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F. NĚMEJC:

Palaeobotanical researches in the travertine sediments of Vyšní and Nižní Ružbachy at Podolinec (Slovakia) and some additional notes to my studies about the travertines of the Northern Slovakia.

I. *Travertines of Ružbachy.* (Fig. 1.)

During the last three years, I paid special attention to the fossil floras of the very complicated system of travertine deposits in the valley of the brook named Rika, as well as of some its affluents, the waters of which unite at Nižní Ružbachy (a small village north from Podolinec) with the river of Poprad. All the calcarous sinters fossile, as well as recent ones, are chiefly confined to the surroundings of Vyšní Ružbachy, which is a small village with bathing place cca 2½ km north-north-west from Nižní Ružbachy.

Very soon I was able to verify to kinds of travertine rocks, which are the chief components of the whole travertine system, but which generally do not build any travertine bed at the same time, composing separately each own special masses or cascades. Only in one case I have seen both those rock types superposed one upon the other. The chief characters of those travertine rocks may be stated as follows. One of them is a very fragile calcarous sinter with numerous plant incrustations, chiefly fibrous algae, very badly preserved mosses and many banks of pure liverwort incrustations, which may be identified most probably as *Pellia Fabroniana.* The colours of such sinters are yellowish till brown yellowish, generally of darker shades, than the second rock type. Very often we may see at the sections through such masses of fragile travertines some patches or beds of rolled stones. All the just mentioned facts point, that these fragile sinters have their origin chiefly in biochemical sedimentation of limestone from waters with relatively low percentage of dissolved $CaCO_3$. The second type of rock building the travertines of Ružbachy is a kind of rather hard, but at the same time also very porous limestone. The colours of it are rather light, whittish till brilliant white, or yellowish till yellow brownish.

From the palaeobotanical point of view, they contain no of such organic structures as mentioned above (algae, mosses or liverworts), or the respective structures are very indistinct and indeterminable at first sight. Especially we are missing here entirely banks of Pellia incrustations. The pores of this rock are very often not caused by vegetation remains, but chiefly by gas bubbles or as hollows arisen in another way without any biological action. Pores of such character I never have stated in the first kind of sinters. It follows therefore, that the biological sedimentation of limestone in this second kind of travertines was of less importance and that a far greater part of their substance is consequent of an anorganic precipitation of $CaCO_3$ from waters with a very high percentage of $CoCO_3$ and CO_2, as we may see this process in the warm recent springs of the bathing place.

a) *The system of fragile limestone sinters.*

The very fragile sinters are deposed chiefly only at the lowest points of the valley of Rika-brook between Vyšní and Nižní Ružbachy. Only in one place I have stated a small occurrence of such fragile sinters at a greater hight, superposed on the second type of sinters, which will be treated briefly sub b), as there are no plantimpressions to be found. As to the great occurrence of the fragile travertines in the valley between Vyšní and Nižní Ružbachy, I suppose them to be of holocene age, at least all those beds, from which I was able to collect plant remains. Their holocene age seems to be sufficiently prooved, first by their position in the lowest part of the valley and second by the shells of molluscs studied just now by J. Petrbok, who recognised there only very young forms and associations. Finally it seems very doubtful, that such fragile limestones could resist just at the bottom of the valley to the strong erosive action of this mountainous region longer, than just during the last periods i. e. holocene. But, as we shall see after examining the associations of plant remains at various places of this travertine system, they are not everywhere of the same age.

The fragile travertine rocks compose two great masses filling up the lowest part of the Rika valley, but being at present cut through by the brook and forming thus deep ravines along the Rika brook.

The first mass of fragile sinters is deposed a short distance from the mouth of the Rika brook. A part of the village Nižní Ružbachy is built upon them, and they reach the valley up till cca. 800 m. Places, from where I gained fossils, are traced in the accompaniing map by the initials A, B, C, D.

A — is an abandoned small travertine quarry, just at the road leading from Vyšní to Nižní Ružbachy. The travertines are here interstratified by small zones of rolled stones; we may see here at the same time incrustations of mosses, algae and liverworts (Pellia), like in all other places (B, C and D). In the upper zones of A I stated an association of plant remains with spruce and beech:

Acer pseudoplatanus — leaves,
Tilia cordata — leaves and fruits,
Cornus sanguinea — leaves,
Fagus silvatica — leaves,
Picea excelsa — leaves and fruits,
Corylus avellana — leaves,
Petasites albus — leaves,
Fraxinus excelsior — leaves,
Ulmus sp. — leaves.

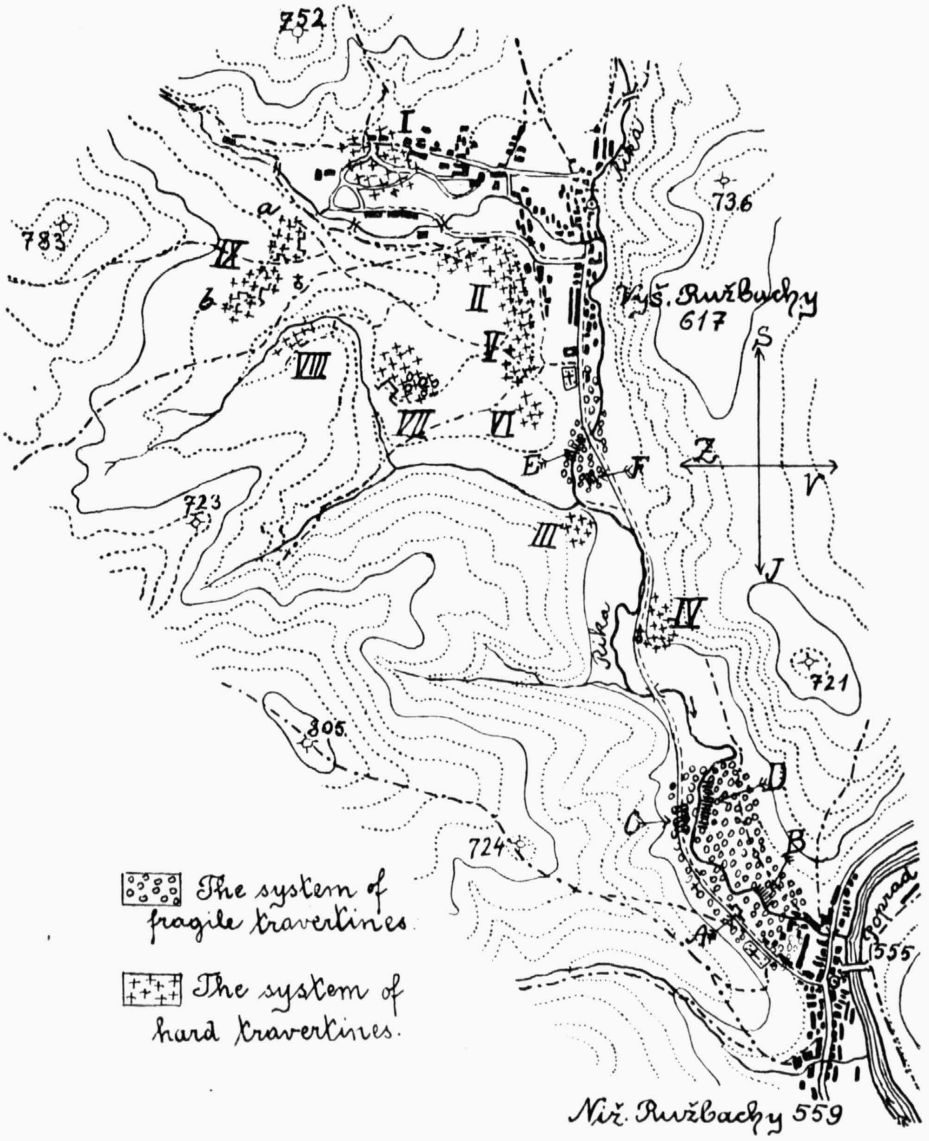


Fig. 1. Travertine formations between Vyšní and Nižní Ružbachy ($^{1}/_{25000}$).

At the base of this quarry just in the neighbourhood of the nests of rolled stones I searched in wain for beech remains. I recorded there an association with numerous elm remains:

Ulmus sp. — leaves,
Picea excelsa — leaves,
Tilia cordata — leaves,
Quercus sp. — leaves.

B — this locality is represented by a deep ravine of the brook Rika about 250—300 m up from Dolní Ružbachy, and in the direction across the valley just opposite to the first locality A. As we see at the bottom of the ravine, the travertine mass is not entirely cut through by the brook and therefore the lowest part of the section through this mass is not exposed and cannot be examined at present. The brook flows here on a bank of rather hard travertine rock. From this place up follow first till cca. 1½—2 m banks of relatively hard and less porous travertines without well preserved bryophytic and algal incrustations (perhaps rather recristalised by the waters of the brook). The higher part of the section untill to the very top is composed of tragile and in many places till argillaceous sinters containing well preserved Pellia, mosses as well as algal incrustations. In the hard travertine banks in the lower part of the section, I stated:

Salix (*capraea* and other sp.) — leaves,
Betula (*verrucosa* or *pubescens*) — leaves,
Pinus sp. (most probably *silvestris*) — leaves at two on the brachyblasts.

That is certainly an association of a relatively cold period. — The fragile travertines of the upper part of the section B yealded me following fossils:

Corylus avellana — leaves,
Cornus sanguinea — leaves,
Picea excelsa — leaves,
Ulmus sp. — leaves.

In wain I searched here for beech remains. I think therefore that this second association of the section B represents remains from the period of broad leafy forests without beeches and eventually also from the time of »*Corylus* maximum«, which succeeded after the *Betula-Pinus* time, represented here evidently by the hard travertine banks. The following time of broadleafy forest with beeches is not represented in this section by any travertine stratum (at least not in any typical developement).

In other places of the same travertine mass (C and D) I gained no new facts:

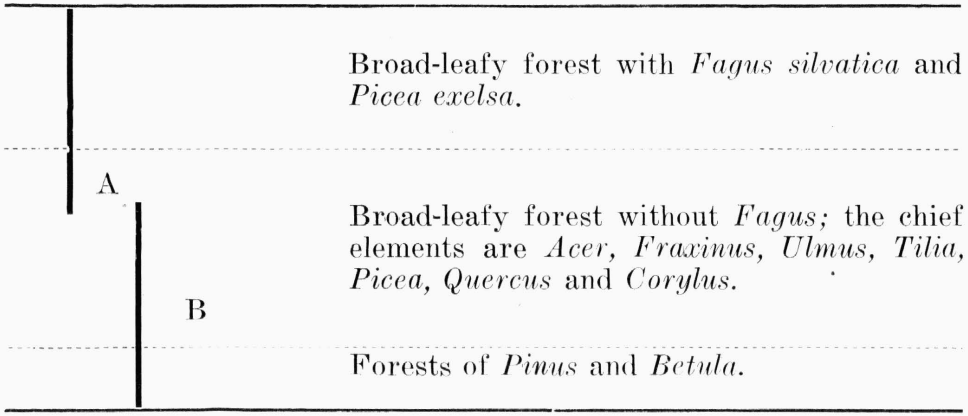
At C in the road incision about cca 250 m up the valley from the locality A I collected:

Tilia cordata — leaves,
Acer pseudoplatanus — leaves,
Ulmus sp. — leaves,
Fraxinus excelsior — leaves, (algal incrustations).

At D, opposite to the loc. C across the valley, in the ravine, where the whole section is built up only of fragile travertines, I found (also at the very bottom of the section):

Corylus avellana — leaves,
Picea excelsa — leaves,
(*Pellia* incrustations and *Salix* leaves).

All just mentioned plant associations seem to proof that the greatest part of the first mass of fragile travertines does not come from the last holocene periods, but from older times during which beech forests were absent or very rare. Only the uppermost zones (in the loc. A) are yealding beech remains. This fact is very clearly marked in the section at A and B. It is not difficult to recognise that both last mentioned sections are completing each other according to the following scheme:



The second mass of fragile travertines extends from the village Vyšní Ružbachy the valley of Rika brook downwards cca 500 m. This travertine mass is also cut through by the brook and in the deep ravine we may easely observe sections through its various zones. Especially we may study well many incrustations of Pellia, the developement of which is here extreemly rich. But examining impressions of other plant remains at various places of the walls in the ravine, especially at its very base, I stated there far simpler palaeobotanical conditions, than in the mentioned travertine mass at Nižní Ružbachy. I stated remains of *Fagus silvatica* through the whole section, from the very top untill to the base. Hence the whole mass, at least so far as exposed in the section, corresponds only to the uppermost zone of the first mass of fragile travertines at Nižní Ružbachy. In the whole I found in this second mass the following plantremains:

in the ravine (E) —
Acer pseudoplatanus — leaves,
Fagus silvatica — leaves,
Ulmus sp. — leaves,
Corylus avellana — leaves,
Petasites albus — leaves,
Fraxinus excelsior — leaves,
Tilia cordata — leaves,
Salix (div sp.)
(*Pellia*, algal — incrustations),
in the small rock at F in the field:
Fraxinus excelsior — leaves.

b) *The system of hard travertines.*

As told before, we may suppose the system of fragile travertines as having been sedimented chiefly from waters, the main quantum of dissolved limestone of which has been already precipitated otherwhere more in the anorganic way. I presume just the system of the hard travertines, to be the first place of precipitation of limestone from the warm springs. And as the sinters deposed in this way are much harder and very compact, compared with the rocks of the holocene system of fragile travertines at the bottom of the Rika-valley, it is not striking, if besides the holocene sediments, we do notice here also older, i. e. pleistocene occurrences. The pleistocene sediments are here of greater extend, than the holocene ones. Their pleistocene age is prooved not only by their position in the region, which is always higher, than the situation of the next holocene sediments, but also by the fact, that many of them are at least partially covered by brook terraces of rolled stones, as will be specially stated in the description of the single localities.

The holocene till subrecent sediments (— I in the map —) of this second travertine system are confined chiefly to the lowest part of the lateral valley next to Vyšní Ružbachy, a part of the village buildings standing just upon them. As told before they are sedimented till now by warm mineral springs. Most of those springs are exploited for the use in the bathing place; the park and many buildings of the bathing place are situated on those very young limestones. Of special geomorphological interest are here three old and now quite inert craters, which remained after former springs and which produced CO_2 as long as their splits have not been artificially studded. Of the same interest is here also one great active crater, representing a small pond full of mineral water in the park of the bathing place.

From the sinters composing the old inactive craters, I have gained the following fossils:

Fagus silvatica — leaves,
Picea excelsa — leaves,
Salix capraea — leaves,
Acer pseudoplatanus — leaves.

(In the bureau of the bathing place, I have examined some greater limestone blocks from the holocene rocks, upon which in the last year a new restaurant building has been constructed. They contain impressions of *Corylus avellana* and *Alnus incana* leaves, sometimes with conserved carbonised leaflamina.)

This all are remains of trees resp. shrubs, which we meet till now in the next neighbourhood. —

As to *the pleistocene travertines,* I suppose them not to represent any continuous bed, but to form a whole series of to day more or less mutually not connected and often not rather thick covers, resting on mesozoic rocks (flysh sandstones or sandy shales). It seems, that such pleistocene travertine rock covers are never reaching the bottom of the valley. Thus the walls of the ravines below such travertine localities are generally not built of travertines, but of older (mesozoic) sandstones or shales, as may be seen f. inst. in the ravines under the localities III and VIII or in the valley of the bathing place below the locality II. (— in other localities there are to many cliff debris or other younger sediments, which prevent us to examine the underlying strata). It is very probable that the discontinuity of the pleistocene travertines is, at least partially, a secondary feature caused by strong erosion of brooks.

The relatively high situation of those travertines is one of the prooves of their higher age then only holocene. The second proof is given by the already mentioned presence of rolled stone terraces upon some of them. Finally the impossibility of a higher age, than only pleistocene, is tested by the examination of the fossil floras, among which I never have found any pliocene or older elements.

I let now follow the lists of found plant impressions (as far as I was able to identify them till now) and some important geological facts throwing light on the stratigraphical position of the found fossils.

Loc. II. and III. — From the localities II and III. I did not gain till now any fossils and as there are no quarries it is very improbable that I shall succeede to collect some in future.

Loc. IV. — The travertine are forming here a terrace like cover in the hight of the contour lines between 600 and 620. This cover has very steep till vertical slopes and in the soils of the fields, situated upon this travertine cover, are to be found besides pieces of travertines also rolled stones, which fact points to the presence of a brook terrace. In the rocky cliff of that travertine cover next to the small chapel at the road I have found following plant impressions:

Ulmus sp. — leaves,
Betula (verrucosa or *pubescens)* — leaves,
Fraxinus excelsior — leaves,
Salix capraea — leaves.

Loc. V. — In the small rocky cliffs exposed at V. I did not find till now any fossils.

Loc. VI. — In the old, to-day abandoned quarry at VI. I found on the travertine blocks only leaves of *Betula (verrucosa* or *pubescens).*

Loc. VII. — This place, representing one of the greatest travertine covers at Vyšní Ružbachy, belongs to the most interesting travertine localities of Ružbachy especially from the geological point of view. In a great quarry there is exposed a deep section through the travertines. Almost the whole vertical wall untill to the very top of the quarry is constructed of hard travertine banks of white yellowish or brownish colours. In the western part of the exposed section the quarried travertine rock is covered with soils containing rolled stones and pieces of travertines. From this place a small distance to north-west and west in the fields the hard travertine rock is exposed as bare cliffs. In the eastern part of the section the conditions following from the top of the hard travertines upwards are extreemly interesting and may be sketched as follows:

Soils of the field containing rolled stones and pieces of travertines.

Cca 50—70 cm yellowish till yellow-brownish fragile travertine incrustations of fibrous algae.
Cca 40 cm loose and somwhat soily material of rolled stones and pieces of old hard travertines.
Travertine conglomerate; — a relatively thinn and irregular bank.

Banks of hard travertines.

As stated in the scheme, we may state among the rolled stones of the zones between the hard travertines and the zone of fragile fibrous limestones, not only rocks of the next surrounding terrain constructed of flysch sandstones and shales, but also mesozoic limestones, the occurrence of which lays in the valley upwards behind the bathing place. Therefore the whole sediment at the top of the quarry upon the hard travertines represents remains of an old brook terrace covered with relatively far younger sinters, than all the underlying rock. Having found anywhere in this interesting zone of fragile travertines no fossils, I am unable to state their relative age. I must state that this occurrence of fragile fossile travertines composed chiefly of organic incrustations, in a higher position, than deep in the valley of the Rika brook, is the unique occurrence of this kind I have seen in this country.

The impressions of plantremains, I have found in the hard travertine banks of that quarry seem to point to a transition from a colder

period of *Pinus and Betula* forests to the warmer period of *Corylus*. In the lower parts I stated:

Betula (verrucosa or pubescens) — leaves, very numerous,
Pinus silvestris — leaves and part of a cone, numerous,
Picea excelsa — leaves and twigs, enough abundant,
Ulmus sp. — leaves, rare,
Salix capraea — leaves, numerous,
Petasites albus — leaves.

At the top of the quarry in the travertine breccias or conglomerates I collected till now only *Corylus avellana* leaves.

Loc. VIII. — From this small travertine cover resting evidently on flysch sandy shales I know only *Betula* and narrow *Salix* leaves.

Loc. IX. The travertines of this group are still higher situated than all preceeding occurrences. They consist chiefly of whittish rocks.

In the southern part (b) of this mass occure only white and very hard travertines, containing many layers rich on rounded small cavities after bubbles of CO_2. They are covered with black humous soil, which contains many travertine blocks. Plantimpressions are here very scarce and till now I discovered only *Pinus* leaves (at 2 on brachyblasts, perhaps *P. silvestris*) and *Salix* leaves.

In the northern part of the massive IX, — a in the map — we may state somwhat more complicated conditions. But studying the section here in the quarries during three years, I came to the opinion, that there are many irregularities in the sedimentation. In the whole there is possible to state 2 very distinctly marked beds: the basal mighty bed of hard and relatively compact travertines (with one less regular brownish and soily zone here and there within it) and than a relatively thin (about 1 m or even somewhat thicker) cover of white but soft and fragile sinters, which is generally covered whith humous soils. Between both may be genarally stated a thin layer — about 15 till 20 cm of humous black soil. The travertines cover here as a cascade evidently the eastern slopes of the flysch hills. The cover of the mentioned white and soft travertines has a smaller extension than the basal mighty bank of hard travertines. They occur chiefly in the vicinity of the field path leading the slope upwards, whereas in the northern part of those places there are exposed just the underlying hard travertine banks.

All those conditions may be studied here in one great quarry just at the base of the whole cascade, as well as in a smaller quarry some steps upwards. Studying the sections of those both quarries, we may state the mentioned constant character of the soft and white travertine cover with the underlying thinn bed of humous soils. In this travertine cover I have collected the following plantremains:

Picea excelsa — leaves,
Larix decidua — leaves and twigs.

The section through deeper zones seems to me not as constant as the section through the mentioned fragile cover. In the year of 1929 I was able to notice in the southern part of the great quarry the following section:

A rather irregular and thin bed of covering humous soils.
Cca 1 m white and soft, fragile travertines with *Larix* remains.
Cca 15—20 cm black and humous soils.
Cca 1¾—2 m rather hard travertines, which are in their upper part whittish, in their lower part more and more of brownish shades. I collected in them *Salix caparaea* and *Betula (verrucosa vel pubescens)* leaves.
A rather irregular zone with cavities containing brown soils here and there also rolled stones.
From here untill to the base of the quarry a mighty bed of hard travertines (— whith plants as cited in the list of the following text).

At my later visits this section except the uppermost fragile zone has been no more as distinctly exposed.

From the cut stones of the hard travertine zone I gained following fossils:

Betula (verrucosa vel pubescens) — leaves.
Picea excelsa — leaves and cones.
Ulmus sp. — leaves,
Populus tremula — leaves,
Salix capraea — leaves

and Mr. J. Petrbok has kindly brought to me also a piece of hard travertine rock with fine needles, of which I presume to be leaves of *Larix.*

In the whole the flora of this northern part of the loc. IX is extreemly interesting on account of the presence of *Larix,* representing the second occurrence of that tree in fossile state found till now in the Slovakia.

I think that in the pleistocene travertines of Vyšní Ružbachy there may be pointet out certain analogies for some of the fossile floras, which I have stated already in other pleistocene localities in northern Slovakia.

The plantremains found in the rocks at IV, V, VI, and VIII points to a period relatively cold, as the chief element is here *Betula*. But there has been also found somwhere *Picea* and even *Fraxinus* and *Ulmus;* therefore I suppose that the travertines did not arise in the main part of the cold *Pinus* and *Betula* period, but at the time of the transition to the warm period. Of course we may not state if this is the transition period of the progression or regression of the interglacial time. According to the conditions, which I stated in the quarry of the loc. VII it seems, that we have here to do with the progression time, as I have stated here remains of Corylus avellana at the top of the section and nowhere in the middle or lower parts, where I foud untill present only *Betula, Picea* and *Pinus,* beside other less important remains. In this respect we may state in this quarry (VII) a slight analogy with the sections in the pleistocene travertines of Lůčky near Ružomberok, where of course the flora of the warm interglatial period is better represented. But just as here, I have also mentioned in Lůčky at the top of the pleistocene travertines a brook terrace of rolled stones. From this point of view the analogy between the pleistocene loc. VII of Vyšní Ružbachy and the pleistocene localities of Lůčky seems to be rather well marked.

The pleistocene locality IX of Vyšní Ružbachy has its analogy in Bílý Potok near Ružomberok, which I shall record about more particularly in the second part of this study, basing on my new collections from the years of 1930 and 1931.

Some additional notes to the Quaternarian floras of Northern Slovakia.

1. *The localities arround Lůčky and their relations to those of Ružbachy.* — In my study »Palaeobotanical investigations in the travertine complex arround the village of Lůčky near Ružomberok in the Slovakia« (Bulletin int. de l'Acad. des Sc. de Bohême 1928) I state an ideal section through the travertine sediments of Lůčky, which after a slight completion is in the whole as follows:

<table>
<tr><td colspan="3">The second period of erosion lasting untill to-day.</td></tr>
<tr><td colspan="3">Black and brown soils with debris of vessels.</td></tr>
<tr><td rowspan="2">Fragile travertines of the ravine behind the church</td><td>Mixed broad leafy forest (Fraxinus, Acer, Quercus, Picea, Corylus and Cornus as chief elements)</td><td rowspan="2">Rather warm and relatively dry period (no Fagus)</td></tr>
<tr><td>Betula is appearing among other broad leafy elements</td></tr>
<tr><td colspan="3">Period of mighty erosion.</td></tr>
</table>

Travertine		
Terrace of rolled stones		
Travertine banks (in the quarries signed by I, II and III)	Mixed broad leafy forest (the same chief elements as in the holocene travertines; in the section III. also Cotinus coggygria)	Rather warm and relatively dry period.
	Betula and Pinus in association of the elements of the broadleafy forest	
	Betula and Pinus forests in a great developement.	Relatively cold period.

Further I stated that in the Lůčky travertines is a remarkable absence of *Fagus silvatica,* but at the same time an interesting occurrence of numerous remains of *Corylus* and *Cornus sanguinea,* in the pleistocene travertines even of *Cotinus coggygria* in association to the broad leafy forest elements. All these facts I regard as a test of relatively dry and warm climatical conditions during the greatest part of the period of travertine sedimentation.

Considering a normal scheme of the developement of the floras in the postglacial and interglacial periods, we see that in the Lůčky travertines are missing the floras of

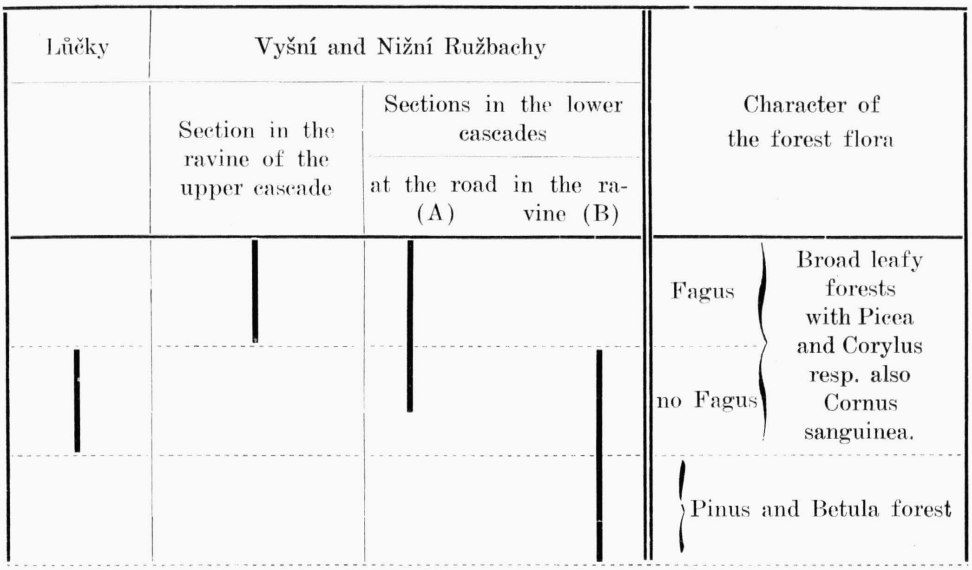
1. the greater part of the cold period in the interglacial and especially in the postglacial period.
2. the second i. e. humid part (with Fagus) of the warm period in the interglacial as well as in the postglacial period,
3. the whole regression time of the interglacial period.

We may compare the travertine floras of Lůčky as follows with the floras found in Ružbachy:

The interglacial ideal section seems to be partly visible in the quarry No. VII. of Vyšní Ružbachy. The main difference betwen both is, that at VII of V. Ružbachy the broad leafy flora is represented only at the top of the section and that in the terrace of rolled stones are here present also pieces of the older travertines. This points to a slight stratigraphical break between the terrace-zone and the zone of underlying travertines, which was not stated from Lůčky. I suppose that the greatest part of the broadleafy forest period of the Lůčky section is missing in VII of Ružbachy.

The holocene part of the ideal section of Ružbachy travertines reaches somewhat further downwards and especially also upwards, than in Lůčky. We have seen in the holocene travertines of Ružbachy a very well represented flora of the cold *Betula-Pinus* period, than the flora of the mixed broad leafy forest with *Picea* but without *Fagus,*

and finally the flora of the same forest containing *Fagus* as chief element. The relation between both ideal sections may be sketched as follows:



For the loc. IX. of V. Ružbachy I have not stated any analogy in the Lůčky travertine complex.

2. *Some new statements in the travertine system of Bílý Potok near Ružomberok.* — During the last two years I have stated further interesting data as to the floras of the pleistocene sediments of Bílý Potok and at the same time I studied also the terrain a little further southwards, where recent and subrecent travertines are sedimented. But from this last point I gained no fossil floras. The sedimentation of limestone sinters is there caused by biochemical precipitation of plants especially mosses and partly also by algae from cold waters. The travertines form here cascadelike covers on the steep slopes of the valley downwards, on which the travertine sedimenting torrent is running as beautiful waterfall into the Revůca river.

My new researches refer specially to the travertine rock, which I signed in my paper from 1929 with the number III. (see: Palaeobotanical researches in some quaternary deposits in the surrounding of Ružomberok, Slovakia. — Bull. intern. de l'Acad. des Sc. de Bohême 1929.) After the publication of this paper, there has been opened a new quarry in the mentioned locality and that in the lower part of the rock, whereas the quarry I knew before 1929 was scarcely at the top of this whole mass. Studying anew the sedimentation conditions of the whole travertine rock in both mentioned quarries, it was easy to state, that the beds of the sinters were deposed on the declined slopes downwards (see my figure l. c. 1929 of the section exposed in the upper quarry).

There may be distinguished two sedimentation phases not only according to the petrographical features of the rock material, but also as to the fossil plants found within them.

The upper travertine cover, exposed chiefly in the upper quarry is composed of unusually white sinters with very bed conserved moss or algal structures and containing, as stated already in 1929, *Larix*, *Pinus* and *Betula* remains.

Quite another conditions may be stated in the lower quarry, where the deeper cover is exposed. The colors of the travertines are here generally white yellowish or brownish and they contain well preserved moss incrustations. The flora, which I found here, consists of the following plant remains:

Acer pseudoplatanus — leaf,
Salix capraea — leaves,
Populus tremula — leaves,
Picea excelsa — leaves and cones,
Pinus sp. leaves at two on the brachyblasts (perhaps *silvestris*),
Betula (verrucosa vel pubescens) — leaves,
Alnus incana — leaves.

The floristical conditions of this locality at Bílý Potok may be easely compared with those found in the travertines no. IX at Vyšní Ružbachy. In both localities are two covers of various petrographical characters superposed, between which a very short stratigraphical break may be stated; this break is, as mentioned above, marked in Vyšní Ružbachy by a thin layer of humous soils. Therefore it is impossible to see in the flora of the upper cover a direct continuation of the flora found in the lower travertine beds. We have here no data to fix whether the flora of the lower beds belongs to the progressive phase or whether it comes from the regressive phase of the interglacial period. As to the flora containing *Larix* and *Pinus* in the upper travertine cover, I think it to be most probably of a regressive character. Both localities may be homologised as follows:

Vyšní Ružbachy	Bílý Potok	Character of the forest floras
Upper cover of white fragile travertines.	Upper cover of white travertines.	*Larix-Pinus-Betula*-forest.
Black soils.	——	——
Lower bed of hard travertines.	Lower travertine banks.	*Spruce*, *Betula* and broadleafy trees; no *Fagus*.

3. *Limestone sinters in the Skutová dolina-valley at Stankovany near Ružomberok.* (Fig. 2.) — The sinters are here deposed just behind the cimetery of the village on both sides of the torrent, which flows to the river Váh. The sinters on the left bank of the torrent are very fragile, of light yellowish or brownish colours and contain numerous nests of algal incrustations. Their upper layers are partly exposed in the incision of the field path leading up along the torrent. They are evidently eroded by the brook, in the ravine of which we may study the lower layers of the travertine mass. The section exposed here contains all layers between the mentioned field path and the torrent. It may be sketched as follows: see fig. 3.

Here we may see quite well, that the travertines are deposed on the youngest rolled stone accumulation of the torrent. Therefore we must regard them as of holocene age. The sinters contain here rather numerous leaf impressions. In the basal layer of black and brown sinters I found the same remains as in the light travertines upwards. I collected here:

Fraxinus excelsior — leaves,
Ulmus sp. — leaves,
Picea excelsa — leaves,
Corylus avellana — leaves,

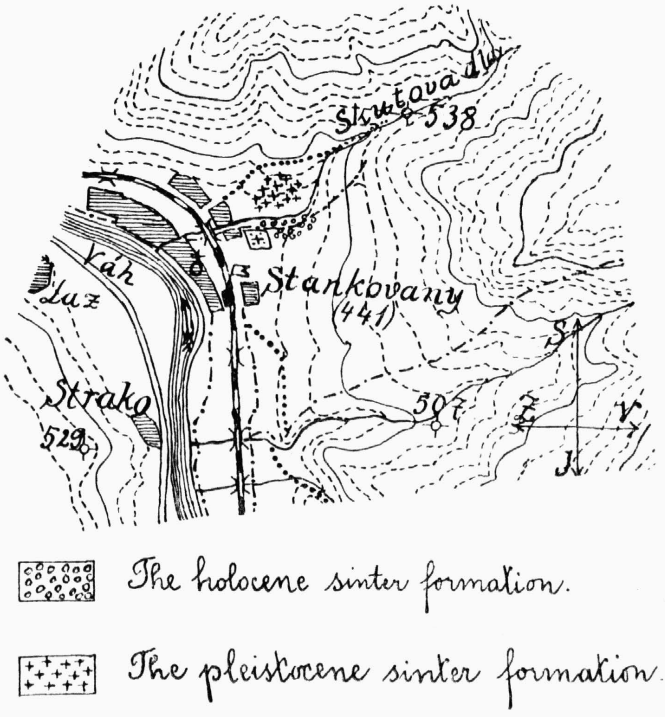


Fig. 2. Travertine formations in the valley Skutová dolina at Stankovany ($^1/_{25000}$).

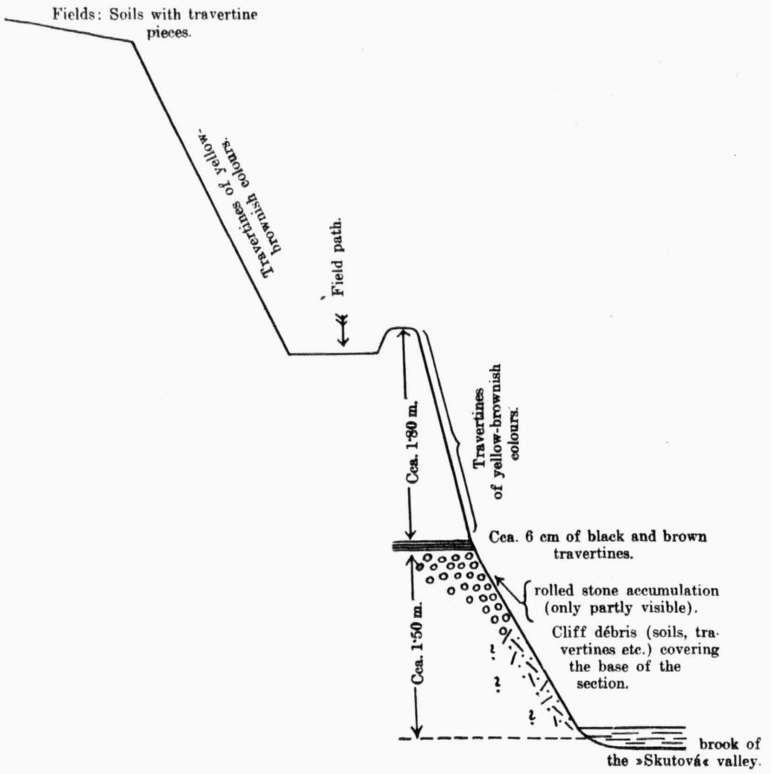


Fig. 3.

Salix sp. (incl. *capraea*) — leaves,
Cornus sanguinea — leaves,
Acer pseudoplatanus — leaves.

This is evidently a flora of the mixed broad leafy forest time containing not yet Fagus. It is quite homologous with the flora of the holocene travertines of Lůčky.

The travertines at right bank of the torrent are composing a small hill within the valley. They are well exposed at their eastern side by the brook ravine and at their top in the quarries. Their character is quite other than that of the young preceeding sinters. They are very hard as generally seen in the pleistocene formations, their colours are light yellowish till brownish. The organic structures (mosses or algae) are very indistinct within them. At their base (very well exposed at the north eastern corner of the mentioned hill) may be stated a zone of travertine conglomerate containing a great many of rolled stones. I regard this conglomerate zone to be remains of an old brook terrace, upon which the whole sinter mass is resting. Therefore I presume this travertine hill to be of pleistocene age. Plant remains, which I found in the quarries are not numerous:

Pinus — leaves at two on the brachyblasts (perhaps *silvestris)*,
Betula (verrucosa vel *pubescens)* — leaves,
Salix capraea — leaves,

Populus tremula — only smaller casts of leaf inpressions.
They represent remains of an interglacial *Pinus-Betula* phase.

If we consider also other floristical data, which I stated already 1929 about other travertine sediments in the region of Stankovany and Rojkov, we may sketch a very interesting comparative scheme between the sediments of Rojkov — Stankovany region and those of Lůčky as well as of other North Slovakian travertine sediments. I join this scheme at the end of this study.

4. *Some additional remarks to the limestone sinters deposed bet-*

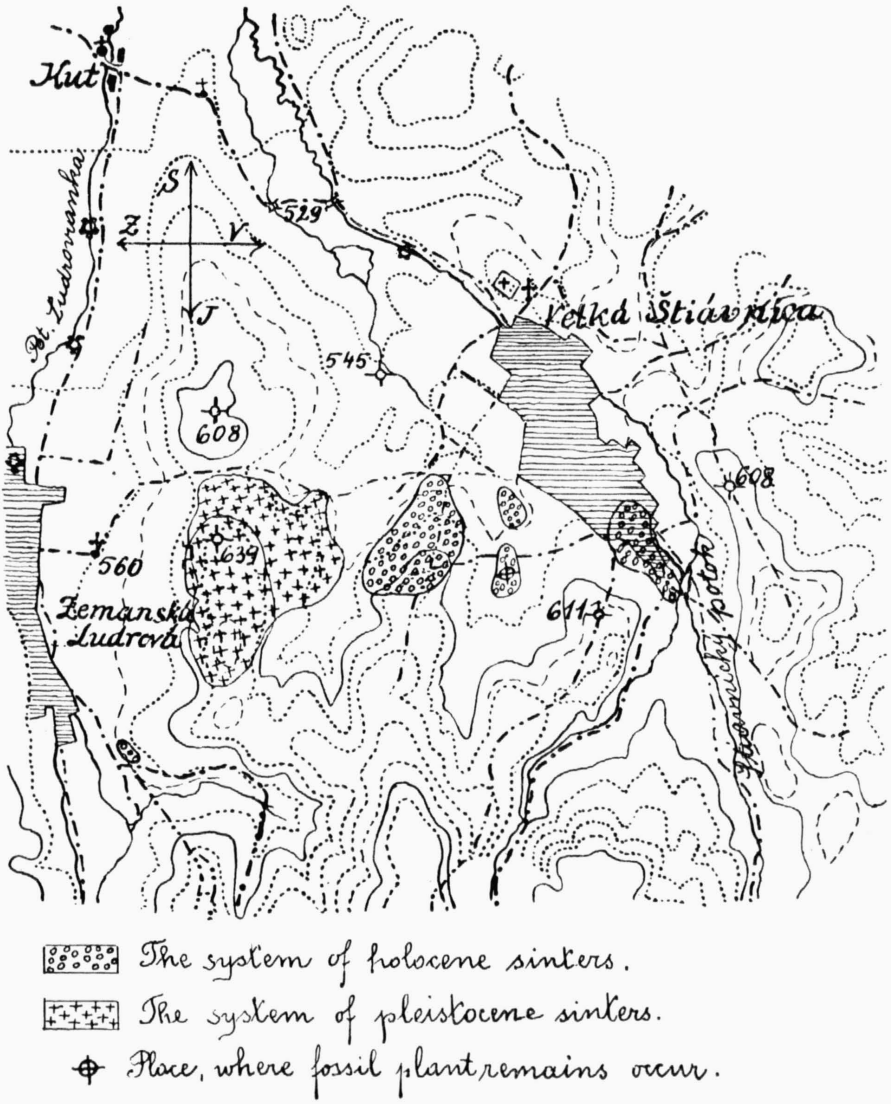


Fig. 4. Travertine formations between Zemanská Ludrová and Velká Štiávnica near Ružomberok ($^1/_{25000}$).

ween Ružomberok and Německá Lupča; — localities: Ludrová, Štiávnica and Vyšní Sliač. (Fig. 4.)

In my paper from 1929 »Palaeobotanical researches in some quaternary deposits in the surroundings of Ružomberok, Slovakia« I mentioned some occurrences of warm mineral sources containing high percentage of $CaCO_3$ and CO_2 in the region between Ružomberok and Německá Lupča at the foot of the Nízké Tatry mountains, along the Valley of the river Váh: Zemanská Ludrová, Velká Štiávnica and Vyšní Sliač. Having hence no detailed geological map at hand, I have not visited at that time all travertine sediments of that region. In 1931 appeared a very detailed new map by Koutek in his study »Geologické studie na severozápadě Nízkých Tater« (Sborník st. geol. ústavu ČSR. 1930. R. IX.) and as I have observed that there exist still other travertines in this country, the occurrence of which was unknown to me, I visited in 1931 this region anew with my friend Dr. Ulrich. I paid special attention to the travertine formations between Ludrová and Štiávnica. From the geological and geomorphological point of view this formation may be compared with the travertines of Vyšní Sliač. Equally as there, we may state also between Ludrová and Štiávnica two sinter complexes laying scarcely at the same relative niveau as at Vyšní Sliač.

One of them is composed chiefly of a hard and whittish till light yellowish or brownish porous travertine rock, which is deposed as a cover on the hill of cô. 639 eastward from Ludrová between the contour lines of 590 and 640, — chiefly round 600 and 620, — this being the same niveau as of the hard travertines at Vyšní Sliač presumed to be of pleistocene age. Unfortunately till now I have not found here any determinable plant remains — the travertines contain here chiefly »Hecksel« of grass leaves. But at our common visit with Dr. Ulrich, we stated in those travertines a very important moment (see also in Koutek l. c.), which may rather help to fix more safely the geological age of this travertine mass and also the geological age of the Sliač travertines, if we consider the relative niveau of the travertines of both those localities. On the western slope of the mentioned hill of cô. 639, the travertine cover is at its base exploited in quarries, by which a very interesting vertical section through the travertine cover is exposed. We have stated here the following strata:

cca. 20 cm black humous cevering soils.
cca. 1½ m yellow brown soils with débris of travertine blocks.
cca. 2 m bank of hard porous whittish till very light yellowish or brownish travertines.
bank of travertine conglomerate with rolled stones.

The very base of the travertine conglomerate was at the time of our visit not exposed. According to Koutek' s map the lowest pleistocene river terrace of that region is laying at the niveau of 520—540. The higher or second pleistocene river terrace may be stated at 600 m. Therefore we may see in our travertine conglomerate with rolled stones remains of an older pleistocene river terrace — at least the mentioned second one. The pleistocene age of the travertines resting on the mentioned conglomerates is by this fact quite safely stated. And as this whole mass of Ludrová has the same character of rock, not only as to the petrographical feature but also from the geomorphological point of view as the mass of hard travertines of V. Sliač (both rocks are partly cleft by erosion in great blocks resp. small ravines) and as both are laying in the same relative niveau, we may just suppose both of them to be synchronous as to the time of their origin.

Young holocene sinters may be stated chiefly eastward from the pleistocene mass, just at the village of V. Štiávnica (where also many mineral sources are present). Westward from it there is only a very small occurrence of holocene travertines, just between the foot of the hills and the mineral sources of Z. Ludrová (see the joined map).

Fossil plantremains I stated only in one place at V. Štiávnica, (⊹ in the joined map), where I found:

Picea excelsa,
Aver pseudoplatanus,
Tilia cordata,
Fraxinus excelsior,
Corylus avellana.

It is evident that these point to a broad leafy forest without *Fagus,* but with *Picea excelsa,* which is the same association as found in the holocene sinters of Vyšní Sliač, of the Skutová dolina valley at Stankovany, in the holocene sinters at Lůčky and in the older part of the holocene sinters of Vyšní Ružbachy.

Conclusions.

All the facts given in the preceeding two studies may be best summarised in the following scheme, to which I have added also the results of my other studies concerning the travertine floras of the Slovakia especially those treating the Gánovce massif:

General character of the strata and their flora.
Gánovce (in the quarry at the bathing place)
Vyšní and Nižní Ružbachy.
Stankovany and Rojkov
Vyšní Sliač
Lúčky
Ludrová and Stiávnica
Bílý Potok
Holocene
Forests of broad leafy trees, Picea and Fagus
Forests of broad leafy trees and Picea, but without Fagus.
Pinus and Betula forests.
at the road
in the ravine
Lower cascade (at N. Ružbachy)
Upper casc. at V. Ružb.
Holoc. Sint. at the bath. place
Rolled stone accumulations
travertines
Young sediments in the Skutová dolina valey
Sinters in the village of Rojkov and on the right bank of the river Vah.
Young sinters near to the mineral spring
Fragile sinter of the ravine behind the church
Sinters of the loc. at V. Stiávnica
Young sint. in the valley between Bukovina and Tisová mountains.
Stratigraphical break
Pleistocene
Travertines.
Terraces of rolled stones.
Travertines
Broad leafy forests with Picea but without Fagus
Pinus and Betula forests.
Terraces of rolled stones resp. travertine conglomerates.
strat. break
Loc. nro. VII.
Old travertines in the Skutova dolina valey.
Old travertines upon the hill.
Sinters between the bathing place and the cimetery.
Cliffs eastward from the village
Old travertines of the hill of cô 639. (flora unknown)