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Examinations on faunal-history of the Hungarian holocene Mollusc fauna (Characterization of the succession phase)

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ABSTRACT: The results of phylogenetical, palaeoecological and biostratigraphical basic researches of regional value made by the help of malacofaunas which have infallible stratigraphic situations explored in the Hungarian mountain range with medium height and in young recess regions are represented by author in his paper. There could be traced four fauna periods in the region of the mountain range with medium height and three ones in the recess regions. They are defined by correlation (anthracotomical, palynological, vertebrate palaeontological, archeological and absolute chronolgoical data, as well as Central European malaco-zones) as biozone of regional value.

The Mollusc fauna acted as the main oecological indicator of the given territory for long in case of the Hungarian quarter stratigraphic examinations. Its cause is twofold. Firstly the malacological material is in contradiction to the vertebrate palaeoecological findings, can be found in great quantities. Secondly, the Hungarian quarter fauna is consist of species are present also in the fauna nowdays, in the majority of cases. The oecological demands of recent species are well-known partly on the authority of foreign scientists and recently on the basis of Hungarian malacologists. It is why that most of oecological data about the quarter formations were yielded by the examination of the Hungarian Mollusc fauna.

Nowdays it is clear for us that the Quarter Mollusc fauna is suitable not only for palaeocological reconstructions but it helps in the dissection of the Quarter sediments, too. It is mainly owing to Endre KROLOPP's activity. The results are summarized in his study written in 1983. This study and the more and more intensive Holocene investigations enabled us to make an attempt (FŰKÖH, 1990), on the basis of malacology, at the examination the history of the last ten thousand years with the help of the exposed faunas. At first however we have to form acquaintances with the history of development of the Hungarian Holocene fauna.

1. TERRITORY OF MEDIUM HIGH MOUNTAIN RANGES

The most suitable regions for the examinations of the Holocene terrestrial mollusc faunas are the karstic medium high mountain ranges in Hungary (Bakony, Bükk, Aggteleki-karszt). Numerous caves and rock shelters served as natural traps accumulating continously the fauna of the enviroment. The great quantity and large sum of species made possible the outlineing of the faunal succession.

1.1. Steppe fauna of the open areas

These Holocene cave faunal assemblages can be characterized excellently by KROLOPP's (1973) statement observing the disappearance of the typical cold Pleistocene climate marker species (Vallonia tenuilabris, Columella columella, Pupilla sterri) after the last cold peak of the glacial, followed by not new Holocene immigrant species, but ones already have been present in the fauna in a subordinate role, breaking forth due to the changes in dominance ratios. The changes in dominance relations are reflected well by the faunas of the Horvátihole, the Kőlyuk II.-cave, the Rejtek I.-rock shelter and the Muflon-cave yielding Early-Holocene assemblages. These faunas can be characterized by the dominance of species preferring an open - area enviroment. Beside the dominance of Vallonia costata which prefers open spaces of kastic shrub vegetation, presence

of rock-steppe species like Granaria frumentum, Chondrula tridens can be demonstrated. In other places - e.g. on the basis of the examination of Rejtek I.-rock shelter' s fauna - occur the species Chondrina clienta living at rocky areas and the xerotherm Cochlicopa lubricella as accessory elements.

The quantitative analysis of the dominance relations, within the faunal assemblages outlined above, shows a 30-80 % relative frequency of the open area preferring species (shrub vegetation, rock-steppe). The variability of 50 % is determined by local subassociations as well as microclimatic parameters.

1.2. Fauna of the closed forest formation

In sediments overlying the Early-Holocene strata, the composition of the fauna has been changed considerably. According to the characteristic faunal assemblages of Kőlyuk II.-cave, Muflon-cave, Rejtek I.-rock shelter, Csúnya-valley I. rock shelter the relative frequency values of species preferring open area decrease, not reaching the value 30 %. The number of individual' s ratio decreases in case of the hitherto dominant Vallonia costata. And predominate the members of the closed forest fauna: the species of the family Clausiliidae, like Orcula dolium, Helicodonta obvoluta, Achantinula aculeata, Acicula polita, Carychium minimum, Vallonia pulchella, Isognomostoma isognomostoma, Daudebardia rufa, Daudebardia brevipes etc.

Here we have to emphasize that in this succession phase the above mentioned description concerns to natural associations only, since this phase is equal with the Neolithic Age from the aspect of archeology, when we have to reckon with significant number of population, in the Carpathian-basin, so at certain places the anthropogeneus influence is not negligible. The effect of anthro - pogeneous activity on the fauna is a significant fauna-modifying factor. (The fauna of the Kőlyuk II.-cave from the sediment above the lower fire - place-layer, or the fauna of the Rejtek I.-rock shelter, second sediment - block, the so called neolithic level).

1.3. Fauna of the secondary forest-steppe formation

After the sediments containing the fauna of the closed forest vegetation we can find again strata with a fauna which is similar to that of the Early Holocene. In the fauna of the Nagyoldali-shaft and Baradla-cave located in the Aggtelek Karst territory; in the fauna of the calcareous tufa mine sediments at Mónosbél, in the Kajlabérc-cave travertine and lime mud deposits of the Szalajka-valley near Szilvásvárad in the Bükk-mountains; and in the fauna of the sediments of Kő-hole at Szentgál in the Bakony-mountains the ratio of those species which prefer open spaces increases again, and their relative frequency is surpassing the 30 % frequency limit. The increase in the number of species Granaria frumentum, Chondrula tridens, Pyramidula rupestris refers to the decreasing of the forest vegetation and to the spreading of the forest-steppe territories. In spite the increase of the steppe-elements' frequency, in contradiction to the faunal composition of the first succession phase the forest elements are dominating. In this phase, according to the archeological examinations, the anthropogeneous activity is remarkable. The agricultural work of the Bronze Age people had begun in the Carpathian-basin.

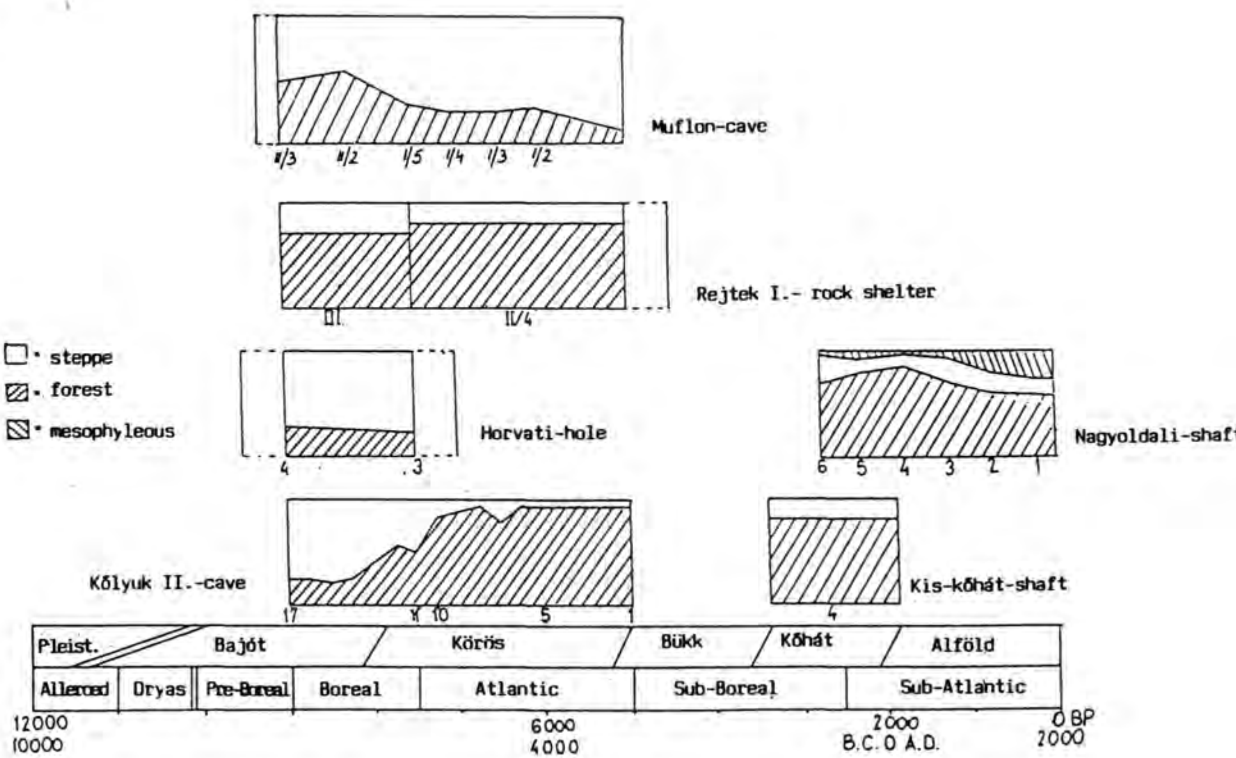
1.4. Development of the second phase closed forest fauna

We cand find here the latest sediments of the Holocene age, which Mollusc fauna is characterized by the closed forest vegetation again. The fauna, originating from the sediments of Kis-kőhát-shaft, Rigó-hole, Kő-lik-cave, Muflon-cave, Háromágú-cave are predominated by species which prefer humid, warm climate: Acicula polita, Vertigo pusilla, Perforatella incarnata, Isognomostoma isognomostoma, Clausilia pumila, Vestia turgida.

Beside the 80 % frequency of the forest species, we can state the complete lack of species preferring open-space vegetation (in natural associations). Only the presence of groove-forest species can be observed, like Aegopinella minor, Helicigona faustina, Helix pomatia.

In natural association the number of forest elements increase again, with predominance of species typical for humid, warm climate. E.g.: **Acicula polita** **Vertigo pusilla** **Carychium tridentatum** **Orcula dolium** The minimum of **Granaria frumentum**	The number of natural, original associations decrease. The anthropogenic transformation of the environment increases.
Beside the predominance of species of the closed forest also characteristic the species of open space and steppe, like: **Granaria frumentum** **Chondrula tridens** **Pyramidula rupestris** The frequency of steppe species does not reach **30 %**.	The closed deciduous forest remains as dominant association, but - as compared the preceding period - the ratio of open spaces increases. At some places the people of Bronze Age change significantly the natural vegetation by growing grain crops.
The faunal assemblage changes significantly. Species preferring open spaces and steppe subordinated. In natural associations the members of closed forest fauna is predominant: **Clausiliidae** **Truncatellina claustralis** **Orcula dolium** **Vallonia pulchella** **Oxychilus orientalis** **Daudebardia rufa** **Vitrea diaphana** It is the minimum of **Vallonia costata.**	Development of closed deciduous forests. Open spaces and rock steppes decrease. Bush vegetation is changed by forest. Palynological examinations indicate the predominance of deciduous trees: **Quercus** **Alnus** **Fraxinus** **Salix** **Corylus** First signs of anthropogenic influence.
Disappearance of Pleistocene species: **Pupilla sterri** **Vallonia tenuilabris** Relative frequency of species preferring open space and steppe is around **30-50 %**: **Granaria frumentum** **Cochlicopa lubricella** **Chondrina clienta** **Chondrula tridens** Predominant: **V a l l o n i a c o s t a t a !**	*The Late Pleistocene forest zones are* substituted by more open karstic bush forests. Palynological investigations indicate the frequency of **Gramineae** wich refers to rock-steppe vegetation.

Temporal progress of the succession



Chronological position of cave Mollusc faunas of medium high mountain ranges plotted against the vertebrate and pollen zones

2. FRESH-WATER FAUNA OF THE SUBSIDED ZONES

In fresh-water faunas the successional processes are accomplished more separable from the enviroment. The essential changes set in at that time when the quality of water (river, lake) changes (e.g. the first and second phase at Sárrét, Fejér county) or when in consequence of the oscillation of the water-level we can observe the signs of periodical palaudal phase or dessication in the sediment (e.g. Fertő-lake: Fertőrákos, profile I., Lesence: fauna of the Nádas-lake).

2.1. River phase

Generally we can conclude that the succession of the Hungarian fresh-water fauna starts with the appearance of species living in rivers (Lithoglyphus naticoides), and beside them characteristic species is the Valvata piscinalis which requires prmanent water quality. After the disappearance of Lithoglyphus naticoides the dominance of Valvata piscinalis can be observed in the sediment. Valvata pulchella can be found mainly in the fluvial sediments of the older layers (e.g. Jászság, Kardoskút: Fehér-lake).

This phase is the beginning of lime mud formation, which sediment with its peculiar fauna is illustrative of the lacustrian successions.

2.2. Lacustrian period

The beginning of the so called real lacustrian period is the formation of lime mud at the investigated territories. This phenomenon can be observed at Transdanubia (Fejér county, Sárrét, Lesence: Nádas-lake) as well as on the Great Plain (Danube - Tisza Interfluve) and in the Nyírség.

This phase can be characterized by the frequency of Bithynia tentaculata, Gyraulus albus, and Lymnaea auricularia. The relatively deeper water of lakes is optimal for these species.

2.3. Fen and peat formation

Beside the terrestrial species this type of sediment can be characterized by the presence of those species which are less sensitive to the chemical reaction, oxygen content, and temperature of the water: Anisus spirorbis and Physa fontinalis (can live in saliferous places), Lymnaea palustris (can live in all type of water), Lymnaea truncatula (can live in wet fields, too).

This type of sediment contains, mainly in the initial phase, the Bithynia leachi which is the vicarious species of Bythinia tentaculata, the characteristic species of the previous phase. Its appearance is connected with the cange of temperature (cooling off). The species Valvata cristata and Gyraulus crista appear in large numbers. Rare, but significant the north-west spreading Gyraulus riparius. Its role in Hungarian fresh-water Mollusc fauna will be mentioned in a farther chapter.

3. COMPARING OF THE HUNGARIAN HOLOCENE MOLLUSC FAUNA SUCCESSION WITH FAUNAL SUCCESSIONS OF OTHER TERRITORIES

During the investigation of the Mollusc fauna of Hungarian medium high mountain ranges we can consume the evolutionary data of the Holocene Mollusc fauna of Czech and Slovakian Republich the best. In Central-Europe malacologists use those oecological categories which writing up thanked to Lozek' s activity. It is why the published data can be used up well to out - line an Europaean evolutionary process in the different countries as well as in Hungary.

Czech and Slovakian Republic

In the Czech and Slovakian Republich, but mainly in Slovakia started a noteworthy faunal development on the Pleistocene-Holocene boundary. According to LOŽEK (1965) 33,3 % of the country's Holocene fauna lived at the end of the Pleistocene. During the Holocene there was remarkable enrichment from the point of view of species. The increase in the number of species was 9,6 % in the Pre-Boreal phase.

Fen and peat formation Euryoek species. Typical swamp fauna. Appearanche of water-side and terrestrial species on the periodically dessicated territories. This phase can be characterized by the presence of **Bithynia leachi** and **G y r a u l u s r i p a r i u s** The latter has important chronological value.	According to the local circumstances, formation of peat and mould in different thickness (Sárrét, Fertő-lake, Danube - Tisza Interfluve, Nyirség). Wet, periodically watery fields.
Lacustrian period Final disappearance of reophylous species. **Valvata piscinalis** can be found at the beginning of the phase. The sediment is characterized by the presence of xerotherm species, like **Bithynia tentaculata** **Gyraulus albus** The relative frequency of **Bithynia tentaculata** decreases significantly at the end of the phase. Characteristic feature, zoogeographically, is the increase of **Holarctic** species.	Typical sediment is the lime mud (Sárrét, Balatonrderics, Danube - Tisza Interfluve, Nyirség). Higher plants apper only in the second half of the phase.
Fluvial phase Characteristic species are **Lithoglyphus naticoides** **Valvata piscinalis** **Valvata pulchella** Zoogeographically it can be characterized by the frequency of **Palearctic** elements.	Gravel, fine grained sand or rarely clay (Sárrét, Vörös-swamp in the Danube-valley)

Temporal progress of the succession

The most significant change of the faunal succession can be observed at the time of Boreal phase, the increase in number of species was 29,9 %. Its reason is, that the faunistic effect of climate changing passed off between the Pleistocene - Holocene periods can be perceptibled at that time, at first. Further increases in number of species were: the Atlantic 15,8 %, the Sub-Boreal 2,8 %, the Sub-Atlantic 7,3 %. This form of faunal development made it possible that malacologists could improve dismembering of the Holocene Age by setting up malaco - zones with help of the appearance of new species in certain phases of this period (HORACEK - LOŽEK 1988). Beside climate marker species have great importance of faunal examination results - like in case of dismembering of the Hungarian Holocene fauna - forming the basis of relative frequency values. As a result of these examinations we known the evolution of the Czech and Slovakian Holocene fauna. According to LOŽEK (1982) the process of this evolutionary progress is the next:

1. Species preferring cold climate are forced back (Columella columella, Vallonia tenuilabris, Vertigo genesii) and appear those species which prefer open vegetation or steppe territories and xerotherm species may be also present (e.g. Chondrula tridens, Helicopsis striata, Pupilla muscorum, Vallonia costata, Truncatellina cylindrica, Cochlicopa lubricella, Granaria frumentum, Aegopinella minor).

2. According to LOZEK's opinion this phase in the richest in species. We can find the species of the previous group at that time, but the forest elements become core and more frequent, like Acicula polita, Acanthinula aculeata, Ena montana, Ruthenica filograna, Isognomostoma isognomostoma, Orcula doliolum, Euomphalia strigella, Bradybaena fruticum. This phase is the maximum of Vallonia costata. (It have to be mentioned here, that the faunal evolution divided into two phases by LOZEK is equal with the first succession phase of faunas of the Hungarian medium high mountain ranges).

3. This phase is can be characterized by partly the maximal development of forest associations partly forging ahead the fauna preferring open-area. The phase can be divided into two sub-phases.

3/a. The most characterizing attribute of the first sub-phase is the entiere decrease of relative frequency of Vallonia costata. Which is more this species disappears in certain cases. Other characteristic feature is the increasing of the frequency of Laciniaria biplicata, and high percentage of Carychium tridentatum.

3/b. This sub-phase is the secondary appearance of open-area preferring species.

The frequency of Chondrula tridens, Granaria frumentum, Truncatellina cylindrica, Vallonia sp. increases on limestone territories. This secondary steppe-formation is in close connection with the people of Neolithic Age. These two sub-phases of LOZEK's third phase can be paralleled with the second succession period of the Atlantic, and with formation of the closed forest fauna, according to the examinations of the Hungarian medium high mountain ranges.

4. The main events of this phase are the improverishment of the forest fauna and the development of fauna liable to anthropogeneous effects on the culture areas. The number of species preffering open areas increases in the natural associations (Granaria frumentum, Vallonia pulchella, Chondrina clienta, Aegopinella minor). Appeares firstly the Zebrina detrina then the Monacha cartusiana, and the Helicella obvia in the culture areas. The stratigraphical ranging of the above mentioned faunal phases are next: first phase - Pre-Boreal and Boreal, second phase - Atlantic, third phase - Epi-Atlantic, fourth phase - Sub-Boreal, Sub-Atlantic. The previously mentioned divergences must be solved by canceling LOŽEK's Epi-Atlantic phase.

Poland

Similar faunal assemblages are mentioned from different territories of Poland by ALEXANDROWICZ) ALEXANDROWICZ - NADACHOWSKI - RYDLEWSKY - VALDE-NOVAK - WOLOSZYN 1985). Characterizing the certain Holocene climatic periods he refers to his observation that the individual frequency of Vallonia costata is constant in the Early Holocene sediments. According to him this is equal with the Boreal phase.

The frequency of forest species is the characteristic feature of the Atlantic, like Acicula polita, Orcula doliolum, Aegopinella pura, Vitrea transsilvanica, Ruthenica filograna, Isognomostoma isognomostoma. About LOZEK's Epi-Atlantic he says that this phase can be characterized by the 70 % frequency of Ruthenica filograna and Isognomostoma isognomostoma. The fauna of the Late-Holocene has changed as the result of anthropogeneus intervention. Xerotherm species forced on limestone territories (Pyramidula rupestris, Pupilla sterri, Truncatellina cylindrica).

Germany

The Early-Holocene (Post-Glacial) fauna of Germany is outlined by Dehm (1976) on the basis of fifty localities. The uniformity of faunas is shown by the permanent occurrence of Discus ruderatus. The collective characteristic qualiti of the different faunas, beside the Discus ruderatus, is that we can find species which are present in those Hungarian sediments which were formed during the Pleistocene - Holocene boundary: Granaria frumentum, Orcula doliolum, Chondrula tridens, Oxychilus depressus. The German Holocene is divided into three periods by Dehm. First period is the Boreal (early warm phase). The climate was warmer and more arid than today.

The presence of hazel and early mixed oaken forests were characteristic for the vegetation. Second period is the Atlantic / middle warm phase. The climate was humid and warmer with 2-3 C^0 than nowdays. Mixed oak tree forest was the typical vegetation. Third perind is the Sub-Boreal (late warm phase). The climate was more arid than today. The mixed oak forests were changed by beeches in this period.

Also well-known from German data - on the basis of malacological examinations of archeological findsites - that after the Pleistocene increases the ratio of species preferring open spaces, during the Boreal. And this ratio decreases in the Middle-Holocene. The Pleistocne-Holocene transitional fauna is characterized with the general presence of Discus ruderatus, by Rähle.

LOŽEK' s activity have exerciesed great influence on the method of the above mentioned investigations. The transitional Pleistocene-Holocene fauna was described as "ruderatus fauna" by him. According to the faunal analysises this species was constant element to the north and to the west of Hungary. The occurence of Discus ruderatus was sporadic in Hungary. It is why not used for the characterzation of the Hungarian Early-Holocene faunal phase. The only place where we can observe the consequent presence of Discus ruderatus is the Early-Holocene sediments of Kőlyuk II.-cave. which is more, the ruderatus/rotundatus change, mentioned by RAHLE (1983), is demonstrable here. Late-Holocene sediments do not contain this species. We have sporadec data from the deposits of the next localities: Rejtek I.-rock shelter III. block, Muflon-cave, Csúnya-valley rock shelters I. and III. According to me, there is no or have not been uncorvered yet sediments containing similar faunal assemblages on the territory of the Hungarian medium high mountain ranges.

4. MALACOSTRATIGRAPHY OF THE HUNGARIAN HOLOCENE FORMATIONS

We have got acquainted with successional progresses of the Holocene faunas of the medium high mountain ranges and subsided zones. There is an opprtunit presents itself to use this progress for the concrete reconstruction of the events of the Holocene Age, and for raising these phases of development to the level of biostratigraphy with help of partly delimitation of the succession's chronological order, partly with description of characteristic associations. As it was mentioned in the introductory chapter KROLOPP, (1983) proved that the Pleistocene Mollusc fauna is suitable for it. Dissection of the Hungarian Holocene were performed by the data of pollen and vertebrate examinations untill this time. In the Czech and Slovakian Republich as a result of LOZEK's activity, the knowledge of the Holocene Mollusc fauna enabled marking of chronozones.

This dissertation is the first attempt to dismember the Hungarian Holocene formations on the basis of the basis of the Mollusc fauna of the sediments according to the data are available and with help of the performed correlations.

Malacostratygraphy can be considered equivalent to vertebrate and pollen biozones in such way.

Biostratigraphical ranging is determined by the dominance ratio and the general aspect of the faina in all cases, and the marker species can be used for corrections within the certain faunal phases, only. Since the faunal phases belong concretely to the fauna of each locality's sequence, so in the cause of applicability on wider domains their generalization were necessary in order to the biostratigraphical categories not to be based on merely the successions disregarded from the contrete taxon composition of the locality. This work can be done with help of the correlation of the results of the Hungarian Holocene examinations and with comparing with the results of the foreign malacological researches.

4.1. Biostratigraphical problems of the Hungarian Holocene Mollusc fauna

The outlined fauna history and succession progress make us possible to attempt biostratigraphical ranging of the explored Holocene formations. Beside the results of the Czechoslovakian, Polish and German Holocene faunal examinations biostratigraphical ranging is made possible by the formerly known succession phases (4th chapter), by the vertebrate paleontological data suitable for correlation, by the results of paleobotanical researches and by the issues of radiometric dating.

Hereinafter I expound the ranging of terrestrial fauna of the medium high mountain ranges. I have to add here, that I tried to content to the description of marker species where it was possible. But because of the above mentioned feature of the faunal evolution I had to take the faunas for my basis first of all. So, the described biozones can be explained as Oppel-zones, too.

Vallonia costata zone

It is characterized by the final disappearance of the Pleistocene elements (lower boundary). And species preferring open space and steppe become predominant with dominance of 30 - 50 %. This zone is also the Pleistocene - Holocene boundary because of the disappearance of Pleistocene cold climate preferring species, like Pupilla sterri, Vallonia costata, Columella columella. Beside the dominancy of Vallonia costata the sediment is characterized by the presence of Granaria frumentum, Cochlicopa lubrica, Chondrula tridens. The upper boundary of its zone is the minimum of Vallonia costata, (0,5 %).

Its stratotype is: Muflon-cave, I. profile 6 - 9 samples, II. profile 2 - 3 samples. The transition between the Pleistocene and Holocene can be registered excellently here.

Other localities are: Kőlyuk II.-cave, 12 - 17 samples, Rejtek I.-rock shelter III. block, Csúnya-valley I.-rock shelter 2. sample, Horváti-hole 3. - 4. samples.

II. Clausiliidae zone

Development of closed forest fauna. Its characteristic feature is the dominancy of the members of Clausiliidae, Zonitidae and Limacidae families (Clausilia cruciata, Lacinaria plicata, Ruthenica filograna, Cochlodina, Cochlodina orthostoma etc.). The species of Clausiliidae family can be found in highest frequency here. The lower boundary of this zone are the minimal occurrence of Vallonia costata (0,5 %), and the subordination of species preferring open spaces and steppe (10 - 15 % frequency). The upper boundary is the appearance of species preferring steppe, again.

Its stratotype is: Kőlyuk II.-cave 8. - 10. layers. The lower boundary of the zone is taken shape sharply in the row of samples. Sediments not earlier than the 8th semple may show anthropogeneous interference.

Other localities are: Kőlyuk II.-cave 1.-7. layers, Rejtek I.-rock shelter II. block, Muflon-cave I. profile 2.-5. samples, the sediments of Háromágú-cave, Nagyoldali-shaft 4.-5. samples, Baradla-cave: sediments of Ossuary-hall.

III. Granaria frumentum zone

We can observe newly the occurrence of species preferring open spaces and steppe beside the dominance of closed forest fauna, in the sediments (Vallonia costata, Granaria frumentum, Aegopinella minor and sometimes Chondrula tridens. Their relative frequency is around 30 %. The lower boundary of this zone is the renewed appearance of Granaria frumentum in the fauna. Its upper boundary is the minimum of steppe fauna.

The stratotype can be found at: Nagyoldali-shaft, 6. sample. At the upper boundary of its zone we can observe the sudden decrease of steppe species) from 30 % to 15 %).

Other localities are: Szilvásvárad: Szalajka-valley 3.-4. samples, Mónosbél: calcareous tufa -mine, Kajla-bérc - cave 3. sample, Petényi-cave H3 sample.

IV. Helicigona faustina zone

The dominance of forest species is around 85 - 90 %, again. The composition of this fauna is similar to Clausiliidae zone s. Characteristic species are Laciniaria biplicata, Laciniaria plicata, Clausilia pumila, Ruthenica filograna. Here appears Helicigona faustina in the sediments for the first time. This species later will be general in recent faunas. The lower boundary of the zone is the change in dominance ratios of the fauna. (The relative frequency of forest species is 85 - 90 %. (The upper boundary is the development of the recent fauna.

Its stratotype is: Kis-Kőháti-shaft 4. sample. The sample can be correlated well with vertebrate stratigraphy.

Other localities are: Rigó-hole, Szentgál: the sediments of Kő-lik-cave, Nagyoldali-shaft 1.-3. samples, Szilvásvárad: Szalajka-valley 1.-3a samples, Muflon-cave I. profile 1. sample, Csúnya-valley the sediments of the third rock shelter, Kajla-bérc-cave 1.-2. samples.

According to our knowledge there is no way for expanded correlation examinations in ranging the Mollusc fauna of Hungarian subsided zones like in case of the fauna of the medium high mountain ranges, but the characteristic species of the succession afford possibility for the description of biozones.

I. Lithoglyphus naticoides - Valvata piscinalis zone

The name of the zone is given by the two characteristic species of it. Among them we have to emphasize Valvata piscinalis in view of its relative frequency (80-85 %). The lower boundary of the zone is the appearance of fauna free from Pleistocene species. The upper boundary is the strong decreasing or accidental disappearing of Valvata piscinalis (Sárrét Sl.II)B-L sample.

Its stratotype is: Fejér county, Sárszentmihály I. (A-I.) C-2 samples.

II. Gyraulus albus - Bithynia tentaculata zone

The zone is named after the characteristic species of the fauna. The dominance of Bithynia tentaculata decreases significantly, or sometimes disappeares from the fauna at the upper boundary of the zone. Among the faunas of the examined territories the relative frequency of Gyraulus albus is 55 - 60 % Sárrét Sl. II./A - 3 - II./B - 2 samples III. - 1 - III. - 3.

Stratotype: Fejér-county, Sárrét, Sárszentmihály, I. locality, II./A - 1 - III.-2 samples.

III. Bithynia leachi - Gyraulus riparius zone

Gyraulus riparius appears in these sediment s fauna at first time, here. And disappeares again at the upper boundary of the zone. Bithynia leachi reaches its maximum here, replacing the previous dominant species, the Bithynia tentaculata.

Its stratotype is: Fejér-county, Sárrét, Sárszentmihály, I. III - 3 - IV/B - 2 samples.

Here can be found the only typical level marker species, the Cyraulus riparius. This species does not occur in Hungary now. Previously it was known from the end of the Pleistocene (KROLOPP, E. 1973). Today the species is also quite rare even in Europe. Its occurrence was reported by Glöer, P. - Meier-brook, C. - Ostermann, O. (1980). According to LOŽEK (1965) this species can be found in Czechoslovakia, too.

After finding this species in Fejér-county at Sárrét, it was also found during the later examinations in the sediments of Kolon-lake, Körösladány: Brickworks, Lesence: Nádas-lake (FÜKÖH, L. 1989b). But it is more important than the growing occurences, that its appearance is characteristic for the final period of the lacustrian fauna succession and for fen formation in all cases. The new occurrence of Cyraulus riparius in Hungary - after the Post-Glacial - refers to the changed climate. It is shown by the change of Bithynia tentaculata - Bithynia leachi, too.

3.2. Correlation of the Hungarian and Central-European malaco-zones

Quaternary malacological ranging of Central-Europe was based on Czechoslovakian data, primarily (HORACEK, I. - LOŽEK, V. 1988).

Beside the malacological data the assemblage-zones worked out by the use of results of vertebrate palaeontological data promise good basis for comparison for the Hungarian malacostratigraphy.

In his study, cited above, LOŽEK ranges the Holocene in seven malaco-zones.

C 1 zone

Beside the dominance of Discus ruderatus, Bradybaena fruticum, Euomphalia strigella, characteristic species are Chondrula tridens, Pupilla muscorum and Vallonia costata. Characteristic feature is the decreasing of Pleistocene species. This zone can be date Pre-Boreal.

C 2 zone

Its fauna is similar to the previous one but begins the immigration of forest species and we can observe the expansion of Granaria frumentum. Steppe species are characteristic. The zone can be date Boreal.

D zone

Dominance of forest species (Orcula dolium, Ena montana, Cochlodina orthostoma, Macrogastra, Laciniaria, Bulgarica, Ruthenica, D. perspectivus, Daudebardia, with decreasing of Helicopsis striata-Chondrula tridens association. Decreases the frequency of Vallonia costata, and increases the individual number ratio of Carychium tridentatum. The zone can be date Atlantic.

E zone

This is the optimum of forest species, and the maximum of Carychium tridentatum. Characteristic feature is the increasing of Laciniaria biplicata and the total disappearance of Vallonia costata. This is the first appearance of the so called modern species, like Oxychilus inopinatus, Cepaea vindobonensis. The zone is dated Epi - Atlantic by LOŽEK.

F 1 zone

Characteristic is the decreasing of forest species. Newly appearance and spreading of species preffering open space can be observed. General of the presence of Cepaea vindobonensis and Oxychilus inopinatus. The zone can be date Sub-Boreal.

F 2 zone

Immigration of modern species: Zebrina detrita, Cecilioides acicula. Frequency of Laciniaria biplicata, Discus rotundatus, Perforatella incarnata is increasing. The zone can be date Sub-Atlantic.

F 3 zone

Strong spreading of modern species (Helicella obvia, Monacha cartusiana, Oxychilus draparnaudi etc). This is the maximum of Laciniaria biplicata. The zone can be date Sub-Recent.

The correlation with the Hungarian malaco-zones is easier if we leave the Epi-Atlantic and Sub-Recent from LOŽEK' s chronostratigraphical ranging, as it was done by LOŽEK in a table of his study (HORACEK, I. - LOŽEK, V. 1988). In this way the E zone placed in Epi-Atlantic have to be counted partly in the Atlantic, partly in the Sub-Boreal. Sub-Recent, according to the Hungarian practice can be considered to Recent.

4.3. Correlation of Mollusc fauna succession with the Hungarian data

Beside the palynological data the results of vertebrate biostratigraphical examinations give excellent possibility to correlate the previously outlined succession progress. It is because the investigation of these two faunas performed by the ramains from the same sediments in case of majority of the examined localities. It is why the similarities and the accidental differences between the two faunas help well this investigation.

Holocene vertebrate faunas of the Hungarian cave sediments was examined by KORDOS, L. (1981). In his study KORDOS by reason of the vertebrate faunas of the exposed sediments confirmed with new faunal phases which were set up by KRETZOI (1965, 1969) and established a new faunal phase. According to his classification the cave-faunas of this study can be placed into the following vertebrate phases:

Bajót - period

Characteristic feature of its fauna is the high percentage of Pleistocene species. But there are present undoubtedly the later spreading species, too. Its upper boundary is the domonance of the newly appeared and spreading species over the Pleistocene species.

Its localities are: Peténvi-cave P_r H_v layers, Rejtek I.-rock shelter III. block.

Körös - period

Pleistocene species have secondary importance. Characteristic is the sudden expansion of certain species.

Its localities are: Baradla-cave: the sediments of the Ossuary-hall, Peténvi-cave IV. layer, Rejtek I.-rock shelter, II. block 4.-5. samples, sediments of Kőlyuk II.-cave.

Bükk - period

The minority of Pleistocene species had remained and were limited among close territories. The fauna became modern, undoubtedly.

Its localities are: Peténvi-cave H_m layer, Rejtek I.-rock shelter II. block 2. sample.

Kőhát - period

Its lower boundary is the final disappearance or drawing back of the Pleistocene species. The fauna is similar to the Recent. The only difference can be seen in dominance ratios.

Its localities are: Kis-kőháti-shaft 4. sample, Petényi-cave H_h layer, Rejtek I.-rock shelter II. block 1. sample, Rigó-hole 9.-6. samples.

Alföld - period

The fauna is influenced by the anthropogeneous activity. Characteristic feature is the increasing ratio of species preferring anthropogeneus enviroment.

Its localities are: Nagy-oldali - shaft 5.-0. samples, Petényi-cave ^{H}I.-II. layers, Rigó-hole 5.-1. samples.

According to this stratigraphical ranging it is clear that it is inaccordance essentially with the malacostratigraphical one. It can be stated, that these two methods complete each other excellently, it why the complex malacological and vertebrate palaeontological examinations of the sediments may be successful in description of Holocene phases.

Beside the correlation with vertebrate faunal periods the other possibility is the palynological and anthracotomical comparision.
Data of the examined localities are the following:

Rejtek I.-rock shelter:

According to the anthracotomical examinations in the earlier part of the sediments of the third block Larix-Picea and Pinus are the dominant, while the upper layers contain Quercus, Tilia, Fraxinus, Ulmus, Salix, Acer, Carpinus, Fagus, Corylus among the deciduous forest species. According to the vertebrate biostratigraphical ranging the age of the sediments is Bajót-period and the beginning of the Körös-period.

Kőlyuk II.-cave:

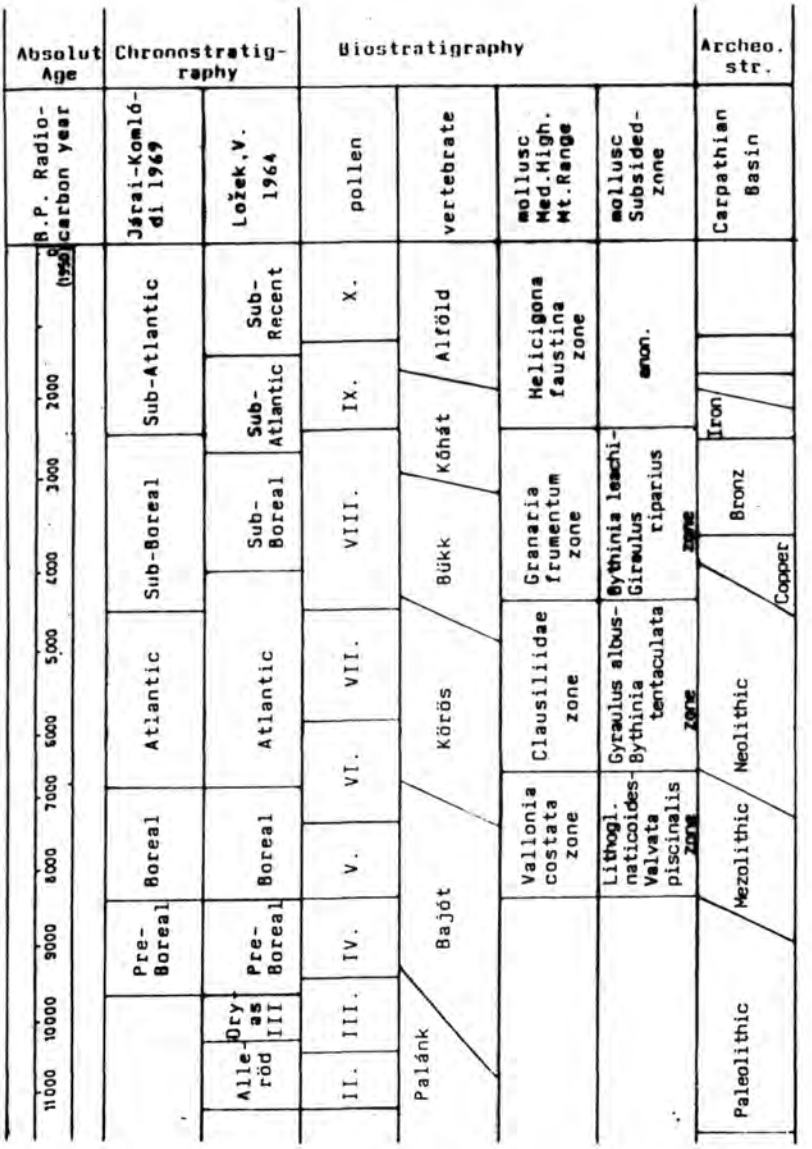
According to the results of palynological examinations in samples from 17.- to 9., namely under the layers containig neolithic culture, firstly the Coniferae (Pinus silvestris) are the dominant, after it occur the pollens of deciduous trees (Betula, Tilia) and Graminae. In samples from 8. to 1. Coniferae are subordinate and more and more frequent the occurence of deciduous trees (Tilia, Fraxinus, Betula, Alnus, Salix, Quercus, Corylus). Here is apparent the change of coniferous and deciduous vegetation. This process of changing has been probable in the Mollusc fauna, too.

On the basis of correlation presented itself the comparision of vertebrate and palynological data the first half of Bajót-period is equal to pine-birch (Pre-Boreal - Boreal) phase, while the end of Bajót-period and the whole Körös-period is equal to hazel-oak (Boreal - Atlantic) phase.

At last the third possibility for correlation may be performed by the use of archeological findings founded in the sediments of the examined caves, where these archeological findings, the malacological and vertebrate material occur together. Such is the Bükk culture, at the end of Neolithic Age (appr. 2800 - 3000 B.C., KALICZ, N. 1974). This culture s undisturbed layers were exposed with help of L. Kordos in Baradla-cave and in Kőlyuk II.-cave. The sediment s vertebrate-faunistic and malacological characters present the same picture. According to the vertebrate stratigraphy the fauna signs the Körös-period, the Atlantic and the end of the Neolithic Age. This ranging is consistant with the results of the malacological examinations, which showed faunal composition concordant with the atlantic phase.

Further connections are: Rejtek I.-rock shelter II. block 4. phase - Neolithic Age - Atlantic phase, Nagy-oldali-shaft - Late Bronze Age - Sub-Boreal phase, Rigó-hole - Roman Age - Sub-Atlantic phase, Szentgál: Kőlyuk-cave - Bronze Age - Sub-Boreal phase.

Synoptic table of stratigraphical ranging of the Holocene Age



4.4. Correlation of malaco-zones with radiometric data

Since I have discussed the correlation possibilities of the Hungarian and foreign Holocene examinations particularly in the previous chapters, here I introduce to the hitherto known data of radiometric dating. For the sake of generalization of biostratigraphical ranging I also use up the data of foreign territories, to confirm in such way the insertation in the results of investigation of the Hungarian Mollusc fauna in due course of the European researches.

1. According to the examinations the basin sediments of Sárrét (Fejér-county) the age of the lime mud deposits is 8200±150 B.P.
2. The lime mud of Danube - Tisza Interfluve is aged 8500±300 B.P. (Verbal communication of Pál SÜMEGI).
3. The age of lime mud explored on the territory of Nyírség is 8000 200 BP.
4. The age of lower fireplace-strata of Kőlyuk II.-cave in Bükk-Mountains is 5895±60 B.P.
5. The sediments of Ossuary-hall in Baradla-cave is aged 3095±60 B.P. According to the derivatographical and palaeobiogeochemical analysises the fauna of the Bükk-culture strata originating also from Baradla-cave is aged 6516±250 B.P.
6. On the basis of comparable faunal-examinations is known that the age of the so called "ruderatus-fauna" is 7750±130 B.P. (ALEXANDROWICZ, S.W. 1984). This the same with steppe fauna preceding the climate-optimum marker closed forest fauna, in Hungary.
7. According to German malacostratigraphical examinations (RAHLE, W. 1983) the age of faunal phase which can be characterized with the dominance of open space preferring species is 8230±40 B.P.
8. According to Alexandrowicz s investigations the age of the Late-Holocene sediments around Gracow is 2475±60 B.P. (This is the beginning of Sub-Atlantic phase.)

Chronological ranging of the Holocene medium high mountain range, terrestrial malaco-zones

I.	Vallonia costata Zone	8200 - 6500 B.P.
II.	Clausiliidae Zone	6500 - 4500 B.P.
III.	Granaria frumentum Zone	4500 - 2500 B.P.
IV.	Helicigona faustina Zone	2500 - 0 B.P.

Chronological ranging of the Holocene malaco-zones of the subsided territories.

I.	Lithoglyphus naticoides - Valvata piscinalis Zone	8200 - 6500 B.P.
II.	Gyraulus albus -Bithynia tentaculata Zone	6500 - 4500 B.P.
III.	Bithynia leachi Gyarulus crista Zone	4500 - 2500 B.P.

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