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Variscan and Pre-Variscan events in the Western Carpathians represented along a geotraverse

(4 obr. v texte)

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Project No. 5
Pre-Variscan and Variscan events
in the Alpine-Mediterranean
mountain belts

Варискоe и довариское развитие Западных Карпат вдоль геотраверзы

В связи с корелационной программой МГКП, пройекта № 5, Варискоe и доварискоe развитие альпийско-средиземноморского пояса, развитие западокарпатского сегмента обработывается вдоль геотраверзы „С" Карпаты — Динариды. Эта геотраверза проходит от альпинского форланда Карпат через панонскую впадину до северозападной части Динарид. Западокарпатский сегмент пересекает в средней части от севера к югу. Для кореляции стратиграфических и тектонических единиц вариского и доварискoго цикла, разрез Карпат дополняется частичными геологическими разрезами больших шкал. Одиночные характеристические развития палеозоя изображаются в литостратиграфических корелационных колонках. Работа сумаризирует до сих пор известных познаний из этого района.

Variský a predvariský vývoj Západných Karpát v reze pozdĺž geotraverzy

V rámci projektu č. 5 korelačného programu IGCP Variský a predvariský vývoj alpínsko-mediteránneho horského pásma sa vývoj západokarpatského segmentu znázornil pozdĺž geotraverzy C Západné Karpaty —Dináre. Geotraverza prebieha od predalpínskeho predpolia Západných Karpát cez panónsku panvu do severozápadnej časti Dinár a západokarpatský segment pretína v strednej časti od S na J.

Na koreláciu stratigrafických a tektonických jednotiek variského a predvariského cyklu sa zvolili prehľadné profily doplnené čiastkovými geologickými rezmi väčších mierok. Charakteristické vývoje paleozoika sú znázornené aj v litostratigrafických korelačných kolónkach.

Within the scope of the IGCP Project No. 5, Variscan and Pre-Variscan events of the Alpine-Mediterranean mountain belts, the development of the Western Carpathian segment should be represented along the Carpathian — Di-

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naride geotraverse C. The geotraverse runs from the Alpine foreland across the Pannonian basin into the NW Dinarides traversing the Carpathian segment from N to S in its central part.

For correlations of stratigraphic and tectonic units of both Variscan and Pre-Variscan development, the presentation of a geological deep profile has been decided to sketch positions of different Paleozoic areas and/or structures within the Alpine belt. Complementary sections aim at illustration of their stratigraphical and structural setting in greater detail. Single characteristic developments are further presented on stratigraphic correlation columns.

The paper reviews present state of knowledge.

Geological deep profile across the Western Carpathians and position of Variscan structures within the Alpine edifice

Recent knowledge upon the Alpine edifice considerably limits our recognition of Variscan and Pre-Variscan development in the Western Carpathians. Notwithstanding existent different views on the Alpine fremework, the best approach to decipher Variscan and Pre-Variscan elements yields the adoption of some until suggested explanation to the Alpine edifice. Since we do not intend deal with Alpine structures, the reader is referred to our previous papers for comprehensive appreciation (P. Grecula 1973, P. Grecula — Z. Roth 1978, I. Varga 1978, B. Leško — I. Varga in print).

Pre-Alpine structures and/or lithological units are unevenly represented along recent erosion level of the Western Carpathian architecture. Paleozoic developments crop out in inner portions of the belt whereas upon their peculiarities in external partions we may assume only indirectly from pebbles in Mesozoic or Cenozoic conglomerates or from geophysical interpretation. Hence, we deal in detail only with inner portions of the belt.

According to until more or less inveterate views, Pre-Alpine units share mainly the Alpine edifice at places where Alpine nappes preserved the connection to their homeland (rooted nappes or nappes de racine). However, such rigorous explanation appears recently as disproved and consequently refused for the most of Alpine nappes and neither homelands of single Mesozoic developments nor of their Paleozoic basement may be convincingly located in the Western Carpathians. Yet, Pre-Alpine units preserved at most in lower Alpine nappes of the Carpathian nappe pile whereas upper Alpine nappes are either devoid of Paleozoic units or they contain only remnants of the Paleozoic development. Such assumption appears as valid disregarding if one attempts to root Alpine nappes into real or supposed sutures in the recent architecture and even if considering all nappes as superficial rootless ones.

The choosen deep structural profile runs from the High Tatra Mts. on the Polish-Czechoslovak frontier across the eastern promontories of the Low Tatra Mts. and the entire Spišsko-gemerské Ore Mts. to the Hungarian frontier N from the Bükk Mts. Such location of the profile is due to available numerous data on the Pre-Alpine development just from these ranges of the Carpathians. We are conscious of possibility to disregard many important data from other West Carpathian regions (Vepor Mts., Little Carpathians a. o.) where Paleozoic sequences crop out but these are generally less known and until insufficiently investigated.

Several exploration data (deep boreholes, mining works) motivated also the choice of such profile. The structural interpretation, at least down to 2 km depth is therefore sufficiently reliable in rough lines. Deeper levels may be inferred from geophysical data available again mainly from this area. To explain relations in deep crustal levels, deep seismic data of the international DSS profile V allow their interpretation (though not even convincing in the Carpathian segment) but extrapolations are reliable based from the new K-III deep seismic profile across the Carpathians running more westernly. The situation of the profile is presented on the sketch map.

Pre-Mesozoic lithologies presented on this profile participate on deeply submerged and partly, during Alpine events, also reactivated North-European platform (P. Grecula — Z. Roth 1978, B. Leško — I. Varga in print) composing the foreland for the Alpine architecture. Another large representation of Paleozoic developments appears in (mostly innermost) Alpine nappe structures. The paleogeographical affinity of Pre-Mesozoic lithologies sharing the architecture will be not treated here, some of sour suggestions may be inferred from the profile.

High-grade crystalline and granitoids participate on the Alpine unit of the High Tatra Mts. ("Tatrides"). The supperposition of this structure over younger sediments may be inferred from recent geophysical results and interpretations (cf. Č. Tomek et al. 1976). We correlate this Alpine unit with lowermost Austroalpine nappes of the Eastern Alps.

Large Paleozoic sequences participate on the Alpine structure in the Spišsko-gemerské Ore Mts. We delimite two independent nappe structures here touching the Tatride belt along the Čertovica line. Interpretations of this line are until very different (see e. g. A. Biely et al. 1968, D. Andrusov 1975). Certainly, the line delimits Pre-Mesozoic developments of southern units where slight metamorphic overprint allows to reconstruct lithological and stratigraphical sequences at least for the Paleozoic period from northern ones where the original sequences broadly concealed within the Pre-Mesozoic (metamorphosed before the Upper Paleozoic sedimentation) crystalline. Differences therefore are due to different Pre-Mesozoic development but also due to another Alpine tectonic history.

Southern limit of this extensive Paleozoic development runs along the Rába-Rožňava disccontinuity belt (P. Grecula — I. Varga in print) limiting from NW the Paleozoic to Mesozoic units comprimed between this discontinuity and the more southern Darnó discontinuity belt. Both alignments may be comprehended as Weste Carpathian outstretches of the Periadriatic-Insubric belt.

The lowermost structural element in the profile represents the North-European Epivariscan platform merging in unaltered shape at least as far as the Pieniny klippen belt. Further continuation of the platform beneath central Carpathians may be only inferred. Probably, between the Pieniny klippen belt and southern margin of the West Carpathian gravity minimum, structures of the platform have been activized and acquired alpinotype pattern during Alpine events.

The deep crustal architecture southwards from the southern margin of the gravity minimum may be not undoubtely deduced from surficial units. Available geophysical data point to considerable differences between tectonic style and content of the lower crust southwards from the gravity minimum when comparing it with more external portions. Deep crustal processes probably entirely effaced the older structural pattern. We presume similar reorganization even for the southernmost portions represented in the profile.

Surficial Alpine tectonic units do not allow to deduce Paleozoic developments in the external Silesic unit. We may only presume a continuation of single Paleozoic developments from the platform foreland into the basement of external flysch nappes beneath the whole extent of Silesic units.

Similarly, any convincing data should be inferred for Paleozoic developments of the Cenozoic Magura nappe correlated recently (M. Mahel' 1978) with the North-Penninic Rhenodanubian flysch of the Eastern Alps but also with all hesitations of such interpretation.

Paleozoic beds do not participate neither on surficial structures of the Pieniny klippen belt and only some pecularities may be inferred indirectly from Mesozoic sequences. Numerous common features of Mesozoic to Cenozoic lithologies in the Magura flysch belt and the klippen belt suggest connections towards recently more southern (and inner) Vepor and Gemer nappes of the Carpathians. The probable Pre-Mesozoic basements of the Magura flysch and that of the Pieniny klippen belt surely resembled Paleozoic and older sequences outcropping now in the latter two nappes.

The Vepor nappe creates the lowermost Alpine nappe structure of the innermost Western Carpathians. It contains low-grade metamorphites of Paleozoic age and Variscan granitoids. The presence of older (Pre-Ordovician) lithologies is highly probable in the nappe, however, exept of rare and insufficiently interpreted radiometric data, not proved. Several partial nappe structures participate on the Vepor composite nappe manifesting also partly different lithological developments.

Considerable part of the structure occupies here the Hron unit (named originally as the Hron complex by A. Klinec 1966) consisting of slightly metamorphosed Early Paleozoic sediments accompanied by huge acid and basic volcanites. The higher Kráľova hoľa unit comprises mainly Variscan granitoids and their polymetamorphic mantle derived from sediments of Early Paleozoic to, probably, Upper Carboniferous age. Sedimentary sequences of the unit were assembled by A. Klinec et al. (1971) under the Hladomorná dolina group name. The Late Paleozoic to Mesozoic cover of the Early Paleozoic in the Vepor nappe consists of detrital quartz-porphyry bearing Permian and shallow-marine Mesozoic beds.

According to available geophysical data, masses of higher density participate on the Hron unit mainly in its deeper portions (probably basic volcanites and heavy sediments) contrary to light constituents in the upper Kráľova hoľa unit (mainly granitoids and their envelope). A clear nappe structure results even from the geophysical picture.

The similarly complex and inner Gemer nappe comprises also independent partial nappe structures. Until supposed differences in age and in the metamorphic grade between the Gemer and Vepor nappe have been recently removed by discovery of comparable Sporomorpha assemblages and lithological content in both units. Remarkably, the lower Alpine structure of the Gemer nappe consists also considerable volumes of basic volcanites (the Rakovec development) as it is in the Vepor nappe. Huge acid volcanites (porphyroide), clastics and less frequent granite bodies participate on the higher Gelnica unit. Differences in the proportions of granitoide bodies between the Vepor and Gemer nappes may have resulted from different erosion level before the Late Paleozoic transgressions.

The sedimentary cover of the Gemer nappe core has been until interpreted in different manner and resulted also different interpretations of the Alpine edifice. Late Paleozoic developments differ on the N and S margin of the nappe. The Late Paleozoic sequence joins basic volcanites, black and variegated shales of the Early Paleozoic along the northern side. The Upper Carboniferous sequence contains here huge conglomerate beds, dark graphiteous psammite and slate accompanied by important basic volcanites of similar nature as in the Early Paleozoic sequence. A new transgression of continental, coarse detritic Upper (?) Permian conglomerate introduced frequent quartz porphyry bodies and evaporite facies of local extent in uppermost levels. Local discordances overpass into the Lower Triassic.

Upper Carboniferous in the cover is missing in the south of the Gemer nappe. A Lower Permian transgression of coarse detritic sequence with frequent quartz porphyry starts as early as the Lower Permian and proceeds upwards into Upper Permian (?) clastics containing rare dolomite levels. The sequence surpasses probably into the Lower Triassic.

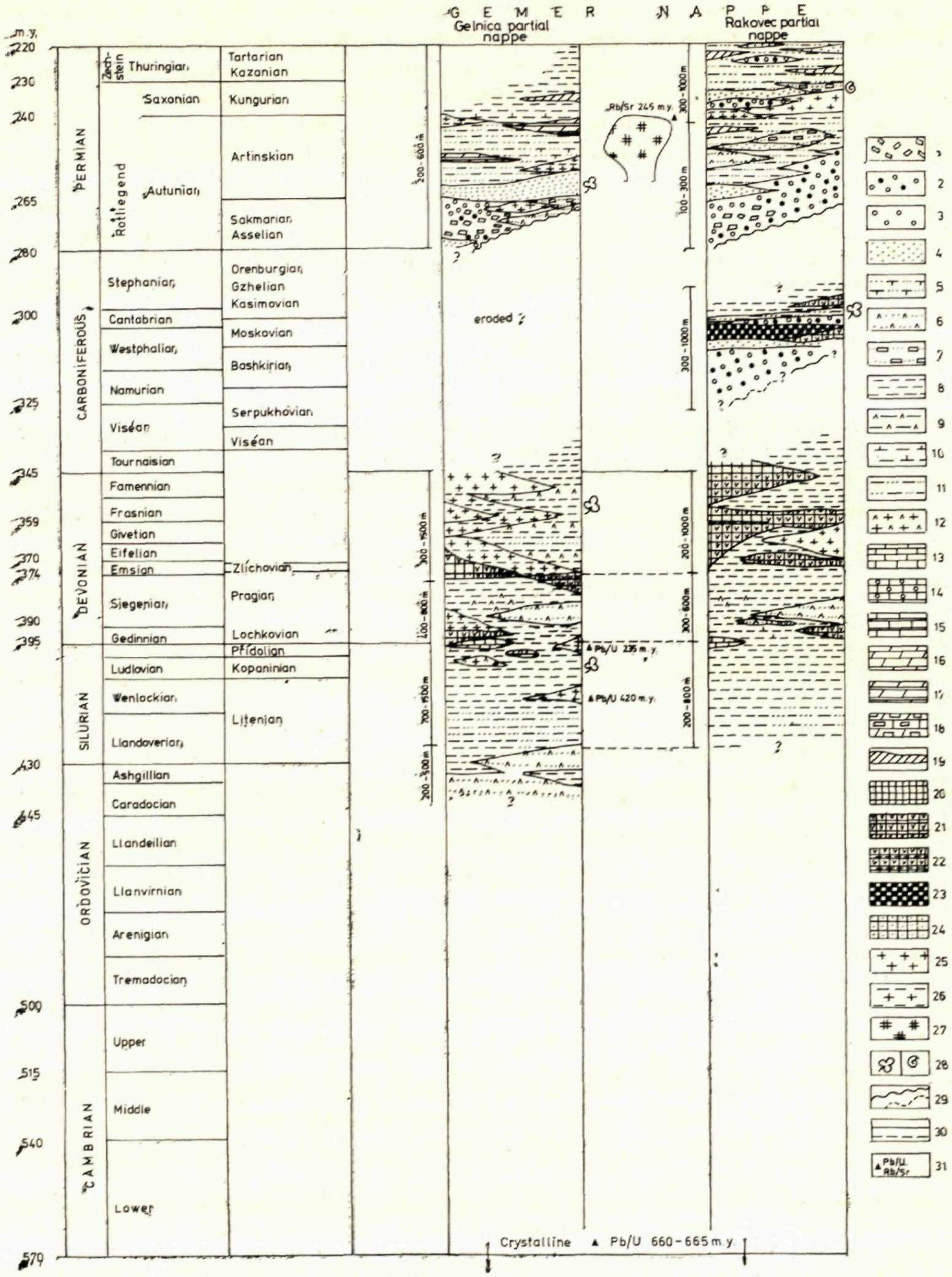
Several Alpine tectonic units well correlating with lowermost Eastalpine nappes by lithology and tectonic position participate on the architecture of High Tatra Mts. ("Tatrides" of A. Matějka — D. Andrusov 1931). The high-grade Variscan metamorphic overprint is conspicuous and the share of Pre-Variscan lithologies seems to be the highest here among all West Carpathian units. The latest metamorphic event preceded the Upper Carboniferous time since unmetamorphosed Stefanian to Permian cover transgredes above the crystalline socle. Also the share of Variscan (and probably also Pre-Variscan) granitoids is the highest here. Mesozoic developments are of geanticlinal nature.

Paleozoic to Mesozoic developments resembling relations in the North Hungarian Bükk Mts. have been discovered recently also in southernmost parts of the Western Carpathians (H. Kozur — R. Mock 1973, R. Mock 1978). An Alpine nappe structure consisting these lithologies appears in evident superposition over the Gemer nappe being separated from the latter by another Alpine nappe structure bearing HP-LT metamorphic assemblages of Alpine age (glaucophanite). Hence, development of the Gemer nappe during the Paleozoic or Mesozoic time may be not immediately related to the Bükk Mts.

Characteristics of single Paleozoic developments along the geotraverse

Paleozoic sequences are best known at present in the Spišsko-gemerské Ore Mts. area.

Two different Early Paleozoic devolopments may be delimited participating to a considerable degree also on independent partial nappe structures of the Gemer nappe. These partial structures were recently delimited almost in the whole extent of the composite Gemer nappe. To what extent participate on these structures also inherited Variscan structures, may be not decided up to present.


G E M E R N A P P E
Gelnica partial nappe
Rakovec partial nappe
m.y.
220
230
240
265
280
300
325
345
359
370
374
390
395
430
445
500
515
540
570
PERMIAN
Zechstein
Thuringian
Saxonian
Rotliegend
Autunian
Tartarian
Kazanian
Kungurian
Artinskian
Sakmarian
Asselian
CARBONIFEROUS
Stephanian
Cantabrian
Westphalian
Namurian
Viséan
Tournaisian
Orenburgian
Gzhelian
Kasimovian
Moskovian
Bashkirian
Serpukhovian
Viséan
DEVONIAN
Famennian
Frasnian
Givetian
Eifelian
Emsian
Siegenian
Gedinnian
Zlíchovian
Pragian
Lochkovian
SILURIAN
Přídolian
Ludlovian
Kopaninian
Wenlockian
Llandoverian
Litenian
ORDOVICIAN
Ashgillian
Caradocian
Llandeilian
Llanvirnian
Arenigian
Tremadocian
CAMBRIAN
Upper
Middle
Lower
eroded ?
Rb/Sr 245 m.y.
Pb/U 235 m.y.
Pb/U 420 m.y.
Crystalline
Pb/U 660-665 m.y.
200-600 m
100-300 m
300-1000 m
300-1500 m
200-1000 m
400-800 m
300-600 m
700-1500 m
200-800 m
200-300 m
Pb/U
Rb/Sr

The Early Paleozoic development represents here an about 3—5 km thick rock pile of psammitic to pelitic flysch-like sequence containing less frequent silicite (phtanite) levels and elsewhere rare carbonate bodies. Huge supercrustal acid volcanites (porphyroide) and basic eruptives accompany the former. Mainly pyroclastics and less frequent effusive bodies represent the acid members. The share of true volcanites is partly higher among basic rocks.

According to available data, this huge sequence accumulated between the Lower Silurian and Upper Devonian and Upper Carboniferous sediments follow already upon the folded (?) Variscan edifice. Paleontological data point to Westfalian A but locally already to Namurian B—C age of the Upper Carboniferous transgression. Yet, the question of the main Variscan orogenic event should be not considered as solved (cf. R. Mock 1978).

The Pre-Silurian development may be not inferred until, since the base of this Early Paleozoic has been not evidenced. Radiometric U/Pb ages of detrital zircon sampled from "lower" detritic part point to the presence of Precambrian units in the source area (660—665 m. y.). Similar ages of authigenous zircon in acid supercrustal volcanics point to 420—395 m. y. (all data from N. P. Semenenko in G. D. Afanasiev et al. 1977).

The reliability of latter for sedimentary ages of sediments accompanying the volcanic activity (fine lithic arenites and slates) may be not judged sufficiently. Tuffaceous volcanites reveal partly evident sedimentogenous textures and may be redeposited in the sequence, however zircon ages concern quartz porphyry bodies. Therefore the subdivision of the Early Paleozoic into partial lithostratigraphic units results only from superpositional relations that are somewhere uncertain due to considerable Alpine tectonization of the whole unit.

Presented lithostratigraphical columns reveal the recent state of the knowledge. Available palynological data (O. Čorná 1972, 1974, L. Kamenický — O. Čorná 1977) delivered Sporomorpha assemblages from graphite shale of different localities ranging from the Uppermost Silurian to Upper Devonian and rare data point to uncertain Lower Carboniferous age of some members. Scarce conodont findings have been until not stratigraphically evaluated.

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Fig. 4. **Litostratigraphical correlation columns of the Gemer nappe Paleozoic.**

Explanations to the litostratigraphic columns: 1 — breccia, 2 — polymict conglomerate, 3 — monomict conglomerate, 4 — sandstone, greywacke, 5 — calcareous sandstone, 6 — quartzite, 7 — arcose, 8 — argillaceous shale, 9 — siliceous shale, 10 — marly shale, 11 — argillaceous siltstone and shale (1—11 *clastic sediments*), 12 — lydite, 13 — limestone, crystalline limestone, 14 — biohermal limestone, 15 — platy (marly) limestone, 16 — dolomite, crystalline dolomite, 17 — platy (marly) dolomite, 18 — cellular limestone, dolomite, 19 — evaporite (12—19 *chemical sediments*), 20 — diabase, 21 — diabase tuff, 22 — diabase tuffite, 23 — gabbro, hornblendite, diorite, quartz diorite, 24 — serpentinite, 25 — quartz porphyry, porphyrite, porphyroide, 26 — quartz porphyry tuff and tuffite, 27 — granite, granodiorite, 28 — floristical and faunistical remnants, 29 — ascertained and supposed discordances, 30 — ascertained and supposed tectonic boundary, 31 — radiometric age.

Similar problems accompany the Early Paleozoic Hron group of the Vepor nappe. Porphyroide, arenaceous shale, intermediate and (in surficial parts?) less frequent basic volcanite constitutes the sequence. Sporomorpha assemblages from fine clasts point to Silurian to Lower Carboniferous age (L. Planderová — O. Miko 1977) but neither the stratigraphic subdivision nor here even the lithostratigraphy are known within the group. We only presume the same stratigraphic span for the Hron group as for the Gemer nappe Paleozoic.

Another Paleozoic group of the Vepor nappe, the Hladomorná dolina group, contains also Sporomorphs resembling assemblages in the Gemer nappe (P. Snopková in A. Klinec 1966). More recently, newer palynological findings point to even Stefanian age of some sequences in the group (E. Planderová — A. Vozárová 1978). Hence the span and lithostratigraphy of this group remains unknown and the possibility that some discordances occur within it, remain unproved.

Lowermost lithological members of the North-Gemeride Upper Paleozoic represents the Upper Carboniferous sequence along the northern margin of the nappe. The coarse detritic (conglomerate) to psammitic sedimentation accompanied by heavy basic volcanism follows obviously after angular discordance upon the Early Paleozoic the latter comprising of conspicuously similar basic volcanie bodies (the Rakovec development). The trangressive relation, however, except for Rudňany and Dobšiná area is not entirely clear. Moreover, some other independent lithostratigraphical units yielding also Upper Carboniferous paleontological evidence along the northern margin of the Gemer nappe mutually differ and may belong also to different Alpine structures. A broadly acceptable correlation within these partial sequences is valid only for some part of the Podrečany—Ochtiná belt or for the portion NW from Košice, where thick carbonate bodies (partly converted to crystalline magnesite) occur in graphiteous clastic sequence. Tectonic limits of these occurences do not allow rigorous interconnection toward other Upper Carboniferous developments of the Gemer nappe.

Despite insufficient paleontological data, lithostratigraphic relations of Permian sequences are well known in the Gemer nappe. Pecularities of single developments appear from the presented columns.

A detritic Late Paleozoic cover of the Vepor Early Paleozoic sequence starts probably but by Upper Permian sequences. Frequent quartz porphyry and pyroclast layers occur in the lower portions. The question of Upper Carboniferous beds in the Vepor nappe has been treated above.

Quartz porphyry producing volcanism along the southern margin of the Gemer nappe appears in the Lower Permian Rožňava-Železník group probably contemporaneously with the intrusion of granite into the Lower Paleozoic sequence. Recent Rb/Sr whole rock isochron data point to 250 ± 26 m. y. age of the granite corresponding to the Autunian. Part of quartz porphyry bodies in the northern parts of the Gemer and Vepor nappe may be relatively younger.

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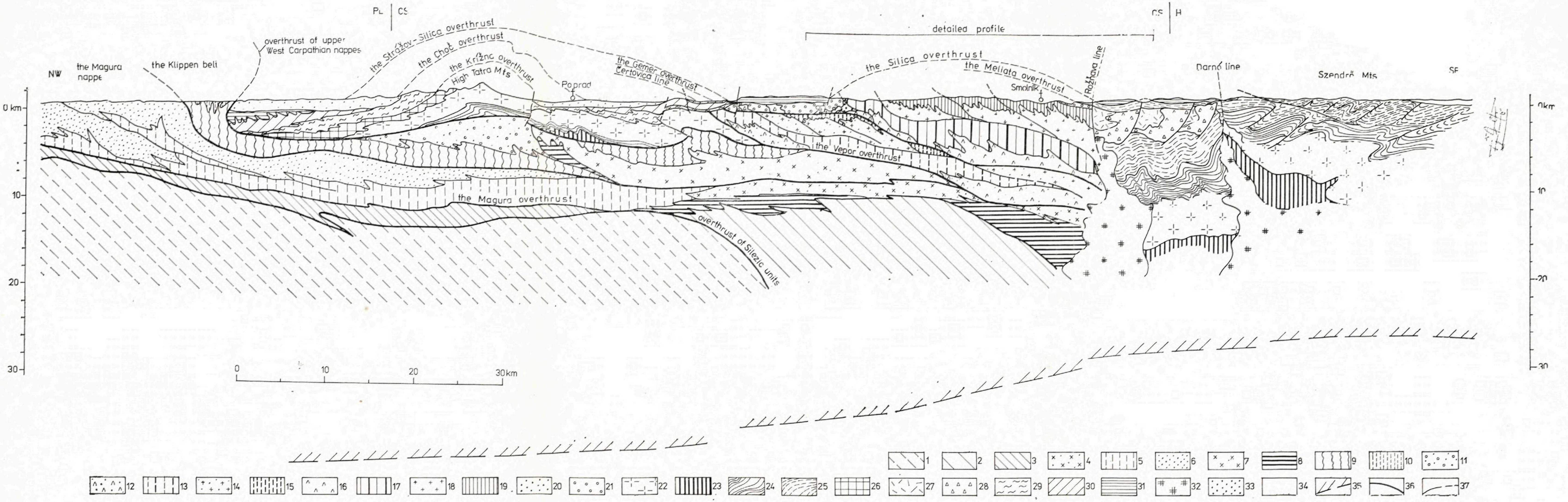

Fig. 2. **Deep geological profile across the Western Carpathians.**

Explanations to the deep geological profile of the Western Carpathians. *The North-European platform and its cover:* 1 — crystalline and Mesozoic of the autochton, undistinguished, 2 — crystalline to Mesozoic of alpinotype activized platform, 3 — Paleozoic to Mesozoic in the Silezic group of nappes. *Penninic units of the Western Carpathians:* 4 — crystalline, 5 — Paleozoic to Lower Cretaceous, 6 — Upper Cretaceous to Paleogene (4—6 the Magura nappe), 7 — crystalline, 8 — basic masses in the Pieniny klippen belt crystalline and in the Magura nappe, 9 — Paleozoic to Lower Cretaceous, 10 — Upper Cretaceous to Paleogene, 11 — supposed Cenozoic sediments of the Pieniny klippen belt (7—11 the Pieniny klippen belt), 12 — crystalline, mainly basic rocks, 13 — epimetamorphosed sediments and volcanites, Early Paleozoic to Mesozoic (12—13 Lower Vepor nappe structure, the Hron group), 14 — crystalline and granitoide, 15 — epi- to mesometamorphosed sediments and volcanites, Early Paleozoic to Mesozoic (14—15 Upper Vepor nappe structure, the Kráľova hoľa unit, the Hladomorná dolina group, 12—15 the Vepor nappe), 16 — crystalline, mainly basic rocks, 17 — the Rakovec development of the Early Paleozoic (16—17 Lower Gemer nappe structure), 18 — crystalline, granitoide, 19 — the Gelnica development of the Early Paleozoic (18—19 Upper Gemer nappe structure), 20 — sediments and volcanites, Upper Carboniferous, 21 — sediments and volcanites, Lower Permian to Mesozoic (16—21 the Gemer nappe). *Upper West Carpathian nappes:* 22 — granitoide and its metamorphic mantle, 23 — basic masses, 24 — meso- to katametamorphic rocks, 25 — Early Paleozoic to Mesozoic, epimetamorphosed, 26 — "envelope" groups, Late Paleozoic to Mesozoic, 27 — Lower Triassic clastics, 28 — evaporite, 29 — Late Paleozoic to Mesozoic in the Krížna nappe, 30 — Late Paleozoic to Mesozoic in the Choč nappe, 31 — Mesozoic in the Silica and Strážov nappes, 32 — intrusive rocks of Eocene (?) and Miocene age, 33 — Central Carpathian flysch, 34 — Paleogene to Pliocene in the Pannonian basin, 35 — inferred Moho surface, 36 — main nappe surface, 37 — subordinate nappe surface and fault.

Fig. 1. **Te course of the deep geological profile across the Western Carpathians and of the detailed geological profile across the Spiš-Gemer Ore Mts.**

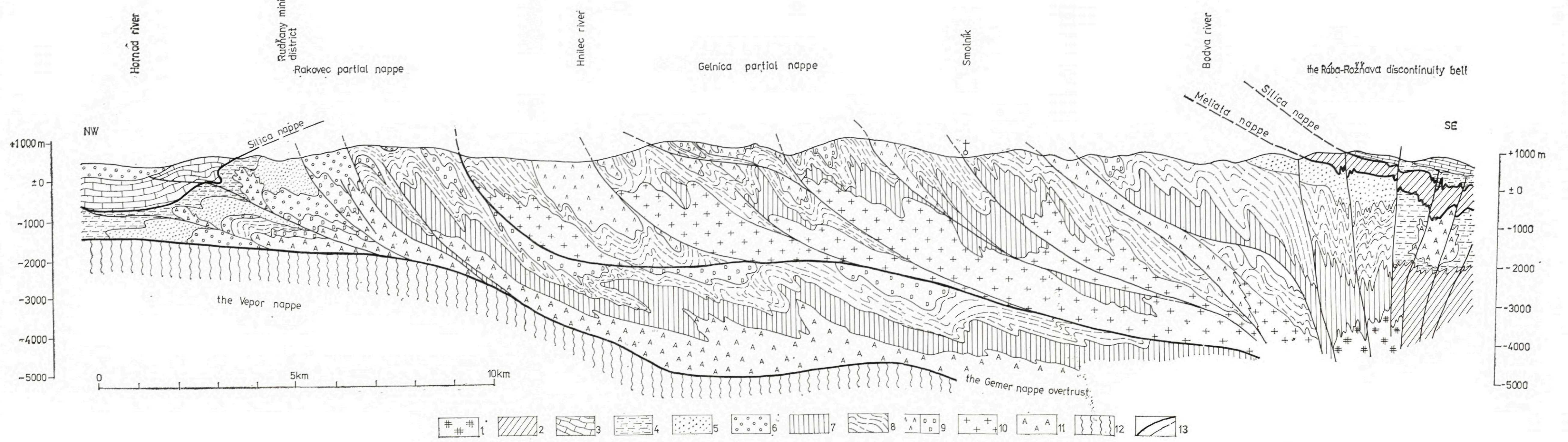

Fig. 3. **Geological profile across the Spiš-Gemer Ore Mts. area.**

Explanations: 1 — intrusive rocks of Eocene to Miocene age, 2 — the Meliata-Bükk Mts. rock facies of Early Paleozoic to Mesozoic age (undivided), 3 — mainly carbonate development of Middle to Upper Triassic and Jurassic in the Silica nappe, *Gemer nappe:* 4 — sandstone, quartzite, arenaceous shale, Lower Triassic, 5 — conglomerate, sandstone, arenaceous shale and rare evaporite layers (mainly anhydrite and gypsum), quartz porphyry and tuff, Permian, 6 — conglomerate, sandstone, pelitic and arenaceous graphitic shale, diabase and tuff, all partly metamorphosed to epidote-amphibolite facies rocks, Carboniferous, 7 — predominating graphite-sericite phyllite, 8 — predominanting chlorite-sericite phyllite, 9 — predominating volcanite, a — acid, b — basic varieties (7—9 the Early Paleozoic development of the Gemer nappe), 10 — granitoides of the Variscan and Alpine cycle (undivided), 11 — basic rocks and crystalline schists in amphibolite facies, 12 — the undivided Vepor nappe, 13 — overthrusts of higher and lower order.

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