AIR THERMAL STRATIFICATION IN THE DEPRESSION AREA FORMS. "DEPRESSION EFFECT". PHYTOGEOGRAPHICAL IMPLICATIONS

MARIN MARCU, VIORELA HUBER
Faculty of Silviculture and Forestry Exploitations, Braşov, Romania

ABSTRACT

The paper brings forth the results of the researches made by the authors in the Depression of Brasov throughout 35 years.

By considering the intramontane depression as a "territorial whole", the authors explain the genesis and the topoclimatic particularities of each morphological component within the depression complex by climatic interaction of all these components with other genetic factors of the clime.

Therefore, there were outlined as follows:

- the topoclimatic particularities of the depression plain, its compartments and topoclimatic areals in horizontal plan, determined by the complex process the authors call "depression effect";
- air local stratification, specific to different weather types leading to, by altitude delimitation, the following (tropospherical) sublayers of the slope clime: "layer of inversion", "warm slope area" and "layer of free atmosphere".

Keywords: topoclimatic areal, topoclimatic compartment, temperature inversion, layer of inversion, thermal stratification.

DEPRESSION OF BRASOV. PHYSICAL-GEOGRAPHICAL SETTING

Situated in the area of Carpathians' great bending, the Depression of Brasov represents an area of discontinuity between the Oriental and Meridional Carpathians.

Pertaining to the tectonic origin, formed at the end of the Pliocene period, the Depression of Brasov appears like a huge basin, with plane base, similar to a wide alluvial plain, slightly directed towards North (Olt). It is surrounded by mountains that dominate it with summits over 2000 m in the South sector, below 1200 m in the East and of about 500 m in the North and West (fig.1).

Due to some mountainous peaks penetrating to interior, the depression presents a lobate form, the two “narrow passages” from Sanpetru and Reci dividing the Depression of Brasov in three compartments:

- Western compartment (“Barsa Depression” noted with I in fig.1);
- Central compartment (“Sf. Gheorghe Depression”, or “Sesul Frumos” - II);
- Eastern compartment (“Raul Negru Depression” or “Tg.Secuiesc”, III).

From the morphometrical point of view, the Depression of Brasov is made up of three levels developed towards the direction of altitude increase:

- the alluvial plain of Olt river, the most limited surface, is about 500 m altitude;
- the depression plains (“the fields”) that occupies the largest area of the depression, actually representing its base level (510-540m);
- the marginal piedmont belt connects the depression fields and the circumdepression mountainous frame, not overtopping 560-600 m altitude.

By its geographical position, the Depression of Brasov is distinguished by the moderate continental climate, dominated by the North-West atmospheric circulation. Towards the meridional direction, the climate of this geographical district is influenced by cold, polar air masses advections, as well as by warm air masses of southern provenience.

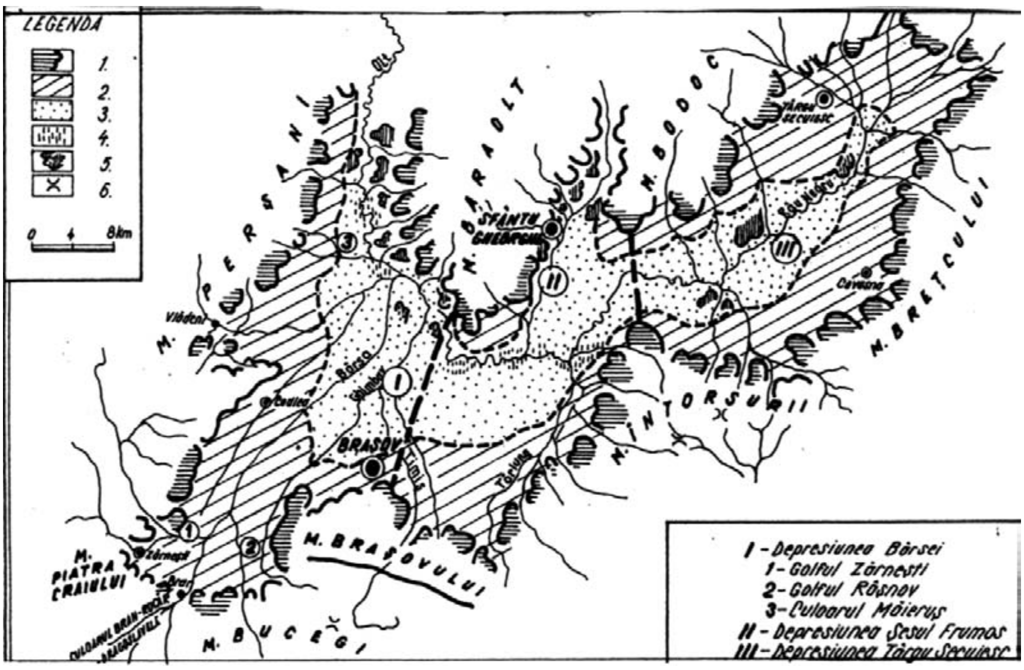

Figure 1. THE DEPRESSION OF BRASOV

1 - Marginal montane and submontane level; 2 - Contact piedmont with the mountain; 3 - Piedmont plains and alluvial plains; 4 - Areas presenting humidity seasonal surplus; 5 - Terraces; 6 - Saddle effects

LOCAL CLIMATIC CHANGES. "DEPRESSION EFFECT".

If we considered only the position of the Depression of Brasov in the climatic sector frame to which it belongs (Carpathian Sector) and its altitudinal disposition in the hill level, this area should be dominated by a relatively moderate thermal regime, joined by sufficient precipitation.

The features of the general climate are strongly modified by the local physical-geographical conditions, so that this depression basin is characterised by a climatic regime with excessiveness variations (great thermal amplitudes), frequent temperature inversions, high frequency of early and late frosts, continental pluviometric regime affected by the surrounding mountainous frame; the depression basin is also characterised by the aeolian regime dependent on the local orography.

All these local modifications the general climate is submitted to and that we generically call "depression effect" are induced by the interaction between the general climatic factors and the major characteristics of the local relief geometry: great surface extension and relative uniformity of base level, imposing morphological setting surrounding the mountainous frame and air-penetrability specific to the depression complex.

Generally speaking the so-called "depression effect" consists, from thermal point of view, of the intensification of the night radiative cooling processes and of the diurnal heating processes, by insolation.

Throughout the periods characterised by radiative cooling during night and wintertime, on anticyclonic weather, relatively warm and with predominantly clear sky, the depression plains get cooler than the higher places. During theses periods, the gravitational sedimentation of the cool air pellicle on the surrounding mountain slopes and the continuous cooling of the accumulated air by radiative way - becoming, by this way, quasistagnant in the same huge orographic "basin", determines considerable differences between the temperatures of the depression relief inferior level and the nearby slopes inferior sectors that remain warmer. This is how we explain the reason why the lowest recorded temperature within the last 40 years was lower in Ghimbav, the depression plain, 534 m altitude (-32.3ş C) than in Brasov, the submontane sector, 609 m altitude (-26.3ş C). By the same "depression effect" we explain the reason that determines the average temperature of January, 1.1ş lower in Ghimbav as compared to Brasov, the reason that determines the daily average temperature in the same month, 2.4ş lower and even the reason that determines the annual average temperature of the daily lowest temperatures, about 1ş lower in Ghimbav as compared to Brasov.

Within the warm periods during the day and in the summer, when the caloric processes on the soil and in the inferior troposphere are "governed" by the radiant energy received from the sun, the depression lowland of Brasov gets warm more intensively than the surrounding slopes so much as the weather is calmer and the nebulosity is lower. This "insolation effect " the land depression forms exert is confirmed by the great values of different parameters of air's thermal regime presented in table 1.

Therefore, the same depression area that favours the cooling processes by radiation

Table 1. The comparative climatic data between the depression low land of Barsa (Ghimbav Station - 534 m) and the submontane sector of Brasov (Brasov station - 609 m)

Climatic characteristics	Ghimbav (534 m)	Brasov (609 m
I. AIR TEMPERATURE (ş C)		
Annual average temperature	7.5	7.7
Annual average amplitude	22.2	21.2
Annual amplitude of daily extreme temperature	11.6	10.4
Highest recorded temperature	35.4	35.4
Lowest recorded temperature	-32.3	-26.3
Annual highest amplitude	67.7	61.7
Annual average number of "frost days" (t_{min}<0ş C)	140.3	130.9
Annual average frequency of temperature inversions	233 days (64%)	
II. ATMOSPHERIC PRECIPITATION		
Annual average quantity	593.7	814.6
Annual average number of days with precipitation (< 0,1mm)	146.6	149.2

in the night and the heating processes in the day accentuates the excessiveness of the diurnal and annual thermal regime of lowland depression.

This increased continental degree of the depression climate that we call "depression effect" is clearly illustrated by other characteristics of the thermal regime (table 1).

The radiative cooling processes favour the occurrence of local meteorological phenomena - dew, hoarfrost, rime and radiation fog, the last one within these hydrometeors considerably reducing the sunshine length of time throughout the cold season months (October-March). During these months, at Poiana Brasov altitude (1026 m) and even on the superior mountainous peaks the sunshine length of time is longer than in the Depression of Brasov that remains for days, even for weeks drowned in fog (fig..2).

The "depression effect" has a deep impact on the precipitation regime as well. It is known that generally, the depression basins, through the "föhn" effects diminish the pluviousity. In the Depression of Brasov, in relation to the dominant atmospheric circulation (North-West direction), the quantity of precipitation is obviously not influenced by this way. By their reduced height, the Persani Mountains do not represent an orographic dam that might bring about föhn effects, but on the contrary, they prefigure a large opening, taking a "funnel" shape from the Depression of Transilvania towards the Depression of Brasov. In exchange, the "föhn" effects exerted by the major relief in the South of the depression, causing the degradation of cloudy systems, influences the precipitation to a certain extent, but these effects are to be felt only under the conditions of atmospheric circulation in the South and South West. However the mountainous relief that guards the depression of Brasov in its southern, South-eastern sector, by the pluvial role of the alpine peaks, under the conditions of western circulation, influences the regime of precipitation in a beneficial way, at least in the marginal, South, South-East depression areal. This piedmont belt and especially the depression "entrances" towards the interior of the mountainous frame (large passages and submontane valleys) benefit from precipitation surplus. Despite the fact that these tentacular entrances are found at low altitudes (600-700, sometimes 800-900 m) they derive advantage from the favourable bioactive thermal potential, specific to the phytoclimatic level of hills, on the one hand, and from the precipitation quantity characteristic to the high mountainous peaks, on the other hand.

These beneficial local influences we call "gulf effect" constitute the base for the high productivity of spruce fir, fir and beech arboreta located at low, premontane altitudes, on one of the weakest soils, formed on cenomonien grit stones (Timis Valley, Calului Valley etc.).

The aeolian regime of the depression of Brasov comprises the characteristics of long intramontane depressions that favour an atmospheric circulation territorially divided. The height and the morphological openings of the Oituz and Vladeni passes allow advections penetrations from North- East and West, assuring an active ventilation of the Depression and imprinting its central areal with less ordinary aeolien characteristics for the depression climates.

As a consequence of the "depression effect" to the aeolian regime, there can be delimitated two distinctive areals in the Depression of Brasov:

- the shelter areal (the piedmonts and the inferior sector of the piedmont slopes) where the calmness reaches a high frequency (30-60%);
- the windy areal that is superposed on the depression lowland, where the shelter effect is low, the average velocities overtop 6 m/s and the very strong winds have a much higher frequency.

CLIMATIC STRUCTURE OF THE DEPRESSION OF BRASOV

Compartments and topoclimatic areals

Although at a first analysis it seems that the Depression of Brasov constitutes a very well individualised climatic unity, yet, the study of territorial distribution considered for the main climatic parameters values (temperature, precipitation, wind etc.) came to the conclusion that this wide spread depression presents three compartments and two distinctive topoclimatic areals:

- Western topoclimatic compartment, that comprises the Barsa Depression, the gulfs and the adjacent depression passages. This compartment is characterised by a moderate and humid climate as a consequence to a stronger influence of western advection corroborated with the pluvial action of mountainous massif in South-West (Piatra Craiului, Bucegi, Postavaru);
- Eastern topoclimatic compartment (Tg. Secuiesc Depression), with an excessive climate, less humid, severe winters and stronger winds - consequences to the influence

of continental atmospheric circulation from East and North East.

The transition between theses two topoclimatic compartments is made through the central compartment of the Depression (Sacele piedmont, Harman plain) and Calnic field.

Our researches came to the conclusion that inside this huge intracapathian basin, within the above three topoclimatic compartments, there are shaped two (areal) topoclimatic belts, relatively concentric and distinctive:

- a central topoclimatic belt, superposed on the depression lowland, developed from the lowest altitudes recorded at the level of the alluvial plain of Olt river (about 500m) to those sectors of piedmont plaines that do not overtop 550 m altitude. This is the areal where the “depression effect” (thermal, pluviometric and aeolian) is outlined to the most intense extent;
- a marginal topoclimatic belt that occupies the contact marginal piedmont level, as well as those depression “entrances” towards the interior of the mountainous frame, represented by the depression gulfs, valley passages and submontane sector of the large valleys that converge to the collector depression basin, extending the depression lowlands towards the interior of the mountainous relief up to 650-700 m altitude (Brasov Valley, Timis Valeey, Tarlung Vallet, etc.).

Air thermal stratification in the Depression of Brasov

The well-known vertical thermal structure belonging to troposphere is clearly modified by the relief local influences.

Our researches lead to the conclusion that above the depression basins, on the convergent valleys and on the slopes directed towards these valleys, the air’s local thermal stratification is a distinctly exposed phenomena; the inferior troposphere outlines a structure that, according to the weather and to other local factors, present the following sublayers:

- the layer of temperature inversions;
- “warm slope area”;
- the layer of free atmosphere.

a) The layer of temperature inversions is the tropospheric layer where there are produced the most frequent and intense temperature inversions. On stable anticyclonic weather, with clear sky and lack of wind in the night and sometimes even in the day, in this layer there is changed the sense of altitudinal variation of air’s temperature, so that its base becomes the level of the lowest temperatures. From this level, the temperature increases together with the altitude up to the superior limit of the so-called “layer of inversion”, where the temperature decreases together with the altitude according to the known law (-0,6^{0}C/100m). The altitudinal extension of temperature inversions depends on: weather, season, nature of air mass, geomorphologic ambience and other local factors (M.Marcu and collaborators, 1995).

On cyclic weather, with great nebulosity, wind and precipitation, in both warm and cold semesters of the year, the night temperature inversions of radiative nature cannot be formed, the generalised turbulence and the layer of clouds determining a normal variation of air temperature with the altitude and the whole troposphere regains the ordinary thermal structure.

In fig.2 there are noticed the two types of thermal structuring of the inferior troposphere and the passing moment from the anticyclonic structure (inversion type) to the

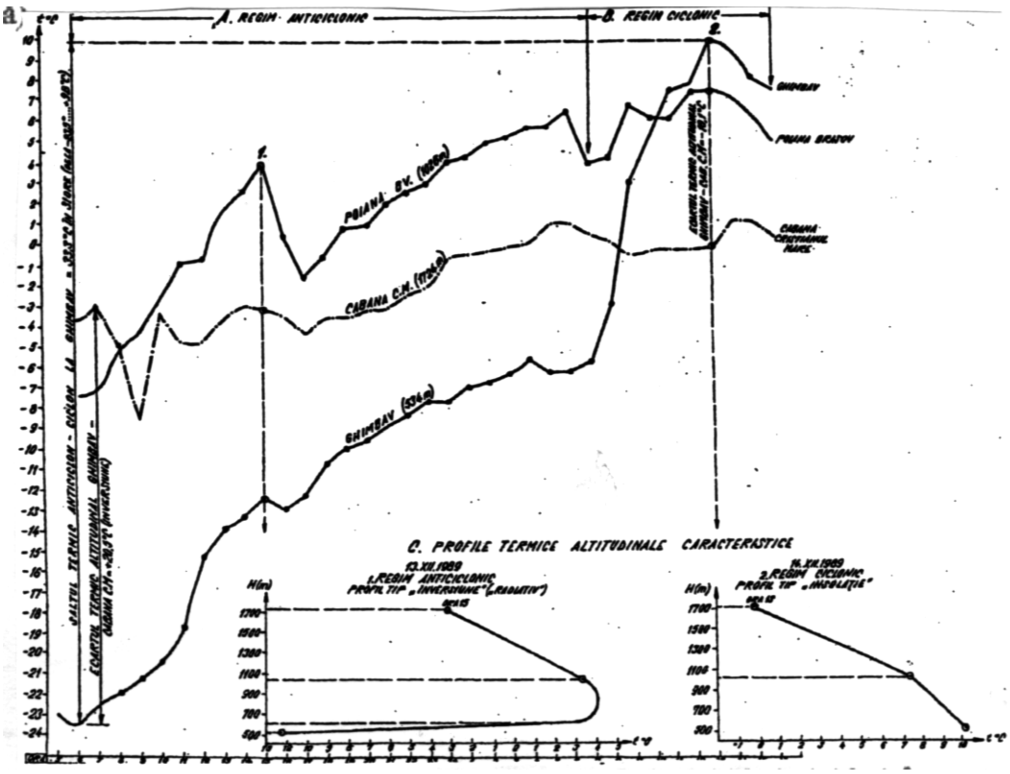

Figure 2. Successive diurnal thermal structure of anticyclonic and cyclonic type on 13 and 14 December. Depression of Brasov

cyclonic structure (ordinary).

There is to be remarked that despite the fact that the temperature inversions stand for phenomena with episodic character, due to their great frequency in the Depression of Brasov they enhance a climatological effect, even in the monthly and annual average air temperatures, confirming the name we give to the tropospheric layer where they are formed - “the layer of temperature inversions”.

The climate (topoclimate) generated in this way is altitudinal extended within Brasov area between 500-650 m, that is a tropospheric layer of 250 m thickness; territorially, it is shaped on the base level, on the lowest forms of depression relief (depression lowland, contact piedmont etc.) where the effect of night cooling phenomena reaches the maximum value.

There appears the most severe frost and accompanying phenomena such as: dew, hoarfrost, rime and radiative fog (Photo - fig.3) reach the highest frequency and intensity.

This kind of depression areas are characterised by accentuated excessiveness of the thermal regime as compared to the nearby regions, they present the highest danger degree for young plants, especially beech and fir trees and for the fructification process in general, reason that determines the foresters to call them "frosty wholes".

These depression thermal effects penetrate in a tentacular manner the interior of the mountainous frame, through the depression gulfs and the valley passages up to altitudes corresponding to the thickness of the inversion layer that stagnate in the depression

Figure 3. The radiative-orographic fog marks the thickness of the inversion layer and penetrate the "depression gulfs" and the intramontane valleys up to the same altitude

basin (Photo - fig.3).

b) The middle layer, called "the warm slope area" stands for that tropospheric layer superposed on the "inversion" layer that, in the Carpathians of Curbura is situated between 650 and1259 m altitudes and represents, from the thermal point of view, the most moderate sector of the mountainous slopes in our country().

From pluviometric point of view this slope sector offers optimum conditions to forest vegetation: 780-1100 mm precipitation (annual average quantity). This optimum pluvial occurrence is explained by both absolute altitude and "orographic surplus" of precipitation reached at the levels where such slope sectors are situated close to high mountainous peaks with important pluvial functions.

At the level of the entire country, in relation to the altitude climatic ranging corresponding to the levels of the Carpathian relief, the "warm slope area" is superposed on the high hill level and on the inferior sector of the mountain level.

Since it is considered a transition climate between the excessiveness specific to the climate typifying the low, depression regions, and the thermal insufficiencies of the climate typifying the superior mountain levels, the “warm slope area” represents, from the climatic point of view, the most favourable Carpathian level. By its great ecological complexity and specific climatic hospitality this biogeographical level assures the survival of various species of forestry fruit-growing) interest. In fact, within this wide spread level of the Carpathian relief we come across the quasitotality of wood species that grow wildly in our country.

Moreover, the orographic, lytological lack of homogeneity of this slope sector brings about a diversity of topo- and microclimatic conditions that generate some of the most interesting biogeographical phenomena:

- vegetation inversions (altitudinal descending of the spruce fir goes under the beech and the fir tree);
- areal interpenetrations: altitudinal climbing of the common oak and of the oak up to 1000-1100 m, at the spruce fir, beech and fir tree level;
- extra areas (islands of xerophyte and termophyte vegetation, specific to steppe climate in deep mountain climate).

c) The superior layer (of the free atmosphere) situated above the “warm area”, at altitude beyond 1250 m, occupies the superior sector of mountain slopes, that is the climatic levels and sub-levels (montane, subalpine and alpine) where the altitudinal variation of climatic parameters usually “listen” to the “altitude law” shaping these slope sectors with climatic features specific to corresponding altitudinal levels.

CONCLUSIONS

For the practical forestry, the thermal stratification, specific to land depression forms means not only what, intuitively, the precursors of the scientific forestry used to call “frosty holes” , but it delimits, by both spatial way and parametric data scientifically and rigorously determined, the two “poles of cold”, situated at extreme levels of the intramontane depression relief:

- the lowest places, corresponding to the base level of the inversion layer, where the cold is radiatively conditioned;
- the level of high peaks where the climatic rigours of thermal nature are generated by the altitude factor and by adective causes.

The so-called “warm slope area”, situated between these two sublevels of thermal extremes, represents the climatic optimum for the most important wooden species in our country, spruce fir, fir tree, beech tree, common oak tree, etc, and the tropospheric inferiour layer, situated below the above mentioned area and located in the depressions and intramontane valleys stands for those biogeographical areas where the cultivation of the fir and beech trees, of the Douglas fir, nut tree and other sensitive species to late and early frost must be avoided.

At the end of the study, we appreciate that there are eloquent reasons asserting the fact that the thermal stratification phenomena specific to the inferior troposphere and amplified in the relief depression forms, cannot be regarded as simple microclimatic phenomena any longer; they outline phenomena of topoclimatic nature, phenomena that arise by climatological and ecological ways and enhanced by biogeographical and social-economic implications of great significance: forestry, fruit growing, energetic (fuel consumption), balneoclimatology, tourism, etc.

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() *What is this "slope warm area" about how "warm" it is and what other climatic characteristics define it are issues that M. Marcu and his collaborators revealed in paper no.5 called "Slope warm area in Brasov mountains"*