

influence on those phenomena are observed in opposing exposures who have meridional direction, so-called shady and sunny slopes. Exposure is modifying the character of sun position above horizon, in such way that it allows an increase in incident angle of sun, sunny slopes, and its decreases on shady slopes (Dragičević, 2007). Sunny slopes are marked with higher insolation which is reflected through greater warming in relation to shady slopes, higher temperature daily amplitude and to shorter retention of snow cover. Analysis of relief exposure within the morphometric characteristics Ravna Mountain and Pale Valley is conducted on the basis of exposure map (fig. 2. d).

At latitudes characteristic of studied area, largest amount of heat gets relief whose slopes are exposed to south, where occurs largest warming of topographic surface and also highest amplitude. This is conditioned by the fact that these exposures for spring and autumn days are illuminated by a larger incident angle of sun, and on basis of the measurements it was found that during the winter period the rocky slopes with southern exposure in afternoon hours can be heated up to 50°C, and at the same time northern slopes have a temperature about 0°C (Šibalić, 1986; Dragičević, 2007).

Tab. 4. Values of aspect categories of studied area

Br.	Ugao ekspozicije (°)	Površina (km ²)	Udio u ukupnoj površini (%)	Kategorija ekspozicije reljefa
1.	horizontalne pov. (-0.5-0)	1,7991	1,54	bez izražene ekspozicije
2.	N (0-22,5 i 337,5-359,5)	19,1241	16,39	sjeverne ekspozicije
3.	NE (22,5-67,5)	19,0818	16,36	sjeveroistočne ekspozicije
4.	E (67,5-112,5)	14,9535	12,82	istočne ekspozicije
5.	SE (112,5-157,5)	14,148	12,13	jugoistočne ekspozicije
6.	S (157,5-202,5)	12,9546	11,1	južne ekspozicije
7.	SW (202,5-247,5)	10,7199	9,19	jugozapadne ekspozicije
8.	W (247,5-292,5)	11,2464	9,64	zapadne ekspozicije
9.	NW (292,5-337,5)	12,6297	10,83	sjeverozapadne ekspozicije
Ukupno		116,6571	100	-

Izvor: Golijanin (2015)

Slopes of northern aspect and larger angle of inclination and approximately same altitude in summer (at period of highest sun position), may have a lower temperature than the south for more than 20° C (Penzar and Penzar 1989). Also, studies have shown that western aspects are warmer than eastern, due period of daily insolation. Eastern aspects are exposed to direct sunlight during the morning hours, when most of the heat is used for evaporation of moisture from topographic surface, while slopes with western aspect are exposed to sunlight in afternoon, when (due to increase in temperature), when most of moisture has evaporated from the soil. During the period of their exposure to sunlight, heat energy is directly spent on heating of topographic surface, and thus of air, which affects the number of interlinked phenomena and processes (temperatures of soils and air, and on this basis, and heat destruction of rocks). Also, it was determined that higher humidity occurs at slopes with northern aspect than with southern, which effects on expressed forests cover and thickness of soil cover, but also on density of river network (the intensity of denudation is smaller than on the southern slopes) (Dragičević, 2007).

For easier overview of slope aspect of Ravna Mountain and Pale Valley we have create aspect map. The map shows the spatial distribution and proportion of all eight aspect categories with category that shows horizontal surfaces, i.e. part of terrain without expressed orientation towards sides of world (Tab. 4).

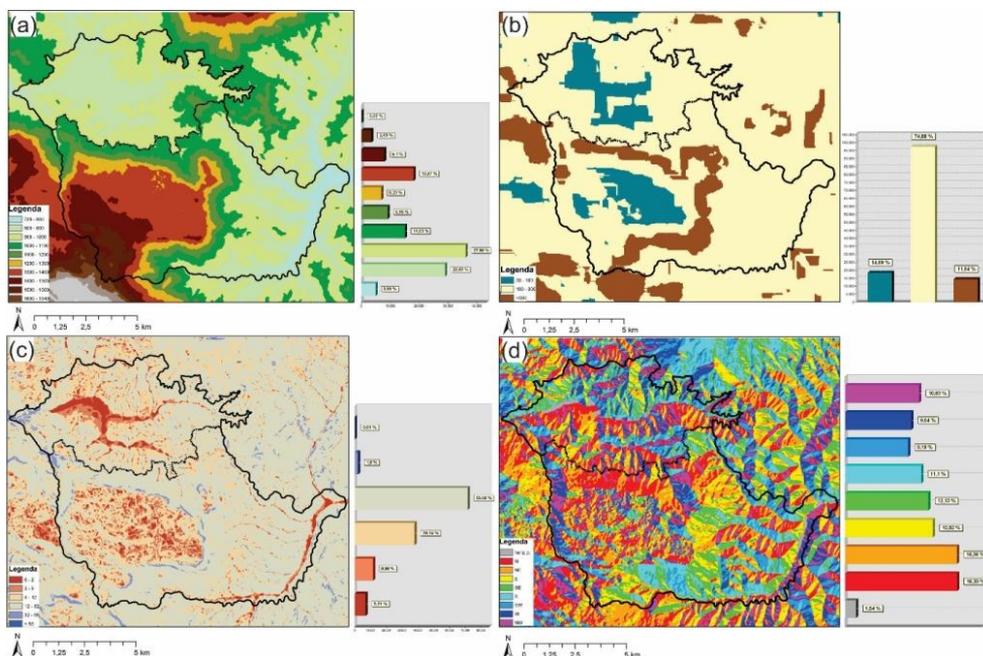


Fig. 2. Morphometric maps of relief Ravna Mountain and Pale Valley: (a) hypsometric map; (b) vertical dissection map; (c) slope map and (d) aspect map

DISCUSSION

By analysing hypsometric map of Ravna Mountain and Pale Valley, it was determined that relief of area has a predominantly mountainous features, with the lowest point at 720 m and the highest at 1640 m. We have highlighted 10 mountainous levels that clearly outline plastics of relief. Terrain altitude from 800 up to 1000 m are the most common (49.91%). The exception to this makes low plains around river flows (altitude below 800 m), with share of 3.65% and isolated peaks (altitude over 1400 m) with a share of 8.76%. Generally speaking, the relief with height up to 1000 m covers more than half of territory (53.56% - low mountain relief), while higher terrain, from 1000 m up to 1640 m altitude covers lesser part of the analysed area. Middle mountain relief, height from 1000 m up to 1500 m covers 43.78%, while terrains with medium mountain terrain over 1,500 m of altitude covers only 2.66% of the territory (Tab. 1.). In the southwestern part of Ravna Mountain, the spatial distribution of elevation zones indicates strongly expressed asymmetry. On the northern and eastern parts are observed lower areas, shaped in valley, while the surrounding higher parts of Ravna Mountain are presented by mountainous hills. Differences in altitude between the various tops of Ravna Mountain are relatively small. Most distinctive relief units in studied area is represented by flattened highlands of Ravna Mountain noticeably hollowed by

numerous sinkholes. It is elongated in the direction of east-west, with a slight drop from south to north. The highest peaks are located directly along the southwestern edge of the plateau faced to Gola Jahorina. The highest, southwestern part of Ravna Mountain has a medium altitude of over 1500 meters (height of tops from 1552 m to 1640 m). Furthermore, to north and northeast medium height decreases, and for largest part the area it is from 1300 – 1400 m (altitude of tops from 1328 to 1422 m). Marginal areas of Ravna Mountain plateau are constrained by numerous river flows that greatly dissect relief. Pale Valley, on the other side, is presented by depression with a few small hills on east and south. It is elongated in direction east - west and makes extension of erosive flow of Paljanska Miljacka. Arched flow of Paljanska Miljacka from north to west around hill V. Koran (1013 m) indicates its neotectonic activity.

Out of a possible six categories of vertical relief dissection, in the studied area are present three categories. There are not present first two categories of small relief dissection (flat relief and low dissected plains), as well as sixth category (very high distinctly dissected relief). On the other side most frequent category makes relief of moderate dissection which participates with a share of 74.88% in total territory. This category of dissected relief is mostly present on areas where in geological structure is dominated clastic. High dissected relief ($>300 \text{ m/km}^2$) dominates along northwest, northern, eastern and southeastern perimeter of Ravna Mountain plateau. It is present with a share of 11.04% of total studied area. Opposite from above, relief of lower absolute values of vertical relief dissection of is mainly present in central parts of Ravna Mountain and along part of Paljanska Miljacka flow and its tributaries. In the mentioned areas is dominated low vertical relief dissection. The lowest category of vertical relief dissection belongs to third category (low dissected relief $30\text{-}100 \text{ m/km}^2$). Present at the bottom of Pale Valley as well as in central and western part of Ravna Mountain (14.09%). It is noticeable that low relief dissection is presented on limestone terrain (central and western part of Ravna Mountain), while terrain dominated by clastic is characterized by higher vertical relief dissection. This transition is also caused by pattern of fault structures.

By analyzing values of angles of relief slope it has been established six categories. Spatial distribution and presence of certain categories of slope angles clearly characterize certain relief regions. In the area of Ravna Mountain and Pale Valley slopes are presented with all six basic categories of relief slope: $0\text{-}2^\circ$, $2\text{-}5^\circ$, $5\text{-}12^\circ$, $12\text{-}32^\circ$, $32\text{-}55^\circ$ and more than 55° . Percent in share of slope, proportionately grow to the category $12\text{-}32^\circ$, after which it rapidly decreases. Slopes of the studied terrain largely reflect morphostructural features of the relief. Largest part of the terrain is characterized by slopes of fourth category (values from 12° to 32°), however, some differences are notable. In overview of share of individual categories of relief slope it is visible that the most common is terrain with significantly inclined relief, with a slope angle of $12\text{-}32^\circ$ (55.08% of area), flat terrains and gently inclined terrains ($0\text{-}5^\circ$) are presented with a share of 14.17%, while Inclined terrains ($5\text{-}12^\circ$) take up to 29.14% of studied area. Terrain with extremely sloped relief (highly inclined terrain and cliffs) covers 1.61%. Mostly, highest values of slopes occur at marginal areas of Ravna Mountain plateau, by the flow of Bistrica River on west and on far western part of Pale Valley. Slopes are particularly expressed in locations of contact of limestone and clastic formations ($32\text{-}55^\circ$ and over 55°), and structural framed predisposed slopes ($12\text{-}32^\circ$ and $32\text{-}55^\circ$). Mostly, a slopes with relatively high value of angle are present in area of fluvial-denudate dissected clastic zone in eastern and southeastern part of Ravna Mountain and peripheral parts of Pale Valley ($12\text{-}32^\circ$). Pale Valley and parts around flow of Prača and

its tributaries are characterized by slopes less than 2° , and slopes whose values range from $2-5^\circ$. Slopes with such small angle values are present at area of central plateau of Ravna Mountain and localities of Dvorišta in west and Podovi in northeast. Central and western parts of the Ravna Mountain are slightly sloped towards the northeast. The lowest slope values are related to bottom of karst uvalas. This is a relatively flattened terrain crisscrossed by individual small areas with a bit higher slope values. Marginal areas of Ravna Mountain are represented by an extremely steep terrain with slope of $12-32^\circ$ and $32-55^\circ$. Only in some smaller areas are presented extremely steep terrain with a slope values over 55° (locations: Hladilo, Dubovik, Ždrijela etc.). At marginal lower areas, high slopes are present in parts of the flow canyon of Paljanska Miljacka and Bistrica, close to point of their merging in northwestern part of studied area. From other slope angles dominate are slopes from 12° to 32° , especially in the northeastern and eastern parts of studied area. Greater presence of significantly inclined terrains (slope from 12° to 32°) in the area of Ravna Mountain and Pale Valley, it is possible to explain by larger number and length of stream flows that cuts deeply into the clastic sediments of this area. So on cartographic representation of slopes are clearly visible higher slopes of fluvio-derasion valley (slope $12^\circ - 32^\circ$) whose direction, in some parts of area, is perpendicular to direction of dominant landforms (N-NW – S-SE). Also, there are clearly visibly bottoms of broad derasion valleys, whose slopes are in categories of less than 5° .

In terms of aspect of relief, in studied area are dominated northeast and north oriented slopes which covers a third of analysed area (32.75%). In a lesser extent are present eastern (12.82%), southeast (12.13%) and south (11.1%) oriented slopes, while in the lowest percentage are presented slopes oriented to southwest (9.19%), west (9.64%) and northwest (10.83%). At studied area there are also horizontal surfaces that are presented with a share of 1.54% . The slopes are significantly less oriented to southern and western sides (about 41%), and in higher percentage are oriented to northern and eastern sides (about 57%) which are considered colder.

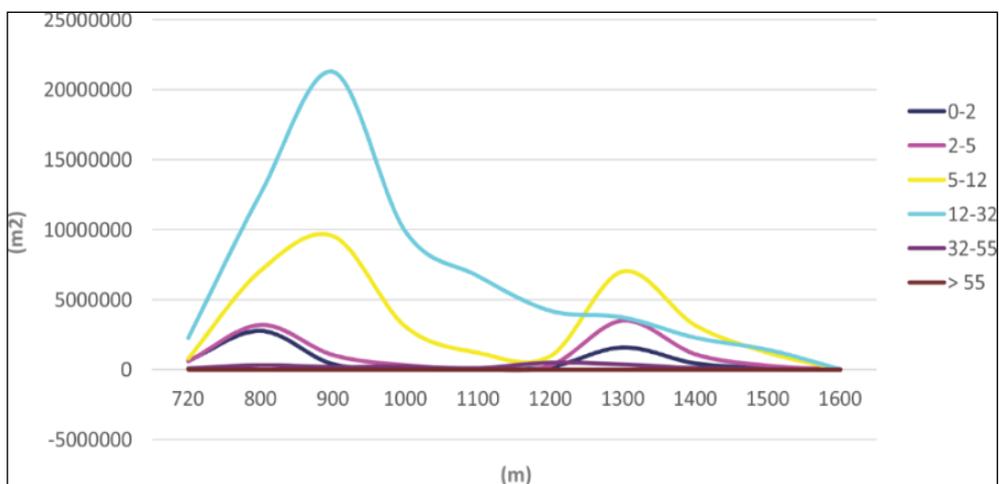


Fig. 3. The distribution of slope categories of Ravna Mountain and Pale Valley in relation to hypsometric characteristics

Distribution of slope categories of Ravna Mountain and Pale Valley in relation to hypsometry (Fig. 3) indicates a peculiarities of primary relief zones of observed area. Lowest category of slopes is linked to hypsometric levels up to 900 m (plateaus of Pale Valley and Podgrab) and it appear again at altitudes above 1200 m as flat parts fragments of Ravna Mountain. Contrary to altitude distribution of flatter slopes, main distribution of steep slopes is linked to hypsometric range from 1150 to 1400 m and refers to slopes of marginal areas of Ravna Mountain plateau. However, undoubtedly is noticeable domination of slopes with slope from 12° to 32° , which achieve its maximum at an altitude of 900 m (area around upper flow of Prača), and with grove of height, slope angles slightly decline.

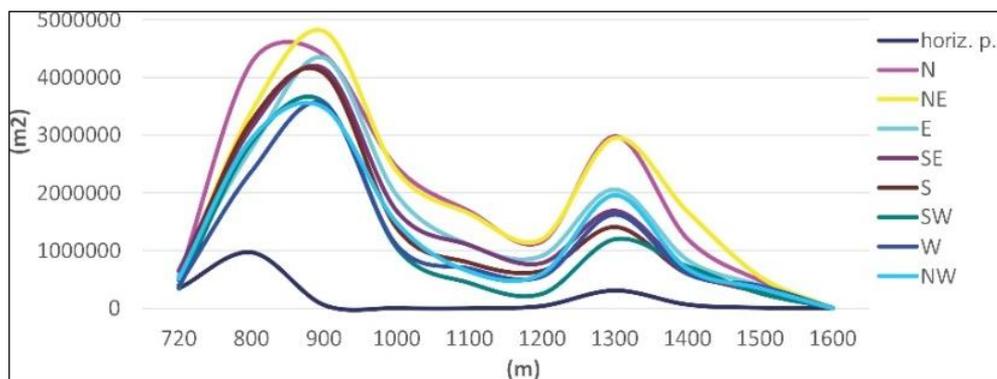


Fig. 4. Hypsometry distribution of Ravna Mountain and Pale Valley relief in relation to aspect

If we observe relationship of slope aspect and hypsometry (Fig. 4.), it is clearly evident domination of aspect in two hypsometric class (900-1000 m and 1300-1400 m) which are two main in studied area. However, it is evident that are dominated slopes with north-east and north direction while providing the least present are slopes of opposite - southwestern direction. To some amount, are present flat areas, especially in basin extensions of Prača and Paljanska Miljacka and plateau of Ravna Mountain, on which are, due to small asymmetry and mild terrain roughness, present all other values of slope. At the highest parts of plateau (over 1400 m), which are presented by small areas, layout of slope aspect is uniform, with no dominant direction. In the southeaster part (left side of Prača flow) slopes are oriented in a north-north-east and south-southwest and going more to west (towards Ravna Mountain) dominates orientation of slopes in direction of east-southeast.



Fig. 5. Slope distribution of Ravna Mountain and Pale Valley in relation to aspect

Distribution of slope at researched

area in relation to the aspect (Fig. 5.) is characterized by clear orientation of significantly inclined slopes which dominate with aspects N-NE-E. This orientation of slopes is present partly because of Dinaric direction of the north-western part of Ravna Mountain (NW-SE). Due this dominant northeast oriented slopes take perpendicular direction in compared to Dinaric direction, while with south-west oriented slopes this is not case. On this situation, influence has had an active tectonics and intersection of orographic structure of Ravna Mountain in southeast in Prača valley, causing that this orographic unit gained direction of west-east, and the slopes of this part of the mountains have north-east and south-west aspects.

Basically there are dominate slopes with northern and eastern aspect at nearly all categories of slope. Curves of lower slope angles also shows dominant direction of north-oriented slopes. Category of slopes less than 2° has a mainly flat line in distribution diagram, i.e. uniform frequency of all aspect grades. Aspect of slopes over 32° is related exclusively to S, SW and NE orientation, while the distribution of slopes from $12-32^\circ$ dominates and shows orientation of slopes partially perpendicular to Dinaric direction. Also, noticeable is the slightly larger presence of northeast slopes in relation to southwestern aspect, which is probably a consequence of asymmetric relief structures of Ravna Mountain, which dominates within studied area.

CONCLUSION

Quantitative parameters covered by analysis, are expression of morphostructural and morphogenetic relief characteristics of Ravna Mountain and Pale Valley area. These features have dynamic character and are used as indicators of form and recent processes occurred in relief. The synthetic character of quantitative geomorphological analysis increases its applicability in practice, in first place for daily and long-term purposes whose task is to identify area favorable from the point of balance and stability (agriculture, water management, infrastructure, construction, urban development, tourism, urban planning, etc.).

Detailed conducted quantitative geomorphological analysis of hypsometric, vertical dissection, slope and exposure of Ravna Mountain and Pale Valley relief is often used in the geocological evaluation of natural resources, as an example can be listed slopes of relief which directly (in the evaluation of relief) and indirectly (e.g. in the evaluation for forestry) is affecting on geocological value of certain area and as such is one of the important criteria of evaluation.

This kind of analysis commonly used geomorphological maps that may have different scale, and in this paper are used large scale maps which give a detailed view of the area based on 1km^2 cells. Also, considering that the database is based on the grid system, the possibility of overlapping data and their correlational analysis is wide and opens numerous possibilities of use and application of geospatial data.

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