MOLLUSCA-PERIODS IN THE SEDIMENTS OF THE HUNGARIAN PLEISTOCENE IV. THE UPPER PART OF THE MIDDLE ARID PERIOD IN THE BORING OF FELSŐSZENTIVÁN

by

A. HORVÁTH

Institute for Systematic Zoology of the University, Szeged, Hungary

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This paper is the fourt member of a series in which each member represents a chapter of a larger work. The first paper (Acta Biol. Szeged 1962. Tom. VIII. Fasc. 1—4, pp. 173—192) gives general informations necessary for the evaluation of the *Mollusca*-material of the boring of Felsőszentiván. The second publication (Acta Biol. Szeged 1963. Tom. IX. Fasc. 1—4, pp. 101—115) divides the boring 77 m deep into 5 *Mollusca*-periods. The periods are named and designed with Roman numerals from above. The uppermost period is described in details. The I., or the upper arid period (1,6—11 m) was characterized by the lack of aquatic fauna, by the sporadic occurrence of thermophilic species and by a more or less arid and cold climate. This period was divided into 8 subperiods (I/1.—I/8.) on the basis of the fauna. The third publication (Acta Biol. Szeged 1964. Tom. X. Fasc. 1—4, pp. 131—146) talks over the II. or upper humid period (11—14,5 m). This period was characterized in contrast to the former period the aquatic and thermophilic fauna occurs in all samples of the period, the aquatic fauna is rich, the number of individuals of the thermophilic species is significant, the climate of the period is more humid and milder. The period was divided into 4 subperiods (II./1.—II./4.) on the basis of the fauna.

The III., or the middle arid period (14,5—44,2 m) bordering with humider periods below and above as well, had a more or less cold and arid climate. Its fauna is divided into 12 subperiods (III./1.—III./12.). The first 5 of these subperiods are described in the followings.

Subperiod III./1. 14,5—19 m

The layer is 4,5 m thick. It consists of running sand, and from 18,6—19 m of humus containing loess with plant residues. The subperiod is distinguished from subperiod II/4 in the sudden and considerable decrease of the fauna (the number of *Mollusca* exemplars altogether decreases from 332 to 35!), while from subperiod III/2 in the presence of a continous aquatic and amphibic fauna. In the 15 samples of the subperiod 510 *Mollusca* exemplars were found.

The aquatic fauna is represented by 9 species and 88 exemplars. More than a half part of the exemplars is *Anisus spirorbis* (47). The quantity of *Anisus planorbis* is much lesser (23). The other species have an unimportant role: *Galba truncatula* 7, *Pisidium cinereum* 4, *Valvata cristata* 2, *Stagnicola palustris* 2, *Bithynia leachi* 1, *Planorbis corneus* juv. 1, *Pisidium obtusale* 1. From the 9

species 7 occur in subperiod II/4 too. Dominance of *Anisus spirorbis* is also a common characteristic in both subperiods. The aquatic fauna of this layer is, however, poor. *Valvata pulchella* and *Gyraulus laevis* occuring continuously in the subperiod II/4 are completely lacking from the whole period III. This lacking is caused rather by the swampy character of the water than by the cold. Pauperity of the fauna is characterized in first line by the low numbers of individuals. In the two samples of subperiod II/4 the number of aquatic species altogether was 53 and 73 respectively, though the aquatic fauna of the period II was here already considerable reduced. In contrast to this in subperiod III/1 the maximum of this number is only 22, in an other sample 11 exemplars were found and in the other 13 samples it is more lower. The aquatic fauna itself, however, generally occurs, it lacks only in two of the 15 samples. This occurrence shows a permanent water. A permanent water, however, would produce a more rich aquatic fauna. Poverty of the fauna might be caused not the lack of water but its low temperature. The *Mollusca*-population may be explained by a temporary water too, because its dominant species is *Anisus spirorbis* which endure well exsiccation. In this case, however, it is interesting that a temporary water survived a period which produced a 4,5 m thick sediment and which had an arid climate according to its fauna. All this may be explained by the supposition of tundra-like circumstances where the water originates from a frozen soil which melts in the warmer period of the year.

The amphibic fauna was observed continuously through the period II and it occurs uninterrupted in subperiod III/1 too. This fauna has also here two species: *Succinea oblonga* (123) and *Carychium minimum* (19). *Succinea oblonga* is the dominant species here too. The number of amphibiotic species altogether, however, is 67 and 125 in the reduced fauna of the subperiod II/4. In this subperiod is this number only 1—34, in 12 samples from the 15 ones less than 10. *Succinea oblonga* occurs continuously, but *Carychium minimum* is already absent from sample 7 (16,6 m) downwards and it occurs only at 43 m again. *Succinea oblonga* indures long aridity by temporary waters too but it is sensitive against low temperature. Decrease of numbers was caused by the increasing coldness and not by lack of humidity. *Carychium minimum* endures coldness somewhat better but it requires more humidity. Its disappearence might be caused by the aridity of the long winters. too.

Hygrophilic ubiquitous organisms are represented by 11 species and 207 exemplars: *Trichia hispida* 43, *Vertigo pygmaea* 40, *Vallonia pulchella* 38, *Pupilla muscorum* 32, *Vallonia enniensis* 17, *Cochlicopa lubrica* 13, *Vertigo angustior* 7, *Deroceras agreste* 7, *Vallonia costata* 5, *Euconulus trochiformis* 4, *Vertigo antivertigo* 1. These species occurs in subperiod II/4 too. Only *Punctum pygmaeum* is lacking which occured in subperiod II/4 in an only exemplare. Number of individuals decreased considerably. Number of hygrophilic ubiquists altogether is in subperiod II/4 144 and 127, while here only 2—45 and in eight samples it does not reach 10. In the period II all species occured continuously, here occurs all species only discontinuously. They occurs, however, through the whole layer, although only discontinuously. Therefore they might live on this area through the period of the formation of the layer. In consequence of their low number, however, they did not get into all of the relatively small samples. *Pupilla muscorum* is the species which endures coldness and aridity in the heighst degree, therefore it lacks only in 3 samples from the 15.

Impoverishment of the fauna indicates the climate of subperiod III/1 as arider and colder than that of the subperiod II/4.

Of inhabitant of groves 5 species and 33 exemplars were found. It is remarkable the lack of *Perpolita hammonis* because it occured in all samples of period II. Occurrence of *Arianta arbustorum,* which is an inhabitant of bread-leaved groves of shores and endures low temperatures, become discontinuous though rather usual yet. From the 23 exemplares 10 were found in an only sample, in the other 8 samples there were only 1 or 2 exemplares. *Clausilia dubia* (4) was represented in period II by an only exemplare. It indicates foresty conditions and a climate which was colder than at present. *Perforatella bidens* (4) occurs in period II continuously but in subperiod II/4 it lacked already. It indicates bread leaved grove and a somewhat temperated coldness. *Goniodiscus ruderatus* indicates a climate colder than at present and groves being an arborophil organism. It occurs in period II continuously, in subperiod II/4 it is already lacking. Occurrence of *Pupilla sterri* (1) proves a climate colder than at present. Number of inhibitants of groves might be reduced by a coniferous vegetation besides poorness of the groves.

Thermophilic organisms are represented by 3 species and 40 exemplares. They occur in period II continuously, while here they are lacking in 6 samples from the 15. The highest number (28) produced the most thermophilic *Helicella hungarica.* It is lacking in the 7 upper samples of the layer, while in the lower half of the layer they occur continuously except 2 of the sapmles. It prefers arid places and therefore it found more favourable circumstances in this period than in the period II which was more temperate but at the same time more humid too. Its presence fits into the subarctic climate supposed above. In this climate long and cold winters were followed by short and rather warm summers. *Helicella hungarica* lacks in the upper part of the layer evidently in consequence of the increased humidity. This increase of humidity is proved also by a more abundant aquatic fauna and by presence of *Carychium minimum.* It is remarkable that in the layer occurrence of *Helicella hungarica* and *Carychium minimum* is vicarious. *Imparietula tridens* (10) endures more coldness and humidity. It is therefore more abundant than the former species. It lacks in the upper 3 samples and it occurs discontinuously in the lower ones. In the period II it occured continuously and in a much larger quantity. The reduction in this period indicates a colder climate. Decrease of number *Abida frumentum* (2) is also very considerable which is also a consequence of a colder climate. Presence of thermophilic organisms indicates warmth and a steppe-like vegetation. Its low number and sporadic occurrence, however, permit the supposition of a temperate warmth only.

On the basis of the precedings the conditions of the area my be reconstructed as follows: The climate of the area was colder and arider than the present climate and also the climate of the subperiod II/4. It was a climate with cold winters and normal summers (subarctic climate). Presence of cold, temporary stagnant waters produced tundra-like conditions. The vegetation was discontinuous, on the shores were poor groves from deciduous and coniferous trees and bushes enduring coldness well. Climate of the lower part of the layer (16,6—19 m) was somewhat arider. The aquatic fauna is here a little poorer, the humidity requiring *Carychium minimum* is lacking and occurs *Helicella hungarica* which prefers arid places. The upper part of the layer (14,5—16,6 m)

was produced in a more humid climate. The aquatic fauna is here more abundant, occurs *Carychium minimum, Helicella hungarica* is lacking. In the seventh sample of the layer (16,3—16,6) 120 exemplares were found, this number is much more higher than the number of exemplares found in the other samples. This the most temperate, humid part of the subperiod which was also the most rich in vegetation. Thermophilic fauna was represented by 3 exemplares only and *Helicella hungarica* was lacking, humidity might be too high for these organisms.

Subperiod III./2. 19—22,8 m

It has a thickness of 3,8 m. According to MIHÁLTZ it consists of loess containing fine sand (19—19,4 m), loess (19,4—19,8 m), humus containing loess (19,8—21,6 m) and loess with mud containt (21,6—22,2 m). The upper border of the period is characterized by the cessation of a continuous occurrence of the aquatic and amphibiotic fauna while the lower border is indicated by an increase and change of the fauna, the beginning of the continuous occurrence of *Succinea oblonga*, appearence of 3 ubiquitous species and of 3 inhabitants of groves and permanently increased number of the *Mollusca* exemplars. From the 17 samples of the subperiod 429 exemplares were found. The aquatic fauna is almost completely lacking, the number of aquatic is reduced from 9 in the former period to 3 *(Stagnicola palustris, Anisus spirorbis, Pisidium cinereum).* These species are represented with one exemplare only and they were found only in two samples. The are was therefore during the time of the formation of the layer arid. Small puddles occured only very rarely. Only 6 exemplares of the amphibic *Succinea oblonga* was found distributed among the 5 samples. Aridity reduced the occurrence of this species too.

From the hygrophilic ubiquituous organisms 10 species and 325 exemplares were found. These species are identical with the species of subperiod III/1 except *Vertigo antivertigo* which is here lacking. *Vertigo antivertigo* occurred in the subperiod III/1 only in the uppermost sample as the last member of a continuous occurrence, in the humid period II. Among the species prevails *Pupilla muscorum* (273) which endures mostly cold and aridity. It is lacking only in 4 samples, it may be considered therefore as a continuously occuring organism. Number of individuals, however, is low. In consequence of cold and aridity this enduring organism lived among unfavourable conditions. Number of individuals is strikingly high (219) in one of the samples (20,5—20,8 m). The maximal number of the thermophilic organisms was found also in this sample. Number of organisms with a higher requirement for humidity was reduced, due perhaps to aridity. *Vertigo pygmaea* (12) was not reduced considerably because it endures aridity well. It occurs discontinuously, from the 5 lower samples it is already lacking. The other species occurs sporadically. *Vallonia costata* (12) is a rather thermophilic organism, it understandable that it occurs only is low number. Its vital conditions, however, were somewhat more favourable than in the former layer because instead of cold humidity it was subjected to cold aridity which it endurs well. Quantity of *Vallonia pulchella* (9) also diminished. The optimal temperature of this species is lower than that of the former one, but its cold-tolerance is lower and its requirement for humidity

higher. Reduction of number of *Trichia hispida* (6), *Vertigo angustior* (5), *Deroceras agreste* (3), *Euconulus trochiformis* (2) is in first line the consequence of aridity and only secondarily the increased cold. Reduction of the rather thermophilic *Vallonia enniensis* (2) caused by the increased cold, while that of the hygrophilic *Cochlicopa lubrica* (1) due to the arid climate is very considerable. The number of the inhibitants of groves became also low. *Arianta arbustorum* (6) is lacking in 12 samples, 5 exemplars occurred sporadically in the lower part of the layer. This reduction was caused probably by aridity and the reduction of vegetation. *Clausilia dubia* (3) and *Pupilla sterri* (1) occurred in the lower part of the layer. Their role is insignificant as well as in the former layer. Lack of *Perforatella bidens* may be explained by the cold, that of *Goniodiscus ruderatus* by the lack of trees.

Thermophilic organismus occurred only in 2 of the upper 6 samples, in the lower 11 samples, however, they occurred generally. *Helicella hungarica* (46) and *Imparietula tridens* (37) shows some increase as compared with the former subperiod. *Abida frumentum* (2) showed no change. Aridity was more favourable for these organismus than the humid, tundralike conditions in the former layer. Their quantity was, naturally, reduced by cold. On the basis of the abovementioned data the climate of the subperiod III/2 was more arid and colder than that of the subperiod III/1, the area was arid, small temporary waters occurred only very rarely. The vegetation was open, steppelike with some bushes, probably coniferous ones.

Subperiod III./3. (22,8—23,6 m)

The layer is only 80 cm thick. It consists of muddy loess. In the 3 upper samples contains 263 exemplares. In the lower sample no *Mollusca* residues were found.

It may be supposed that the shells were destroyed in consequence of the sediment formation (humic acids?). This sample was ranged on the basis of the geological profil. No aquatic fauna was observed. Increase of the number of the amphibic *Succinea oblonga* (18 exemplares) shows more humidity than that of subperiod III/2. Number of the hygrophilic ubiquitous species is unchanged (10), number of individuals is altogether 152. *Vertigo angustior* is lacking; it occurred in subperiod III/2 only in the two upper samples and only in low numbers. Its lack is caused by the cold. A dominant role has *Trichia hispida* (64), it occurs downwards continuously. It is one of the most frequent snail of the Hungarian loesses. Its number increases downwards rapidly, obviously in consequence of increasing humidity. Increase of *Vallonia costata* (21) proves an increase of warmth besides the increase of humidity. *Punctum pygmaeum* (17) was widespread in the upper humid period. In the middle arid period it occurred first here. This proves also an increased humidity. The situation of the euryeciq *Pupilla muscorum* (12) did not change essentially in this climate which is also here arid and cold. The situation of *Vertigo pygmaea* (8), which demands more warmth and humidity, is similar. Increase of the number of the hygrophilic *Euconulus trochiformis* (11) and *Cochlicopa lubrica* (9) indicates more humidity, while the low number of exemplares indicates a climate which is arid and cold after all. The role of *Vallonia pulchella* (4), *Deroceras agreste*

(4) and that of the rather thermophilic *Vallonia enniensis* (2) is insignificant here too due to cold and aridity.

Inhabitants of groves occurs with 6 species and 54 exemplars. Number of species increased with 3 as compared to the former subperiod. Increase of the value of inhabitants of groves altogether is also considerable. *Clausilia dubia* (25) got in the boring of Felsőszentiván first here a more considerable role. *Perpolita hammonis* (19) occurred in period II continuously, in period III it occurs first here. *Goniodiscus ruderatus* (2) is lacking in subperiod III/2, its role is also here insignificant. These changes prove more humidity and a richer vegetation than that of the former subperiod. In Hungary the three species mentioned occurs at present in the mauntains, their presence proves a climate in the Hungarian Plain which was colder than the present one. Increase of *Arianta arbustorum* (5) and appearence of *Fruticicola fruticum* (2), till now lacking in period III, may be explained by increase of humidity. Situation of *Pupilla sterri* (1) did not change. At present it is an inhabitant of rocks of the Alpes and Carpathians. Its presence on the Hungarian Plain too indicates a climate colder than that of today.

The thermophilic fauna is represented by 32 exemplares of 3 species occuring also in the former subperiod. *Imparietula tridens* (23) occurs in largest number while *Helicella hungarica* (7) occurs only in the third sample. In accordance this sample is the warmest part of the subperiod but *Helicella hungarica* is also here preceded by *Imparietula tridens*. Role of *Abida frumentum* (2) is insignificant in this subperiod too. The thermophilic fauna of the two upper samples is poorer than that of the lower part of subperiod III/2 which is a consequence of increasing humidity.

Vallonia tenuilabris is in Europe a pleistocenic species, at present it lives only in Asia. Its presence on the Hungarian Plain proves undoubtedly a cilmate colder than today. According to author's experiences till now it prefers the relatively milder and humider parts of the Hungarian periglacial zone. In period III it occurs first here and it may indicate similar conditions.

On the basis of the data mentioned above the climate of the subperiod III/3 was much more arid and colder than the climate of the Hungarian plain at present but it was milder and humider than the climate of subperiod III/2. The vegetation was grove-like, most probably from cold-resistant decidous and coniferous trees.

Subperiod III./4. (23,6—24,2 m)

The layer is 60 cm thick. It consists of loess. It is bordered with poorer faunas upwards and downwards as well. Although the middle sample no *Mollusca* residues were found, assignment of the borders of the subperiod seems logical on the basis of the similarity of the other two samples. In these two samples 21 species and 532 exemplares were found.

The aquatic fauna represented by *Anisus planorbis* (4) and *Anisus spirorbis* (1) is very poor. Its appearance, however, after a long a continuous absence indicates humider conditions and proves temporary stagnant waters.

Increase of number of individuals of *Succinea oblonga* (35) was observed only in the upper sample. The 6 exemplares in the lower sample fit into a

continuous occurrence downwards. Increase of number of individuals in the upper sample is explained by the presence of stagnant water only.

The hygrophilic ubiquitous organismus are represented by 9 species and 325 exemplares. *Vertigo pygmaea* and *Vallonia enniensis* are lacking, although on the basis of their ecology they might be occur in the circumstances reconstructed with the aid of the fauna. Perhaps they did not get into the sample due their low numbers. 7 species are common with the subperiod III/3.

Trichia hispida (128) is dominant in this subperiod too. This indicates the increase of warmth and humidity. Increase of number of individuals indicates in the case of *Vallonia costata* (53) in first line more warmth, in the case of *Pupilla muscorum* (40) and *Vallonia pulchella* (27) more warmth and humidity while in the case of *Deroceras agreste* (26), *Euconulus trochiformis* (24) and *Cochlicopa lubrica* (16) more humidity. Situation of *Punctum pygmaeum* (10) did not change. It seems that the surroundings did not change enough to transform the vital circumstances for this species. *Vitrea crystallina* (1) occurs in this subperiod first here. Its appearance may indicate an increased humidity and an increase of the vegetation.

The fauna of the upper sample is much richer than that of the lower one. Increase of number of individuals in the upper sample as compared with its upper neighbour is striking by all species (except *Punctum pygmaeum).* In the lower sample the surplus is only by *Vallonia pulchella, Euconulus trochiformis* and *Trichia hispida* considerable as against the following subperiod.

Inhabitants of groves are represented by 5 species and 74 exemplares. *Pupilla sterri* and *Fruticicola fruticum* were rare in subperiod III/3, here they are already lacking. An increase of *Clausilia dubia* (35), *Arianta arbustorum* (12), *Goniodiscus ruderatus* (5) was observed in the upper sample, that of *Perpolita hammonis* (16) nor there. *Columella edentula* (5) occurs in the middle arid period first here, it was lacking in the upper humid period too. It is represented by the subsp. *columella* which lives in high mountains above the zone of forests. In the Pleistocene it was an inhabitant of the cold steppe. Its presence proves a climate much colder than at present, the low number of individuals may indicate a climate warmer than its optimum. The inhabitants of groves altogether show a cilmate colder than at present. The vegetation was in the time of the formation of the upper sample more abundant than that of the subperiod III/3. In the lower sample the vegetation might be similar to that of the subperiod III/3.

The thermophilic fauna with its 3 species and 86 exemplares is relatively rich. Dominant is also here the more hygrotolerant *Imparietula tridens* (65). *Helicella hungarica* (17) living in more arid circumstances occurs in lower number. Increase of *Abida frumentum* (4) is strikung in contrast to its low number. It occurs, however, in the upper sample only. This fauna in the upper sample indicates a climate warmer than that of the subperiod III/3 while in the lower sample it indicates a climate similarly warm than that the warmest sample of subperiod III/3. Presence of *Vallonia tenuilabris* (7) indicates a relatively mild, although glacial period.

After all, the climate of the subperiod had a relatively mild glacial character, and it was milder and warmer than the climate of the subperiod III/3. The vegetation was richer than in the former subperiod. This difference is striking in the upper sample while in the lower one there is a difference as

againts the lower part of the subperiod III/3 only. The lower sample, as shown by the amphibic, hygrophilic ubiquitous organismus and inhabitants of groves equally, was arider and lead a poorer vegetation than the mildest sample of the subperiod III/3. This difference is not balanced by the two exemplares of auqatic organismus in the lower sample and their lack in the other one. Moreover, it is striking that the terrestric fauna indicates an arider suroundings — in contrast to the presence of water. The twoo samples seem equally warm on the basis of their thermophilic fauna. According to these the climate of the lower sample was arider, with warmer summers and more continental while the mildest sample of the subperiod III/3 might have a climate with a more oceanic character.

Subperiod III./5. (24,2—25,4 m)

The layer is 120 cm thick, it consists of loess and it is bordered with richer faunas upwards and downward equally. As an explanation of the lower borderline the data of the uppermost sample of the subperiod III/6 are also given. Evaluation of this sample belongs already to the following paper. Its fauna shows, however, a considerable milder and humider climate. The 6 samples of the subperiod III/5 have 19 species and 341 exemplares.

Aquatic organism was found in the uppermost sample only: a single exemplare of *Anisus planorbis*. The lack of the aquatic fauna shows aridity.

The low number of individuals and the continuous occurence of the amphibic *Succinea oblonga* (36) indicate a little humidity of the soil in an arid and cold surrounding and some groves and bushes which gave some shelter against desiccation.

Hygrophilic ubiquitous organisms are represented be 10 species and 218 exemplares. 8 species are common with the subperiod III/4. The most numerous among them are *Trichia hispida* (84) and *Pupilla muscorum* (27) which are frequent in our loesses. They endure cold and aridity well, their number, however, diminished in consequence of them. Half of the exemplares of *Vallonia costata* (22) were found in the uppermost sample which shows a transitional character. Its occurrence, regarding its low number, is due to its considerable cold-tolerance and not to warm. Continuous occurrence in low numbers of *Deroceras agreste* (22) and *Cochlicopa lubrica* (21) corresponds to the temperate humidity already indicated by the occurrence of *Succinea oblonga*. In consideration of humidity one must remember that the demand for humidity of the snails is lower at lower temperatures. Quantity of *Vallonia pulchella* (17) was more lessened than that of *Punctum pygmaeum* (14) by aridity and cold. Decrease of the more hygrophilic *Euconulus trochiformis* (9) in the 3 upper samples and its lack in the lower ones also indicate a humidity than it was in the subperiod III/4. Occurrence of *Vertigo pygmaea* (1) and that of the rather thermophilic *Vallonia enniensis* (1) lacking in the subperiod III/4 may be hardly considered as a surplus, their low number is a newer proof of cold and aridity. If the lack of the hygrophilic *Vitrea crystallina*, which was represented by an only exemplare in the subperiod III/4, may be evaluated, it may indicate a decrease of humidity.

Inhabitants of groves are represented by 5 species and 52 exemplares. In the uppermost sample their number is equal that of the lower sample of subperiod III/4; in the other samples they are considerably diminished. *Clausilia dubia* (27) occurs continually, although in low number. Lack of *Arianta arbustorum* (14) in the second sample may be accidental: the probability of getting into a relatively small sample of a rather large organism is lower than that of the smaller species. *Perpolita hammonis* (4) occurs sparsely. *Columella edentula* subsp. *columella* (5) indicates subalpine conditions, naturally in a degree corresponding its small number. The species of the inhabitants of groves are common with the subperiod III/4, decrease of number indicates a sparsing of the vegetation. This fauna is very poor it indicates no decidious forests. On the other hand, this fauna does not fit into an arid place with an open vegetation: Such circumstances are contradicted by the presence of *Succinea oblonga*, which needs some shelter against desiccation. Author supposes a steppe with coniferous bushes and groves on this area.

Among the thermophilic organismus dominates *Imparietula tridens* (26) in this layer too. The more thermophilic *Helicella hungarica* (8) remains far behind it. The decrease of the number of exemplares of both species is considerable, they occur however, in all samples. The low number indicates cold, the continuous occurrence a considerable, although not constant and total aridity and an open, steppe-like vegetation according to the temperate cold of the periglacially located area.

The lack of *Vallonia tenuilabris*, which prefers the milder glacial periods, may be explained by the cold too.

On the basis of the fauna the subperiod III/5 was an arid, cold glacial period with slightly humid soil and steppe with coniferous shrubs.

The stratigraphical chronology

It was mentioned already in author's previous papers that according to MIHÁLTZ the loess layers indicate glacial while the humus containing and quicksand layers indicate interstadial and interglacious periods with milder climate. According to this the 3 loess layers of the upper dry *Mollusca* period correspond the three Würm glacial periods while the quicksands between them indicate the interstadial periods. The humus containing loess and quicksand sediments of the upper humid *Mollusca* period are from the Riss-Würm interglacial period. On the upper part of the middle arid *Mollusca* period the quicksand till 18,6 m, as a part of the quicksand of the upper humid *Mollusca* period beginning at 12,4 m and unable for further stratigraphical division, belongs to the Riss-Würm interglacial period too. Accepting this stratigraphical chronology, the loess between 18,6—23,6 m, containing mostly humus and mud, must be arranged also in the Riss-Würm interglacial period. Besides this loess there are two furher loesses till the large Mindel-Riss interglacial period. To this interglacial period, however, are only two loesses (corresponding to Riss 2 and Riss 1 resp.) to be expected.

From the three loesses the two lowers consist of pure loess and therefore these two ones are considered as the products of Riss 2 and Riss 1 respectively.

On the basis of the fauna the followings may be remarked to this chronology based only on the processes of sediment formation. The quicksand on the upper part of the period III (14,5—18,6 m) corresponds to the larger part of the subperiod III/1. It is already milder and humider than the subperiod below it and it is followed also upwards by subperiods more milder and humider. Therefore it may be considered as an introductory part of the interglacial period which climate was chilled by the inland ice cover. The same may be said about the loess containing a small amount of humus (18,6—19 m), which belongs already to the subperiod III/1 on the basis of its fauna. The loess formation characteristic to the glacial period here continues but the fauna and the humus formation indicates already the growing milder of the climate. It seems logical to consider the subperiod III/2 consisting of humus and mud containing loess as belonging to the Riss-Würm interglacial period if humus and mud in the loess is considered as an indication of a mild climate. On the basis of the fauna, however, this subperiod is not a product of an interglacial but an arid, cold glacial period with inland ice cover. This loess is otherwise the fourth loess layer of the profil in the area between the rivers Danube and Tisza investigated by MIHÁLTZ. It has a homogenous and considerable thick occurrence on a large area. On the basis of the fauna author deduced at the time a glacial climate which was arider and colder than that of the third loess layer. Essentially, the fauna was similar to that of observed in the other borings. The mud containing loess between 22,6—23,6 m was regularly observed also on the profil investigated by MIHÁLTZ. The milder and humider character of its climate as compared to that of the loess above it was also established at the time by the author. Here it coincides with the subperiod III/3 except its uppermost sample. Change of climate was indicated by the fauna earlier than by the formation of sediments — as it was observed by other instances too. To consider this layer as a part of the Riss-Würm interglacial period is disquieting in contrast to its relatively mild climate, because above it the fauna indicates a glacial period. Between 23,6—28,2 m follows a typical loess layer. On the basis of the stratigraphic chronology followed till now it must be considered as the sediment of the Riss 2 glacial period. Extension of the Riss-Würm interglacial period to the border of this loess seems logical, when only the sediment formation is considered. This loess was divided into four parts on the basis of the fauna. Only two of them are described in detail in this paper. The fauna of the subperiod III/4 indicates a milder, that of the subperiod III/5 a stronger glacial climate. This climates fits into the scheme given by the stratigraphical chronology.

The astronomical chronology

The climate changes of the Pleistocene are represented by the climate-curve of MILANKOVICH and BACSÁK. This climate-curve might be followed till now with the aid of the *Mollusca* periods of Felsőszentiván. On the climate-curve the upper arid *Mollusca* period corresponds to the end of Würm 3. The upper humid *Mollusca* period corresponds to the upper four period of the Würm 1—Würm 2 interstadial period. As a control author proved to follow the Riss-Würm interglacial part of the climate-curve with the fauna of the upper humid *Mollusca* period — but this was impossible.

Astronomical chronologie	Würm$_1$ — Würm$_2$ subarctic																Würm$_1$ glacial cold and arid																												Oceanic			Antiglacial			Riss$_2$							
Stratigraphical chronologie	Riss—Würm interglacial																																													Riss$_2$											
Mollusca subperiods	III./1																III./2																												III./3			III.4			III./5								III./6
Stratigraphical profil	Running sand														Loess with few humus		Fine sand with loess	Loess																																	Loess till 28,2 m										
																				containing humus and mud														muddy	with humus and mud				muddy																					
Species	Depth m.	14,5—14,8	14,8—15	15—15,3	15,3—15,5	15,5—16	16—16,3	16,3—16,6	16,6—16,9	16,9—17,3	17,3—17,6	17,6—18	18—18,3	18,3—18,6	18,6—18,8	18,8—19	19—19,4	19,4—19,6	19,6—19,8	19,8—20	20—20,2	20,2—20,5	20,5—20,8	20,8—21	21—21,2	21,2—21,4	21,4—21,6	21,6—21,8	21,8—22	22—22,2	22,2—22,4	22,4—22,6	22,6—22,8	22,8—23	23—23,2	23,2—23,4	23,4—23,6	23,6—23,8	23,8—24	24—24,2	24,2—24,4	24,4—24,6	24,6—24,8	24,8—25	25—25,2	25,2—25,4	25,4—25,6
Valvata cristata O. F. MÜLL.		1					1																																													
Bithynia leachi SHEPP.							1																																												
Stagnicola palustris O. F. MÜLL.	1							1									1																																				
Galba truncatula O. F. MÜLL.	1	1					3	2																																												2
Planorbis corneus L. iuv.				1																																														
Anisus planorbis L.	2	2	2	1	1		5	2					6	2																								2		2	1							
Anisus spirorbis L.	5	6	4	5	7	1	10	5		1	1				2											1										1												
Pisidium cinereum ALDER	1						2				1															1																						
Pisidium obtusale C. PFEIFFER		1																																																
Aquatic species altogether	10	11	6	7	8	1	22	10	—	1	2	—	6	2	2	—	1	—	—	—	—	—	—	—	—	2	—	—	—	—	—	—	—	—	—	3	—	2	1	—	—	—	—	—	2
Carychium minimum O. F. MÜLL.	2	4		6	4		3																																										
Succinea oblonga DRAP.	6	5	4	18	4	1	31	19	7	3	9	2	6	6	2		2	1				1		1		1							5	1	12		29		6	8	9	5	6	3	5	52
Amphibiotic species altogether	8	9	4	24	8	1	34	19	7	3	9	2	6	6	2	—	2	1	—	—	—	1	—	1	—	1	—	—	—	—	—	—	5	1	12	—	29	—	6	8	9	5	6	3	5	52
Cochlicopa lubrica O. F. MÜLL.	1	1		2			4	2	1					2			1																4		5		13		3	4	2	3	3	2	7	129
Vertigo pygmaea DRAP.	2	6		5	6	2	4	3	2			1		9			3	2	1	1		2	1			1	1						1	2	5				1						6
Vertigo antivertigo DRAP.	1																																															
Vertigo angustior JEFFREYS	1		2	2				1							1		4	1																															
Pupilla muscorum L.	1	1		1	1		4	4	1	2	4		2	7	4		4	1	1			219	3	6	2	19	1	7	3	6		1	2	2	8		31		9	8	5	2	5	4	3	24
Vallonia pulchella O. F. MÜLL.	1	5	1	10	6		7	5	1		1				1		1		1			2				3	1					1	1	1	2		11		16	2	3	3	2	2	5	15
Vallonia enniensis GREDLER	1			1	4		6	3	1						1		2																1	1						1						2
Vallonia costata O. F. MÜLL.	1							2			1			1			1									3	1		7				5		16		41		12	11	4	3	3		1	49
Punctum pygmaeum DRAP.																																	5	4	8		7		3	5	2	3	3	1		107
Vitrea crystallina O. F. MÜLL.																																					1										
Euconulus trochiformis MONT.		2		1			1																					1				1	1	1	9		16		8	4	4	1			28
Deroceras agreste L.	3	1							1				1	1												1	1	1							4		23		3	9	7	2	2	1	1	24
Trichia hispida L.	3		2		2		19	3	2		3	1	4	4					1	2												3	7	10	47		105		23	13	12	7	18	11	23	323
Hygrophil ubiquist species altogether	15	16	5	22	19	2	45	23	9	2	9	2	7	24	7	—	16	4	4	3	—	223	4	6	2	27	5	8	11	6	—	6	27	21	104	—	248	—	77	57	40	24	36	21	40	707
Columella edentula DRAP.																																					4		1	3		1	1			16
Pupilla sterri v. VOITH													1																			1		1											6
Clausilia dubia DRAP.					1		3																					1				2	7	2	16		26		9	9	5	1	6	1	5	71
Goniodiscus ruderatus STUDER							1																										1		1		5		1				1			7
Perpolita hammonis STRÖM																																	2	4	13		8		8	3	1		1			26
Fruticicola fruticum O. F. MÜLL.																																	2													
Perforatella bidens CHEMN.							2							2																																	
Arianta arbustorum L.	2	2			2	2	10		1		1			2	1											2		1		1		1	2		3		10		2	6		2	3	1	2	10
Inhabitant of the groves altogether	2	2	—	—	3	2	16	—	1	—	1	—	1	4	1	—	—	—	—	1	—	—	—	—	—	2	—	2	—	1	—	4	14	6	34	—	53	—	21	21	6	4	12	2	7	136
Abida frumentum DRAP.							1		1																							1	1		1	1	4									
Imparietula tridens O. F. MÜLL.				1	1		2	2	1		1			1	1		2					3		1	1	10	2	4	9	1	2	2	2	1	20		41		24	7	7	3	6	1	2	32
Helicella hungarica SOÓS ET H. WAGNER								5	2		2		14	3	2		3		2			12	2	3		3	5	2	2	4	8				7		13		4	2	1	2	1	1	1	3
Thermophilic species altogether	—	—	—	1	1	—	3	7	4	—	3	—	14	4	3	—	5	—	2	—	—	15	2	4	1	13	7	6	11	5	11	3	2	2	28	—	58	—	28	9	8	5	7	2	3	35
Vallonia tenuilabris AL. BRAUN	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	7	—	5	—	2	—	—	—	—	—	12
Mollusca exemplars altogether	35	38	15	54	39	6	120	59	21	6	24	4	34	40	15	—	24	5	6	4	—	239	6	11	3	45	12	16	22	12	11	13	48	30	185	—	396	—	136	96	63	38	61	28	55	944

On the climate-curve from above downwards the fifth and at the same time the lowermost climate type of the Würm 1—Würm 2 interstadial period was a 10 400 years long subarctic period. This cold and continental climate type with cold winters and normal summers was considerably chilled by the inland ice of the Würm 1 which in the summer thawed but it was yet rather thick. This climate was cold and arid, similar to that of the Würm 1 glacial period, although it was somewhat milder and the thawings in the summers produced tundra-like circumstances. All these correspond to the circumstances reproduced with the aid of the fauna of the subperiod III/1. This subperiod may be identified with this subarctic period.

On the climate-curve this subarctic period is followed by the Würm 1 glacial period. It lasted 11 400 years. The climate deduced from the fauna of the subperiod III/2 corresponds to the 6400 years long cold and arid continental part of the glacial period which followed the formation of the inland ice cover. The milder and humider climate of the subperiod III/3 may be identified with the part of the glacial period with an oceanic climate type. According to the calculations this period lasted 5000 years, during which yet dominated a climate with chill summers and normal winters which is characteristic for the original glacial climate type (cold oceanic).

On the climate curve follow thereafter the 7 different ice-free periods of the Riss-Würm interglacial period, 48 200 years long in all. This times has no traces in the fauna. Here is the question brought up in which degree could be transformed the overlying loess by the which vegetation of the interglacial period destructed by the climate change. The vegetation was a considerable one even in the glacialoceanic part of the Würm 1, from the fauna for this period mixed groves may be deducted. Supposing that the loess of the subperiod III/2 was sedimented already in the arid and cold continental time as indicated by the fauna, but this loess was sedimented on layers originated in milder and humider times, and this layers transformed the lower part of the loess. This supposition may solve the apparent contradiction between the fauna and the sedimentation processes. Accordingly the Riss-Würm interglacial period has no own sediments on the area of the profil investigated. The existence of this period is proved by the transformation of the lower part of the fourth loess layer.

Thereafter follows in the series of layers a pure loess, which may be the sediment of the Riss 2 period, according to its position. The glacial period Riss 2 lasted 10 800 years. This glacial period was followed by a 2000 years long subarctic and a 9800 years long antiglacial climate with warm summers and normal winters (warm continental climate type). According to Bacsák the inland ice of the Riss 2 period was melted by the warm summers at the end of the antiglacial period. Consequently, the glacial, loess-producing period of the Riss 2 lasted till the end of the antiglacial period.

On the upper part of the loess for the III/4 *Mollusca* subperiod a mild glacial climate was supposed by the author and in the lower sample the continental characteristic with relatively warm summers was also demonstrated. This subperiod corresponds therefore to the antiglacial times mentioned above. The subperiod III/5 as an arid, cold, continental time may be identified with the Riss 2 glacial period. The relatively short subglacial time following this

glacial period could not produce considerable change in the climate. Only a thin loess layer might be produced during this period. Consequently, it is not indicated sharply in the fauna.

The uppermost sample of the subperiod, however, has a somewhat transitory character. From the other samples it differs mainly in the considerably higher number of the inhabitants of groves. The only aquatic organism of the subperiod was found here too. This differences indicate more humidity which may be attributed to subarctic effects.

After all, the astronomic climate curve of MILANKOVICH and BACSÁK might be followed in this occasion too.

(To be continued)