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Problems of the Lithology and Stratigraphy of Loesses of Eastern Slovakia

Problemy litologii i stratygrafii lessów wschodniej Słowacji

Проблемы литологии и стратиграфии лёссов Восточной Словакии

ABSTRACT

Loesses, loess-like deposits and typologically differentiated soils occurring among them were investigated. In soil horizons symptoms of solifluction and few cryogenic structures were found. They pointed to the occurrence of frozen ground of undefined type. The analyses of heavy minerals proved that the sources of loess silt had existed at small distances. Thermoluminescence (TL) datings confirmed the opinion that the loesses in eastern Slovakia were accumulated not only during the last glaciation (Würm) but also during that before the last (Riss). The oldest of the fossil soils investigated in the section at Veľký Šariš can be correlated with Cromerian Interglacial or with Mindel 1/2 interstadial on the basis of the TL datings. Over this soil there occur the loesses of Drenthenian (Riss 1) Glacial, rubefied brown soil of Riss 1/2 interstadial and the loesses of Warthanian (Riss 2) and Würm glaciations.

INTRODUCTION

Loesses in eastern Slovakia are rather limited in extent. Larger loess areas are situated in the East Slovakian Plain, in the Košice, Hornád, Spiš, Poprad and Lubovňa basins as well as in the river valleys of the Topľa, Ondava, Laborec, and of their tributaries (Fig. 1). This situation is the consequence of complex geological morphostructures of the Czechoslovakian Carpathians in which differentiated morphological processes

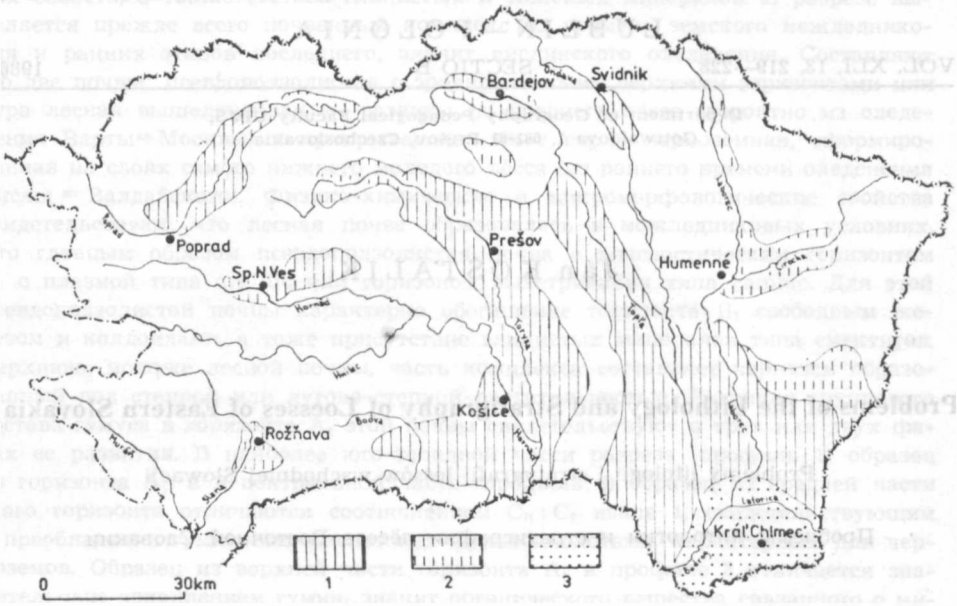

Fig. 1. Occurence of eolian sediments in eastern Slovakia
1 — loesses; 2 — loess-like sediments; 3 — dune sands

were in progress and these were additionally influenced by climatic interferences in the Pleistocene period.

In spite of the fact that loess is an important technical raw material (for the production of bricks and other building materials) as well as a good soil substrate, it has been little investigated in eastern Slovakia. Consequently, the information available on our loesses is rather sketchy and schematic. From among the more important works on the subject, the papers of L. Urbánek (1933, 1937) should be mentioned who mapped the Quaternary sediments of the area adjacent to the town of Prešov and stratigraphically situated them into the late Pleistocene, namely into the Würm glacial. B. Lešku (1957) studied the Quaternary sediments in the environments of the town of Prešov as part of the geological research of the Carpathian Paleogene. Loesses and loess-like sediments are to be found on the southern and south-eastern slopes of the relief; they were sedimented by westerly and south-westerly winds in the late Pleistocene, namely in the Würm glacial. Further information, although limited in scope, on the loesses of eastern Slovakia, can be found in the works of J. Karniš and J. Kvitkovič (1970), J. Harčár (1972), V. Ložek (1973), I. Vaškovský (1977) and others. M. Lukniš (1973), on the basis of a geomorphological study of the relief of the High Tatras and of their foreland, mentions not only

Würmian loesses but also loesses originating in the third glaciation stage, the Riss.

Loess sediments of eastern Slovakia have been systematically studied by J. K o š t'á l i k (1980, 1982, 1985, 1986). It has been possible for him to draw important stratigraphic conclusions from extensive rock exposures (Fig. 2) which have been documented and analyzed by mechanical, chemical and mineralogical methods, as well as by X-ray photography, electrone microscopy and micromorphology. His cooperation with Professor H. Maruszczak and Dr. J. Butrym from the Department of Physical Geography of the Maria Curie-Skłodowska University in Lublin (H. M a r u s z c z a k et al. 1984), and with Professor S. W. Alexandro-

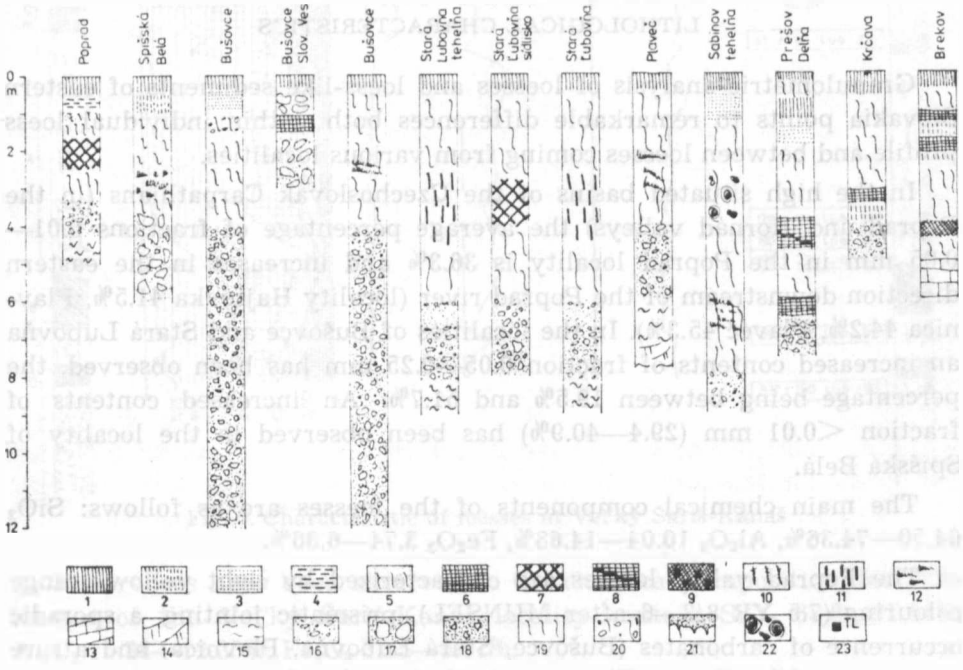

Fig. 2. Characteristics of selected profiles from the eastern Slovakia
1 — humus horizon (recent soil); 2 — illuvial horizon (recent soil); 3 — intermediate h/p horizon (recent soil); 4 — eluvial horizon; 5 — horizon with a less marked pedogenetic process; 6 — fossil horizon (Fh) of humus nature and chernozem; 7 — fossil horizon (Fh), illuvial; 8 — fossil horizon (Fh) of gleyey nature; 9 — fossil horizon (Fh), illuvial gleyed (podzol-pseudogley?); 10 — fossil horizon (Fh) textural (podzol-pseudogley?); 11 — fossil horizon (Fh) of gleyey nature (interglacial?); 12 — marked laminations, positions of Mn and Fe; 13 — limestones (Mesozoic); 14 — sandstones (Paleogen); 15 — claystones; 16 — gravel, sands (river terrace); 17 — gravel accumulation (glacifluvial cone); 18 — deluvium; 19 — loess; 20 — loess concretion of $CaCO_3$; 21 — loess and cryogenic structures; 22 — malacofauna; 23 — taking of samples for TL analyses

wicz from the Academy of Mining and Metallurgy in Cracow, has brought a remarkable progress in the study of loesses and loess-like sediments as well as in their situating within the stratigraphic system. This progress has been made possible due to the application of chronology based on thermoluminecence (TL) analyses done by Dr. J. Butrym. The profiles Vel'ký Šariš-Kanaš, Prešov-Delňa and the Petrovany have been found as the most suitable for detailed research (Fig. 2, 3, 4).

This paper contains characteristics of loesses and loess-like sediments from selected profiles in eastern Slovakia. The Vel'ký Šariš-Kanaš profile has been situated in the chronostratigraphical system more accurately on the basis of TL data.

LITHOLOGICAL CHARACTERISTICS

Granulometric analysis of loesses and loess-like sediments of eastern Slovakia points to remarkable differences both within individual loess profile and between loesses coming from various localities.

In the high situated basins of the Czechoslovak Carpathians (in the Poprad and Hornád valleys) the average percentage of fractions 0.01—0.05 mm in the Poprad locality is 36.3% and increases in the eastern direction downstream of the Poprad river (locality Hajtovka 41.5%, Plavnica 44.2%, Plaveč 45.3%). In the localities of Bušovce and Stará Lubovňa an increased contents of fraction 0.05—0.25 mm has been observed, the percentage being between 19.5% and 51.7%. An increased contents of fraction <0.01 mm (29.4—40.9%) has been observed in the locality of Spišská Belá.

The main chemical components of the loesses are as follows: SiO_2 64.50—74.36%, Al_2O_3 10.04—14.68%, Fe_2O_3 3.74—6.36%.

The Poprad valley loesses are characterized by light yellow-orange colouring (7.5 YR 8/3—6 after MUNSEL), prismatic jointing, a sporadic occurrence of carbonates (Bušovce, Stará Lubovňa, Plavnica) and a rare occurrence of fossil soils. They are sterile in malacofauna.

The mineralogical association is represented by the following heavy minerals: magnetite+ilmenite+limonite+zircon+garnet. Further minerals found are pyroxene+chlorite+epidote+amphibole+turmaline+ +apatite+siderite. The shape of the minerals is column-like to prismatic and they are little dressed. The occurrence of spheric shapes is rare. The habit and the association of accessory minerals point to the assumption that the loesses have been blown out of the near-by sediments of the Central Carpathian Paleogene (the Levocă Mountains, the Spišská Magura Mountains) and that they originated only in a lesser degree from

the crystalline massifs of Western Carpathians (the Tatras, Král'ova hol'a).

The loesses of the Košice Basin and of the Šariš Lowland (localities of Vel'ký Šariš-Kanaš, Prešov, Prešov-Delňa, Petrovany) are characterized by a different granulometric composition. In Vel'ký Šariš-Kanaš locality there is an increased contents of 0.05—0.25 mm fraction (34.49—57.32%). In the Petrovany locality an increased contents of this category has been observed only in the base layer of the profile (42.16—66.99%). Otherwise the contents of fraction 0.01—0.05 mm in the entire profile is 28.24—45.27%.

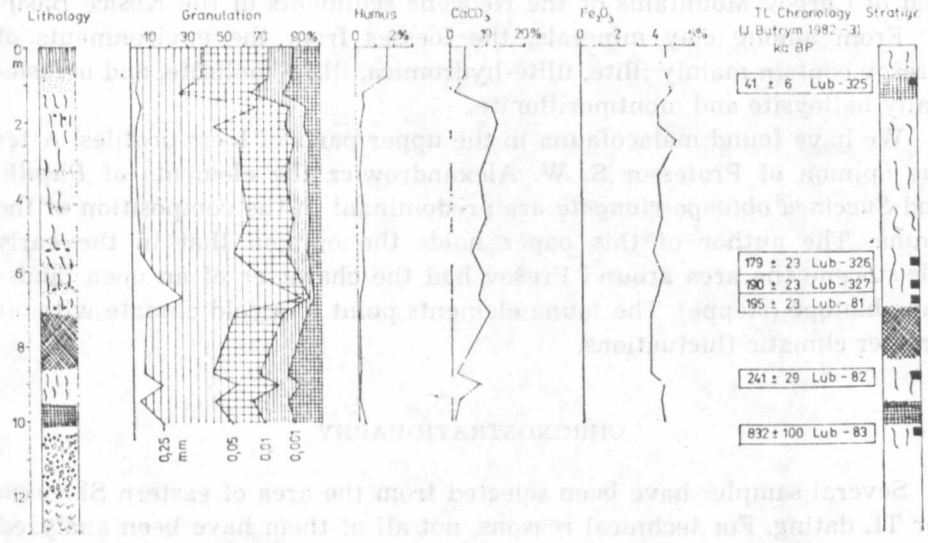

Fig. 3. Characteristic of loesses at Vel'ký Šariš-Kanaš

Differences have been observed in the chemical composition, too. The loesses of the Vel'ký Šariš-Kanaš locality contain SiO_2 63.8—67.66%, Al_2O_3 10.34—12.35%, Fe_2O_3 3.75—5.01%.

The loesses are differentiated into eolian, fluvial and also swamp facies, light-coloured (10 Yr 8/3—4—6, 10 YR 7/3—4), frequently with a schistic texture, a typical jointing, containing carbonate with vertical or horizontal $CaCO_3$ layers of 3—12 cm. The occurrence of fauna is sporadic (the localities of Sabinov, Vel'ký Šariš-Kanaš, Prešov — the brickyards). The loess sequence separate fossil soil horizons — type rubefied brownearth, meadow chernozem, brownearth, carbonate-containing mycellar chernozem.

The main chemical components of loesses from locality Petrovany are as follows: SiO_2 64.12—80.47%, Al_2O_3 — 8.75—14.63%, Fe_2O_3 2.75—

6.51%. Fossil soil residues and illuvial horizons of the podzol or pseudogley type containing well-preserved cryogenous structures — frost cracks — have been observed in the profile (Fig. 4).

The assemblage of heavy minerals of the loesses in the environment of Prešov is formed by opaque minerals + hypersthene + garnet + rutile + + zircon + turmaline + amphibole + apatite + augite + disthene and sporadically chlorite. The assemblage corresponds to minerals typical of an area of neovulcanites. The alimentation area from which the loesses were blown were mainly the vulcanic mountains of eastern Slovakia (the Slánske Mountains, the Kapušany Mountains and other mountain ranges), and only in a lesser degree the Paleogene sediments of the Šariš Upland and of Čergov Mountains or the Neogene sediments of the Košice Basin.

From among clay minerals, the loesses from the environments of Prešov contain mainly illite, illite-hydromica, illite-kaolinite, and occasionally halloysite and montmorillonite.

We have found malacofauna in the upper parts of loess profiles. After the opinion of Professor S. W. Alexandrowicz the elements of *Pupilla* and *Succinea oblonga elongata* are predominant in the composition of the fauna. The author of this paper holds the opinion that in the early Pleistocene the area around Prešov had the character of an open landscape biotope (steppe). The fauna elements point to a cold climate without greater climatic fluctuations.

CHRONOSTRATIGRAPHY

Several samples have been selected from the area of eastern Slovakia for TL dating. For technical reasons, not all of them have been analyzed by now. Therefore, we are only going to discuss the results obtained from the Vel'ký Šariš-Kanaš profile in this paper (Fig. 3).

The Vel'ký Šariš-Kanaš loess profile is situated along the left bank of the Torysa river in a well-preserved condition. On an erosion claystone substrate rests a gravel accumulation (thickness approx. 4 m) composed of flysch pebbles and containing some neo-vulcanite gravels in the eastern part of the profile (the left tributary Dzikov). The upper part of the profile is composed of a complex of loesses separated by three fossil soils.

The uppermost part of the fluvial gravel accumulation is intermixed with loess material. According to TL data, its age is 832 ka BP, which chronologically corresponds to the Günz glaciation stage. Soil of the meadow chernozem type was developed on fluvial sediments due to the changed climatic conditions (hot and dry periods alternating with hot and wet periods). We have not classified this type of soil from stratigraphical point of view, but it could have originated in one of the

early Pleistocene stages, namely either in the interglacial period G/M or in the Mindel interstadial M 1/2.

Two loess layers (depth 8.70—9.39 m — Fig. 3) are well preserved in the superposition of the meadow chernozem. According to the TL data the age of the upper layer is 241 ka BP, which stratigraphically corresponds to the Riss stage R1 (Drenthenian). The overlying part of the profile is composed of a fossil soil 1.50—1.70 m thick. Its colouring on the micromorphological thin section is brownish-red with a brick-red tinge. The mineral skeleton is aggregated with coagulated soil plasma. It was created "in situ" by decomposition and transformation of primary minerals. The soil clay has a scelsepic or masepic internal structure. It is oriented and to a certain degree movable. New morphological structures are represented by organic-mineral nodules as well as by primary and secondary shapes of calcite. Typologically it represents a deep illuvial horizon of rubefied brownearth. Soils of a similar character originated on loesses in Europe, including Czechoslovakia, during warm and wet interglacial periods of the early and middle Pleistocene. According to the TL dating they were created 241—195 ka ago; namely chronologically they correspond to the Gerdaunian — interstadial R 1/2.

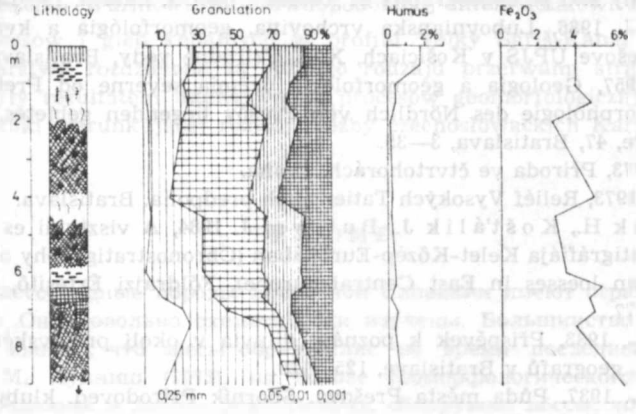

Fig. 4. Characteristic of loesses at Petrovany

In the superposition of this fossil soil horizon some layers of loesses occur. The lower of these layers are dated by the TL method for 195, 190 and 179 ka BP (Fig. 3), i.e. they correspond to the Riss 2 (Warthanian) glaciation. In the upper layers exposed in the road ravine, brown earth occurs. It is dated by the TL method for 41 ka BP, so it corresponds chronologically to the younger Würm; perhaps it represents Hengelo interstadial.

Therefore, in the investigated sections typologically differentiated

soils occur which account for the changes of geographical conditions in Pleistocene. The layers of loesses and soils preserved in these sections are separated by numerous stratigraphic hiatuses. These hiatuses resulted from intensive geomorphological processes or from the influence of neotectonics which conditioned the development of the relief of the Czechoslovak Carpathians in Pleistocene.

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STRESZCZENIE

Lessy i lessopodobne utwory wschodniej Słowacji mają zasięg ograniczony. Poznane były dotychczas względnie schematycznie. Większość autorów przyjmuje, że lessy powstawały tylko w okresie ostatniego, tzn. würmskiego zlodowacenia. Na podstawie badań geomorfologicznych w Tatrach i na ich przedgórzu M. Lukniš (1973) stwierdził jednak występowanie lessów z okresu przedostatniego, tzn. risskiego zlodowacenia.

Autor przeprowadził systematyczne badania w dolinach Popradu i Torysy, w Kotlinie Koszyckiej i na Nizinie Wschodniosłowackiej. Badania te potwierdziły fakt występowania lessów środkowoplejstoceńskich (Mindel, Riss). Istotne znaczenie przy tych badaniach miała współpraca z Zakładem Geografii Fizycznej UMCS w Lublinie, a szczególnie datowania metodą termoluminescencyjną (TL) wykonane w tym zakładzie przez dr. J. Butryma.

Badane lessy wyróżniają się specyficznymi cechami: barwą, pionową oddzielnością, strukturą, zawartością węglanów i szczątków fauny. Kopalne gleby śródlessowe są dość wyraźnie zróżnicowane pod względem typologicznym; związane są z nimi oznaki rozwoju soliflukcji i rzadko występujące struktury kriogeniczne. Zespół minerałów ciężkich świadczy o niewielkiej odległości transportu pyłu lessowego.

Zagadnienia stratygrafii rozpatrywano na podstawie badań profilu Vel'ký Šariš-Kanaš, dla którego były wykonane datowania metodą TL. Lessy były akumulowane tutaj na terasie rzecznej; najwyższe warstwy osadów rzecznych są datowane na 832 ka, tzn. zapewne odpowiadają zlodowaceniu Menapian (Günz). Na tych warstwach rozwinięta jest gleba kopalna typu czarnoziemu łąkowego, którą można paralelizować z interglacjałem Cromerian (G/M) lub z interstadiałem elsteriańskim (Mindel 1/2). Nad tą glebą występuje less datowany na 241 ka, co odpowiada zlodowaceniu Drenthenian (Riss 1). Na tym lessie rozwinięta jest rubifikowana gleba brunatna, którą można korelować z Gerdauanianem (interstadiał Riss 1/2). Przykrywają ją lessy datowane na 195, 190 i 179 ka, co odpowiada zlodowaceniu Wartanian (Riss 2). Najmłodsza, zachowana w tym profilu gleba kopalna występuje bezpośrednio pod glebą dzisiejszą; jest to gleba typu buroziemnego datowana na 41 ka, co odpowiada młodszemu Würmowi, najprawdopodobniej interstadiałowi Hengelo.

Badania lessów i gleb kopalnych w profilu Veľký Šariš-Kanaš wykazały, że zachowane warstwy rozdzielone są różnego rodzaju przerwami stratygraficznymi. Przerwy te były rezultatem intensywnych procesów geomorfologicznych lub wpływów neotektoniki warunkującej rozwój rzeźby czechosłowackich Karpat w plejstocenie.

РЕЗЮМЕ

Лёссы и лёссовидные породы Восточной Словакии имеют ограниченное распространение. Они довольно схематически изучены. Большинство авторов придерживается мнения, что лёссы образовались во время последнего, вюрмского оледенения. М. Лукниш (1973), на основе геоморфологического исследования Татр и их предгория в долине реки Попрад, обнаружил лёссы, которые образовались во время предпоследнего, рисского оледенения.

Автор осуществил систематические исследования в долинах рек Попрад и Ториса, в Кошицкой котловине и Восточнословацкой низменности. Эти исследования подтвердили, что здесь встречаются среднеплейстоценовые (Миндель и Рисс) лёссы. Болшое значение при разработке данной проблемы имело сотрудничество с Кафедрой физической географии Университета М. Ц.-С. в Люблине, а специально термолюминесцентные (ТЛ) датировки сделанные в этой Кафедре др. Ю. Бутримом.

Исследуемые лёссы отличаются специфическими признаками — цветом, вертикальной отделяемостю, структурой, содержанием карбонатов и фауной. Ископаемые почвенные горизонты отличаются по типологии; среди них находятся

признаки солифлюкции с редкими криогенными структурами. Ассоциация тяжелых минералов говорит о небольшом расстоянии транспорта лёссовой пыли.

Вопросы стратиграфии рассмотривались на основании изучения разреза Велький Шариш-Канаш, для которого получено датировки ТЛ методом. Лёссы акумулированные здесь на уровне речной террасы; самые верхние речные слои датированные 832 тыс. лет, значить соответствуют оледенению Менапиан (Гюнц). На этих слоях образовалась ископаемая почва типа лугового чернозема, которая наверно образовалась в межледниковие Кромериан (Г/М) или в елстерианском интерстадиале (Миндель 1/2). Выше этой почвы распространенный лёсс датирован 241 тыс. лет, что соответствует оледенению Дрентениан (Рисс 1). На этом лёссе образовалась бурая рубифицированная почва, которую можно сопоставлять с периодом Гердауаниан (интерстадиал Рисс 1/2). Она прикритая лёссами датированными 195, 190 и 179 тыс. лет, что соответствует оледенению Вартаниан (Рисс 2). Самая молодая, сохраненная ископаемая почва в разрезе прямо под современной почвой; это почва типа буроземов датированная 41 тыс. лет, что соответствует младшему Вюрму, наверно интерстадиалу Хенгело.

Изучение лёссов и погребенных почв в разрезе Велький Шариш-Канаш указало, что среди сохраненных слоев существуют различные стратиграфические перерывы, которые были результатом интенсивных геоморфологических процессов или же влияния молодой тектоники обусловливающей развите рельефа чехословацких Карпат в плейстоценовое время.