Abstract: The article presents an attempt at a new look at the natural environment of the Tatra Mts. On the basis of detailed results of field investigations carried out in the catchment basin of the Białka, extrapolated on the remaining part of the Polish Tatra Mts, three basic spatial orders were distinguished; belt, vertical zonal and morphological. These orders and the relationships among them were shown on the example of the western part of the Tatra Mts. – the Chochołów Valley. The spatial orders condition the organization, functioning and development of the natural environment; they may be treated as geo-ecological “co-ordinates” of the Tatra geosystem.

Key words: spatial orders, vertical zonality, morphological sequence, natural environment, the Tatra Mts.

Introduction

The most frequently employed way of learning the natural environment is a study of its elements; geological structure, relief, climate, water conditions, soils, plant cover, and of animal world. This is usually done separately, which means that each element is the subject of study of an independent discipline. That way of learning the natural environment is relatively long and not necessarily “effective” since the natural environment is something more than a simple total of its components (Kalesnik 1969, Richling 1982).

The relatively recent complex physical geography, created in the second half of the XXth century, with its holistic look at the natural environment has made its purpose to discover other ways of learning the natural environment. These include among other things, investigating the organization of the natural environment as an integrated entity. The present article presents a proposal of a complex glance at the natural environment through the separation in it of spatial orders.

Spatial orders are meant to represent main regularities in the ‘ordering’ of the natural environment in space, i.e. its spatial diversification considered in a holistic way (Balon 1992). The existence of spatial orders is expressed by diversification of the elements and features of the environment. The aim of the article is to present...
The method

Spatial orders in the Tatra Mts. were distinguished by way of induction, on the basis of detailed investigations of the natural environment in a chosen area – the catchment basin of the Bialka, the High Tatra Mts. (Balon 1992). The survey covered a topographical area of 36.24 sq. km, which constitutes 1/4 of the area of the Polish Tatra Mts.

The method of physical-geographical mapping was applied, which led to the separation of 4,355 basic geocomplexes in the rank of landscape units. As a result of an intricate typological procedure 143 types of landscape units were first obtained to be combined into 544 individual terrains. Similar areas were grouped into 41 types of terrain, treated as environment types. The method was described in detail in another paper by the author (Balon 2000).

Each of the separated areas has a characteristic set of environmental features. Some of them may be considered as guiding since they affect a considerable number of other features to be considered as subordinated. A detailed analysis of relationships among environmental features (Balon 1992) made it possible to distinguish three features conditioning organization of the natural environment of the Tatra Mts., which involves a complex diversification of the whole of the natural environment in relationship to the guiding feature. Each of the three features is a basis to separate in the Tatra Mts. one of the spatial orders. These area:
1. Occurrence of tectonic units expressed by belt order (environmental belt arrangement)
2. Absolute height expressed by vertical order (environmental vertical zonality)
3. Relative height (above base-level of denudation) expressed by morphological order (morphological sequence).

Each of the separated types of the environment is characterized by an internal uniformity of spatial orders since they lie in a single vertical zone and physicogeographical belt and within a single unit of morphological sequence. The induction-obtained spatial orders of the natural environment of the Bialka catchment basin (some 1/4 of the surface of the Polish Tatra Mts.) were extrapolated – by means of an analysis of detailed thematic maps (Atlas 1985) – onto other areas of the Tatra Mts. For purposes of the result presentation a fragment of the western part of the Polish Tatra Mts. was used– the Chochołów Valley situated in the southern part in the mezoregion of the West Tatra Mts., in the northern part of the mezoregion of the Regle Tatra Mts. (Balon et al. 1995).

The belt order

The belt order is meant to be one of the spatial orders of the natural environment; it consists in the occurrence of parallel landscape belts each of which is marked by a different character of the environment. Belt changeability of the environment
is first of all caused by diversification of the geological structure and terrain relief, which affects other elements of the environment. The cause of the origin of belt arrangement is the co-occurrence of the influence of endogenic and exogenic factors as well as resistance differentiation of the rocks. As a result, there occur on the Earth’s surface, frequently parallel to one another, areas of higher and lower location: mountains, uplands as well as lowlands and basins.

In mountain areas particular landscape belts are marked by small width; e.g. from 1 to 10 km in the Tatra Mts. The fundamental features of the environment changing in a belt-like way are: tectonics (guiding feature), lithology, rock resistance, bedrock reaction, absolute and relative heights, type of relief, some morphogenetic processes, kind and abundance of underground waters, scale of water retention, kind of surface waters, soil types and species, kind of habitats and the relevant types of plant communities. The belt diversification in the Tatra Mts. was chiefly dealt with by geologists (Passendorfer 1971) and geomorphologist (Klimaszewski 1988); the belt diversification of water conditions was characterized – as hydrographic regions – by K. Wit-Jóźwik (1974). Attention was also paid to the impact of bedrock reaction (the fundamental belt feature in the Tatra Mts.) on the occurrence of soils (Skiba 1985) and the distribution of plant life (Radwańska-Paryska 1974).

In the territory of the Tatra Mts, especially of the Polish Tatra Mts., there occur four physicogeographical belts:

a) the crystalline belt to be found within the Palaeozoic crystalline core of the Tatra Mts.
b) the Wierchy belt occurring within the Mesozoic Wierchy series
c) the Regle belt to be found within mesozoic Regle series
d) the flysch belt within the central Carpathian flysch (Fig. 1)
Their detailed characteristics is to be found in another article (Balon 2002). In the Chochołowska Valley (Fig.1) the boundaries of physical-geographical belts run approximately parallel. The largest surface is covered by the crystalline belt (southern part of the catchment) and its boundary with the top belt assumes a zigzag course associated with irregular degradation of sedimentary rocks covering the crystalline core. The top belt is much narrower and gradually becomes narrow to the west; the rocks of the Regle units in the region of Bobrowiec are heavily extended to the south. The crystalline and the top belt represent the high-mountain part of the Tatra Mts. Within the middle-mountain part of the Tatra Mts. the Regle belt is comparatively broad, with the flysch belt poorly conspicuous to the north.

The vertical zonal order

Vertical zonality is a phenomenon of regular changeability of the environment, associated with the diversification of absolute heights (Balon 1991). As opposed to other spatial orders it occurs solely in mountain areas. The guiding agent here is absolute height. As it increases it affects climatic, water, soil, plant and animal conditions as well as some relief-modelling morphogenetic processes, e.g. cryonival processes. The effect is the formation of physical-geographical vertical zones of varying environmental features. The kind and arrangement of the vertical zones depends on various agents. The most important of them are: absolute height of the mountains determining the “upper” range of vertical zonality and the location of the mountain foot in a definite landscape zone. In the Tatra Mts. located in the moderate warm zone, in a relatively humid climate, the lowermost zone corresponds to the natural plant formation to be found at the foot of the mountains, i.e. the forest vertical zone. The highest portions of the Tatra Mts., on account of climatic and partly orographic reasons, do not have present-day glaciation, so with some simplification it can be said that the Tatra Mts. are too low for a glacial or nival vertical zone to occur (Hess 1974) (Fig. 2).

Generally, four physical-geographical vertical zones can be separated in the Tatra Mts. (Balon 2000). These are (starting from below);

a) the forest vertical zone, also called the Regle zone. It is sometimes subdivided into the lower and the upper Regle zone, differing (on the northern slope) by a set of plant communities (Pawłowski 1977) and somewhat different soils (Skiba 1985); the forest zone reaches the tree-line which runs at a height from some 1,350 to some 1,670 m a.s.l. In the Chochołowska Valley that vertical zone predominates, covering the northern part of the catchment basin as well as valley floors in the southern part (Fig. 2) the mountain pine vertical zone, otherwise subalpine zone, reaches the upper limit of the mountain pine. It runs at a height from some 1,750 to some 1,920 m a.s.l.. It is worthwhile to pay attention that contrary to some papers dealing with other mountain areas, the brushwood of mountain pine used to be traditionally “excluded” from forest areas in the Tatra bibliography, thus the tree-line is drawn lower – not as in the Alps (Korner 1999) – above the mountain pine zone (Plesnik 1971, Radwańska-Pryska 1974). In the Chochołowska Valley the mountain pine vertical zone occurs in the central and southern part of the catchment basin, mainly on
slopes, on some ridges (Bobrowiec, Grześ) and in the bottoms of glacial kettles located high but below the main crest of the Tatra Mts.
b) the alpine vertical zone (alpine meadows and pastures). Its chief limitation is the occurrence range of the set of *Juncus trifidus* and *Orechloa disticha*. The boundary runs here from about 1,950 to some 2,180 m a.s.l. and used to be identified with the theoretical course of the snow line (Hess 1974). In the Chochołowska Valley the alpine zone covers ridges and higher portions of the slopes, chiefly in the southern part of the area, with one of the lowest occurrences in the region of Trzydniowiański Wierch (some 1,750 m a.s.l.).
c) the subnival vertical zone (semi-nival by Kotarba et al. 1987) is frequently called, though not quite fortunately, the tower rock zone). That zone according to M. Hess (1965, 1974) lies above the climatic limit of permanent snow; present-day glaciers are not to be found here for orographic reasons. In the Chochołowska Valley, as in the whole West Tatra Mts. that zone does not occur on account of too small absolute heights.

The morphological order

Morphological order or morphological sequence is a spatial order expressed by a diversification of the natural environment in relation to relative heights, i.e. to the base-level of denudation. The lowermost element of the sequence is usually a valley floor (frequently – river bed in the floor) above which such landforms of the slope catena occur as terrace levels, slope segments varying in character as well as ridge flattenings. The altitudinal location of a valley floor affects the diversification of landforms, morphogenetic processes (their kind and intensity), mesoclimate as well as water conditions and soil and plant diversification.
In the Tatra Mts. the diversification of the natural environment along the slope catena was studied first of all by geomorphologists (Kotarba 1976, Kotarba et al. 1987) who paid attention chiefly to the dynamic aspect of the phenomenon. The diversification of waters within the morphological sequence was also studied by hydrographers who separated the so-called hydrographic vertical zones (Wit-Jóźwik 1974), Ziemońska 1974). The morphological sequence in the Tatra Mts. should be recognized as the most composite among spatial orders. This is due to several agents:

1. The Tatra valley bottoms lie at very different altitudes, show various width and character (alluvial, rocky and morainic floors, lakes).
2. Slopes in the Tatra Mts. are marked by heavily differing lengths and relative heights ranging from a few tens of meters to more than 1,000 m.
3. Considerable differences in the geological structure resulting from rock resistance as well as a composite history of relief development result in serious morphological differences within a slope.
4. Ridge flattenings also vary in character, from broad flattenings through dome-like and narrow ridges to sharp crests with serrated long profile (Fig. 3).

Hence, with regard to the four belts and four or five vertical zones, the number of principal elements of morphological sequence is significantly higher. These include (Balon 1992): a) hilltops (of various character), b) precipitous slopes (walls and rock slopes), c) steep slopes with tors, d) smooth steep slopes, e) steep slopes.

![Diagram](image-url)
covered with morainic material, f) talus slopes, g) inclined bottoms of glacial kettles and of nival niches (with a mosaic of firm rock, screes and morainic deposits), h) glacielfluvial slopes, i) alluvial valley floors, j) morainic valley floors, k) rocky valley floors, l) valley floors taken by mountain lakes. Even if not all the elements mentioned occur simultaneously (as it happens e.g. in the Chochołowska Valley – Fig. 3), then the image – even if strongly simplified – of the main elements of morphological sequence forms a relatively composite mosaic while the arrangement of a single catena; valley floor - hilltop, contains three to even as many as seven or eight elements.

Relationships among spatial orders

The imposition of the distinguished spatial orders forms a fairly composite mosaic of the units (Fig. 4a). In order to increase its legibility, its chosen fragments situated in various parts of the valley were enlarged. They were additionally enriched by means of numbers and explanations to tell which physical-geographical belt, vertical zone and element of morphological sequence they represent (Fig. 4b). In the Chochołowska Valley there are 37 possible combinations of the elements of the three spatial orders. These combinations, obtained by way of deduction (“from up”), correspond to environmental types separated by way of deduction (“from below”) in the Białka Valley. (Fig. 4).

Conclusions

The organization, functioning and the direction of environment development are decided by three spatial orders – belt, vertical zonal and morphological. As opposed to a number of other high mountain uroczyskos, there is no conspicuous diversification in the Tatra Mts. to be linked with two other spatial orders- zonal and continental-oceanic. The position of the Tatra Mts. in the middle part of the moderately warm zone causes that the thermal differentiation (as well as humidity) between the northern and the southern slope of the Tatra Mts. is relatively small (Konček 1974) and is chiefly manifested in a higher situation of the boundaries of vertical zones on the southern slope. Instead, the diversification of plant communities on both sides of the massif is a resultant not of climatic but of edaphic differences. In turn, the small size of the Tatra Mts. and their parallel course make these mountains to constitute no barrier to humid air masses flowing from the westerly directions. Therefore it is difficult to point to significant differences between the theoretically more humid “oceanic” west-facing slope and the drier “continental” east-facing one. The separated spatial orders may be treated as a kind of geo-ecological “co-ordinates” of the natural environment of the Tatra Mts. The determination of these three co-ordinates for any given place within the Tatra area makes it possible to distinguish these features of the natural environment which decide about its organization and functioning in a given area. The spatial orders do condition the structure, functioning and the development of the natural environment. Their separation may be considered as one of the possibilities to obtain a holistic, synthetic image of the natural environment of the Tatra Mts. as well as of other mountain territories on the Earth.
General picture
Obraz ogólny

Enlargement of selected sectors
Powiększenie wybranych wycinków

Fig. 4. Imposition of three spatial orders in the Chochołowska Valley
Ryc. 4. Nałożenie trzech porządków przestrzennych w Dolinie Chochołowskiej
Fig. 4. Explanations:
1 – hilltops in the flysch belt, forest vertical zone; 2 – smooth steep slopes in the flysch belt, forest vertical zone; 3 – alluvial valley floors in the flysch belt, forest vertical zone; 4 – hilltops in the Regle belt, forest vertical zone; 5 – precipitous slopes in the Regle belt, forest vertical zone; 6 – smooth steep slopes in the Regle belt, forest vertical zone; 7 – alluvial valley floors in the Regle belt, forest vertical zone; 8 – rocky valley floors in the Regle belt, forest vertical zone; 9 – hilltops in the Wierchy belt, forest vertical zone; 10 – hilltops in the Wierchy belt, mountain pine vertical zone; 11 – hilltops in the Wierchy belt, alpine vertical zone; 12 – precipitous slopes in the Wierchy belt, forest vertical zone; 13 – precipitous slopes in the Wierchy belt, mountain pine vertical zone; 14 – steep slopes with tors in the Wierchy belt, forest vertical zone; 15 – steep slopes with tors in the Wierchy belt, mountain pine vertical zone; 16 – steep slopes with tors in the Wierchy belt, alpine vertical zone; 17 – smooth steep slopes in the Wierchy belt, forest vertical zone; 18 – smooth steep slopes in the Wierchy belt, mountain pine vertical zone; 19 – slopes covered with moraine in the Wierchy belt, forest vertical zone; 20 – talus slopes in the Wierchy belt, forest vertical zone; 21 – alluvial valley floors in the Wierchy belt, forest vertical zone; 22 – morainic valley bottoms in the Wierchy belt, forest vertical zone; 23 – hilltops in the crystalline belt, forest vertical zone; 24 – hilltops in the crystalline belt, mountain pine vertical zone; 25 – steep slopes with tors in the crystalline belt, mountain pine vertical zone; 26 – steep slopes with tors in the crystalline belt, alpine vertical zone; 27 – smooth steep slopes in the crystalline belt, forest vertical zone; 28 – smooth steep slopes in the crystalline belt, mountain pine vertical zone; 29 – smooth steep slopes in the crystalline belt, alpine vertical zone; 30 – steep slopes covered by moraine, forest vertical zone; 31 – steep slopes covered by moraine in the crystalline belt, mountain pine vertical zone; 32 – talus slopes in the crystalline belt, forest vertical zone; 33 – talus slopes in the crystalline belt, mountain pine vertical zone; 34 – talus slopes in the crystalline belt, forest vertical zone; 35 – alluvial valley bottoms in the crystalline belt, forest vertical zone; 36 – morainic valley bottoms in the crystalline belt, forest vertical zone; 37 – morainic valley bottoms in the crystalline belt, mountain vertical zone.

Ryc. 4 Objawienia:
1 – wierzchowiny w pasie fliszowym, w piętrze leśnym; 2 – stoki strome gładkie w pasie fliszowym, w piętrze leśnym; 3 – aluwialne dna dolin w pasie fliszowym, w piętrze leśnym; 4 – wierzchowiny w pasie reglowym, w piętrze leśnym; 5 – stoki urwiste w pasie reglowym, w piętrze leśnym; 6 – stoki strome gładkie w pasie reglowym, w piętrze leśnym; 7 – aluwialne dna dolin w pasie reglowym, w piętrze leśnym; 8 – skalne dna dolin w pasie reglowym, w piętrze leśnym; 9 – wierzchowiny w pasie wierchowym, w piętrze leśnym; 10 – wierzchowiny w pasie wierchowym, w piętrze kosodrzewiny; 11 – wierzchowiny w pasie wierchowym, w piętrze alpejskim; 12 – stoki urwiste w pasie wierchowym w piętrze leśnym; 13 – stoki urwiste w pasie wierchowym w piętrze kosodrzewiny; 4 – stoki strome ze skałkami w pasie wierchowym w piętrze leśnym; 15 – stoki strome ze skałkami w pasie wierchowym w piętrze kosodrzewiny; 16 – stoki strome ze skałkami w pasie wierchowym w piętrze alpejskim; 17 – stoki strome gładkie w pasie wierchowym w piętrze leśnym; 18 – stoki strome gładkie w pasie wierchowym w piętrze kosodrzewiny; 19 – stoki pokryte moreną w pasie wierchowym w piętrze leśnym; 20 – stoki usypiskowe w pasie wierchowym w piętrze leśnym; 21 – aluwialne dna dolin w pasie wierchowym w piętrze leśnym; 22 – morenowe dna dolin w pasie wierchowym w piętrze leśnym; 23 – wierzchowiny w pasie krystalicznym, w piętrze leśnym; 24 – wierzchowiny w pasie krystalicznym, w piętrze alpejskim; 25 – stoki strome ze skałkami w pasie krystalicznym, w piętrze kosodrzewiny; 26 – stoki strome ze skałkami w pasie krystalicznym, w piętrze alpejskim; 27 – stoki strome gładkie w pasie krystalicznym, w piętrze leśnym; 28 – stoki strome gładkie w pasie krystalicznym, w piętrze kosodrzewiny; 29 – stoki strome gładkie w pasie krystalicznym, w piętrze alpejskim; 30 – stoki pokryte moreną w pasie krystalicznym, w piętrze leśnym; 31 – stoki pokryte moreną w pasie krystalicznym, w piętrze kosodrzewiny; 32 – stoki usypiskowe w pasie krystalicznym, w piętrze leśnym; 33 – stoki usypiskowe w pasie krystalicznym, w piętrze alpejskim; 34 – stoki usypiskowe w pasie krystalicznym, w piętrze kosodrzewiny; 35 – aluwialne dna dolin w pasie krystalicznym, w piętrze leśnym; 36 – morenowe dna dolin w pasie krystalicznym, w piętrze leśnym; 37 – morenowe dna dolin w pasie krystalicznym, w piętrze kosodrzewiny.
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Porządki przestrzenne w środowisku przyrodniczym Polskich Tatr

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