SOME MICROCLIMATIC CHARACTERISTICS OF THE THERMAL—HOUSEHOLD PROCESSES IN SOILS OF DIFFERENT EXPOSURES

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The microclimates of dolinas have already been studied from several aspects with a view to understanding the denudative processes occurring in the microareas. Apart from the characteristics of the course of the air temperature, primarily the differences in the course of the soil temperature in various exposures have been demonstrated in a dolina in the Bükk Mountains (BÁRÁNY, 1975). Earlier investigations (JAKUCS, 1971) showed that the edaphic CO_2 production which affects the intensity of denudation depends predominantly on the amount of bacteria to be found in the soil, and to a lesser extent on the macrovegetation. The number of bacteria increases most rapidly in the event of optimum temperature (25 °C) and soil moisture (25%). In the region of the Central Hungarian Mountains, such a temperature optimum in the soil can arise in the case of a favourable exposure only in the immediate vicinity of the surface. However, values close to the optimum may be observed at certain times of the day. Accordingly, there is a diurnal fluctuation in the bioactivity. RUSSEL (1924) and JAKUCS (1971) demonstrated close correlations between the number of bacteria or the carbon dioxide content and the diurnal course of the temperature. Only references were made, however, with regard to how the temperature levels and temperature extremes develop in the soil profile. Such an investigation of the soil profile is also considered to be important as by this means it is possible to narrow the area in which future soil-quality and soil-biological examinations must be concentrated.

The thermal conductivities of the various substances covering the surface can be calculated from a knowledge of the distance, the temperature and the quantity of heat transported. However, the theoretical values can not be related with general validity to the concept of temperature of soils in microareas occurring in a mosaic-like pattern, each with its own regularities.

The characteristics of the thermal-household of the active soil layer near the surface were analyzed in detail by WAGNER (1965) and by WAGNER and TAKÁCS (1966), with regard to microareas too. By determining the cool and warm levels of thermal flow (the warm level [divergency level] is the relatively hottest level from which heat flows vertically in two directions, while the cool level [convergency level] is the relatively coldest level to which heat flows from two directions), they demonstrated that the diurnal changes in these are important characteristics of soils. The organic processes in the soil (activity of microorganisms, soil respiration, etc.) are influenced considerably by the diurnal changes in the cool and warm levels; thus, if differences due to exposure can be detected in this respect, then we may come closer to an understanding of the denudative processes occurring in different exposures.

Dolinas, as micromorphological units, are also independent microclimatic areas, within which (under the effect of higher-order microclimatic areas) particular, local influences (turbulent air flow, shading effect) are manifested. Accordingly, the exposure differences can not be evaluated without considering these factors. In a study of the extreme soil temperature values and the inversion levels, the findings include the effects of the vegetation and the nature of the soil (a detailed analysis is required in this respect too), but the tendencies are valid, and merely the interpretation of the phenomena may be augmented in such investigations. (The site of the examinations is an open dolina, with grassy vegetation, at Kurtabérc, the thickness of the soil layer exceeding 30 cm in all exposures.)

In the isopletes of the east-west cross-section (Fig. 1) there is a striking difference in the lowering in time of the cool level. On the eastern exposure the uniform lowering of the cool level towards the warmer layers begins between 5 and 6 a. m. and lasts until 8 a. m. On the western exposure the downward migration ot the cool level slows down below the 5-cm soil layer, and attains a more appreciable value again only around 10—11 a. m. At 8 a. m. there is already thermal conductance downwards from the surface in the upper 10-cm profile. On the western exposure the cool level falls deeper than 10 cm only after 10 a. m. In the 10-cm soil layer near the surface here, until 6 a. m. the cool level is at a higher temperature than on the eastern exposure.

There are also significant differences in the migration of the warm level. The lowering of the warm level begins on the eastern exposure at about 12 a.m. It migrates progressively downwards to 10 cm, and then more rapidly after 8 p.m. to deeper levels than this. On the western exposure the warm level falls below the surface only at around 4 p.m. This is a natural consequence of the exposure. Here, however, the warm level does not fall below 10 cm; at 11 p.m. it is already moving upwards. From the movements of the active levels it may be stated that the heat transport is more balanced on the western exposure, both near the surface and in the deeper layers; on the eastern exposure, particularly in the upper 10-cm layer of the soil, the temperature extremes are higher, and this has a considerable effect on the biological processes.

In addition to all this, there are also appreciable differences in time in the thermal conductance processes on the two exposures. The alignment of the inversion levels is convergent on the eastern exposure, and divergent on the western exposure.

The differences in the northern and southern exposures (Fig. 2) show up in the extents of warming-up and cooling-down, and not in the natures of these. The migration tendencies of the inversion levels are identical, but the temperature isopletes are higher by 2—3 °C at every level on the southern exposure than on the northern exposure. There is no essential shift in time in the lowerings of the inversion levels. A certain difference is observed, however, in that (despite the progressive lowering from the beginning) the warm level on the northern exposure penetrates to a depth of 8 cm only, whereas by midnight the warm level on the southern exposure has reached down to 11—12 cm.

The differences of the maxima and minima vary with the depth (Table 1). In an east-west cross-section the tendency is for the maximum of the western exposure to be somewhat more positive at a depth of 2 cm, less so at a depth of 5 cm, and considerably more so at a depth of 10 cm. This exposure difference decreases at depths greater than 10 cm. The difference of the minima decreases with the depth. However, while the diurnal temperature amplitude is greater on the eastern exposure

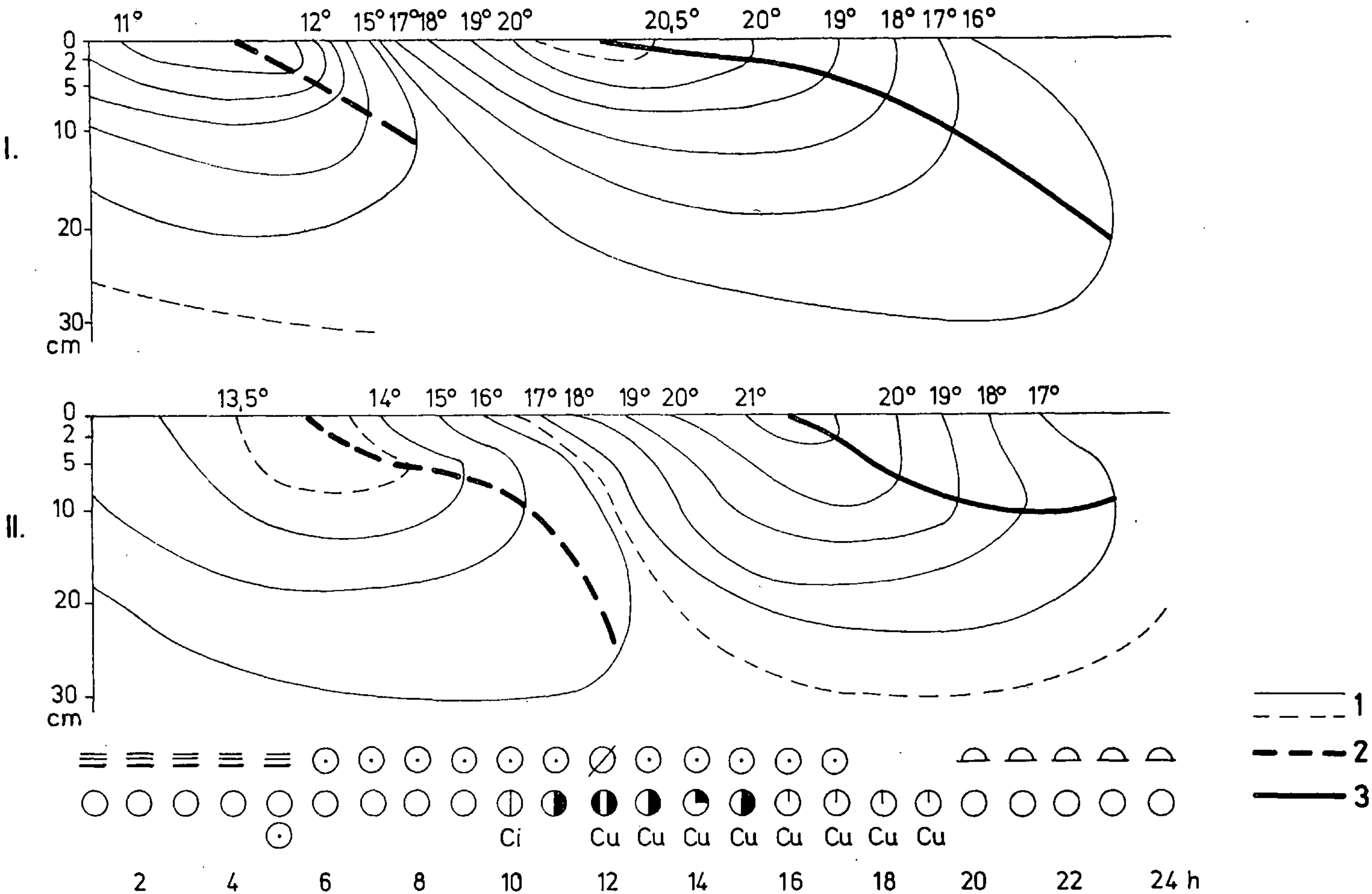

Fig. 1. Soil temperature isopletes in a Bükk Mountain dolina.
Kurtabérc, 14 August 1971. I=eastern exposure; II=western exposure; 1=isopletes; 2=cool level; 3=warm level

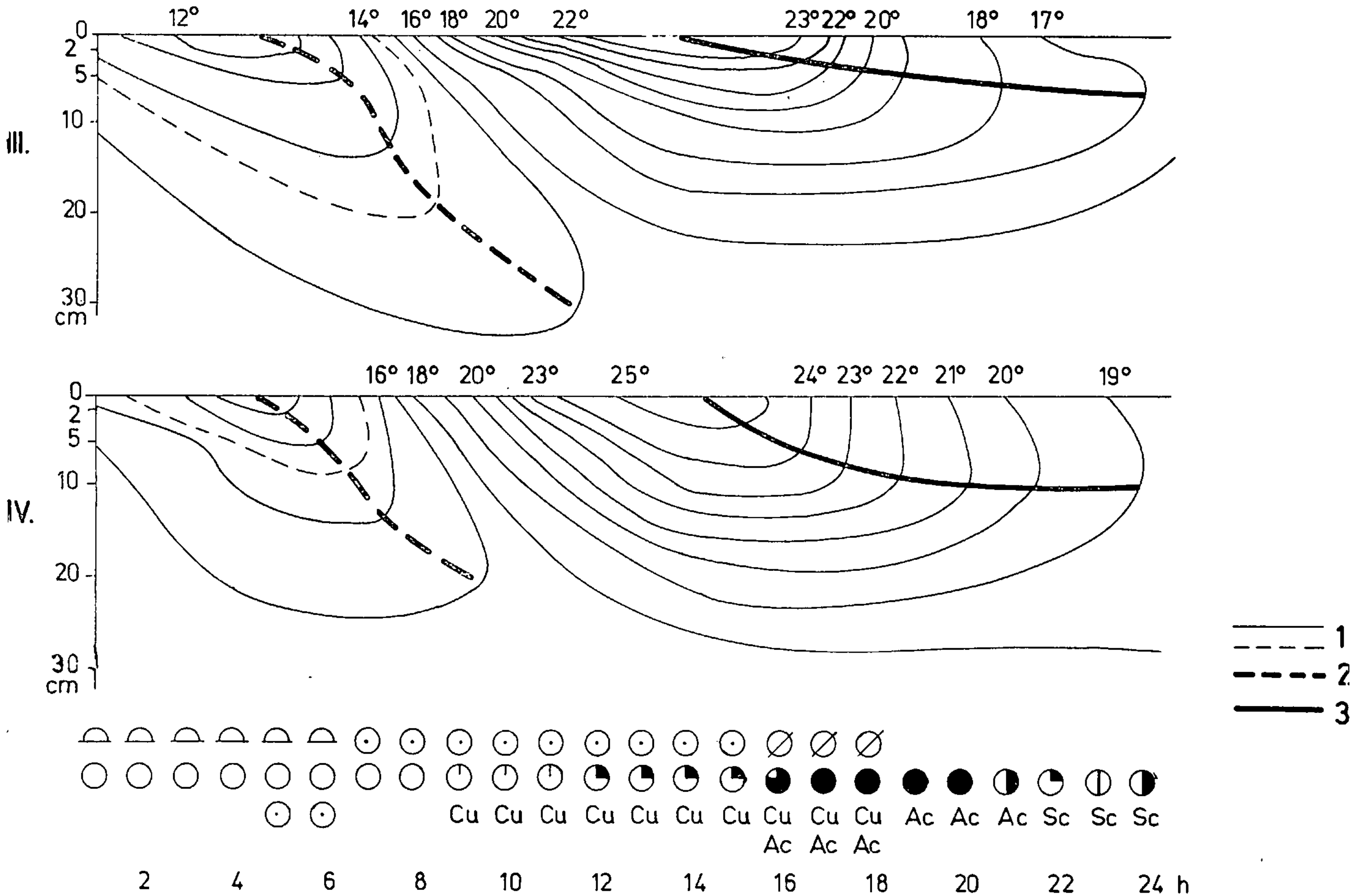

Fig. 2. Soil temperature isopletes in a Bükk Mountain dolina.
Kurtabérc, 3 August 1969. III = northern exposure; IV = southern exposure; 1 = isopletes; 2 = cool level; 3 = warm level

TABLE I

Extreme values and amplitudes of the soil temperature in a Bükk Mountain dolina

Date		2 cm W	E	Δ	5 cm W	E	Δ	10 cm W	E	Δ	20 cm W	E	Δ	30 cm W	E	Δ
7. 8. 1971	Max.	24,9	23,3	1,6	23,5	22,4	1,1	23,5	20,2	3,2	19,0	17,7	1,3	17,7	16,9	0,8
	Min.	16,2	13,6	2,6	16,1	14,2	1,9	16,1	15,1	1,0	16,6	15,7	0,9	16,7	16,0	0,7
	Ampl.	8,7	9,7	—1,0	7,4	8,2	—0,8	7,3	5,1	2,2	2,4	2,0	0,4	1,0	0,9	0,1
14. 8. 1971	Max.	21,8	20,6	1,2	20,8	20,1	0,7	21,1	18,4	2,7	16,9	16,6	0,3	16,0	16,0	0,0
	Min.	13,2	10,1	3,1	13,4	11,4	2,0	13,6	13,2	0,4	14,7	14,8	—0,1	15,1	15,3	—0,2
	Ampl.	8,6	10,5	—1,9	7,4	8,7	—1,3	7,5	5,2	2,3	2,2	1,8	0,4	0,9	0,7	0,2
15. 8. 1971	Max.	23,1	21,4	1,7	22,0	20,7	1,3	22,3	18,8	3,5	17,8	17,0	0,8	16,4	16,3	0,1
	Min.	14,4	11,5	2,9	14,5	19,5	2,0	14,6	13,9	0,7	15,3	15,1	0,2	15,6	15,5	0,1
	Ampl.	8,7	9,8	—1,1	7,5	8,2	—0,7	7,7	7,9	2,8	2,5	1,9	0,6	0,8	0,8	0,0
		S	N	Δ	S	N	Δ	S	N	Δ	S	N	Δ	S	N	Δ
4. 8. 1969	Max.	24,2	20,7	3,5	23,5	19,2	4,4	22,6	18,3	4,3	19,5	16,2	3,3	17,9	15,3	2,6
	Min.	15,8	13,5	2,3	16,2	14,7	1,5	16,8	15,1	1,7	17,5	15,0	2,5	17,5	15,0	2,5
	Ampl.	8,4	7,2	1,2	7,4	4,5	2,9	5,8	3,2	2,6	2,0	1,2	0,8	0,4	0,3	0,1
5. 8. 1969	Max.	23,9	21,0	2,9	23,6	18,9	4,7	22,2	18,2	4,0	18,8	16,2	2,6	17,7	15,4	2,3
	Min.	13,7	11,9	1,8	14,6	12,7	1,9	15,3	13,2	2,0	16,5	14,0	2,5	17,1	14,6	2,5
	Ampl.	10,2	9,1	1,1	9,0	6,2	2,8	7,0	5,0	2.0	2,3	2,2	0,1	0,6	0,8	—0,2
6. 8. 1969	Max.	25,8	20,3	5,5	24,6	18,5	6,1	22,6	17,5	5,1	18,5	15,8	2,7	17,3	15,3	2,0
	Min.	12,8	10,3	2,5	14,3	11,6	2,7	14,7	12,8	1,9	16,4	13,7	2,7	16,9	14,7	2,2
	Ampl.	13,0	10,0	3,0	10,4	6,9	3,4	7,9	4,7	3,2	2,1	2,1	0,0	0,4	0,6	—0,2

at soil depths of 2 and 5 cm, it is greater on the western exposure at depths of 10 cm and more. The change of the cool and warm levels also exhibits this tendency.

It may be stated quite definitely, therefore, that the exposure difference is significant in the upper 10—15-cm soil profile of the active heat transport. In the case of the southern and northern exposures, a difference of such a nature is restricted to the upper 5—10-cm soil layer, but the amplitude is always greater on the southern exposure.

The succession in time of the occurrence of the extreme values in the soil temperature may similarly be an important indicator of the exposure characteristics. On the basis of the earlier-drawn trigonometric polynomials (BÁRÁNY, 1975), an approximative curve was constructed to illustrate the times of the maximum and minimum temperatures as a function of the depth (Fig. 3). This was necessary because, when the actual shift in time of the extreme temperature values was plotted, the resulting diagram resembles the third-degree parabola:

$$y = a + bx + cx^2 + dx^3$$

In the interest of exact formulation, it was practical to determine these parabolic functions, which express the characteristics of the shifts of the maximum and minimum values in time and in depth for the various exposures. The approximative curves show the inflexion point, which indicates that level in the soil where changes occur in the extension of the extreme temperature values. From the data represented by the curves, calculations were made as to how the rates of spreading of the temperature waves vary on the different exposures, this process being assumed to be uniform. It is natural that the spreading of the temperature waves in the soil is not uniform (it is affected by many factros), but since we do not need concrete spreading rate values for the various depths, but wish to demonstrate the tendencies of the temperature waves to spread between the levels under consideration, the assumption of a uniform rate does not distort the evaluation. The rates of spreading of heat in the soil display the same tendencies on the southern, western and northern exposures, though there are appreciable differences in the absolute values (Table 2). On all three exposures the rate of spreading increases down to a depth of 20 cm, and decreases downwards below this. (The limiting levels are presumably to be found at the inflexion points.) The inflexion points of the spreading rate curves on the northern and southern exposures are at nearly the same depth, but much deeper than this on the western exposure. The explanation of this is considered to be that the prolonged

TABLE 2

Rates of spreading of the temperature waves in the soil (cm/min.)

Depth	Exposure			
	E	W	S	N
2—5 cm	0.10	0.06	0.05	0.05
5—10 cm	0.08	0.28	0.14	0.10
10—20 cm	0.28	1.67	0.21	0.11
20—30 cm	0.83	0.04	0.05	0.04

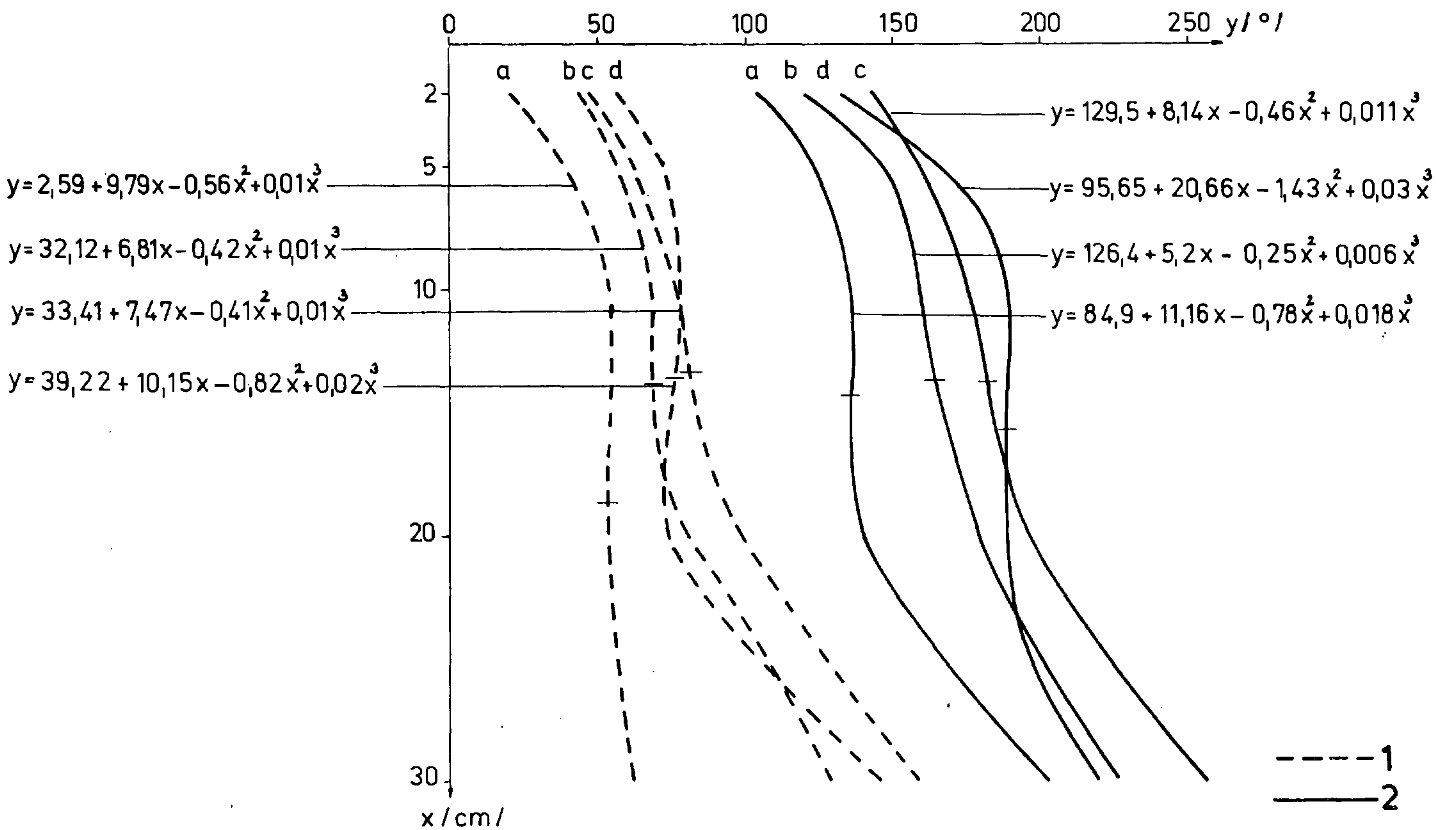

Fig. 3. Migration of soil temperature maxima and minima.
1 = minima; 2 = maxima; a = eastern exposure; b = southern exposure; c = northern exposure; d = western exposure

afternoon irradiation ensures the heat replacement from the surface for the longest time on the western exposure. While part of the energy of the morning irradiation on the eastern and northern exposures is devoted to drying up the dew, and therefore the maxima are lower, on the western exposure the maxima are relatively higher in the absence of this loss of heat. The migration of the maxima is slowest on the northern exposure as a result of the nature of this exposure.

As has already been seen from several respects, the eastern exposure behaves differently here too. The rate of spreading of the temperature waves decreases down to a depth of 10 cm, and increases at greater depths. A role is clearly played in this by the above-mentioned heat extraction (dew drying), and by the fact that the e-radiation begins earliest here because of the self-shading.

To summarize, it may be stated that the thermal-household on the eastern exposure differs from those on the other exposures; this is indicated by the migration of the inversion levels, and by the shifts of the extreme temperature values in space and time. In the upper 10-cm soil layer the rate of spreading of the temperature waves is decreased by the heat extraction connected with the drying-up of the morning dew. For just this reason, the upward flow of heat below 10 cm is more significant than on the other exposures. The later establishment of the maxima on the western exposure, and their greater absolute values, are consequences of the fact that there is no heat extraction here, while the heating-up of the soil profile, with its relatively higher temperature, proceeds more rapidly (the eradiation finishes sooner). A contribution to this is also made by the upward conductance of heat. The rate of spreading of the temperature waves down to 20 cm is the greatest here. On the above basis, the thermal-household on the eastern exposure is favourable, since on the occurrence of the maxima in the morning the soil has not yet dried out, and thus bioactive carbon dioxide production is favoured by both the temperature level and the soil moisture. On the western exposure, however, the more intense heating-up and the rapid succession of maxima with the depth lead to a greater drying-out of the soil, which decreases the intensity of activity of the microorganisms. The southern exposure exhibits a certain similarity with the eastern, and the northern exposure with the western.

Our observations thus provide further factual explanations in support of the interpretation by JAKUCS (1971) of the differing dynamics of karst corrosion on the dolina slopes with different exposures.

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