUSION

Sana drainage basin is located at the contact of two completely divergent morphological units: the Pannonian Plain in the north and Dinarides on the south. Tectonic differentiation is accompanied by relief dynamics whose morphostructural expressive

elements have distinct morphogenetic characteristics. In addition, the Una-Sana drainage basin represents the meso morphologic region, which its lower basin part belongs to a quieter part of the relief, and the upper sub-region to the limestone pavements and the poljes. This last sub morphological regional unit is made of linear mountain ranges and ridges. Between them extend, parallel to the orographic directrix, plateaus and poljes, individually or in groups in rows, of which the most important are: massif Grmeč with plateaus of karst polje Jelašinovci and karst plateau in Krasulje or series of mountain ridges Smetica, Crna gora and Kurozeb with its high mountain bays between them.

The most representative morphostructural relief members in Sana drainage basin include: central massifs, basins and plateaus in the karst, pediments, foothills and alluvium of river. Central massifs, which are the most frequent relief units in the Sana drainage basin, are divided into the following sub-units of relief: the central mountain massif of the Alpine orogenic belt with complex tectogenesis (Majdanska mountain, Lisina and Strmec), ribbed-fault thrust mountain massifs of the Alpine orogen (four sets of mountain ranges and massifs in the south and southwest, hypsometrically highest part of the Sana drainage basin) and ribbed-thrust and scaly mountain massifs of Dinaric ophiolitic belt (Kozara). In Sana drainage basin plateaus of poljes are formed in karst are located in the part that belongs to the tectonic unit of the Outer Dinarides, edge or partially in the drainage basin, but because the largest part of the basin draining into the drainage basin, fully processed Glamočko, Bravsko and Jelašinovačko polje (polje Jelašinovci-Luči Palanka). As a special form of relief in this area stand out in the karst plateau Zmijanje and Krasulje (in the central part of the drainage basin). Pediments in the research area is directly related to the hills and mountains ridges of Kozara (976 m), Šiša gora (1387 m), and the hills and mountains of Grmeč (Crni vrh, 1603 m), Crna gora (Gola kosa, 1651 m), Dimitor (1483 m) and Manjača with Zmijanje (1236 m). Representative examples of foothills stand out Kozarački foothill which is with foothill characteristics and foothill Piskavice as an example of independent type. River alluvium are mostly located in the northern and central basin where they presented with plateau of Prijedorsko-omarsko polje and significantly expanded ravine of Sanski Most. As a special relief units it is allocated complex composite valley of the river Sana with its approximately meridian north-south direction, grooves all listed relief units. It is a complex valley and one of the largest valley in Bosnia and Herzegovina (the length of the Sana river is about 146 km). Valley of the river Sana is a composite-complex valley which relief represent gorges (or canyon) constriction and widening of ravine. The valley is also polygenetic and polyphase at its origin, because of asymmetric heterogeneous lithologic composition, fault tectonics and exposure and mostly longitudinal valley with the exception shorter sections when it is transverse to the general direction of providing geological stratum and dominant elevations.

Literature:

- Bognar, A., 1980.: Tipovi reljefa kontinentuskog dijela Hrvatske, *Spomen zbornik proslave 30. obljetnice Geografskog društva Hrvatske*, Zagreb
- Burbank, D., Anderson, R., 2001.: *Tectonic geomorphology*, Blackwell Science, Malden-Oxford-Carlton
- Jovanović, Č., Magaš, N., 1986.: Osnovna geološka karta 1:100.000, Tumač za list Kostajnica, Beograd
- Jurić, M., 1977.: Osnovna geološka karta 1:100.000, Tumač za list Prijedor, Beograd
- Mojičević, M. i drugi, 1976.: Osnovna geološka karta 1:100.000, Tumač za list Banja Luka, Beograd

Pregledna geografska karta 1:500.000, Geografski atlas Jugoslavije, SNL, Zagreb, 1987

Spahić, M., 2000.: Rijeka Una-potamološke karakteristike, *Zbornik naučne tribine „Sedra rijeke Une i Una bez sedre*

Temimović, E., 2009.: *Rijeka Sana-potamološka studija*, Goldprint, Ključ

Uzunović, O., 1958.: Jedna utvrđena podzemna bifurkacija voda u krškom rejonu Zapadne Bosne, *Geografski pregled, br. 2.*, Sarajevo

Author

Emir Temimović

Doctor of geographical sciences, associate professor at the Faculty of Science, University of Sarajevo, Bosnia and Herzegovina. Editor of the scientific journal *Acta geographica Bosniae et Herzegovinae*; author of 20 scientific papers and two books from the scientific domain of physical geography.