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A CONTRIBUTION TO THE QUESTION OF THE GEOGRAPHICAL CHARACTER OF EUROPEAN HIGH MOUNTAINS

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Concernant la différenciation du milieu géographiqe, il y a une grande différence entre les montagnes plus petites et les grandes et hautes européennes. C'est l'étagement vertical qui caracterise les montagnes moins grandes. Dans les grandes et hautes montagnes on observe, aussi, la zonation horizontale des bords vers le centre de la montagne, les zones intramontagnardes. La differenciation du milieu géographique dépend surtout de l'altitude et massivité, de la structure orographique et de l'orientation de la grande et haute montagne vers les vents portant des précipitations. Le caractère géographique de chaque grande et haute montagne est très individualisé.

We gathered the material for this article mainly from our own observations of mountains we have visited (the Western and Southern Carpathians, the Alps, Pyrenees, Massif Central, French Jura, Rila, Pirin, Rhodope, Stara Planina, some of the high mountains in Yugoslavia and Corsica); for some other mountains, we utilize literature data. For comparison, we also included the Caucasus. When considering the character of different high mountains, we principally rely on the laws of the spatial distribution of vegetation, which integrates the manifestations of several geographical landscape components. For comparison, we shall also speak about lower mountains which just attain or slightly surpass the upper limit of forests.

In *lower mountains* of Europe, which attain or only slightly surpass the forest upper limit, with increasing altitude especially the climatic conditions are relatively uniformly changing (the temperature decreases, the precipitation increases etc.) and so do also the other geographical landscape components. Exceptions are found in vertically very rugged territories with closed depressions and canyon-like valleys (particularly the karst regions), where frequently temperature inversions occur, disturbing the regularity of vertical gradualness.

Due to intense climatic changes upwards, the hydrogeographical, soil and biogeographical conditions are strongly changing too. Sudden and expressive modifications of the soil and vegetational cover occur, so that with increasing altitude superimposed zones or belts are formed. In Central Europe, the lowest positions (of 500—550 m above sea level) are occupied by the oak belt, represented chiefly by mesophilous oak growth. Above them (up to about 1250 m), the beech belt extends which, upwards, passes into the pine belt, reaching up to the forest upper limit. The altitude of vegetational belts decreases towards the north and west. The character of gradualness in extensive

territories is little changing both in the E-W and in the N-S directions. There are no essential differences (except the altitude) between the gradualness in the Schwarzwald in western Europe, in the Muntii Apuseni (Rumania) or in the western part of Stara Planina (Bulgaria). We observe vegetational belts in lower mountains of the Mediterranean region too, but here they are partly represented by other woody plants or associations. On the whole, the simple upward differentiation of the vegetation into superimposed belts is typical for the lower mountains.

In *high mountains,* we observe another, more diverse differentiation of the natural landscape components, which is substantially connected with the orographical structure of high mountains. The earth mass, raised in the height, is faster warmed up and cooled down, so that here analogous features may be observed as in the continental climate. For instance, considerable temperature differences are already observed within the Western Carpathians. The July mean air temperatures in the High Tatra are sensibly higher than those in the analogous altitudes of the Low Tatra or Babia Hora which, in comparison with the High Tatra, are lower and less massive (7). But this is not precisely the same complex of features of greater continentality, as that caused by a larger distance from the ocean, because, in the high mountains the air being less dense, the insolation and radiation is more intensive. In contrast to normal continentality, caused by the distance from the ocean, we call that in the high mountains *„the high-mountains continentality"*, because it reflects the climatic differences between lower and high mountains.

Substantial differences between high and lower mountains are caused by their exposition to winds bringing moisture. In Central Europe such winds are mainly the western to north-western ones, in the Mediterranean region various winds of the southern sector (SW — S — SE). In lower mountains, especially on isolated ridges and hills, the influence of exposition to rain bringing winds, in general, is very weak so that we don't observe marked changes on the vegetation, provoked by various expositions to such winds. On the contrary, high mountains — especially those having on their windward side high compact ridges — retain much of the precipitation on the windward side bordering slopes, so that the winds bring less precipitation into the high mountains. The mentioned effects manifest themselves very markedly on the vegetation, so that the orientation according to rain-bringing winds can be estimated as one of the fundamental differential factors. We observed it in the Bulgarian high mountains and, above all, in the Pyrenees and Alps. In the Pyrenees (except their eastern part), as a rule, the differences between the northern and southern sides are still more expressive, because the southern slopes of the Pyrenees not only receive more solar energy, but they also lie in the rain shadow. But in the south-eastern part of the Alps, in the Julian Alps, the moisture-bringing winds come from the Mediterranean Sea (thus from S-SW) and reduce, the differences between the southern and northern sides of the mountains, which are normal in our geographical latitudes. Likewise from the differences in the vegetation in the Scandinavian mountains (2) and in the Ural, we can deduce that there are influences caused by the orientation towards moist western winds.

Especially striking differences in the conditions of moisture have been observed f. i. in the French part of the Alps. In the Couvent de la Grande Chartreuse (about 1000 m above sea level), in the French Préalpes precipitation amounts, on the average, to 2500 mm yearly (10). But in the inner parts of French Alps, the mean yearly precipitation is considerably less: in Modan (1060 m, in the Haute Maurienne valley) 639 mm and in Briancon (1300 m) 587 mm only (1). Moreover, one must also take into account, that owing to less dense air and greater insolation, the *evaporation* from the

soil and vegetation is greater so that, at equal precipitation amounts, the effect of moisture is different in the high and lower mountains. The formation of icing too, f. i. on the southern side of the High Tatra, is substantially smaller than in the lower mountains of the Western Carpathians (Plesník 1971).

The orographic structure of high mountains influences the differentiation of other landscape components in various manners. The extent and general shape of mountains are most important in this respect. Especially great differences occur between the narrow, and oblong high mountains on the one hand, and the extensive high mountains having broad oval or circular ground plans, on the other. Beside the massivenes and height of mountains, the disposition of high ridges and their ruggedness are very important as well.

Narrow and very oblong high mountains. They have less features characteristic for the typical high mountains; in some of them, one may observe the transition to lower mountains. The *Eastern Carpathians* (Pietrosul 2305 m) and *Southern Carpathians* (Moldoveanu 2543 m) considerably exceed the upper limit of forests, but have a narrow,

Fig. 1. The Pyrenees at the Franch-Andorrian frontier.

Fig. 2. The glacier of Alibek.

very elongated shape. Nevertheles, we observe in them a similar gradualness of the vegetation as in the lower mountains: above the oak belt, the beech belt extends, passing in the pine belt. In the Southern Carpathians, which more expressively interfere with the Alpine belt, in the region of the forests upper limit (5), the stone pine (Pinus cembra L.) or, in places, the larch (Larix decidua MILL.) are abundantly widespread.

The *Pyrenees,* which are higher and broader than the Southern Carpathians, have completely different vegetation belts on their southern and northern sides (8). On the northern windward side of the Pyrenees, above the oak and beech belt (except their westernmost border), a belt with dwarf pine (Pinus mugo ssp. uncinata) Ant. (DOM.) is widespread, reaching up to the forest upper limit. On the southern side (except its eastern border, strongly influenced by the Mediterranean Sea), above the belt of xerophilous (Quercus ilex) and subxerophilous (Quercus pubescens WILLD.) oak growths, there is an extensive belt with Scotch pine (Pinus silvestris L.), which in the upward direction, is deplaced by a belt with dwarf pine (Pinus mugo ssp. uncinata) (ANT.) DOM.) reaching up to the forest upper limit. Beech (Fagus silvatica L.) and

fir (Abies alba MILL.), very abundant on the northern side of the mountains, do not penetrate in the inner valleys of the central part, of the Pyrenees where pines are absolutely dominating, as in lower places the Scotch pine and above it (or often at the same level) the dwarf pine do. From the composition of forests, we can assume that the inner parts of the highest central section of the Pyrenees have a more continental character than the northern slopes.

In the *Caucasus,* representing a strongly elongated chain with a conspicuous principal ridge along the mountains axis, the rain-bringing winds come from the Black Sea (from the south). Therefore the southern slopes, rich on precipitation, are covered with mesophilous mountain woods (except the low positions near the Black Sea), composed mainly of beech (Fagus orientalis), fir (Abies nordmanniana) and spruce (Picea orientalis). The mentioned woody plants absolutely prevail in the mountain forests of the northern slopes of the principal ridge too but, with increasing distance from the principal ridge, towards the northern border of the Caucasus, their number decreases and they persist on sites with greater soil and air moisture (on northern slopes, deep soils, bottoms of narrow valleys) and make room for pine growths (Pinus hamata) which, at a greater distance from the principal ridge, generally become absolutely prevailing since, towards the mountains northern border, the precipitation considerably decreases (9, 11, 12).

Extensive high mountains. In general, they are characterized by more expressive alpine features than the narrow chains. This is caused especially by the fact that here relatively more earth mass is concentrated and lifted (when comparing the lifted earth mass with the air mass influenced by the corresponding part of the Earth surface). Consequently, here an increased effect of insolation and radiation can be observed, when we compare the extensive mountains of equal height with the narrow and oblong ones. Since the influence of high mountains is essentially smaller at the borders, the borders of the extensive high mountains usually possess an expressive gradualness (vertical zonality), similarly as in the lower mountains. From the border to the interior of mountainous complexes the natural conditions are quickly and fundamentally changing so that, towards the mountains interior, entire vertical structures change as well, and differing concentrically arranged horizontal belts are formed. Increasing insolation augments the influence of exposition, not only on the whole, but also in the details, and therefore in such cases the influence of relief acquires a greater importance. The thermic, humidity (and other) differences between convex and concave forms of the surface become greater, the wind, snow (and other) circumstances become more complicated, the inversions increase. This still deepens the total differences between the valley bottom and adjacent hillsides, so that f. i. cirques, troughs and summits emerge as markedly different physico-geographical complexes. This modifies the style, the arrangement of the physico-geographical landscape: the gradualness (vertical zonality) disappears and the tendency to a mosaic arrangement of the physicogeographical image comes in the foreground.

The intensity of changes in the geographical landscape primarily depends on the massivity and height of high mountains, on their extent and breadth, and upon the distribution of high ridges and crests. The changes of geographical environment, from the border to the interior of high mountains, are so intensive that they significantly manifest themselves in the general structure of the landscape. We observe here striking changes not only in the vertical (as in the low mountains), but also in the horizontal direction. Therefore, we call the belt-like arrangement of geographical structures in the horizontal direction the *„intramountainous zonality"*.

The *Alps* offer a good example of high mountains. The mentioned general regularities

can easily be observed in the French part of the Alps. The French Préalpes, on the W to NW border of the Alpine system, are high and they retain a considerable part of moisture brought by W and NW winds. The climatic, hydrogeographical, soil and biogeographical differentiation is quite other here than in the central parts laying in the rain shadow. So the main woody plants, which in the Préalpes, represent the individual vegetational belts, f. i. in the region of Briancon, in the interior of the Alps, are either missing (beech) or persist only sporadically on relict sites (fir, spruce). And the Scotch pine and larch, abundantly widespread in the lastly mentioned region, are completely (or almost completely) absent in the Préalpes. The dwarf pine, owing to its considerable ecological breadth, is the only exception.

The Tatra — especially its highest part, the High Tatra (2655 m) — overtops expressively the Western Carpathians. The highest localities here surpass almost by 1000 m the climatic limit of forests and have a strongly developed glacial relief. In lower mountains of the Western Carpathians, we meet in the main the same gradualness as in other lower mountains of Central Europe. In the Tatra, the described vertical differentiation of forest cover is disturbed mainly in consequence of the „high-mountains continentality". In the Tatra region, beech is infrequently represented and, in large continuous areas of the southern side of the mountains, it is completely lacking, so that the spruce mounts from the basins up to the forest upper limit, where the stone pine (Pinus cembra L.) occurs. On the southern slopes of the Tatra, the spruce is associated with larch. Tatra has thus the landscape components disposed in a quite different way than the other orographical units of the Western Carpathians, though the differentiation of natural environment here is by much less manifold and expressive than in the Alps.

An obvious, but less marked vegetation differentiation, as compared with the Western Carpathians, may be observed in the Bulgarian mountains. In the greatest part of Bulgaria's lower mountains (western part of Stara Planina, middle part of Rhodope, Vitosha), we find an analogous gradualness as in Central Europe. The contiguous high mountains of *Rila, Pirin and western part of Rhodope* represent a high-mountain complex of wide oval ground plan, the highest summits of which (in the Rila and Pirin) exceed the climatic frontier of forest by almost 600 m. On the western slopes of the Pirin and Rhodope, there are many beech stands which disappear in the central and eastern parts of this territory (in the Mesta valley and the western part of Rhodope); on sunny slopes they cede their place to pine growths (Pinus silvestris L.) which are abundant mainly in the western part of the Rhodope, and persist only in the northern slopes and humid valley furrows. In the Pirin and Rila, in the region of upper forest limit, the endemic pine Pinus pecue, and on carbonaceous substrates of the Pirin the endemic Pinus heldreichii are widespread. In the Bulgarian high mountains analogous general regularities are valid as in the Alps, Carpathians or other high mountains.

From the Slovak translated by J. Belaj

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K OTÁZKE GEOGRAFICKÉHO CHARAKTERU EURÓPSKYCH VYSOKÝCH POHORÍ

V príspevku sa zaoberáme diferenciáciou zložiek zemepisnej krajiny (najmä vegetácie) vo vysokých pohoriach Európy a porovnávame ju s diferenciačnými zákonitosťami v nižších pohoriach. V resumé sa obmedzujeme viac na všeobecné zákonitosti, kým vo vlastnom článku uvádzame detailnejšie poznatky jednotlivých vysokých pohorí, na základe ktorých sme dospeli ku všeobecným záverom.

V nižších pohoriach Európy, ktoré nedosahujú alebo len slabo presahujú výšku hornej hranice lesa, s rastúcou nadmorskou výškou sa pomerne rovnomerne menia najmä klimatické pomery, v dôsledku čoho sa v smere nahor menia silno hydrogeografické, pôdne a biogeografické zložky krajiny, takže sa vytvárajú vertikálne pásma čiže stupne. Aj keď ich nadmorské výšky smerom k Z a S celkove klesajú, charakter stupňovitosti v nižších pohoriach sa na rozsiahlych územiach v podstate nemení. Niet podstatných rozdielov (okrem výšky) vo vegetačných stupňoch vo Schwarzwalde (NSR), v Malej Fatre či v Munţii Apuseni (Rumunsko).

V typických vysokých pohoriach Európy pozorujeme odlišnú, oveľa rozmanitejšiu diferenciáciu prírodných zložiek krajiny, ktorá zásadne súvisí najmä s orografickou stavbou vysokého pohoria a jeho orientáciou k vetrom, prinášajúcim zrážky. Zemská masa vyzdvihnutá do výšky sa rýchlejšie ohrieva, rýchlejšie chladne. Riedky vzduch ešte zvyšuje insoláciu, takže tu pozorujeme tendenciu k zväčšenej kontinentalite, ktorú nazývame „vysokohorskou" (na rozdiel od normálnej, súvisiacej so vzdialenosťou od oceána).

Rozsah diferenciácie prírodných elementov úzko súvisí nielen s výškou, ale najmä s celkovým tvarom vysokého pohoria. V úzkych a silno pretiahnutých vysokých pohoriach pozorujeme jednoduchšie usporiadanie zložiek zemepisnej krajiny ako v rozľahlých a rozsiahlych. Napríklad Východné Karpaty a Južné Karpaty majú úzky pretiahnutý tvar a pozorujeme v nich obdobnú schému stupňovitosti lesnej vegetácie (s výnimkou oblasti hornej hranice lesa) ako v nižších pohoriach. Výraznú stupňovitosť pozorujeme aj v Pyrenejach, vegetačné stupne na severných úbočiach sa však podstatne líšia od stupňov na južnej strane pohoria. Na Kaukaze (v oblasti Kluchorského priesmyku a doliny Teberdy) prichádzajú zrážkonosné vetry od Čierneho mora (od J), čím do určitej miery mizne vplyv celkovej expozície pohoria, takže južné úbočia Kaukazu majú podstatne mezofilnejšiu vegetáciu ako severné (opačne ako v Pyrenejach).

Rozložité vysoké pohoria so široko oválnym až kruhovitým pôdorysom sa vyznačujú všeobecne výraznejšou diferenciáciou krajiny. Je to spôsobené najmä tým, že je tu skoncentrovanej a vyzdvihnutej relatívne viac zemskej masy (ak dáme do vzťahu vyzdvihnutú zemskú masu

so vzdušnou masou, ktorú príslušná časť zemského povrchu ovplyvňuje). V dôsledku toho pozorovať tu zvýšený efekt insolácie a vyžarovania. S riedkym vzduchom a zvýšenou insoláciou súvisí silnejší výpar, takže vlhkostný efekt pri rovnakej sume zrážok sa líši vo vysokých nízkych pohoriach. Pretože na samom okraji vplyv vysokohorského masívu je podstatne menší, okraje rozložitých vysokých pohorí majú spravidla výraznú stupňovitosť (vertikálnu zonálnosť) — podobnú ako v nižších pohoriach. Prírodné podmienky smerom od okraja dovnútra vysokohorského komplexu sa rýchle a zásadne menia, preto sa menia v spomenutom smere celé vertikálne štruktúry a vytvárajú sa koncentricky usporiadané pásy (ide o vnútrohorskú zonálnosť). Tým že sa zväčšuje insolácia, zväčšuje sa aj vplyv expozície, v dôsledku čoho vplyv reliéfu nadobúda na význame. Zväčšujú sa termické, vlhkostné (a iné) rozdiely medzi konvexnými a konkávnymi tvarmi povrchu a zvýrazňujú sa inverzie, zložitejšími sa stávajú veterné, snehové (a iné) pomery. Tým sa zvýrazňujú celkové rozdiely medzi dnom doliny a priľahlými svahmi, takže, napr. kary, trógy a štíty vyniknú ako výrazne odlišné fyzickogeografické komplexy. Tým sa mení štýl usporiadania fyzickogeografickej krajiny: mizne stupňovitosť a uplatňuje sa tendencia mozaikovitého usporiadania fyzickogeografického obrazu.

Spomenuté zákonitosti veľmi výrazne vystupujú vo francúzskej časti Álp. V Préalpes, ktoré zachytávajú množstvo zrážok zo Z až SZ prúdenia, pozorujeme zreteľnú stupňovitosť vegetácie. Naproti tomu vo vnútroalpských dolinách Álp (napr. Briançon), ležiacich v dažďovom tieni, je stupňovitosť lesnej vegetácie veľmi potlačená, takže napr. smrekovcové lesy vystupujú od dna doliny (1200 m) až po hornú hranicu lesa (do 2450 m n. m.). Okrem toho zloženie lesov v Préalpes je úplne odlišné ako v oblasti Briançon. Osobitné priestorové usporiadanie vegetácie pozorujeme aj v Západných Karpatoch, kde Tatry vystupujú ako vysokohorská jednotka so svojráznymi vegetačnými pomermi. Menej výraznú, ale zreteľnú diferenciáciu vegetácie pozorujeme aj v bulharských pohoriach, kde blízo seba ležiace Rila, Pirin a západná časť Rodop predstavujú veľký komplex, v ktorom pozorovať viaceré vplyvy vysokohorského charakteru.

Obr. 1. Pyreneje na francúzsko-andorrskom pohraničí.

Obr. 2. Alibekský ľadovec (Kaukaz).