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The editor has changed the name as follows: Institutul Geologic al României (vol. I–XXXVI, 1910–1952), Comitetul Geologic (vol. XXXVII–LII/1, 1953–1966), Comitetul de Stat al Geologiei (vol. LII/2–LV/1, 1967–1969), Institutul Geologic (vol. LV/2–LX, 1970–1974), Institutul de Geologie şi Geofizică (vol. LXI–75, 1975–1993).

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Introduction

The second ALCAPA meeting is hosted by Romania. Following the 1992 first ALCAPA meeting from Graz, it sheares the same goal: to bring together researchers in Earth Sciences from, or interested in the geology of Alpine, Carpathian and Pannonian regions. The direct contact, in field excursion, at the conference, or in front of the posters, between scientists from Eastern, Central and Western Europe, and even from outside Europe is in fact vital for finding, if not a common view, very unusual in science, at least a common language and acceptance of the basic facts. Indeed, the last tens of years have introduced an eastward increasing gap in information, circulation of persons and papers and interpretation of field data between geologists from the free countries and those from the communist countries of Europe. If the former are for a long time familiar with computer modelling, structural analysis and modern geochemical and isotopic techniques, the latter have reached high field, paleontologic, lithostratigraphic and/or sedimentologic knowledge of their study areas. So, when teams from east and west are doing joint work, the former might find difficult to understand computer modelling, paleostress analysis or comparisons with the Alps, while for the latter the details and names of the multitude of tectonic, stratigraphic or petrographic units from the Carpathians might seem a jungle.

It is also by the way of the ALCAPA project, now project no. 114 within the East-West fund of the Austrian Academy of Sciences, submitted in 1991 and founded starting with 1995, that this gap might be reduced.

In the last 2-3 years many scientific contacts were established between different groups, which started to work together in the field or in the laboratories from eastern or western universities or institutions, after ALCAPA I meeting. Also a lot of other forms of scientific facilities, like short courses, conferences given by well-known scientific personalities, bilateral visits, stages of specialisation, PhD or postdoctoral grants, create a real interest for research activity, especially among the young scientists. We hope that in the future programs the eastern scientists will be involved and work in more and more international programs, in the same normal conditions and style as the western ones.

ALCAPA I was a success due to our collegues from Graz, especially by the effort and interest of Prof. E. Wallbrecher and Prof. F. Neubauer. ALCAPA II will now start due to the enthusiasm of a team from the Geological-Geophysical Department of University Bucharest and from the Geological Institute of Romania. We are happy to thank both institutions for the logistic help offered whenever we asked for. Special thanks to Prof. F. Neubauer, now at Salzburg University, for the active managing and scientific contribution, and for the financial help in printing the Abstracts and Field-guide books.

And now we wish to the participants to the ALCAPA II meeting a fine weather for the field excursion and success in the symposia.

Prof. Dr. Corneliu Dinu
Bucharest University

Dr. Tudor Berza
Geological Institute of Romania

CORRELATION OF THE CAUCASUS, PONTIDES, BALKANS AND CARPATHIANS IN PHANEROZOIC TIMES: A NEW SYNTHESIS

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In the Phanerozoic the Caucasus-Pontides, Balkans and Carpathians evolved as the northern active margin of the Tethys. The major suture of the latter is believed to be marked by the lesser Caucasian-North Anatolian-Vardar ophiolitic suture. According to recent data, fragments of the Paleozoic and Mesozoic oceanic assemblages occur together in the Lysogorsc, Amassia, Artvin and Erzincan accretionary prisms within this suture. A complex system of the Paleozoic island arcs, back-arc and inter-arc basins and of the Andean type volcanic belts occurred along the northern margin of the ocean. At present these units are preserved as strongly tectonized and more or less metamorphosed fragments within the huge accretionarey wedge of West Pacific type, known as the Variscan orogen.

Overall correlation of these tectonic units throughout the region is impossible but the assemblages, comparable by their sedimentary and magmatic sequences, age and type of metmaorphism - presumably formed in similar paleotectonic environments - can be distinguished: The Lower-Middle to Upper Paleozoic phyllite-diabase (oceanic) assemblages formed at accretionary ridges and in hotspots are encountered in the Dzirula mass of the Transcaucasus, in the Western Pontides (the Istanbul nappe), in the Balkans (Rhodope massif), in the Southern and Western Carpathians (Stara Planina and Spyssko-Gemerske Rudohorie); The Lower-Middle Paleozoic oceanic arc - back arc structures with tholeiitic to boninitic magmatism occur in the forerange of the Greater Caucasus and in the Amassia accretionary prism of the Main Tethyan suture (western Armenia). Middle-Upper Paleozoic island arcs on the transitional type crust are represented by the plagiogranitic-granitic and andesitic assemblages of the Transcaucasus (Dzirula, Loki, Khrami), Eastern Pontides (Artvin-Baiburt), Western Pontides (Istanbul nappe), Balkans (Rhodope Massif), Southern and Western Carpathians; The Upper Paleozoic (Upper Carbonifereous-Permian) calc-alkaline volcanism of the mature island arcs occur in the Greater Caucasus (Forerange and Main Range), in the Transcaucasus (Dzirula), Eastern Pontides, Southern Carpathians and Northern Dobrogea. Also in the Western Carpathians (Slovenian Rudohorie and Lower Tatras). The Variscan orogeny resulted in the large-scale accretion process, accompanied by granitoid intrusions and formation of continental crust.

The Upper Triassic-Jurassic suprasubductional assemblages of the Transcaucasus-Pontides-Balcans-Carpathians can be subdivided into ensialic (mainly with Variscan basement) and oceanic (boninitc-tholeiitic) magmatic rocks preserved mainly in the ophiolitic accretionary complexes. A double chain of arc - back arc structures can be distinguished in the Caucasus - Crimea and in the Pontides. From the Upper Cretaceous increasing involvement of the Gondwanian blocks into the arc magmatism within the northern and southern branches of the Tethys is encountered (South Armenian and Anatolian blocks). Transcaucasus - East Pontian - West Pontian, Balkan and Carpathian arc segments with the Adjara-Trialetian - East Black Sea, West Black Sea, Sredna Gora and Carpathian back arcs (marked by flysh sedimentation) can be distinguished. Geochemical and isotopic signatures of the Mesozoic - Cenozoic magmatic assemblages are discussed in relation with tectonic setting and mantle processes in each structural unit.

EVOLUTION OF THE SEDIMENTARY BASIN OF THE OUTER DACIDES (EAST CARPATHIANS ZONE): A RESULT OF THE VARIATION OF THE LITHOSPHERE STRETCHING FACTOR

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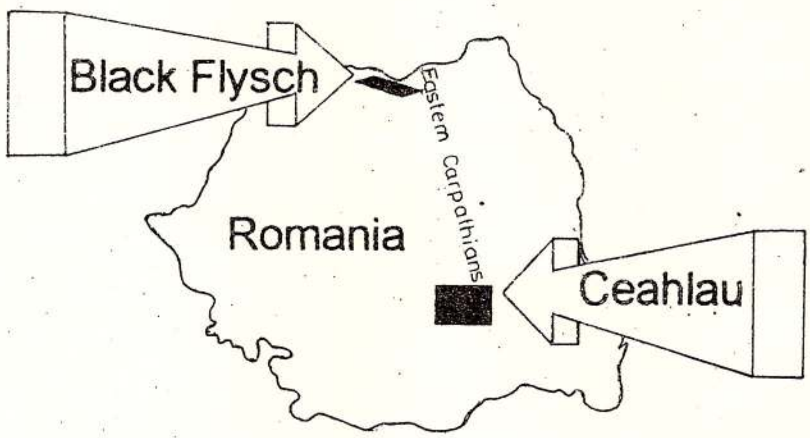
The External Dacides sedimentary deposits from Eastern Carpathians (now situated in more thrust sheets) originate in an intracontinental stretching sedimentary basin active between J2(J1?)-K1.Only to the north (Black Flysch thrust sheet) and less to the south (Ceahlau thrust sheet-Bratocea Unit) a magmatic was preserved.



It is thought to represent the effect of the fault controlled subsidence. At the post-rift thermal subsidence, Upper Tithonian-Aptian sedimentary deposits were accumulated. Departure from a pure shear instantaneous stretching developed on the European continental margin was tested by the geohistory analyses. By the backstripping method were plotted the subsidence curves for both areas of External Dacides basin and, also, was obtained the stretching factor (β: 1.1 for northern area and 1.32 for the southern one. For the northern area the observed values of syn-rift sedimentary deposits thickness fit well the theoretical values. However, for the southern area, taking into account the normal lithosphere parameters (see for example Allen & Allen, 1990),the syn-rift sedimentary deposits thickness is much larger than the measured one. That is, it can be due to several factors:

1. The ophiolites are not in fact the basement and they could have had at their base another thick sedimentary stacking, which could have been consumed by the Cretaceous thrusting events. The ophiolites found in an actual position could be only one of the last occurrences generated by stretching.

2. The southern area of External Dacides may have been uplifted prior to fault controlled subsidence.

3. An uplift event in Tithonian and eroding may have removed an important thickness of Tithonian syn-rift sediments.

4. The theory which assumes essentially instantaneous stretching may be an inappropriate one for this area of External Dacides.

By regional reason, this discrepancy concerning the syn-rift sediments thickness seems to be explained from both 2 and 1 observations.

The problem of too low stretching factors values to explain the occurrences of asthenosphere and/or mantle material may be related to:

1. The initial lithosphere was affected by an abnormally warm asthenosphere pulse.
2. The peridotite solidus was not "dry", but"wet".
3. The mechanical boundary layer (100 km for a normal continental lithosphere) was only about 60-70 km thick immediately prior to Jurassic rifting.

The presence between both analysed areas of syenitic massif of Ditrau containing minerals with volatile traces, suggests a "wet" asthenosphere material.

By structural and sedimentary facies reasons, the northern area of the extensional basin of External Dacides seems to has been located in a more complicate dynamic regime as strike-slip type due to the evolution of oceanic basin of Tethys,which constrained a stretching-blocking-migration evolution.

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GEOLOGICAL AND GEOPHYSICAL MODELS OF THE LITHOSPHERE IN THE WESTERN CARPATHIANS

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A consistent interpretation model of the lithosphere has been worked out by combining the results of several geophysical methods (gravity, seismic, magnetotelluric sounding, magnetic and heat flow density data) and geological data. The geophysical modelling has been carried out with particular reference to the results of deep seismic data from several profiles (e.g. Profile 2T, Profile 3T, and others). This study is to improve knowledge and understanding of the processes of continental crust formation and evolution.

Analysis of the geophysical modelling and recent geological data predicts that the crustal and lithosphere structure of the Western Carpathians represents an extreme tectonic complicated segment of the Alpine mountain system, which is a result of several tectonic phases- repeating of compression and extension processes during the long-term Alpine and Hercynian orogenic evolution.

The cross-sections show geometry of the contact between European plate and the southern one, which is modified by arching of the Central Western Carpathians. The arching of the upper part of the lithosphere collision zone including asthenosphere upward in the southern plate represents the last stage of this contact and collision. This process is associated with the extension conditions in the upper lithosphere, its tectonic upset following by the unroofing.

The global picture of the lithosphere based on geophysical modelling predicts also that there are preserved relicts of the older (probably Hercynian) segments in the present structure of the Western Carpathians. The results suggest the crustal shortening only about 50 km in neo-Alpine evolution of the Western Carpathians. The difference of the continental convergence process not only in time, but in space as well are proved also by geophysical modelling in the western and central parts of the Western Carpathians.

TOPOGRAPHY, GRAVITY ANOMALIES AND FLEXURE OF THE LITHOSPHERE IN THE WESTERN CARPATHIANS

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The Carpathians are included in the northern branch of the European system of the Alpides. Together with the Eastern Alps and Dinarides they are the results of Mesozoic and Cenozoic continental collision between Europe and several continental fragments to the south, including Africa. The Carpathian fold belt is characterized by a positive-negative anomaly "couple" as in the case of the Alps and Appalachians. The maximum elevations crossed by profiles are ca. 1800 m in the Western Carpathians and 1600 m in the Eastern Carpathians. For determination of the effective elastic plate thickness and effectice flexural rigidity of continental lithosphere beneath the Carpathians thin elastic plate theory was used. The elastic thickness for the Carpathians increases from 24.2 km in the western Carpathians to 84.3 km in the Eastern Carpathians. On the average it is 32 km in the Western Carpathians and 50 km in the Eastern Carpathians. Increasing of the effective elastic thickness could be associated with the age of the platform, that is growing old eastward. Analysis of deflection, topographic and gravity data shows that the lithosphere in the Carpathians behaves elastically and flexural bulge of topography in foreland can be described in terms of the flexure of an elastic lithosphere acted upon by a vertical force and a bending moment. The origin of lithosphere deflection is the result of both surface and subsurface loading. A long-wavelength asymmetric gravitiy low, which spans the mountains, is associated with the flexure basin and/or in other words with the basement deformation of the passive margin of the European underthrusting plate. On the other hand, the gravity high that is unrelated to the topographic relief and surface geology has to be associated with the buried loads.

TRIASSIC FACIES TYPES, EVOLUTION AND PALEOGEOGRAPHIC RELATIONS OF THE TISZA MEGAUNIT

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Triassic facies pattern of the Tisza Megaunit bear witness of a transgression from N to S, i.e. from a southernly lying open sea towards a northernly lying continental hinterland. Distribution of different facies is shown on fact maps and facies reconstructions for four major events of the Triassic sedimentary evolution: Upper Scythian (redbed stage and early stage of transgression), late Lower Anisian – early Middle Anisian ("Upper Wellenkalk", preceeding the formation of intrashelf basins), Ladinian (Wetterstein platform stage) and Carnian-Norian (plus lower Rhaetian) in general (Keuper stage and Dachstein platform stage, respectively). There facies patterns prove that the block of Tisza Megaunit was located on the Northern Tethyan margin adjacent to Europe in the Triassic, and was part of the Austroalpine domain which was deformed in Cretaceous.

TECTONICS OF THE TRANSYLVANIA BASIN

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The Transylvania Basin, with its present - day roughly circular shape, lies in a very complex and interesting position in the middle of the Carpathians. The basin is surrounded by the East and South Carpathians and by the Apuseni Mountains. The Carpathians are a Cretaceous to Neogene mainly external-vergent fold and thrust belt. The Apuseni Mountains, on the contrary have acquired their main tectonic structures during the Early Cretaceous. In the eastern part of the basin the Neogene volcanic chain of andesitic affinity is found.

The Transylvania Basin shows low heat flow (<40 mW/sqm), a Moho at 30 km depth in the central part and 34 km in the eastern sector and a strong magnetic anomaly related to the presence at depth of ophiolitic rocks. The Transylvania Basin which has a quite flat morphology between 600 - 800 m elevation, is geodeticaly stable but surrounded by strongly uplifting area (3mm/yr in southern Carpathians).

The substratum of the basin is formed by Cretaceous nappe pile, similar to that Apuseni Mountains and Carpathians (Bucovinian Nappe).

The oldest sediments of the basin fill are Late Cretaceous turbidites which show more proximal facies in the eastern age of the Apuseni Mountains and in the south and western part of the Carpathians and more distal shally facies in the central part of the basin. The largest thicknesses (more than 1300 m) are found in a roughly N-S oriented through which is possibly controlled by W-E crustal extension. In the latest Cretaceous, contractional deformation folded and steepened the western part of the basin as is also visible in the eastern part of the Apuseni Mountains.

Preliminary fission-tracks data from the Preluca Mountains (NW part of the basin) demonstrate strong uplift during this time.

At the top of Late Cretaceous a major unconformity forms the base of Eocene and younger sediments (less deformed sediments).

The Paleogene sediments are presently found mostly in the northern part of the basin where they form a roughly SE ward thinning wedge. The presence of pre-Early Miocene thrust in published seismic lines suggest a foreland basin for these deposits.

The fission-tracks data from the granitic core of the Apuseni Mountains point to ongoing uplift during this stage.

A new tecto-sedimentary cycle started in Burdigalian, marked by a basin-wide unconformity. The Neogene sediments were deposited all over the place and riched the maximum thickness in its central part.

These Neogene sediments are affected by two contractional deformations. One with NW -SE direction and the other with a roughly N-S direction.

KINEMATIC ANALYSIS IN THE BEND ZONE OF THE EAST CARPATHIANS

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We did measurements in an area between Prahova Valley to the south and Slanic Valley to the north, only in the sedimentary rocks. Those deposits are Tithonian - Neocomian in age (the oldest) and Quaternary (the youngest).

For kinematic analysis, the brittle and brittle-ductile structures have been measured. Those structures show three phases of compression.

a) a WNW - ESE compression which led to backthrusting in the middle part of the studied area;

b) a W - E compression which led to thrusting in the East Carpathians. That W - E compression was accommodated by strike - slip movement in the South Carpathians and in the northern part of the East Carpathians.

c) a N - S compression which led to thrusting in the South Carpathians (i.e. the Getic Depression). The N - S compression was accommodated by strike - slip movement in the flysch zone of the East Carpathians.

So, in fact it was a reactivation, but with different behavior, or an overprinting of the older structures which show a very complex structural style.

The whole system recorded at its boundary the main deformational phases while in its middle part the deformation was less important.

SEISMIC EXPRESSION OF THE MID-HUNGARIAN LINE

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The Mid-Hungarian line is a major tectonic feature cutting Hungary in half and stretching in a NE-SW direction. This structure was defined by surface and subsurface geological data (Wein 1969, Gczy 1973, Flp 1987, Dank et al. 1987) and its effects are visible on gravimetric and magnetic anomaly maps as well. In Hungary the line is fully covered by young Tertiary rocks.

Although it is well confined by adjacent boreholes, the real structure of the line has not been on seismic sections so far. In the present work the study area ranges from the SE outskirts of Budapest to the Mtra mountains (NE-Hungary). The area contains the trace of the Mid-Hungarian line (Fig. 1).

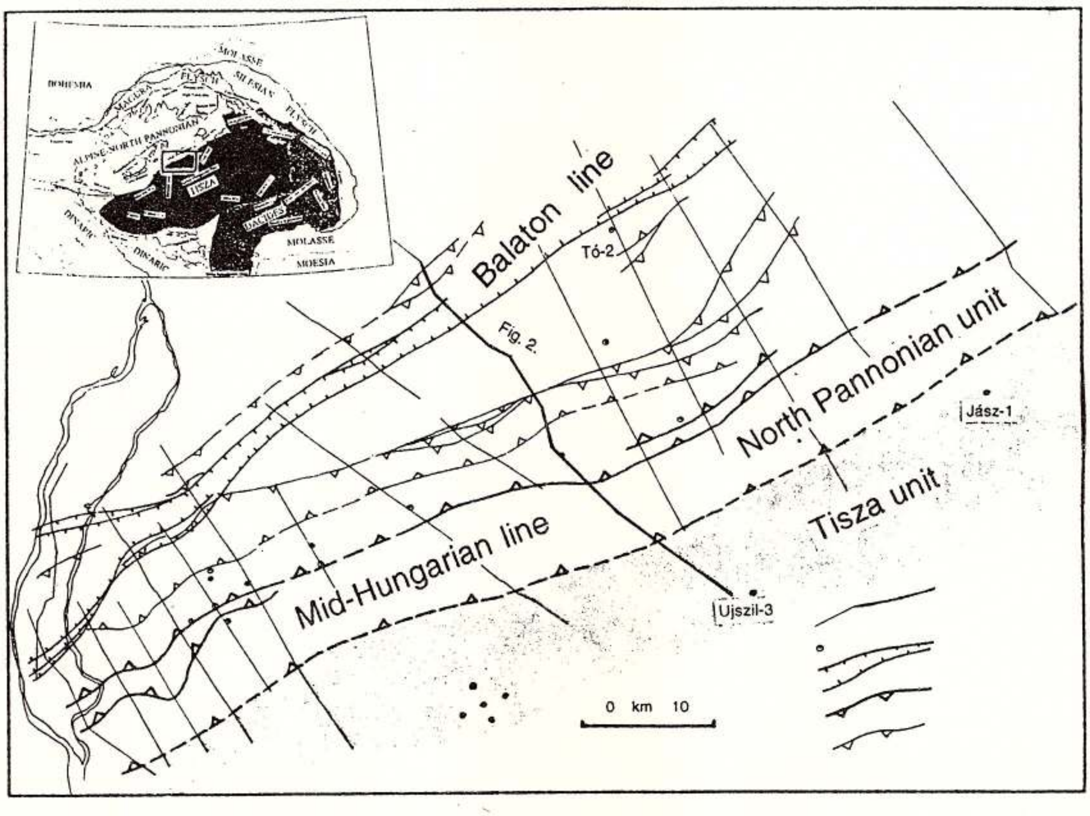

Fig. 1 Structural map of the investigated area. Insert: contours of the area in a great tectonic setting.

Several seismic sections were studied in this region. These, combined with borehole data, suggest that the line has a complex history with several reactivations. The last is a south-directed Early Pannonian (Late Miocene) thrust, involving Middle Miocene volcaniclastics, too (Fig. 2). The line and its satellites have functioned as a transpressive zone during and at the end of Paleogene, too. The major fault is a NNW dipping thrust. The Balaton line and its northern continuation is a Late Pannonian transtensional fault, rooting on the flat detachment of the Mid-Hungarian line. Where the zone is not reactivated in Late Miocene times, its original seismic image is hidden by the thick Middle Miocene volcaniclastics following the trace of the line.

The mainly thrust character of the Middle-Hungarian line corroborates well with earlier observations and interpretations made south of lake Balaton (Balla et al. 1988).

The above data suggest that the Middle-Hungarian line, a north dipping thrust surface, functioned as a transpressive zone or as a pure thrust during the amalgamation of the intra-Carpathian blocks. This interpretation favours rotations (ca f. Balla 1984) versus lateral displacement (but does not exclude it) during Late Paleogene-Early Miocene. Compressive reactivation during later inversion phases emphasizes the earlier structures.

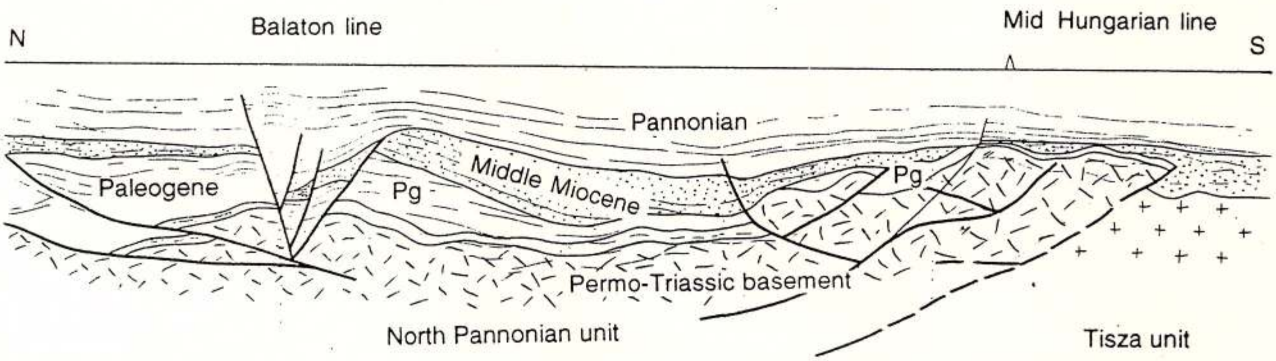

Fig. 2 Seismic section across the Mid-Hungarian line

PRE-VARISCAN, VARISCAN AND ALPINE TECTONOTHERMAL EVOLUTION WITHIN THE SOUTHERN CARPATHIANS, ROMANIA: EVIDENCE FROM $^{40}Ar/^{39}Ar$ HORNBLENDE AND MUSCOVITE AGES

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Muscovite and hornblende concentrates from basement and some whole rock phyllite samples from Late Paleozoic cover sequence within all major tectonic units from Southern Carpathians, Romania, have been dated to resolve the record of Alpine and pre-Alpine tectonothermal events.

A hornblende concentrate of the Tismana diorite (Danubian parautochton) yielded a disturbed argon release spectrum with a minimum age of ca. 575 Ma at high temperature increments of the experiment.

Samples with well-preserved high-T deformational fabrics within the Danubian, Getic and Supragetic nappe complexes display internally concordant release spectra with well-developed plateau which record only minor (ca 5–10 %) radiogenic argon loss during Alpine events (see Figure 1 for hornblende release spectra). Plateau ages hornblende include (Fig. 1): 316.7±0.6, 319.5±0.5 and 322.6±0.5 Ma (Getic nappe complex); 317.0±0.8 Ma in the Supragetic nappe complex. Plateau ages of muscovites include: 296.0±0.2

Ma (Danubian "parautochthon"); 309.5±0.5, 299.4±0.5 Ma, and 300.8±0.5 Ma (Getic nappe complex); 307.4±0.4, 294.6±0.5, 301.8±0.4 Ma (Supragetic nappe complex). The age of Alpine tectonothermal activity is not clearly resolved in the release spectra. An apparently older thermal event (ca 200 Ma) may be recorded by internally discordant release spectra which characterize muscovite concentrates from Getic basement within the Bahna klippe. The age of Alpine tectonothermal activity is constrained by whole-rock phyllite plateau ages of 117.9±0.2 Ma and 118.6±0.3 Ma from Carboniferous sequences along the Supragetic/Getic nappe boundary.

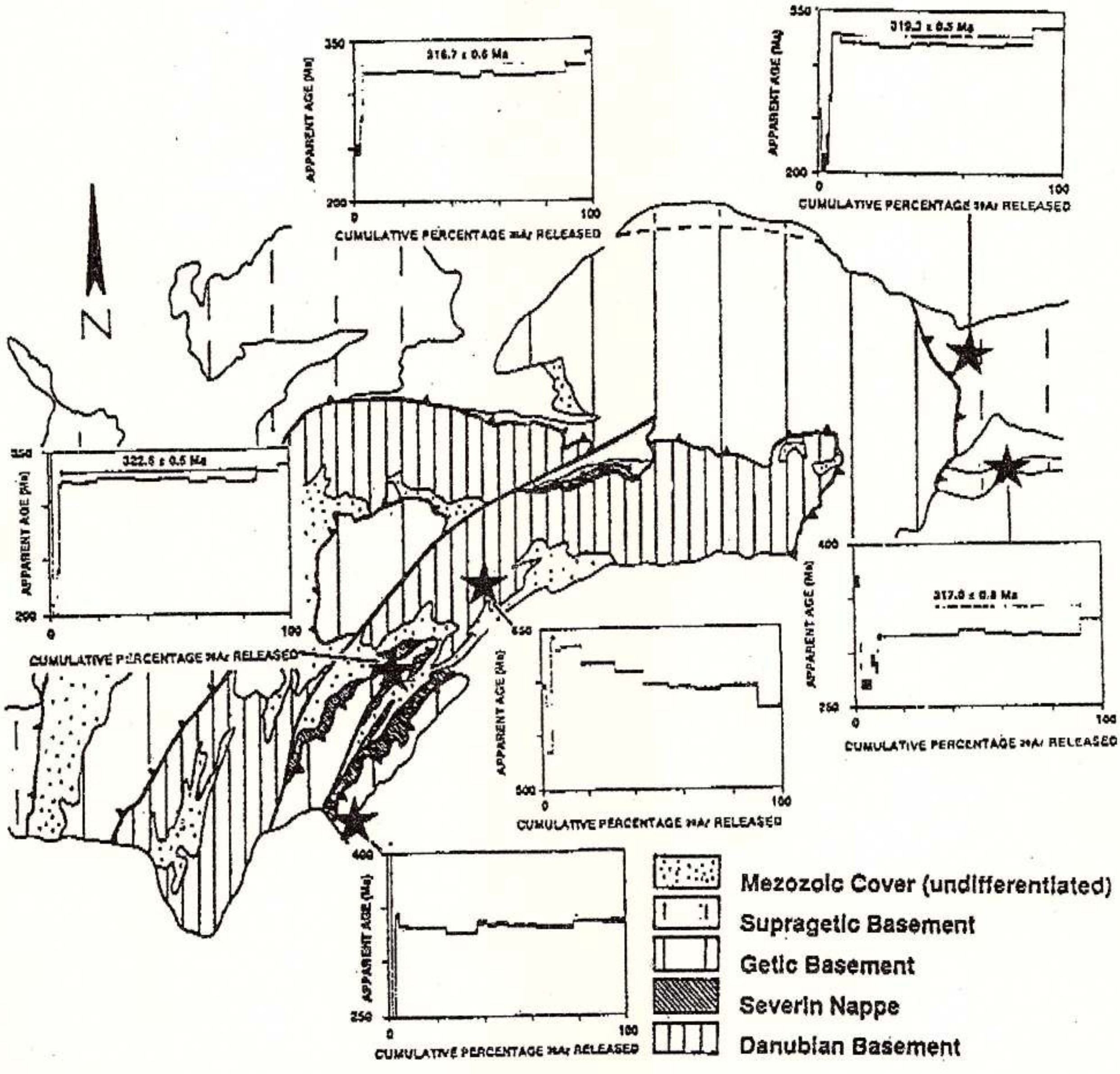

Fig. 1: Simplified geological map of the Southern Carpathians with argon release spectra of hornblende concentrates.

The $^{40}Ar/^{39}Ar$ results indicate only minor record on a pre-Variscan, Cadomian orogenic activity, and a similar "late" Variscan age for the high-temperature tectonothermal overprint within the basement rocks in all major basement units in the Southern Carpathians. These data record slow cooling within a ca. 15 Ma time ca 500^0 to ca 350^1 following the last penetrative deformation. Cooling and uplift was obviously linked to contemporaneous deposition of Late Carboniferous overstep sequences on the basement in the Southern

Carpathians. The apparent 200 Ma-age event may represent a rifting event at the Triassic/Jurassic boundary within the former Variscan orogen,. Ages of ca 118 Ma are interpreted to date the onset of Alpine thrusting along the Supragetic/Getic nappe boundary (early Cretaceous), and suggest footwall propagation of thrust during maintenance of very low-grade metamorphic conditions.

The Late Variscan cooling ages indicate that South Carpathians units were accreted onto a Cadomian belt of central to eastern Europe in a last step of plate collision between Gondwana and Northern Europe.

VARISCAN VS. ALPINE TECTONOTHERMAL EVOLUTION WITHIN THE EASTERN ALPS AND WESTERN CARPATHIANS, AUSTRIA – SLOVAKIA

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$^{40}Ar/^{39}Ar$ dating has been completed along a traverse across the Inner Western Carpathians (IWC) to compare timing and succession of pre-Alpine and Alpine tectonothermal events with those recorded in the Eastern Alps (EA).

A preliminary data set includes the following results from hangingwall to footwall units within the IWC (Fig. 1): Four phengite concentrates of the Meliata unit display internally consistent ages of 150.5±0.2 Ma, 150.5±0.1 Ma, 158.5±0.2 Ma, 160.0±0.1 Ma (not shown in Fig. 1). Whole rock phyllite within the Permian cover on the Gemeric basement yielded a plateau age of 105.8±0.3 Ma, that within the Veporic cover is of 85.2±0.2 Ma and 86.4±0.2 Ma. Muscovite records plateau ages of 86.9±0.2 Ma (Permian sequences) and 83.9±0.4 Ma (mylonitic granite of the Pohorela line within the Veporic basement). A similar, but slightly discordant spectrum (total gas age: 84.6±0.3 Ma) is recorded by a whole rock phyllite of the Permian cover from the (Supra-) Tartic unit.

The Alpine metamorphic overprint did not exced greenschist facies conditions throughout most portions of the IWC. A muscovite concentrate from a mylonitic othogneiss within a regional important, pre-Alpine high temperatute thrust zone in the Tatric basement yielded a plateau age of 332.4±0.6 Ma and records ca 10 % argon loss in low temperature increments as a result of an Alpine metamorphic overprint. This is confirmrd by an isotope correlation age with a 357±0.7 Ma in high temperature portions of a hornblende concentrate.

By comparison with previous data from the EA we conclude: (1) mineral data from the Tartric basement recor Early Carboniferous cooling after pre-Carboniferous thrusting (not observed in the corresponding basement units of the EA); (2) the Meliata oceanic suture was closed during late Jurassic as revealed by the phengite data; and (3) the Middle to Late Cretaceous data record loading of Meliata suture onto the Austroalpine unit and younging of thrusting from hangingwall to footwall units within a time interval similar to the Eastern Alps. The ca. 85 Ma ages from the Veporic cover are significantly younger than those within corresponding Middle Austroalpine units in the Eastern Alps (ca. 100 – 93 Ma) suggesting diachronism within respectively dissimilar crustal levels during Alpine nappe emplacement.

In contrast to previous models, the data sets from EA and IWC record a footwall propagation of thrusting within a thick-skinned tectonic wedge from hangingwall to footwall units beneath an ophiolite-bearing suture zone (Meliata zone of IWC). The $^{40}Ar/^{39}Ar$ mineral data reveal the early Alpine succession of thrusting and subsequent extwnsion of the overthickened orogenic wedge. Furthermore, the new mineral data do not record any tectonothermal overprint of the Austroalpine/IWC units during late Alpine (early Cenozoic) emplacement onto the Penninic units during collision with the European foreland.

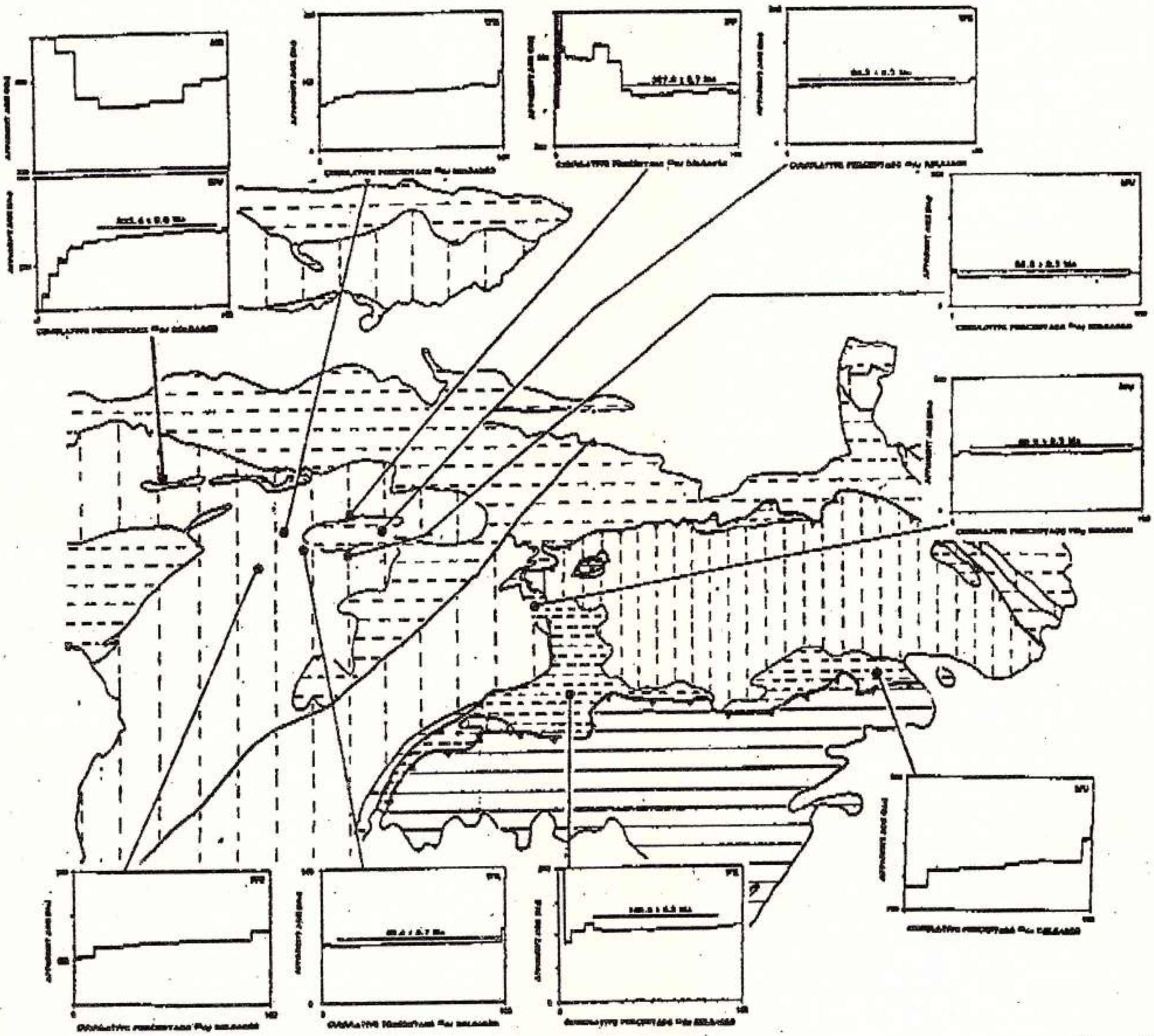

Figure 1: Simplified geological map of the Inner Western Carpathians with argon release spectra of muscovite (MU) and hornblende (HB) concentrates and whole-rock phyllite samples (WR).

VARISCAN VS. ALPINE TECTONOTHERMAL EVOLUTION WITHIN THE APUSENI MOUNTAINS, ROMANIA: EVIDENCE FROM $^{40}AR/^{39}AR$ MINERAL AGES

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The Apuseni Mountains are comprised of a series of variably metamorphosed nappe complexes. These were derived from a pre-Alpine palinspastic location situated between the Tethys and Meliata Oceanic Domains. Their overall palinspastic setting was similar to that of structural units within the eastern Alps and western Carpathians. Results of recent detailed field work and collaborative $^{40}Ar/^{39}Ar$ mineral dating have enabled calibration of a complex tectonothermal evolution that included late Variscan and polyphase Alpine events. These new data require major revision of traditional interpretations of the geologic history which included metamorphic events in the middle Proterozoic, Caledonian and Variscan orogenic cycles followed by middle-late Cretaceous (Alpine) thrusting.

Basement rocks exposed within the Apuseni Mountains comprise four major tectonostratigraphic units. Structurally upward these include: 1) the Bihor autochthon/parautochthon (Arada and Somes Series); 2) variably migmatized amphibolite and granite of the Codru Nappe Complex; 3) a generally low-grade, polydeformed greenstone-granite terrane of the internally imbricated Biharia Nappe Complex (Highis, Bihor and Ariseni Series); and, 4) an internally imbricated association of carbonate and gneisses (baia de Arieş Nappe Complex).

Hornblende from the autochthon/parautochthon records internally concordant $^{40}Ar/^{39}Ar$ plateau and isotope-correlation ages of ca 317-306 Ma. Muscovite from these units records plateau ages of ca 314-303 Ma. The hornblende and muscovite ages are interpreted to date diachronous cooling through the contrasting temperatures required for argon retention following late Variscan tectonothermal activity. Samples from southern areas display up to ca 10-15 % rejuvenation of intracrystalline muscovite argon systems during an ca 120-125 Ma (Alpine) thermal overprint. Muscovite concentrates prepared from samples collected within various structural units of the Biharia Nappe Complex record variable ages. Some samples record post-Variscan cooling ages of ca 300 Ma. Other samples display internally discordant $^{40}Ar/^{39}Ar$ age spectra which suggest extensive Alpine (ca 120 Ma) rejuvenation of Variscan cooling ages. Some samples record Alpine plateau ages of ca 100-105 Ma. Hornblende and muscovite within northwestern structural units of the Baia de Arieş Nappe Complex record Alpine plateau ages of ca 120-111 Ma. One hornblende concentrate separated from a sample collected within a southeastern structural unit of the Baia de Arieş Nappe Complex records an anomalous but well defined plateau and isotope-correlation age of 155 Ma. This suggests a polyphase Alpine tectonothermal evolution. Structural relationships suggest that this was associated with an early Alpine sinistral transpressional followed by a late Alpine, northwest vergent thrusting.

PETROLOGICAL EVIDENCES OF DISTURBANCE OF THE VARISCAN METAMORPHIC COVER OF BRATISLAVA GRANITOIDIC MASSIF (MALÉ KARPATY MTS)

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The Pre-Alpine basement of the Western Carpathians is represented mainly by medium to high grade paragneisses and other metamorphic rock complexes. They were later intruded by granitoidic rocks of Variscan age. The sedimentary overburden was metamorphosed to greenschist facies before granitoidic rocks intrusion and periplutonic processes became the most dominant in the area.

The Malé Karpaty Mts are the westernmost and outermost "core mountains" and possess some distinctive features in comparison to other core mountains.

In chosen metamorphic profiles around Bratislava granitoidic massif, the metamorphic reaction progress, dehydration and volume changes have been used to test the continuity of periplutonic progressive changes.

Computed protolith mineralogy, mass balance equations and modal proportions of reactants and metamorphic reaction products enabled the quantification of the progressive metamorphic fluid production and volume changes.

In most profiles of periplutonic zones, the appearance of index minerals, metamorphic reaction progress variables, volume changes and dehydration processes represent the absence of the continuity of these changes. This is considered to be the evidence of Alpidic tectonic destruction of the original Variscan metamorphic zonality. Temperature zonation is represented by the development of biotite, garnet, staurolite and sillimanite zone. These zones spanning the distance of ca. 600-900 m exist as tectonic remnants in the NW part of the Bratislava massif.

Geothermobarometric analyses of the contact periplutonic mineral assemblages determine the metamorphic recrystallisation at depth of 14-18 km at peak progressive temperatures of 580-620^0 C.

Calculated approximative P-T trajectories indicate different uplift conditions of the tectonic blocks. This is confirmed by different occurrence of retrograde mineral domains and morphological appearance of garnets.

Retrograde garnet rims are in some samples small (20-50 m) indicating a rapid cooling during uplift. Morphological appearance of these idioblastic garnets, absence of minor retrograde reaction features clearly represent the quenched mineral assemblage.

As well as these garnet types, non-idioblastic garnets occur in the assemblages of the periplutonic zones. The crystal size distribution (CSD) of these two different garnet types shows 1) linear CSD of idioblastic garnets, suggesting a contact aureole metamorphic environment and 2) regional metamorphic conditions for other garnet group considered to be older. CSD analyses of the these garnet groups indicate differences in average nucleation rate in individual tectonic blocks and differences in garnet crystallisation residence time. The extent of garnet mass transfer during annealing indicate prolonged cooling from temperatures reflecting regional metamorphic thermal histories for samples that have now the periplutonic tectonic position.

Clearly, orogenic rock block transport and tectonic restructuring occurred during Alpine movements, which destroyed and displaced the polymetamorphic Tatric crystalline basement units into new structural positions.

These results strongly stimulate the revision of Variscan metamorphic zonality in some areas.

TERRANE MAP OF THE ALPINE-HIMALAYAN BELT, MEDITERRANEAN PART

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The terrane map (sacle 1: 2,500.000) of the Alpine Himalayan Belt (AHB) will be one of the prominent results of IGCP Project No. 276. The whole belt should be documented in terrane maps, accretionary diagrams, terrane graphics, and terrane descriptions. Organisationally the map is divided into a Himalayan part (coordinated by A.K. SINHA & G. FUCHS) and a Mediterranean part (coordinated by F. EBNER, F. NEUBAUER & G. RANTITSCH). Both maps are in an advanced stage of preparation. First drafts were presented during the International Geological Congress in Kyoto, 1992.

From the Mediterranean part we gratefully get materials from the Caucasus, Turkey, Hellenides, Balcanids, Carpathians, Dinarids, Hungary, Eastern Alps, Sardinia, Calabria, and Morocco from the respective national working groups. Fortunately an Iranian Working Group (leader M. ALAVI) was established last year. So we hope to diminish the existing gap between the Mediterranean and Himalayan part of the map.

The map of the Mediterranean part displays the age and nature of basement units which are included in the Alpine belt and the time of successive accretion and amalgamation of these units which now form the Alpine belt. Basement units of adjacent cratons are included to get information where Intra-Alpine basement terranes derive from. The following conclusions may be drawn from the preliminary draft of the map:

Cadomian/Baikalian/Panafrican basement units are widespread in the AHB. These units include ophiolites and island arc sequences which indicate an apparently continuous late Proterozoic mobile belt which is also obvious from increasing thickness by Ripheain deposits along southern and southwestern margin of Laurussia. The late Proterozoic basement of the AHB apparently links Panafrican units of Arabia/Africa with Cadomia of western Europe and Baikalides of Siberia. This belt has been later dispersed by Variscan/Alpine displacement.

Terranes from the southern margin of the AHB include in part passive continental margin sequences of Cambrian, in part such of Silurian/Devonian age. Both sequences often postdate Cadomian basement.

Terranes which are situated in the northern part of the AHB have been accreted during successive stages of Ordovician and middle Devonian times. All together, these terranes may indicate a middle Paleozoic passive continental margin system south of the later Laurussian margin. Often occurring Ordovician magmatic and metamorphic complexes suggest a widespread collision-type event which happened during this time.

All these terranes have been accreted in the Mediterranean part of AHB by continent-continent plate collision during Variscan times. The Variscan tectonothermal overprint loses the importance from west to east, combined with domains which remained open until Mesozoic times. The entire AHB is overprinted by effects of oblique opening and closure of the Mesozoic Tethys which led to dispersion of previously accreted terranes.

All the data indicate that the Mediterranean part of the AHB has been a Pacific-type mobile belt since late Proterozoic times.

The Mediterranean part of the map will be cordinated in close coperation with members of the individual IGCP No. 276 National Working Groups:S. ADAMIA, M. ALAVI, A.A. BELOV, G. BONARDI, L. CARMIGNANI, A. CHALOUAN, M. DIMTRIJEVIC, M.N. DIMIRIJEVIC, F. EBNER, I. FILIPOVIC, B. FIORETTI, M.C. GONCUOGLU, P. GOCHEV, I. HAYDOUTOV, S. KARAMATA, V. KNECEVIC, D. KOZHOUKHAROV, S. KOVACS, H. KRUTNER, B. KRSTIC, Gy. LELKES-FELVARI, F. NEUBAUER, V.C. OMELCHENKO, J. PAMIC, D. PAPANIKOLAOU, V. PERRONE, G. RANTITSCH, B. RUSSEGGER, J.D. SHAVICHVILI, R. STOJANOV, T. SZEDERKENYI, J. VOZAR, A. VOZAROVA & S. YANEV.

DYNAMIC AND KINEMATIC CONSTRAINTS ON DEFORMATION IN THE CARPATHIAN-PANNONIAN AREA

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Tertiary deformation of the East-Alpine - Carpathian orogen is characterized by significant shortening which is partitioned between nappe emplacement, strike-slip faulting and escape tectonics. These deformations are associated with formations of sedimentary basins with different geodynamic character. The formation of the orogen was partly coeval with opening (stretching) of the Neogene Pannonian basin system.

Analysis of brittle structures is very important in understanding the structural evolution and basin formation of the area. One of the methods used in such research is the determination of paleo-stress fields which generated the deformations. These new methods were developed during the last twenty years and progessively introduced into the area. Tectonic research including stress analysis can give strong dynamic and kinematic constraints for basin formation processes, evolution of the main structures of the Pannonian basin as well as of the Carpathian orogen. Such tectonic research has to be combined with paleomagnetic investigations in these strongly deformed areas.

The Mesozoic-Tertiary evolution of stress-field is planned to be reconstructed in the Carpathian-Pannonian region based on field structural and paleomagnetic observations. In order to investigate the relationship between brittle deformations and basin formation, sedimentological and paleogeographical analyses will be combined with structural data. A three-year program is planned in this project. The first year will be devoted to the establishment of the common data base, the reinterpretation of data with similar methods, common interpretation of tectonic significance and time constraint of the recognized phases and the comparison of existing tectonic and paleomagnetic results. These analyses will be performed in order to give a better understanding of the deformations and dynamic and kinematic constraints for a possible stepwise palinspastic restoration and forward modelling of the entire area.

^{40}Ar/^{39}Ar SINGLE GRAIN AGE DATA FROM THE PENNINIC-AUSTRO-ALPINE BOUNDARY, TAUERN WINDOW, EASTERN ALPS

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The Tauern Window in the Eastern Alps exposed the Penninic units of the lower plate beneath the Austro-Alpine hangingwall units, that represent the upper plate during the main Alpine collision. Along the investigated eastern margin of the Tauern Window one can distinguish three tectonic units in the hangingswall,, masinly basement units, and two major units in the Penninic footwall, a higher ophiolitic and a lower basement unitr. The Austro-Alpine nappes are characterised by different amounts of pre-Alpine metamorphic overprints (amphibolite facies in the highest nappe, below garnet-in the middle one, greenschist facies in the lowest one.) and a generally inverted Alpine metamorphic sequence from lower greenschist to amphibolite facies. In the highest nappe Alpine metamorphic peak conditions post-date the main tectonic overprint, related to nappe emplacement, in the deeper nappes the main deformational event is essentially synmetamorphic., A second, static Alpine metamorphic overprint, related to fluid infiltration, occurred after a folding of the penetrative Alpine foliation. The Penninic units within the window exhibit an increase in metamorphic peak conditions from middle greenschists to amphibolite facies conditions towards the footwall. The main deformational event predated the thermal climax in the higher parts and is more or lkess synchronous in lower parts. An extensional event, detaching the Austro-Alpine from the Penninic base, occurrend on the cooling path of the Penninic unit.

A white mica from the Austro-Alpine uppermost nappe exhibits an age of about 100 Ma, compatible with other age data from this unit White mica of the next lower unit that define the main foliation display ages of about 85 Ma, while mica of the second generation that grew statistically across the foliation show partly disturbed age spectra, one a spectrum with an inferred age of about 80 Ma. A hornblende from that unit displays a disturbed Variscan age spectrum, biotite from the same sample nice plateau with an age of 120 Ma, obviously incorporation excess Ar. Two white micas from the Lower Austro-Alpine unit, close to the next higher unit, show late Variscan ages, one close to the Penninic unit a disturbed Alpine spectrum (integrated age of ca. 100 Ma), a biotite from the same sample a plateau with 95 Ma and first steps decreasind to about 45 Ma.

White mica from tectonic higher parts of the Penninic unit display ages between 32 and 22 Ma (32.0 ± 1.4, 27.1 ± 1.3, 22.9 ± 1.1, 21.9 ± 1.1, 29.9 ± 0.2), a biotite an age of 29.0 ± 2.9 Ma, possibly also influenced by excess Ar.

The presented age data support the following points:

Thrusting in the Austro-Alpine units occurred over an extended time-span. The Alpine thrusting in the highest unit (pre-metamorphic) and the subsequent cooling from the highest greenschist facies to about 350–400^{0}C predates 100 Ma. In the next lower unit thrusting could have persisted until ca 85 Ma.

Nappe stacking must have propagated from the hangingwall to the footwall, incorporating the foreland area successively.

The attainment of higher temperatures in higher nappes of the Austro-Alpine unit and the subsequent thrusting onto progressively cooler units of the same mega-unit points to a continuous accretion of parts of the footwall to the hangingswall in the stacking process. Thus thrusting could be explained by an intra-Austro-Alpine subduction.

The beginning of subduction of the oceanic Penninic lithosphere could be dated by the second generation of white mica at the base of the Austro-Alpine unit, the grew due to fluid infiltration. One sample yielded ca 80 Ma, but more data would be desirable.

The main deformation in the higher Penninic parts, related to their subduction and intra-Penninic stacking is pre- to syn-metamorphic. Hence the oldest age from that unit, already cooling ages, give an upper time limit for that deformation phase.

TERTIARY TECTONIC EVOLUTION OF THE MARAMUREŞ AREA, MINERALOGICAL AND GEOCHEMICAL CONSTRAINTS

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Maramureş area is located in the northern part of Romania at the border between the Transylvania Basin and the northern part of the Eastern Carpathians.

Considering all the geological data, the studied area had the same tectonic evolution as the Transylvania Basin, until Miocene.

Since the Sarmatian, the NE–SW compression has been yielding major differences between the evolution of this area and that of the surrounding areas (e.g. an important mass of volcanic rocks and ore deposits).

The NE–SW compression (demonstrated also by the paleostress analysis) generated extensional faults with the same direction. These faults were the channel-ways for hydrothermal fluids circulation.

Some of them are involved in generating important ore deposits, mainly of gold - silver and base metal character, from the mineralogical - geochemical ponit of view.

The same NE–SW compression reactivated the older structures (veins) providing pathways for the second stage of mineralization. In fact this led to the reactivation of the older faults as extensional faults (again) and strike - slip faults.

The former show only little reactivation (i.e. second stage mineralizations comprise breccia - fragments from the first one, but the fault strike is the same) while the latter show a strike - slip movement with generation of horse tail structures. In this second type of reactivation breccia fragments of the first stage of mineralization can be seen, as well as in the new faults (i.e. horse tail structures) that contain a completely new type of mineralization.

The most important thing is that eventually when this NE–SW compression ended, strike-slip faults not only with NE–SW direction but also with W–E direction were formed.

In the studied area veins and stockworks occur, showing different mineralogical and geochemical features. According to our data stockworks are located at the end of horse tail structures, which are involved in generating this particular type of deposits; mineralogical and geochemical investigations revealed interesting evidences resulting in good concordance with tectonics.

STRUCTURAL EVOLUTION OF SE HUNGARY AND NEOGENE BASINS OF THE APUSENI MOUNTAINS (ROMANIA)

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The pre-Neogene basement of SE Hungary is made up of Alpine (Late Cretaceous) nappe units which are exposed in the Northern Apuseni Mountains (Ianovici et al. 1976, Bérczi-Makk 1986, Szepesházy 1979).

On the other hand the Neogene basins of this area (Hód-Makó, Békés Basins) are oriented NW-SE which is roughly perpendicular to the strike of the other Neogene basins in the Pannonian area. Neogene basins with the same NW-SE orientation are found at the NW rim of the Northern Apuseni Mountains (Zarand, Beiuş, Borod basins).

To compare the structural evolution of the two areas two different methods were applied. In SE Hungary the structural elements were studied on seismic profiles. In the Apuseni Mountains we studied more than 60 outcrops in the Zarand, Beiuş and Borod basins. Our investigation was focused especially on microtectonic measurements of brittle structures (striated faults). Integrating the results of seismic and microtectonic data interpretation, were established:

1) In the basement of SE Hungary we were able to define the westward continuation of the Alpine nappes described in the Apuseni Mountains (Bleahu 1981). It was possible to define the lowermost Bihor zone which continues in the Villany zone. Upon them structural elements of the lower Codru nappes were identified (e. g. Békés-2 well). In uppermost position Upper Codru nappes were found (e. g. T-I well). The Biharia zone is probably missing in the basement.

2) The Senonian basins superposed on the nappe system were interpreted as flexural-type basins, because the thickest preserved Senonian strata were consequently found above major nappe boundaries.

3) In the Apuseni Mountains three Neogene tectonic phases were separated (Fig. 1):

(i) The earliest phase (pre-Badenian) is characterized by NW-SE compression and NE-SW extension (SONDZEICHEN 115 $\sigma 2$ vertical). This stress field initiated the formation of a major NW-SE trending fault system in the Apuseni Mountains. A fault system with similar orientation was recognized in SE Hungary. According to the microtectonic, borehole and seismic data, these faults were interpreted as low-angle normal faults with dextral component.

(ii) The second phase (Badenian) characterized by NE-SW compression and NW-SE extension (SONDZEICHEN 115 $\sigma 2$ vertical) reactivated the structures of the first phase in the Apuseni Mountains. In SE Hungary a second, NE-SW trending normal fault system was recognized on seismic sections. These were regarded as normal faults with sinistral component formed during the second phase. The roughly parallel former Alpine thrust-faults were also reactivated as normal faults.

(iii) The third (post-Sarmatian) phase is characterized by NW-SE extension (SONDZEICHEN 115 $\sigma 1$ vertical). In this phase high angle faults were included which formed during the earlier two phases, and were reactivated later as oblique/normal slip faults. Pannonian reactivation of earlier extensional structures was also recognized on seismic sections in SE Hungary.

(iv) The Neogene stress fields of the Zarand, Beiuş and Borod basins suggest that between these no rotation occurred in the Neogene.

1) Neogene structures are very frequently rooted in deeper parts of the main Alpine detachments.

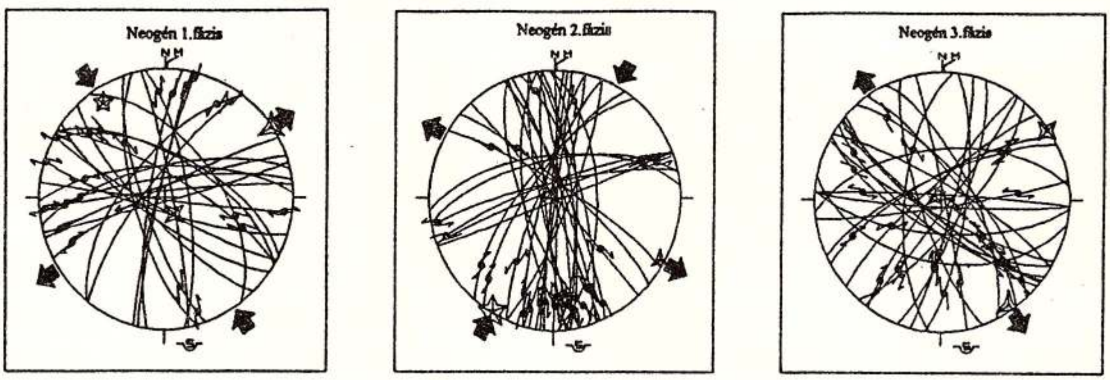

Fig.1 – Orientation of Neogene stress-fields in the Northern Apuseni Mountains.

PALEOMAGNETISM OF PLEISTOCENE VOLCANICS FROM THE PERŞANI MOUNTAINS, EAST CARPATHIANS (ROMANIA)

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Pleistocene intraplate basaltic volcanics from the Perşani mountains, East Carpathians, show normal, reversed and intermediate polarities. All sites from one volcanic complex comprising pyroclastics, lava flows and a scoria cone reveal the same intermediate polarity, indicating an extremely short eruption interval for the whole complex.

Quaternary volcanic rocks occur in the north-western part of the Perşani Mountains near the valley of the Olt River and its tributary the Bogata River. The volcanics are composed of basal pyroclastics, lava flows with intercalations of pyroclastics and scoria. At least two main phases of volcanic activity can be recognized. The build up of scoria cones marks the end of each eruption phase (SEGEDI & SZÁKÁCS, pers. com.). MIHĂILĂ & KREUZER (1981) reported ages of the volcanic activity spanning the interval from 0.33 to 1.41

Ma. According to former paleomagnetic studies basalts show normal and reversed polarity (GHENEA et al. 1981, RĂDAN et al. 1990). During field campaigns in 1992 and 1993 18 sites were sampled. 323 individually oriented cores were drilled resulting in 882 specimens. Mainly AF demagnetization was used to determine the characteristic remanence. It was possible to obtain paleointensities from 7 sites using modification of the Thellier method (SCHNEPP 1994). Rock magnetic experiments were carried out in order to recognize the carriers of natural remanent magnetization and as a check on the suitability of the volcanics for paleointensity determinations.

Curie temperatures of $\leq 350^0$ C and of $\leq 600^0$ C indicate Ti-rich and Ti-poor magnetite as the main magnetic phase in the basalts. Hematite, with Curie temperatures $\geq 600^0$ C, seems to be present in the scoria. The ratio Bcr/(SIRM/k) displays a wide range in grain size of the carriers of magnetization, ranging from multi-domains to single-domains. This wide range in grain size is probably due to different cooling rates and oxidation states of the minerals.

Analysis of the demagnetization experiments reveals ten sites of normal, three of reversed and five of intermediate polarity. The latitude of the virtual geomagnetic pole (VGP) of one of the normal and two of the reversed polarity sites diverge by about 30^0 or more from the axial dipole field. The intermediate directions occur only in the Racoş volcanic complex (Fig. 1).

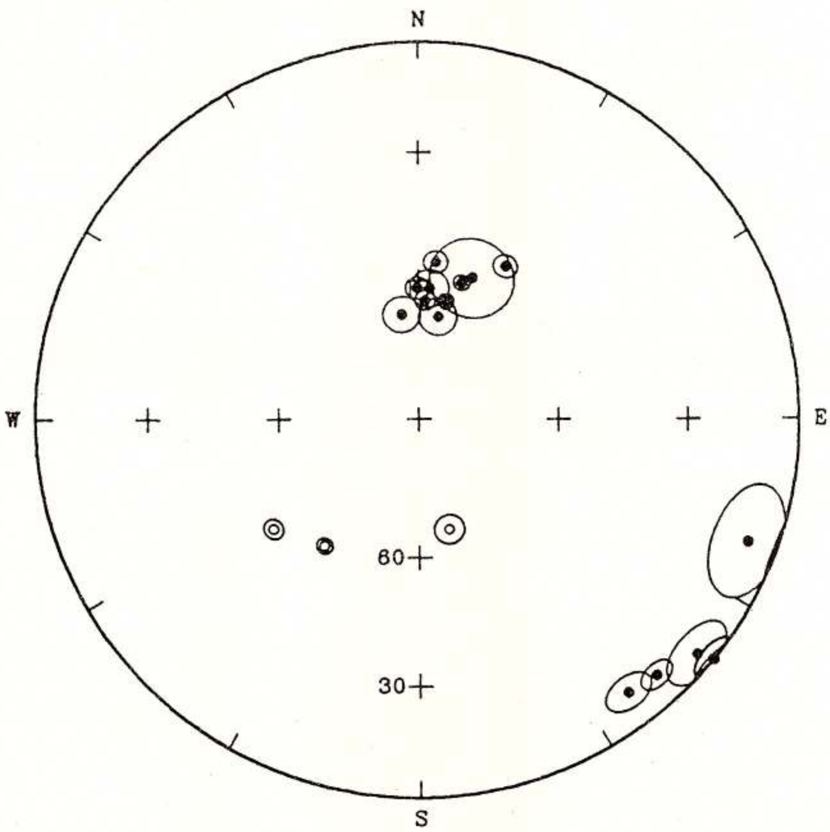

Fig. 1 Equal area projection of the characteristic remanence. 18 site mean directions are given with their confidence circle. Open/closed symbols = upper/lower hemisphere.

Regarding the polarities and the available radiometric ages, the volcanic activity spans the Brunhes and Matuyama geomagnetic chron. In the Bogata valley it is possible to distinguish the volcanics by their magnetic polarity. At least two volcanic events, producing lava flows, can be recognized. The uniformly intermediate polarity of all volcanics of the Racoş complex sampled so far strongly argues for an extremely short eruption interval of probably less than one ka. Recently, a new radiometric age of 1.19 Ma has become available (DOWNES pers. com.). Due to this age, the intermediate polarity of the Racoş complex might be correlated with the Cobb-Mountain geomagnetic event (TURRIN et al. 1994).

Paleointensities ranging from 4.4 (Racoş) to 82.9 μT were determined (today's local average about 48 μT). The extremely low paleointensity correlates with the low VGP latitude of the Racoş complex supporting the model of decreasing virtual geomagnetic dipolmoment (VDM) during reversals of the Earth's magnetic field.

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DIACHRONOUS ALPINE THRUSTING WITHIN UPPER LEVELS OF THE AUSTRO-ALPINE NAPPE COMPLEX, EASTERN ALPS

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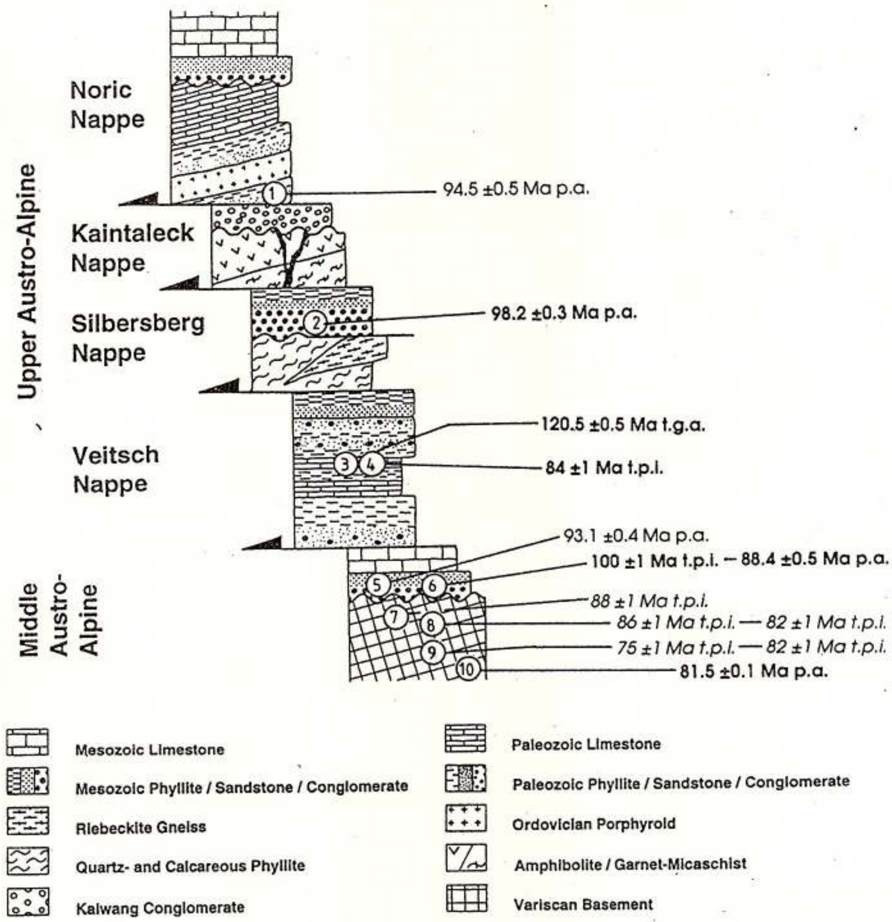
Within upper levels of the Austro-Alpine Nappe Complex several Alpine nappes can be distinguished. At the eastern margin of the Eastern Alps the Middle Austro-Alpine Nappe Complex has been overthrust by the Upper Austro-Alpine Nappe Complex, which comprises - from bottom to top - the Veitsch, Silbersberg, Kaintaleck, and the Noric Nappes (Fig. 1). These nappes are comprised by contrasting pre-Alpine basement complexes, which are covered by similar Permian to Mesozoic cover sequences. An Alpine age of nappe assembly is indicated by the incorporation and penetrative ductile deformation of these cover sequences.

$^{40}Ar/^{39}Ar$ and/or Rb-Sr dating of white mica concentrates and whole-rock samples from penetratively ductile deformed rocks has been carried out in order to constrain the age of Alpine thrusting. Petrographic observations of the analysed samples indicate only an Alpine metamorphic overprint under lower greenschist facies metamorphic conditions, which indicates that closure temperatures for the Ar and Sr isotopic systems in white micas have not been exceeded due to Alpine metamorphic overprint. By contrast, Rb-Sr analyses on biotites from Variscan metamorphic basement units of the Middle Austro-Alpine Nappe Complex, which lacks Alpine penetrative ductile deformation, indicate that Alpine metamorphic conditions have been sufficient to reopen this isotopic system in biotites. However, Alpine white micas and whole-rock phyllites recrystallized or grew new below their respective closure temperatures. Therefore, ages obtained by geochronologic investigations on white micas and whole-rock samples have to be interpreted as formation ages, giving the time of penetrative ductile deformation, which means thrusting and nappe assembly.

Results of the geochronologic investigations are compiled in Fig. 1. Due to different closure temperatures in different isotopic systems, a reasonable interpretation of the data set can only be established by comparing results, obtained from analyses using the same geochronologic method performed on the same type of mineral.



The general trend of decreasing apparent ages with decreasing present-day tectonic position of the samples is interpreted to represent different times of deformation, and thus thrusting and nappe assembly. Rb-Sr and $^{40}Ar/^{39}Ar$ plateau ages (samples 1-5), indicate that thrusting within the Upper Austro-Alpine Nappe Complex started at ca 100-90 Ma. This event is also indicated by the Cretaceous basin subsidence within the Northern Calcareous Alps ("Roßfeld Formation"). Further compression caused footwall propagation of the master fault and the formation and deformation of the Middle-Austro-Alpine Nappe Complex at ca 90-80 Ma. This event was contemporaneously with regional uplift and cooling of this thrust sheet as indicated by Rb-Sr cooling ages of biotite (samples 7-9). Late Cretaceous cooling and uplift of the Middle Austro-Alpine basement is associated with E-W extension within a sinistral wrench corridor, which caused the formation of Gosau basins. The general tectonic frame-work for this coeval uplift of metamorphic core-complexes, sinistral east-west directed strik-slip faulting, and basin formation has been ascribed to a model of continental escape.

THE CAMBRIAN ISLAND-ARC ASSOCIATION IN THE TERRITORY OF BULGARIA

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The old, probably Pan-African ophiolites of the Balkan peninsula are closely connected with Cambrian island-arc associations.

In the realm of the Protomoesian micro continent this association is widely represented and is formed by: intrusive, extrusive, and sedimentary-volcanic complexes.

The intrusive complex is build up by the so-called Struma Diorite Formation (SDF). This Formation is an old igneous association widely represented in SW Bulgaria. It is a specific, irregularly metamorphosed, complex with a number of characteristic features. They include: diverse composition, multistage formation of its igneous components, relationship with ophiolites, and typomorphic geochemical character.

The formation is build up by gabbros, gabbrodiorites, diorites, and granites, as well as dike swarms (diashistic lamprophyres). It is composed by typical igneous rocks and such ones having clear traces of recrystallization and intense metamorphic reworking. This undoubtedly indicates its multistage origin. Three series were separated during this period of investigation: earlier igneous impulses (dioritised and felsic), intrusive rocks, and a dike series.

The intrusive complex intersects the extrusive one, which is built up mainly of diabases, with rear keratophyre lenses.

The sedimentary-volcanic cpomplex forms the northernmost outcrops of the association. The sedimentary rocks of its lower part are predominantly pelitic. In the middle of this part a carbonate level, covering a large area, crops out. The sediments of the upper part of the association section are represented by turbidites. The volcanic suite of this complex comprises spilites, keratophyres, and pyroclastics. Petrological features indicate that the spilites represent island-arc tholeiites.

The geochemical character of the association of igneous rocks proves their belonging to the island-arc igneous series.

The igneous rocks of the association intersects the old ophiolites. Numerous dikes and bodies out all the units of the ophiolite association.

The Cambrian age of the island-arc association is determined by the presence of a Lower Cambrian Archaeocyathus and the potassium-argon dating of SDF (560-660 Ma).

THE KAINTALECK METAMORPHIC COMPLEX: EVIDENCE FOR PRE-VARISCAN POLYMETAMORPHIC BASEMENT WITHIN THE UPPER AUSTRO ALPINE (EASTERN ALPS)

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The Kaintaleck Nappe, which has an intermediate tectonic position within the Eastern Greywacke Zone has been structuraly, geochemicaly, and geochronologicaly investigated. This studies from several areas suggests, that three lithotectonic units (Ritting complex, Frauenberg complex and Prieselbauer complex) exist, which experienced individual but always pre-Variscan tectonothermal evolutions. All units are affected by low-grade metamorphic conditions and ductile deformation during Cretaceous nappe emplacement.

(1) The Ritting complex is predominantely composed of garnet-zoisite amphibolites, serpentinites, micashists, and thin calcitic marbles. Pegmatites and aplitic veins are crosscutting the medium- to high-grade metamorphic suite. The chemistry of amphibolites shows affinity to tholeitic N-MOR-basalts or transitional within plate basalts. The protolith age is not known. Amphibolites indicate serveral metamorphic stages. A mid-Paleozoic tectonothermal event seems to be the most dominant and widespread metamorphic overprint. Radiometric investigations (40Ar/39Ar and/or Rb-Sr dating of amphibole and muscovite) resulted in ages ranging from 470 to 360 Ma. The peak of amphibolite facies metamorphism is prior to 420 Ma. Ages of discordant pegmatite and aplite (390 to 364 Ma) are interpreted to reflect post magmatic cooling, post-dating the main intra-Devonian tectonometamorphic activity. An earlier eclogitic memory of unknown age

is deduced from high pyrope content of garnet, from symplectite amphibolite, and from phengitic muscovite in accompanying micashists.

(2) The Frauenberg complex is composed of paragneiss and minor plagioclase amphibolite which display a mid-alkaline trend. Zirkons yielded a U-Pb upper intercept age of 2.53 Ga (protolith crystallisation) and a lower intercept age of 516 Ma (age of late Cadomian metamorphism).

(3) The Prieselbauer complex is composed of migmatic augengneiss and micashists, minor amphibolite and aplitic veins. Zircons from paragneiss yielded a lower intercept U-Pb age of about 390 Ma, which is interpreted as the age of metamorphism. This Devonian metamorphic event might link the Prieselbauer complex to the Ritting complex. Again, an upper intercept zirkon age of a discordant aplite of 363 Ma, which reflects the protolith crystallisation is identical with ages obtained from similar lithologies within the Ritting complex.

Some of these crystalline basement compexes are unconformably covered by a low-grade metamorphic meta-conglomerate, for which a late-Devonian age of sedimentation is suggested.

HIGH GRADE METAMORPHIC ROCKS IN THE PRE-ALPINE NAPPE STACK OF THE GETIC DOMAIN-SOUTH CARPATHIANS

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High grade metamorphic rocks (eclogite-granulite facies) from the South Carpathians are spatially related to medium grade rock assemblages constituting a pre-Alpine nappe stack. They are located in some litho-tectonic units or are directly related to medium-high grade pre-Alpine shear zones of thrust or strike-slip type.

Having in view lithologic or structural control, petrographic and paragenetic features, type of metamorphic evolution and nature of the associated protholiths, four types of eclogitic rocks have been distinguished.

a) Eclogites as infracontinental tectonic lenses with retrograde type evolution in the Sebeş Group are associated with HP granulites and garnet lherzolites. The paragenetic association of the eclogitic stage, is: Cpx+Grt+Ky+Amp+Zo+Ru. Cpx inclusions in Grt show a core with Jd 24–25 and a corona with Jd 18–22; Cpx in matrix is Jd 25–26. Garnet composition is variable from core (Py 44) to rim (Py 51). A decompression stage is indicated by Cpx II+Pl symplectites in a mafic eclogite. Granoblastic-coronitic felsic rocks contain relict Gt (Py 25–28 - core to Py 17 - rim) and Ky with successive coronas: Sp+Pl (An 70–94). In granoblastic banded rocks, garnet composition is variable in mafic (Py 27–32) and felsic (Py 12–22) bands and show a partial re-equilibration of garnet in retrograde conditions.

Fine neoblasts of St, Bi, Mu and Pl, Amp in coronas and matrix are in equilibrium with M 1 and M 2 parageneses of the country rocks of the Sebeş Group.

b) Eclogite nuclei dispersed in the Cumpăna Group are associated with mafic (garnet granulites, garnet metagabbros) and ultramafic rocks in a complex rock-assemblage containing Kfsp augen gneisses. Eclogites registered a complex metamorphic evolution: preeclogite stage: Amp (winchite-MgHb)+Zo, garnet inclusions; eclogite stage: Gt (Py 42 - core+Gpx (Jd 38–42)+ Ky Ru+Q+Bi; post-eclogite (deccompression stage): Cpx (Jd 15) + Pl (An 10) as symplectic intergrows in equilibrium with Gtrim (Py 46) and Sp+Pl coronas on Ky. Estimated peak metamorphic conditions are: Pmin+20–22 Kb and T+620–720^0 C. There are prograde, unequilibrated high-grade mafic, utramafic, felsic rocks initimately associated, suggesting an initialy prograde evolution before retrogression.

c) In the dismembered ocean-like crustal rocks of the Lotru Group, the eclogites are associated with garnet-bearing metagabbros and peridotitic rocks with well preserved magmatic textures. In an analysed sample the garnet with inclusions of Ts Amp and Pl (An 19–25) shows a zonal distribution of pyrope content from core (Py 19) to rim (py 27). High grade paragenesis is: Gt–(Cpx I)+Qu+Ru+Ilm.

In the matrix Cpx IL+Pl (An 30) are initimately associated in equilibrated aggregates; in the matrix and on garnet Ti bearing brown pargasitic Hb+Pl (An 61–42) develop. External coronas of green, pargasitic hornblende+plagioclase (An 42–43) reflect a retrograde reequilibration under amphibolite facies conditions during orogenic uplift.

d) Eclogitic rocks with well developed tectonitic facies (high grade mylonites) in the Leaota Mts exhibit a direct structural control to deep–seated shear zones. They are related to white micaschists, garnet metagabbros and metagranites containing prograde garnet coronas (biotite-plagioclase reaction products). Some differences in mineral chemistry are related to whole rock composition of the high grade rocks. Eclogitic paragenesis in Mg-protoliths is Grt+Omp (Jd 41–46)+Amp (Win)+Ky+Ru+Phen+Zo. Pyrope contents of the garnet vary from 25 in the core to 36 in the rim. Pick eclogite stage is registered by well crystallised, oriented Omp+Ky+Win in equilibrium with garnet rim.

The estimated physical conditions are: T–780–860^0 C at a minimum P of 20–22 Kb (Johan et al., 1994, in press). Phengite is present as inclusions in garnet and in matrix. In ferrous protholiths pyrope contents of the zoned garnet are 12 (core) – 16 (rim), Cpx I is 39 and Cpx II (Jd 14–24) forms symplectites with Pl (An 3–10). Amphibole inclusions in garnet is a ferroan pargasite and zoned amphibole in the matrix is Mg – Taramite (core) and Edenite (rim). Superposed greenschist facies parageneses may also occur.

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HERCYNIAN GRANITIC ROCKS OF THE WESTEN CARPATHIANS - PRODUCTS OF THE CRUSTAL REACTIVATION AND REMAGMATISATION

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Granitic rocks form numerous plutons in the Western Carpathians (W.C.). The majority of the granitoid plutons are metaluminous to peraluminous and are composed of several types of rocks ranging from tonalite to leucocratic granite. Silica contents of granitic rocks vary in a range of approx. 60 - 75 wt%, documenting the increase of alkalinity from tonalites to leucogranites. The prevalence of Na_2O over K_2O is a common geochemical feature, except for the porphyric granite type in which K is exceeding Na. Carpathian granitoids represent low- to high-potassium calk-alkaline series of magmatic rocks. Biotite is the dominant Fe-Mg mafic mineral, hornblende is occuring only rarely in the W.C. granitoids. Accessory minerals (magnetite + allanite & monazite + ilmenite) show in some plutons antagonism and/or dichotomy, which allows to distinguish two principal granite groups (Broska & Uher, 1991; Peterík & Broska, 1994). The occurrence of mafic microgranular enclaves in the magnetite-bearing granites and the presence of host (metamorphic) rock-xenoliths in the magnetite-free granits supports this dividing in the Western Carpathians. But in some plutons (the Tatry Mts, the Malá Fatra Mts) one can observe both - enclaves and xenolithes - in one place. REE are typically LREE enriched, chondrite-mormalized patterns of the REE exhibit absence or slight negative Eu anomalies and uniform distribution trends for various granite types. Initial $^{87}Sr/^{86}Sr$ ratios in granites are low (0.705 - 0.708), suggesting a mixed lower crustal and mantle component and/or a Rb-poor crustal source (Rb/Sr = 0.1 – 0.5 for common tonalite - granite types, but for some leucogranites extending from 0.6 to 1.6). The $\varepsilon_{Nd}(0)$ values, varying from -4.6 to -6.4 for granitic rocks of the Velká Fatra Mts (Kohút et al. in prep.), are comparable with data from Liew & Hofmann (1988). Apparent crustal residence ages indicated by Nd model age (T_{DM} = 1.2 - 1.9 Ga respectively T_{DM2} = 1.2 - 1.4 Ga) support the authors' (l.c.) concept that Hercynian Europe comprises mainly recycled Proterozoic components with significant new Paleozoic addition.

All mainly geochemical features suggest that the Hercynian.granitoids are analogous VAG (CAG) granites related to subduction processes. However, during late Devonian and early Carboniferous times, metamorphic, sedimentary and structural data rule out this scenario as similar as almost everywhere in Europe and suggest continental collision processes. This collisional process with overthrusting of the deep crustal nappes juxtaposed with crustal reactivation and granitoid production. Field evidence together with P-T-t-paths (generally clockwise) suggest in the Tatra Mts (Janák, 1993) tectonic inversion of metamorphism, documented by thrusting of hotter, higher-metamorphosed slabs (migmatites, gneisses, amphibolites) over cooler parautochthon (micaschists). A comparable situation is in the Mla Fatra Mts. and in the Nzke Tatry Mts. During climax of the Hercynian collision tectonic (350 - 340 Ma) older igneous material was partially melted in the Western Carpathians. This anatectic granitic rock inherited VAG geochemical character (from older Caledonian - Panafrican ? events), showing low degree of magma fractionation and represent common products of the crustal reactivation and remagmatization.

ALPINE REACTIVATION OF THE EASTERN VEPORIC BASEMENT METAMORPHITES (WESTERN CARPATHIANS)

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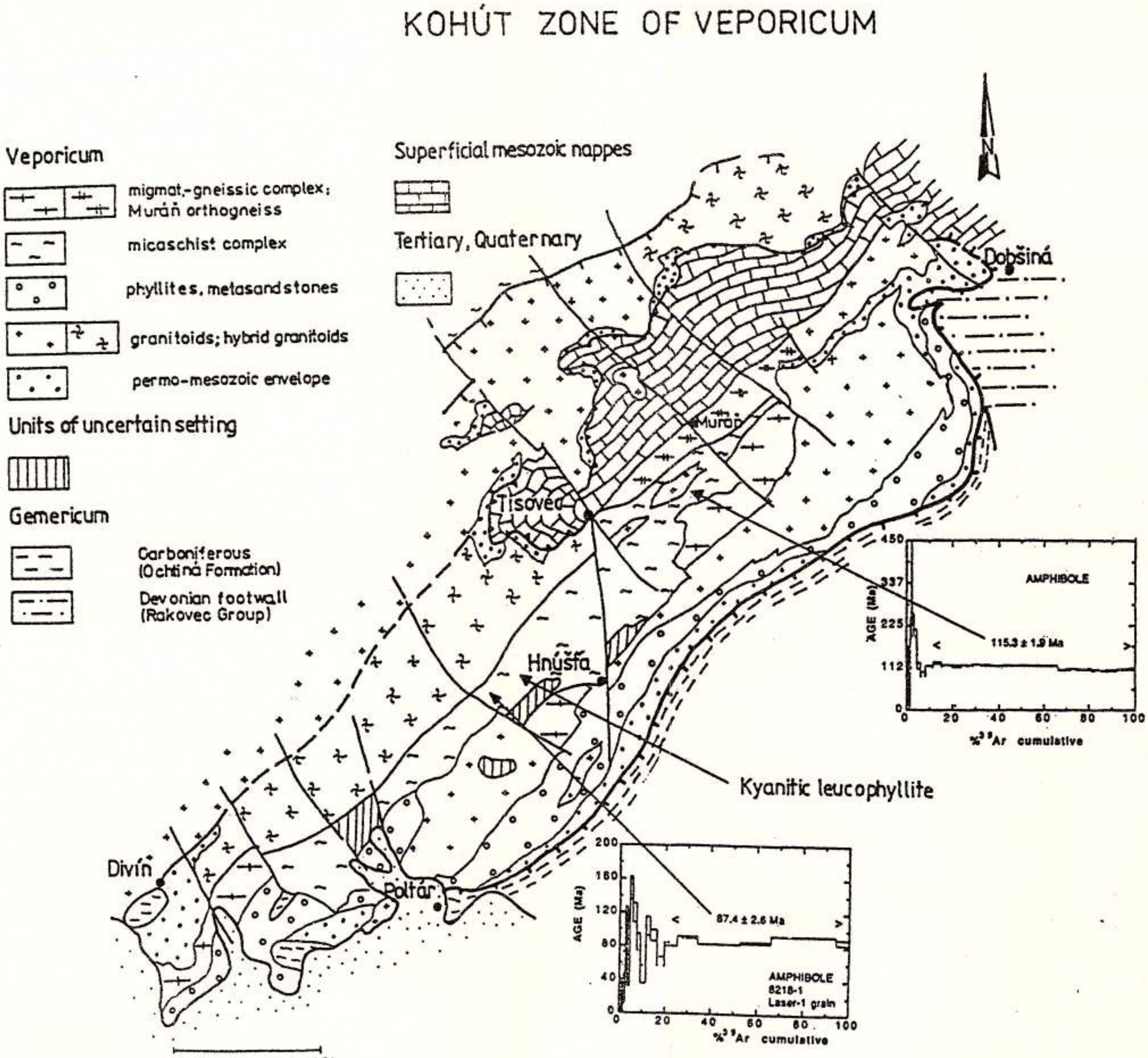
Among the Pre-Alpine units of the West Carpathians it is the Veporic Unit that exhibits the strongest Alpine overworking. The basic conception is unified on these features: the Gemericum was N-wardly thrusted over the Veporicum with the Middle Cretaceous tectonometamorphism took place, afterwards followed superficial Mesozoic nappes and that all was sealed by postorogenic Senonian sediments (Andrusov 1938, Zoubek-Snopko 1955, Biel 1961, Kantor 1961). In the Veporic Permo-Mesozoic cover the conditions of the Alpine metamorphism have been established on 300-350^0 C (Plašienka et al. 1989), however blastesis is often postkinematic (Vrána 1966).

In metapelites of basement the randomly oriented amphiboles were occasionally found. They are overprinting the Hercynian metamorphic assemblages (of the upper greenschist to lower amphibolite facies) as well as the Alpine penetrative lineation. New formed amphibole created due to allochemical supply is of tschermakitic type (with close relation to pargasite), where beside large tschermakitic substitution a higher Fe/Mg ration and Na content took part. (On the other hand the composition of pre-Alpine amphibole comming from amphibolitic bodies of the mica-schist complex is ranged to the hornblende (Leake 1978), which was partly transformed into actinolite during the Alpine shearing). Apart from many uncertainties of the open-system reactions, tschermakite might have been produced from the matter like epidote-clinozoisite group, chlorite and albite. All these minerals together with micas belong to the common retrograde phases in basement. Newly formed amphibole is predeterminated as a reliable indicator of the real age of crystallization, because the blocking T (about 500^0 C, Jäger 1976) is supposed to be higher than the forming T (max. under middle part of greenschist facies). Two plateau age spectra - 115 and 88 Ma - obtained by $^{40}Ar/^{39}Ar$ dating give evidence about higher conditions of the Middle-Cretaceous metamorphism. The first data may indicate that the time span of the Alpine metamorphism is longer as has been documented on basis of phengites (Dallmeyer et al. 1993).

Another useful marker of Alpine tectonometamorphism is the kyanitic leucophyllite determined in the vicinity of the magnesite-talc deposit. The examined rock is ranged to a distinct sheare zone separating two crystalline complexes in the ENE-WSW strike. This belt includes variagated hydrothermaly altered phyllonites with pronounced late extensional cleavage planes. New formed assemblage Mg-chlorite - kyanite -tourmaline (dravite) muscovite, quartz was formed on expense of an alumosilicate rock (most probable of granitoid origin) in the course of Mg-metasomatism. In the West Carpathians uncommon metamorphic assemblage of "whiteschist" type is a product of Mg, Al, H_2O and LREE supply, besides of the Si, Na, K, and HREE removal. Randomly oriented porphyroblasts of kyanite postdate the main shearing effects. Stability of kyanite in Al-saturated system, composition of chlorite and muscovite indicate that the metamorphic condition reached about 350-420^0 C and 2.5-4.5 kb. The steatitisation of magnesite is regarded as synchronous with forming of the studied metamorphic assemblage.

The temptation to interpret the postkinematic blastesisis terms of extensional thermal relaxation should be taken with care, because of the Barrowian nature of the mentioned minerals. Postkinematical growth can be besides the lithological overburden also caused by additional heating beneath the thickened domain (convective thinning of the mantle"). Etheridge-Loosveld 1990, what is together with metasomatism manifested on the basement heterogenities mainly.



THE EARLY EVOLUTION OF THE SOUTHERN TETHYS ON THE EXAMPLE OF WESTERN SICILY AND THE INTERACTION OF THE SOUTHERN TETHYS WITH THE ALPINE-CARPATHIAN BELT

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As pointed out by Catalano et al. (1991), the evolution of the Alpine Carpathian realm is directly related to the evolution of the Southern Tethys. The development in both Tethyan branches is in many respects complementary. Thus, the compressive regime in the Olenekian of the northern margin of the Southern Tethys (e.g. olistostromes and strong calcalkaline volcanism in Crete) is contemporaneous with the opening of the Northern Tethys in the Kotel- and Strandzha Zone. The wide-spread calcalkaline Late Anisian and especially Ladinian volcanism in the entire Southern Tethys is contemporaneous with the sea-floor spreading in the Northern Tethys indicated by large amounts of ophiolites and pillow lavas in the Meliaticum. A Middle Jurassic to early Oxfordian extensional regime is present in the Southern Tethys, where in many places basic volcanism or sea-floor spreading (indicated by large ophiolitic bodies) of this age can be observed. On the contrary, Middle Jurassic to early Oxfordian flysch (turbidites with early Oxfordian coarsening upwards sequences) is characteristic of the Meliaticum of the Northern Tethys. All occurrences of Triassic oceanic magmatic and sedimentary rocks in the Meliaticum of Western Carpathians and Eastern Alps, with the exception of those from salinar melanges at the base of the overlying nappes, are blocks in Middle Jurassic to early Oxfordian turbidites. This situation was now also confirmed in the Meliata type locality (Kozur & Mock, in press).

The Early Mesozoic oceanic connection of the Meliaticum in Eastern Alps and Western Carpathians to any Tethyan branch in the E or SE is today interrupted by continental units which came into their present position by Mesozoic, but especially by Tertiary lateral movements (Tisia, Moesia). The Middle Jurassic to early Oxfordian flysch (turbidites and coarsening upwards sequences) with blocks of oceanic or at least deep basinal Triassic (main characteristic of the Meliaticum) can be also found in the Kotel Zone. For this reason, most of the geologists connect the Meliaticum through the Transylvanides to the Kotel- and Strandzha zones (e.g. Tollmann, 1988, Kozur, 1991). The root zones of the Kotel- and Strandzha zones are differently interpreted in these reconstructions. Tollmann (1988) originated these zones at the northern margin of the Vardar Zone south of the Rhodope Zone and explained their present position by a several 100 km nappe transport from the south. Kozur (1991) rooted these zones north of the Rhodope Zone. Kovács (1993) regarded these connections of the Meliaticum with the Kotel- and Strandzha zones through the Transylvanides by Tollmann (1988), Kozur (1991) and many other authors as "absurdity" because in the present(!) arrangement of the units no connection is present. He overlooked that no connection of the Meliaticum with any oceanic branch in the E or SE is preserved and his assumed connection of the Meliaticum through the Maliak ocean (margin of the Pindos ocean) with Oman is today also interrupted by Tisia. Moreover, the post-Triassic development of the Pindos-Maliak-Oman oceans is totally different from the Meliaticum with its Middle Jurassic to early Oxfordian flysch and closing in the Middle Oxfordian. Disregarding these new results of the Meliaticum, Kovács (1993) regarded the Jurassic flysch of the Strandzha- (and Kotel) zones as non-Alpine Jurassic in contrast to the Alpine Jurassic from the Alps to China. Therefore he must regard as non-Alpine also the Jurassic development of the Meliaticum. His Aegean-Sicilian ocean from the Karakaya Complex in the NE through Crete to Sicily in the SW is likewise unrealistic (like the Middle Triassic subduction zone in the Adria which is for facial reasons impossible). This ocean cuts perpendiculary several uninterrupted facies zones at the northern margin of the Southern Tethys. It is only based on the erroneous correlation of the same tectonofacies (turbidites and olistostromes units) of totally different age and tectonic importance. The turbidite-olistostrome unit of the Karakaya Complex is of Norian age and connected with the closing of this branch of the Northern Tethys at the Triassic-Jurassic boundary. The turbidite-oilstostrome complex of eastern Crete is of Olenekian age and related to subduction processes at the northern margin of the Southern Tethys. The turbidite-olistostrome complex of Sicily is of Cathedralian (Early Permian) age, indicating last Hercynian movements. The Tethyan branches in Sicily and Crete closed only during the Tertiary. This example shows that detailed knowledge of the tectonic development in the different Tethyan branches is very important for paleogeographic reconstructions.

The most complete, unmetamorphic South Tethyan Permian and Triassic deep-water and slope development is known in the Sicanian Paleogeographic Domain of western Sicily. In the Sosio Valley, two complexes in nappe position are known. At the base of the Upper Tectonic Unit sensu Catalano et al. (1991), here designated as Palazzo Adriano Nappe, a Permian to Early Triassic slope to base-of-slope development, overlain by Middle-Upper Triassic basinal development, is present. The Permian and Triassic deep-basin development does not belong to the Upper Tectonic Unit (Palazzo Adriano Nappe) as assumed by Catalano et al. (1991), but to the Lower Tectonic Unit and to slices below the Palazzo Adriano Nappe. The Cathedralian (Early Permian) turbidites of the Lercara-Roccapalumba area (Lercara Fm.) belong to this development, because the olistoliths in the Roadian Olistostrome Unit are exclusively rocks of the Lercara Fm. Admixtures of Cathedralian slope limestones in the outcrop SW of Pietra di Salomone are blocks from a tectonic melange at the base of the Palazzo Adriano Nappe and have been derived from this nappe. Because the Permian slope development lies in the higher nappe unit of the Sosio Valley area, it was originally situated north of the Permian deep basin development (the nappe transport was from N to S). The predominantly siliciclastic Cathedralian deep-water turbidites (Kungurian flysch sensu Catalano et al., 1991), the Roadian Olistostrome Unit, gray Wordian-Capitanian deep-water claystones, red Late Permian deep-water claystones with calcarenites, early Ladinian radiolarites, tuffites and siliceous limestones and late Ladinian to Cordevolian reddish-greenish nodular cherty limestones and marly claystones belong to the basinal development described by Catalano et al. (1991). Cathedralian to Capitanian (? Dzhulfian) slope to base-of-slope limestones (Flügel et al., 1991), red Changxingian deep-water clays with thick coarse calcarenites and calcareous snadstones, the Scythian slope to base-of-slope development, in the Olenekian partly also red marly pelagic limestones (Gullo & Kozur, 1993), pelagic early to Middle Anisian limestones, siliceous greenish tuffitic filamentous late Anisian limestones, red siliceous Ladinian limestone and gray Cordevolian limestones belong to the sequence of the Palazzo Adriano Nappe. Basic volcanics of latest Ladinian or Carnian age are also known from this tectonic unit. The middle Carnian to early Tuvalian Mufara Fm. and the Middle Tuvalian to Norian Cherty Limestone Fm. are in both units similar, but in the Norian of the Palazzo Adriano Nappe a facies like spotty marls occurs beside cherty limestones.

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PRE-ALPINE TERRANES IN THE ROMANIAN CARPATHIANS

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The main alpine terranes in the Carpathians were formed in the early Mesozoic extensional stage, as pieces split of from the Variscan continental crust, by the Eoalpine rifting and spreading system. Thus the Bucovino-Getic, Danubian, Codru-Biharia, Bihor composite terranes, with early Alpine platform evolution, may be distinguished, interposed between terranes consisting mainly of Jurassic oceanic crust, intraplate volcanics and related sediments (Pindos, Vardar-Transylvanian, Civcin-Severin terranes). Distinct associations of metamorphic rocks from the variscan crust are preserved in the mentioned terranes. As only pre-alpine tectonic relationships may be observed between this pre-Mesozoic complexes, they may be considered as terranes according to the definition by Keppie & Dallmayer (1990).

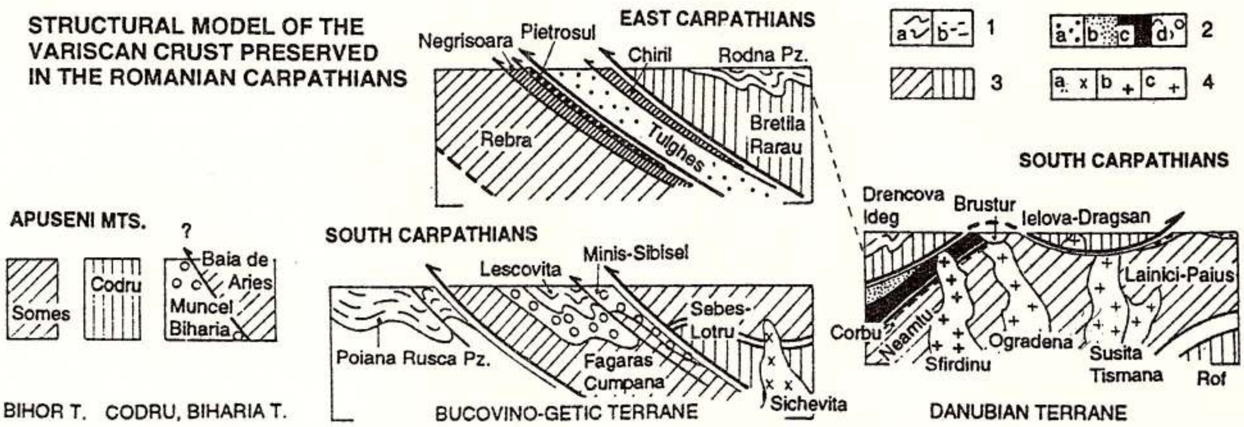
In the Bucovina-Getic composite terrane the pre-Mesozoic rock assemblages may be assigned to the following pre-Alpine terranes:

The Poiana Ruscă Terrane (PR) is represented by the Silurian and Devonian-Lower Carboniferous sediments and intraplate volcanics of an eastern rifting zone, initiated in the Silurian, reactivated in the Devonian and covered in the Lower Carboniferous by a carbonatic formation followed by flysch deposits. The whole sequence has undergone a variscan LT/MP metamorphism and was overthrust in the Variscan tectogenesis by Precambrian rocks of the Rodna-Făgăraş Terrane (R-F). This is represented by a well defined lithostratigraphic sequence of polymetamorphic rocks (MT/MP, MT/LP, LT/LP) - the Carpian Supergroup-, described in the East Carpathians as Rebra Group, in the South Carpathians as Făgăraş and Cumpăna groups and in the Apuseni Mts as Baia de Arieş Group. In a higher tectonostratigraphic position occur early Caledonian metamorphics of LT/MP character, assigned to the Tulghes Sibişel Terrane (T-S), represented in the East Carpathians by the Cambrian Tulgheş Group, in the South Carpathians by the Sibişel (Cibin) Group and the Bocşiţa-Drimoxa, Locva and Lerest formations of albite-porphyroblast schists, in the Apuseni Mts by the Biharia and Muncel formations. In the East Carpathians a tectonic sheet of dacitic (Pietrosul) porphyroids and biotite paragneisses (Negrişoara Formation) - the Pietrosul Bistriţei Nappe - are interposed between the T-S terrane (Putna Nappe) and the R-F terrane (Rodna Nappe). In highest pre-Alpine tectonostratigraphic position are placed the Rarău Terrane (R) and the Sebeş-Lotru Terrane (S-L), both of a heterogenous lithologic constitution: a) a polymetamorphic gneiss-amphibolitic basement (Bretila Group) covered by Silurian-Lower Carboniferous Variscan metamorphics (Rusaia, Repedea, Cimpoiasa groups) in the East Carpathians and b) a pre-Variscan polymetamorphic complex (Sebeş-Lotru) in the South Carpathians, constituted of at least three pre-Alpine tectonic sheets (Armeniş gneiss-amphibolite formation, Vaideeni blastomylonitic complex, Negovanu micaschist formation - Săbău, 1992 M.).

In the Danubian composite terrane three main pre-Alpine terranes are recognised: The Tisovita Terrane (T) represents a late-Proterozoic-Eocambrian oceanic crust with a typical sequence including umber, hyaloclastics, pillow-lavas, massive basalts, sheeted dykes (Haydoutov, 1987), gabbroic, pyroxenic, dunitic cumulates and tectonitic harzburgites (Mărunţiu, 1984). According to Haydoutov (1987) in the Stara Planina this oceanic crust is covered by an island-arc volcano-sedimentary formation of Cambrian age (Berkovica Group, echiv. Corbu formation ss.). The mentioned piece of oceanic crust was obducted to the east (Corbu mylonitic zone, Mărunţiu & Seghedi, 1983) on a Precambrian continental crust assigned to the Neamtu-Lainici Păiuş Terrane (N-LP) of mainly gneissic constitution, intruded by cadomian granitoids inducing MT/LP metamorphism and migmatisation in the mentioned gneisses. The obduction may be related to the early-Caledonian event, as it is proved to be late-Cambrian or intra-Ordovician. In the Variscan tectogenesis parts of both the T and N-LP terranes were overthrust by a Precambrian amphibolite-gneiss association of MT/MP metamorphism, assigned to the Ielova-Drăgşan Terrane (I-D). In the Ordovician-Silurian platform clastics developed on the N-LP terrane, phanconglomerates and olistostrome deposits on the obduction zone, and extensional (riftogen) basic volcanics, as well as Lower Carboniferous limestones and siltites on the I-D terrane. In lowest pre-Alpine tectonic position the Rof Terrane (Ro) and the Furcătura Terrane (Fu) may be distinguished, represented by the MT/MP metamorphics and granitoids respectively.

In the Codru-Biharia composite terrane Precambrian and early-Caledonian rock associations similar to those pf the R-F and T-S terranes occur, as well as Paleozoic low-grade metamorphic sequences (Păiuşeni Form.) and Variscan granitoids.

In the Bihor composite terrane mainly Precambrian polymetamorphic gneissic rock assemblages (Someş Group) occur that extend to the west in the basement of the Pannonian basin.



1. *Ordovician-Lower Carboniferous:* a. rift basin, b. platform; 2. *Cambrian:* a. magmatic arc, b.island arc, c. oceanic crust, d. back arc basin; 3. Variscan overprinted Precambrian continental crust; 4. *granitoids;* a. variscan, b. early-caledonian, c. cadomian.

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KINEMATIC AND ISOSTATIC MODELS OF LITHOSPHERE DEVELOPMENT IN EASTERN ALPINE, WESTERN CARPATHIAN, PANNONIAN BASIN REGION

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The Eastern Alpine/Western Carpathian/Pannonian Basin region is studied by combining gravity observations with interpretations of lithosphere thickness obtained through seismic delay-time studies.

The Alpine/Carpathian analysis incorporates a kinematic model of ocean basin closure, utilizing two important constraints: 1) the sections are balanced, in the sense that continental crustal volume is conserved; and 2) the models maintain isostatic equilibrium during crustal shortening and erosion. Once a starting model for the ocean basin is established, Bouguer gravity anomalies can be interpreted as follows: 1) the width of the anomaly is proportional to the amount of continental crustal shortening following ocean basin closure; and 2) the amplitude of the anomaly reveals how much erosion and accompanying isostatic rebound has occurred. Results suggest that the broad Bouguer anomaly in the Eastern Alps is due to about 175 km of continental crustal shortening; the -140 mGal amplitude of the anomaly suggests that 10 km of erosion and isostatic rebound has occurred. Gravity anomaly widths and amplitudes are lower in the Western Carpathians, suggesting only 50 km of continental crustal shortening and 4 km erosion.

In the Alps, rebound of a full-thickness craton beneath the foreland means that a relatively thin wedge of sediments is preserved in the Molasse Basin. By contrast, the crust/mantle boundary first deepens southward toward the Western Carpathians, but then shallows beneath the interior of the mountains. This "keel"" geometry of the Moho is a consequence of only partially underthrusting the passive continental margin of Europe; very thick flysch deposits remain intact beneath the Outer Carpathians because they are compensated by shallow mantle from the preserved continent/ocean transition zone.

For the lithosphere/asthenosphere system as a whole, gravity anomalies are modelled by isostatically balancing effects of topography, the crust/mantle boundary and the lithosphere/asthenosphere boundary. The Eastern Alpine crustal root, which extends 15 km below the average depth for the region, overcompensates the topography and results in gravity anomalies that are 30 mGal lower than those observed; an extra 70 km of lithosphere, as revealed by seismic delay-time analysis, provides excess mass that achieves isostatic equilibrium. Gravity anomalies and local isostasy are also consistent with the thin crust and thin lithosphere observed beneath the Pannonian Basin region; the 60 km of elevated asthenosphere is a mass deficiency that compensated the shallow mantle beneath the thin crust.

THE TWO DEVELOPMENT MODELS OF THE SOUTH APUSENI MOUNTAINS

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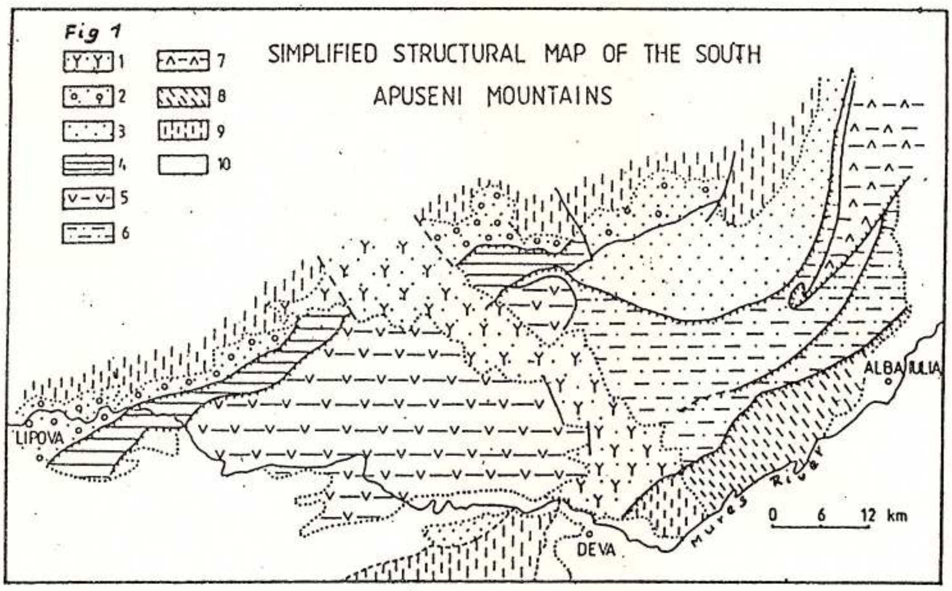
The South Apuseni Mountains, are within the Alpine-Carpathian area, the only region in which the Tethyan related active continental margin frame is cropping out. Although the time in which the oceanic crust opened in this area is still uncertain (Triassic, Lower or even Middle Jurassic) along the western margin of the Transylvanian-Tethyan branch two, in time succession, couples of marginal basins and (Fig. l) magmatic arcs appeared and later, during the mid-Cretaceous and Laramian tectogenesis, built up a complicated structure in which 15 units, most of them nappes, are involved.

Two different geotectonic development models generated this complicated structural framework.

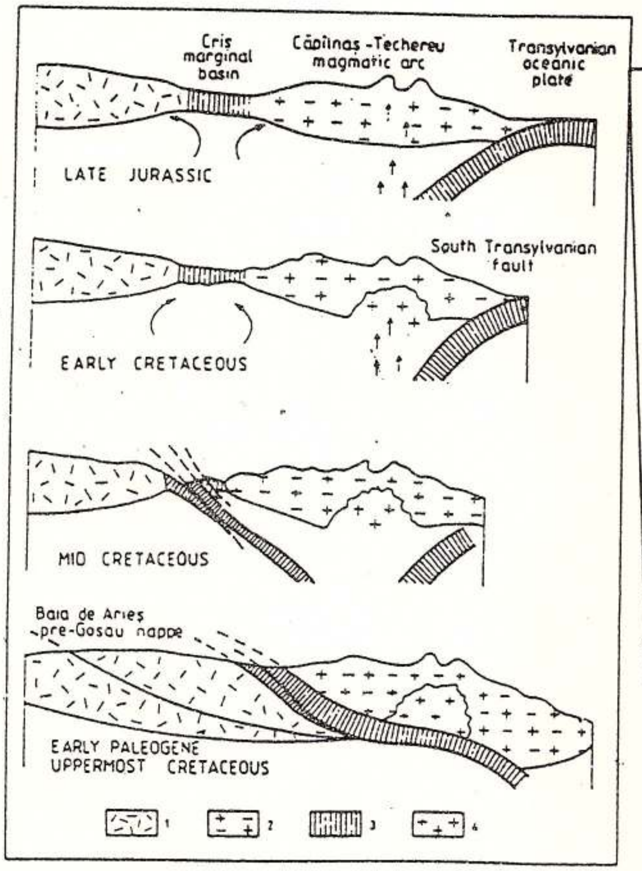
The first one characterises the central-western part of the South Apusenids and involved a couple of marginal basin (future Criş nappe) -magmatic arc (future Căpîlnaş-Techereu nappe), situated in the southern flank of the North Apuseni crystalline. South of the magmatic arc (Fig. 2) the subduction of the Transylvanian-Tethyan oceanic crust was obliterated along the South Transylvanian fault which, initially, was sinistral. Along this fault the Căpîlnaş-Techereu magmatic arc as well as the Criş marginal basin suffered a westward displacement. The first posttectonic covers tarted in this area with the Vraconian which covered both the South Apuseni ophiolitic rocks and Lower Cretaceous deposits, as the Supragetic crystalline. The mid Cretaceous tectogenesis started and the Laramian one accomplished the creation of the north-vergent nappes in the central and western part of the South Apusenids, as an effect of the Criş marginal basin subduction.

In the eastern part of the South Apuseni Mountains the history of the Feneş marginal basin - Bedeleu magmatic arc (Fig. 3) couple started later (the Feneş marginal basin opened during the Neocomian).

This couple remained, in its northern part, in its initial position whereas the southern part was turned westward. The mid Cretaceous tectogenesis, as an effect of the westward subduction of the Transylvanian oceanic crust, created within the Bedeleu magmatic arc eastvergent nappes - with similar vergency with the East Carpathians Transylvanian nappes. Later, during the Laramian tectogeneiss, this group of nappes as a whole was overthrust toward the west as an effect of the subduction of the Feneş marginal basin.



1. Neogene magmatites and sedimentary formations; 2. Senonian posttectonic cover; 3. Bucium unit; 4. Criş Nappe - former marginal basin; 5. Căpîlnaş-Techereu Nappe - former magmatic arc; 6. Feneş Nappe - former marginal basin; 7. Bedeleu Nappes Group - former marginal basin; 8. Bozeş Nappe; 9. Metamorphic rocks; 10. Neogene and Quaternary deposits.



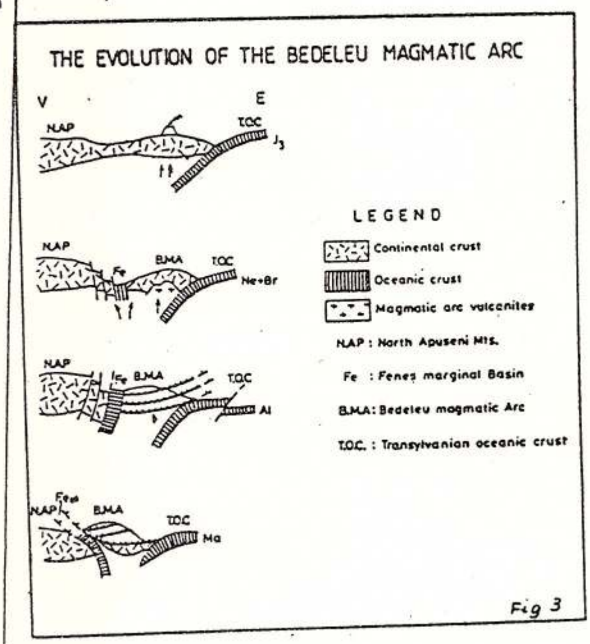


Fig. 2. Development model of the Criş marginal basin.
1. continental crust; 2. magmatic arc; 3. oceanic crust; 4. intrusive magmatites.

Key words: Apuseni Mountains, Jurassic, Cretaceous, magmatic arc, marginal basin, subduction, Midcretaceous, laramian tectogenesis.

GEOTHERMAL MODEL OF THE LITHOSPHERE IN THE WESTERN CARPATHIANS

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The thermal state of the lithosphere and its development in a collisional mountain range of the Western Carpathians is studied. Mainly thermal effects of Upper Cretaceous - Neogene processes involving the whole lithosphere and of local and regional geologic events, such as subduction, lithosphere thinning, development of diapir, nappe overthrusting, magmatism, etc. were evaluated and discussed. The basic results were obtained on the cross section along the deep reflection seismic line 2T crossing the Carpathian arc in the central part of the Western Carpathians. These modelling results supplemented by geothermal models along eight Carpathian profiles KP were used for construction of 3D model of the temperature field of the Western Carpathians. The final model is represented by temperature and heat-flow density distribution at the Moho-discontinuity, at four horizontal levels (5, 10, 15, and 50 km) including the description of geological structures and by the map of thickness of the Western Carpathian lithosphere.

TECTONIC MODELLING OF THE GETIC DEPRESSION – PRELIMINARY RESULTS

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The Getic Depression represents an area which was the geological research subject for nearly 50 years, starting with the first field observation in outcrops, through the drilling exploration and ending with the modern seismic stratigraphy developed in the area. This study is trying to give a first interpretation taking into account some elements of basin geodynamic quantitative modelling.

As a general view, the flexural model is first emphasising the retreated position of the boundary conditions along all the observed profiles. Placing these conditions at the position of the surface limit with the Danubian Autochthon or more retreated in the depression is suggesting a short "subduction", or more correctly, a short underthrusting of the Moesian plate under the Carpathians. In these conditions it is very difficult to speak about a classic subduction zone. Thus, the Southern Carpathians foredeep can be classified as a retreating subduction boundary, with subduction greater than convergence. If we look into details at the flexural model obtained, the most important feature to underline is the shape of the EET profile along the depression; this profile is showing an important decreasing, from 22km, in the central eastern part, to 7.5km, in the western part of the area. The most reasonable assumption for the lithosphere weakness in the western part is that, at the moment of basin formation, the stretching of the lithosphere in this area was more intense than in the eastern part. Taking into account that small EET values give short and deep basins, while large EET values give long and shallow basins, the effects that can be observed are the shortening of the stratigraphic wedge towards the east, after the Olt valley and the step type shape of the basement along strike in the depression. The flexural response in the western area will give a flexural forebulge with an advanced position, while, in the

eastern part, at the same strike level, the basin is deeper, the forebulge having a retreated position. The result is the presence of an important lateral ramp west of the Olt valley. If we take into account the hypothesis that the ramp was active during the basin evolution, the effects will give pseudo - strike-slip structures due to advancing on lateral ramp, over the deformation episodes, or real strike-slip structures (positive flower structures) due to differential nappe advancing because of different underthrust Moesian Platform shape. This last assumption raises an important question, about the presence of strike-slip structures in the Getic Depression: are these structures generated by a dextral movement of the Southern Carpathians in respect to the Moesian Platform, or these ones are generated just by differential movement over the step type shape of the Moesian Platform. Even if the flexural model gives as more reasonable this last assumption, the problem should be clarified in details in further studies.

In the frame of subsidence analysis, the tectonic component of the vertical movement is reconstructed, using backstripping techniques. An attempt was made to define a Warnicke simple shear model of strechning at Cretaceous - Paleogene level. After the deposition of Cretaceous and Paleogene stratigraphic sequences, deformation stages start with Burdigalian, foredeep deposits being thrust over the Moesian Platform. Taking into account the different EET profile, the idea is that the deposits should thrust a more advanced uplifted shape of the foreland in the western part. Sarmatian time evidentiates a strong reactivating of the deformation, especially in the lower part of the interval. While the internal part has small values, due to thrusting and uplifting, the external part has an important tectonic subsidence, as an effect of flexure due to loading. For the whole Burdigalian - Sarmațian period strike differentiation appears to be located in the middle of the studied zone, with a slow migration from the north-east to the south-west. This is an important indication for the strike-slip events, which gives flower structures, with differential uplifting of sedimentary horizons along the strike.

GEOCHEMISTRY AND TECTONIC SIGNIFICANCE OF SOME PALEOZOIC METAVOLCANIC ROCKS IN GETIC AND SUPRAGETIC UNITS (BANAT AREA, ROMANIA)

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Chemical data concerning the metavolcanic rocks of the Caraş Group and Buceava Group in Supragetic and Getic Units, respectively, are presented.

Caraş Group is a Lower Paleozoic greenschist facies volcanic-sedimentary association of Bocşa Supragetic Unit in Banat area. The Naidaş-Rafnic Formation in the lower part of Caraş Group is mainly composed of metagraywacke and bimodal igneous association represented by metabasalts (actually seen like actinolite-epidote-albite schists), metadolerites, metagabbros, metaultramafics (plagioclase wehrlites) and metarhyolites.

The chemistry of basic rocks is consistent with comagmatic origin by differentiation of LILE-enriched tholeiitic melt dominated by plagioclase and clinopyroxene fractionation and segregation of some products with cumulus rock chemical features.On the contrary, the chemistry of high-Si, low-Al rhyolites precludes their comagmatic origin with basic rocks but it is typical of rhyolites deriving from a mantle or low crustal silicic magma.

Distributions of Zr, Y, Ti, V, P and LIL-elements in metabasalts point out their affinity to within-plate, intracontinental magmatism. The intracontinental protorift tectonic-setting of bimodal volcanics is also consistent with types of metasedimentary terrigenous rocks of Caras Group.

Ordovician prehnite-pumpellyite facies Buceava Group in Bozovici Paleozoic Unit of Getic Nappe contains igneous rocks associated with black shales and, locally, epiclastic rocks. They are represented by basaltic flows, sometimes with pillow-lava structures,and basaltic tufaceous rocks, the latter strongly recrystallised in foliated aggregates. Dolerite and basaltic-andesite dykes and gabbro bodies are present, too.

These tholeiitic basic rocks can be divided into two groups, high-Ti and low-Ti, with distinct differentiation trends dominated by olivine, plagioclase and clinopyroxene fractionation. In addition, cumulus processes and open-system fractionation generally induce a geochemical diversity among basic rocks. Incompatible element distribution suggests a different degree of partial melting of a common depleted mantle source for generation of high-Ti and low-Ti series parental magmas.

High LIL/HFS ratios, geochemical parameters and discriminant trace element diagrams based on immobile elements indicate back-arc basin affinity for the basalts of Buceava Group.

SOME SEISMOGEOLOGICAL PARTICULARITIES OF THE ROMANIAN CRUST

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The paper represents a synthesis of seismic information (reflection, refraction and log data) obtained until present since seismic studies are carried out on the Romanian territory. Observations are referring to the foreland zone of the Carpathian arc (Moesian platform, Carpathian foredeep, Scythian platform, Moldavian platform) and internal depression as Transylvanian basin and Pannonian depression.

So, the Moesian platform is characterized by seismic markers from the bottom of Sarmatian, the surface of Cretaceous limestone, the layer of Triassic dolomite, the surface of calcareous complex of Paleozoic age and also the seismic interface sedimentary / crystalline basement.

On the Transylvanian basin, seismic studies were dedicated to the Neogene seismic sequence (where the main accumulations of gas from Romania are placed), the seismic markers of Dej tuff and salt formation. For the areas of tectonic upliftings of crystalline basement, the seismic marker, both for reflection and refraction seismic are corresponding to Mesozoic limestone and also to sedimentary cover / crystalline basement.

The Pannonian depression is characterized by seismic sequence of Pannonian age with reflections easy to be correlated on long distance. The structure is horizontalized, as contrasted with the pre Pannonian seismic sequence which are of bad quality. They are difficult correlable and affected by high seismic noise (diffractions and multiple waves). Similarly, a high seismic contrast between sedimentary formations and crystalline basement of depression is to be pointed out.

On the Carpathian foredeep there is a characteristic geological sequence of Neogene age. It has a variable thickness and is represented by a succession of parallel reflection markers with high velocity contrast.

Moldavian platform has a particular feature represented by the anhydrite layer of Badenian age. Just near the thrusting plane of sedimentary wedge of the Carpathian orogene, it allows a clear observation of orogene - platform transition, being easy correlable on very long distance far to the East European platform. The Mesozoic sequence, consisting of singular reflections of high quality, perturbated by many diffractions generated by pre Neogene erosion is the second sequence. The last one is of Paleozoic age (the deepest depth of investigations for hydrocarbons by seismic method) and is characterized by sporadic reflections of low frequency, limited extension, discordant in comparison with the cover formation. Another seismic marker is again represented by sedimentary cover / crystalline basement transition, in the same manner as other units.

Within the framework of the above mentioned seismogeological provinces there are presented data on seismic velocities (longitudinal P waves) resulted from logging and processing of field reflection data. In order to give a more complete view on the characteristic layers, the reflection coefficients corresponding to the seismic markers are presented. The main geological units are analysed by velocity - depth correlations.

The seismogeological features presented for the major tectonic provinces of Romania point out a series of not only similarities but also differences. They allow to conclude some main particularities of sedimentary environment of the main sedimentary litho - stratigraphical sequences and their tectonic evolution.

UPPER CRETACEOUS DEFORMATION OF THE PIENINY KLIPPEN BELT; WEST CARPATHIANS

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The paper aims to reconstruct the Late Cretaceous position and dynamics of the Pieniny Klippen Belt of the West Carpathians, which lies behind the Paleogene flysch accretionary prism.

As shown by the reconstruction based on structural, sedimentological and paleomagnetic data, the Pieniny Klippen Belt occupied a WNW-ESE to NW-SE trending zone during the Late Cretaceous which acted as an oblique convergent boundary between the ancestral West Carpathians and the oceanic lithosphere attached to the North European platform. Sediments of the Pieniny Klippen Belt were part of both the mountain belt and foredeep at that time. Known change from pelagic micritic limestone to a flysch sequence is progressively younger seawards in the thrust-slice stack forming the Pieniny Klippen Belt. The synsedimentary record includes flysch, olistostrome and wildflysch sediments. Both the NW-SE thrusting along the NE-SW striking faults and dextral strike-slip faulting along the WNW-ESE to NW-SE striking faults were active in the Late Cretaceous area of the current Pieniny Klippen Belt.

PALEOSTRESS PATTERNS IN THE SOUTHERN CARPATHIANS: STRIKE-SLIP AND EXTENSION BY OROCLINAL BENDING

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Orientations of principal stresses deduced from outcrop-scale fault patterns of ca. 80 stations within the Southern Carpathians between the Danube and the Fagaraş Mountains have been investigated in order to constrain late stage collisional effects between the Southern Carpathians and the Moesian platform. This study completes, therefore, a previous paleostress orientation study by Ratschbacher et al. (1993).

The resulting patterns display a significant variation along the Southern Carpathian mountain belt (Fig. 1): (1) Along the external portion of the Southern Carpathians, predominant subhorizontal sigma 1 orientations were observed. Furthermore, these orientations display a fan-like pattern with sigma 1 perpendicular to external margins and a predominant E-W sigma 1 orientation near to the Danube and N-S orientations along southern Fagaras Mountains. (2) Extensional patterns dominate central and inner portions of the Southern Carpathian belt.

Furthermore, nearly no overprints have been observed on faults. These observations constrain reactivation of older faults during the last step of compression during the Neogene. In accordance with previous authors, e.g. Ratschbacher et al., 1993, we explain these patterns to be an effect of oroclinal bending of the Southern

Carpathians around the corner of the Moesian platform during the final stage of continent-continent collision. This resulted in dextral along faults parallel to the external margin and extension by bending in the interior of the mountain chain.

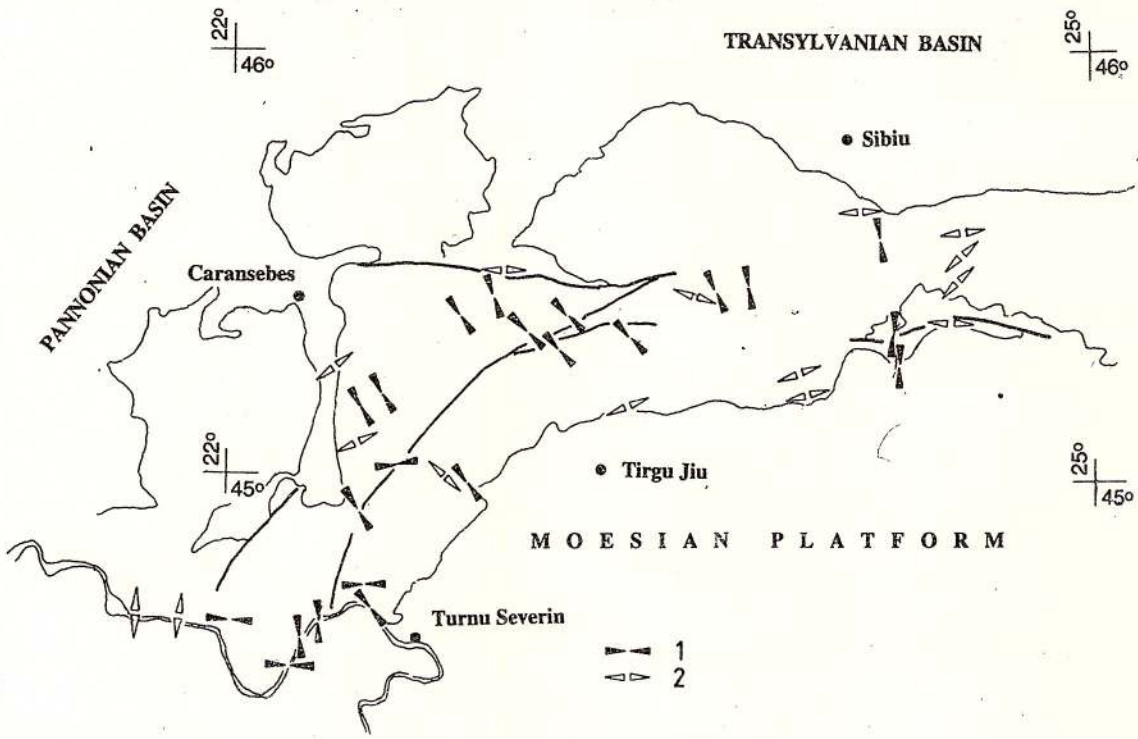

Fig. 1 – Geological sketch with paleostress orientation variation within the Southern Carpathians. 1, strike-slip pattern with black arrow displaying sigma 1 orientation; 2, extensional pattern.

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Ratschbacher, L., Linzer, H.-G., Moser, F., Strusievicz, R.-O., Bedelean, H., Har, N., Mogos, P.-A., 1993: Tectonics, 12: 855-873.

GRANITES OF ALPINE AGE IN THE WESTERN CARPATHIANS? - A STRUCTURAL APPROACH

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According to geological maps, several granites intruding the Veporitic and Gemeric basement complexes of the Inner West Carpathians are of Cretaceous age. The maps are based on K/Ar and Rb/Sr ages of 70–140 Ma which were obtained from biotite, muscovite, and wholerock granite. Until the late eighties, these ages were interpreted as emplacement/crystallization ages. Although the data have been reevaluated in the light of improvements in the understanding and methods of dating metamorphic tectonites, the concept of granitic intrusions associated in time and space with Alpine events lingers on tenaciously in the literature (e.g. Hok et al. 1993) and influences interpretations of Mesozoic events in the Inner West Carpathians. The granites and their structural setting were therefore investigated in some detail.

The Lubenik Line, the western contact between the Veporic (footwall) and Gemeric (hangingwall) units, is shown by meso- and microscale data to be a large scale, shallowly dipping (15–20^0) normal fault, with relative movements of the hangingwall block to the east/southeast (O'Shea and Sperner 1992, Hok et al. 1993). The youngest rocks affected are Triassic in age. There is no evidence that the fault is a reactivated Variscan structure. A top-to-south/southeast sense of shear is observed in granite and in Permian sediments in the northern part of the Gemeric unit. Published geophysical data (Kucharic et al. 1990) indicate that the Gemeric granites at the surface belong to the same intrusion complex at depth, which is truncated by a flat-lying fault zone at a depth of 3.8 km below sea level. In the Veporic Rochovce granite borehole data indicate a near-horizontal trend of the magnetic susceptability (Gregor et al. 1992). Muscovites from Permian sequences of the Veporic footwal close to the Lubenik Line have been dated at 86.9 *pm* 0.2 Ma (Ar/Ar; Dallmeyer et al. 1993). The Lubenik Line is therefore interpreted as a major Cretaceous detachment fault, and the Gemeric unit as the originally autochthonous cover of the Veporic basement and the uppermost zone of the Variscan granitoids intruding that cover. Furthermore, the overlying Mesozoic Meliata and Silica units are parautochthonous on the Gemeric unit.

Widespread Eoalpine crustal extension is proposed for the Inner West Carpathians on the basis of microstructural studies and detailed structural investigation in the field. A model is presented in which Mesozoic normal faults are reactivated, as the result of extension in the overriding plate due to slab pull (Royden 1993), prior to continental collision in the early Tertiary. Basement half-grabens alternate with Mesozoic basin fill. Crustal extension also facilitated detachment of the Gemeric unit and its overburden from its crystalline basement. The "normal" crustal thickness beneath the Inner West Carpathians (32–36 km; Horvath 1993, Lillie et al. 1994) reflects not only Mesozoic and Neogene extension but also the lack of significant Eoalpine shortening of the overriding plate. The "reset" Eoalpine ages of the Variscan Veporic and Gemeric granites reflect these extensional events.

GEODYNAMICS OF THE AREA BETWEEN THE ALPS, DINARIDES, AND THE PANNONIAN BASIN IN SLOVENIA

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The territory of Slovenia lies on the junction of several geotectonic units: the Alps, the Dinarides and the Pannonian basin. The Adriatic basin, External and Internal Dinarides, Southern Alps and the Austro-Alpine nappes of the Eastern Alps are considered to be parts of the supposed Adriatic microplate. Hercynian basement of the Pannonian basin, south of the Zagreb - Balaton zone and north of the Internal Dinarides ophiolitic zone supposedly represents a separate lithospheric fragment.

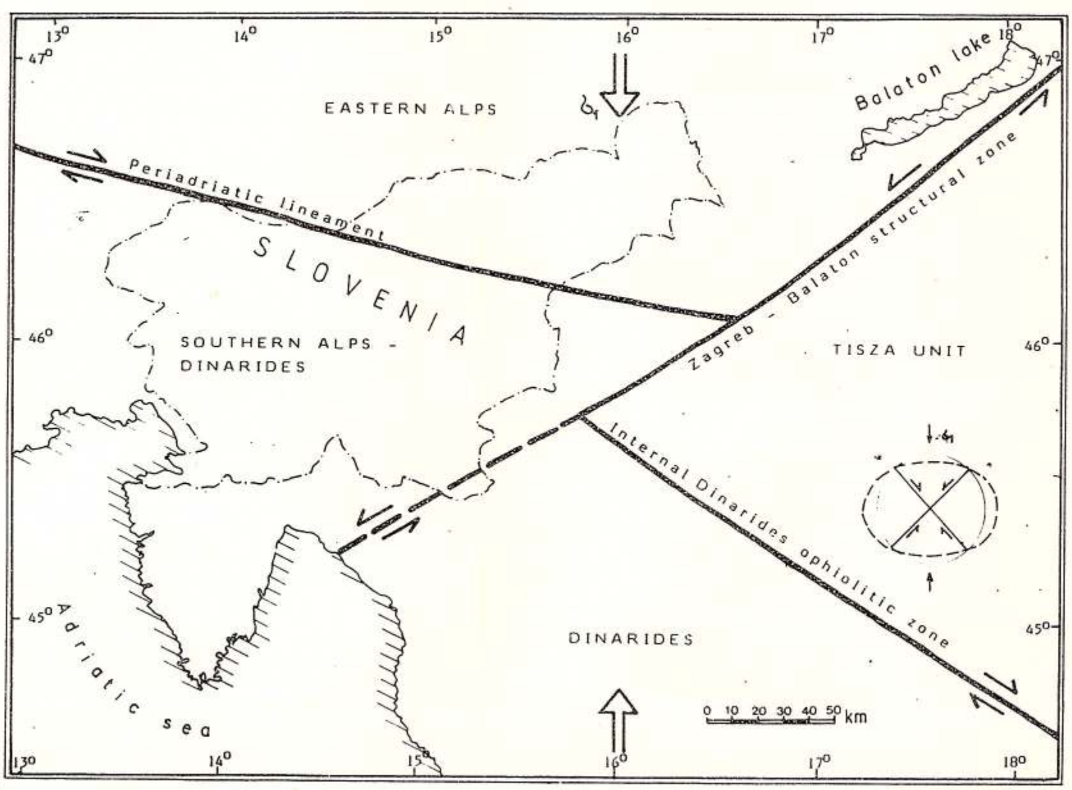
The lithosphere thickness exhibits diversities regarding geotectonic units with greater values in the Alps and Dinarides and lower in the Pannonian basin.

The Moho isobaths are in the Dinarides NW-SE oriented, and in the Alps E-W oriented with maximums reaching 45 and 55 km in depth. In the Pannonian basin, the depth of the Moho is between 20 and 30 kilometers.

Most of the seismicity in situated on the deformed rim of the Adria microplate with average depth of hypocenters on 10 kilometers. The exception are earthquakes along the Dinaric ophiolitic belt with depth of hypocenters up to 40 kilometers. Fault plane solutions exhibit in most cases strike-slip and reverse components of tectonic dispacement.

Finally, the entire area is characterized by large strike-slip faults as well as by the thrusts that show horizontal displacement along thrust planes.

Thus, we believe that recent tectonic activity is taking place along strike-slip faults, whereas the main faults situated along large geotectonic units function as pair-set of shears in the pure shear style of structural deformations.



TECTONIC EVOLUTION OF THE GIUDICARIE LINE (INSUBIRIC LINE; NORTHERN ITALY)

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The Giudicarie line represents a major irregularity within the Insubric line. It juxtaposes the Austroalpine Tonale basement nappe over the sedimentary cover of the Southern Alps along a NW-dipping fault zone. Large left-lateral strike-slip movements have been postulated along this fault, which apparently offsets the E.trending Insubric line of some 80 Km (Laubscher, 1990). This paper reports deformation mechanisms and kinematic indicators collected along the fault zone of the Giudicarie Line from Val di Sole to the area of Proves (Trentino-Sdtirol), in order to constrain the tectonic evolution of the Insubric line during the upper Oligocene-Miocene.

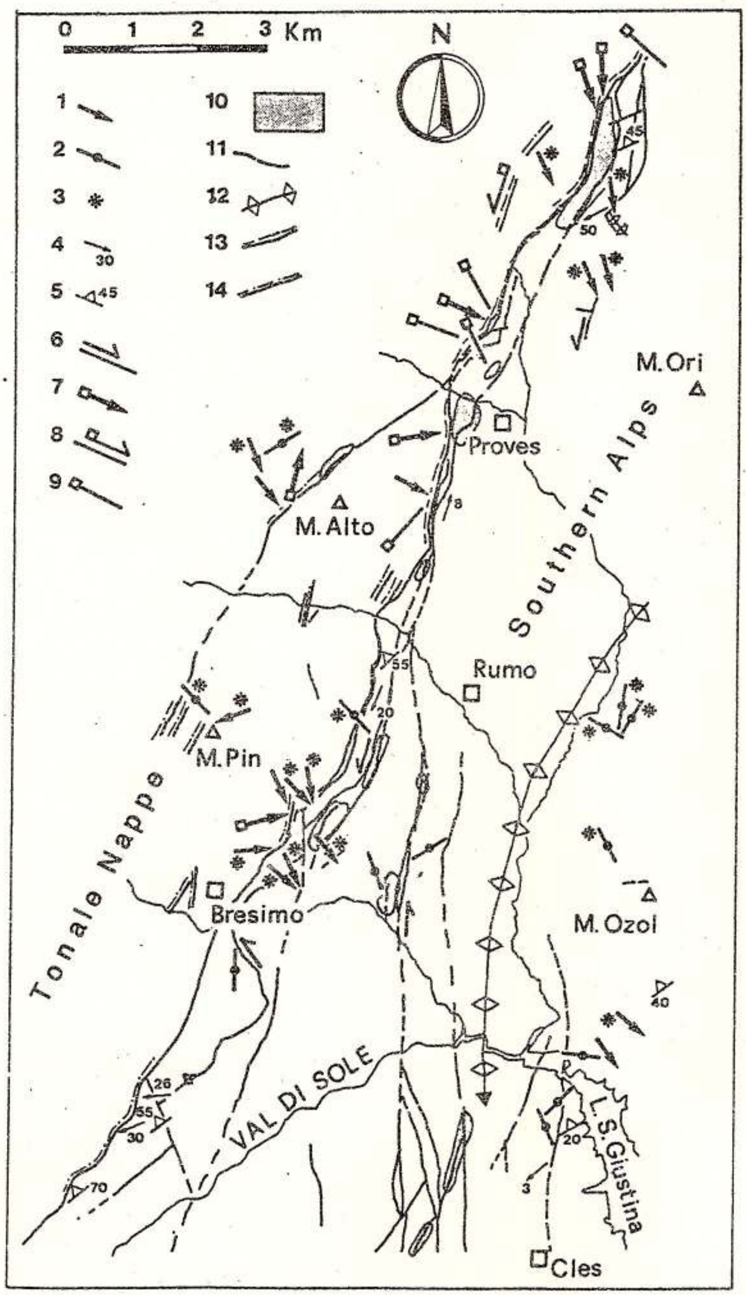
Fault rocks of the Giudicarie line display different deformation mechanisms from S to N. In the southern sector, which extends from Dimaro to Rumo (Fig. 1), cataclastic rocks prevail, while north of Rumo low grade mylonites originate from the Tonale paragneisses and from thin slices of limestones and marls of supposed Triassic age. Cataclasts cut the magmatic and solid-state foliations of some tonalites of upper Oligocene age (Martin et al., 1993), which sometimes occur along the fault plane of the Giudicarie line.

Kinematic indicators have been measured both in brittle/ductile mylonites and in minor faults associated the main tectonic line.

A) Mylonites display stretching lineations outlined by quartz, chlorite and calcite on a 30-40^0 NW-dipping foliation. Stretching lineations are nearly E-trending from Bresimo to Proves (Fig. 1), whereas north of this locality they gradually change to a NNW direction. Shear sense indicators point out thrust movements of the Tonale nappe over the Southern Alps, coupled with a dextral component in the southern part and a sinistral component in the northern part of the Giudicarie line.

B) Brittle fault populations within the sedimentary cover of the Southern Alps are mainly related to a NNW/NW-directed compression. Near the Giudicarie line minor faults and the attitude of cleavage planes indicate a SSE-directed thrusting of the Tonale nappe. Anastomosing left lateral strike-slip faults are widespread in the footwall of the Giudicarie line. They display kinematic compatibility with the same NNW-directed compression.

Both mylonites and brittle faults developed after the emplacement of the Upper Oligocene tonalites. Mylonites are allochthonous over the sedimentary cover of the Southern Alps. They developed first, at deeper structural levels, probably during the "Insubric phase" (Schmid et al., 1989) of Lower Miocene age. Therefore dextral strike-slip movements along the Insubric line were synchronous with transpressions along a NNE-directed proto-Giudicarie line. Later SSE-directed compressions reactivated the Giudicarie line as a left-lateral transpressive fault. This event was synchronous with the main tectonic activity within the central Southern Alps, of Middle-Upper Miocene age. Left lateral displacements accentuated the Giudicarie irregularity and the Insubric line acquired its present shape.



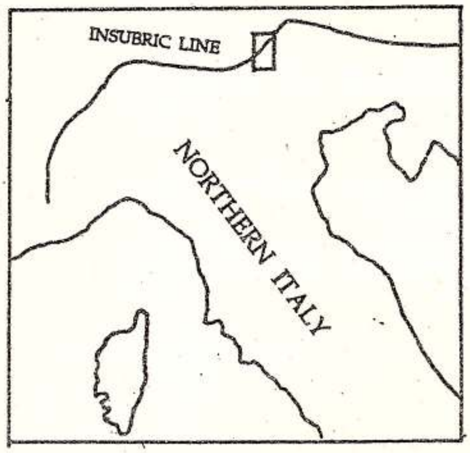


Fig. 1 – Tectonic map of the Giudicarie line form Val di Sole to Proves.
1. Maximum compression from fault populations with prevailing thrust movements.
2. Maximum compression from fault populations with prevailing strike-slip movements.
3. Stress tensor calculated after CAREY (1979).
4. Fold axes.
5. Pressure-solution cleavage.
6. Shear sense of strike-slip faults.
7. Tectonics transport direction in mylonites.
8 Shear sense of mylonites with strile-slip movements.
9. Stretching lineations.
10. Intense brittle deformation.
11. Main faults.
12 Large scale fold axes.
13. Main mylonites.
14. Foliated cataclasites.

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ALPINE REMOBILIZATION OF THE WESTERN CARPATHIAN VARISCAN BASEMENT (i): EVIDENCE FOR THICK-SKINNED, THIN-SKINNED, TRANSPRESSION AND EXTENSION TECTONICS IN TATRO-VEPORIC ZONE

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The paper deals with relics of the Variscan basement shear zones (Fig. 1.) scarcely preserved in a strongly remobilized Tatro-Veporic Alpine tectonic segment of the central Western Carpathians (Fig. 2.).

Early Variscan collision (430 ? - 380 Ma) is indicated by southward mid-crustal thrusting of the Tatra Nappe including LAC over the Hron Nappe. Layered structures of amphibolites, alternating with intermediary to acid orthogneisses (about 420 Ma old, according to U-Pb and wr Rb-Sr dating, Krist et al. 1992), formed in deep-seated shear zone, due to deep-crustal thinning, extensional uplift and accompanying melting processes.

Other Early Paleozoic (Silurian-Early Carboniferous) complexes prove Variscan extension in the area of pre-Carpathian terrane (Fig. 1.). Some of them represent incomplete ophiolitic (the Rakovec, Kl tov and Pernek) complexes (Ivan et al. 1992). Strong deformation indicates Late Variscan uplift and exhumation.

Thickened crustal rocks of the Tatra Nappe underwent melt enhanced deformation due to extended anatexis, accompanied by generation of Variscan granitoid plutons. The inverted metamorphic zoning (Jan k 1992) is preserved along the thrust of the Tatra Nappe over the Hron one. The orthogneiss mylonites in the hangingwall of the Tatra Nappe show ductile deformation of quartz and feldspars at temperatures higher than 450^0 C (Fritz et al. 1992, Putiš 1992, 1993).

The Alpine nappes of the southernmost Supratatric and the whole Veporic basement (incl. the cover rocks) originated mainly due to the Late Jurassic-Early Cretaceous thick-skinned tectonics, related to the continental shortening phase. It occurred in the area adjacent to the closed Triassic-Jurassic basins and the Meliata oceanic basin situated S of the Veporic and Gemeric zones. Alpine metamorphism of the Veporic

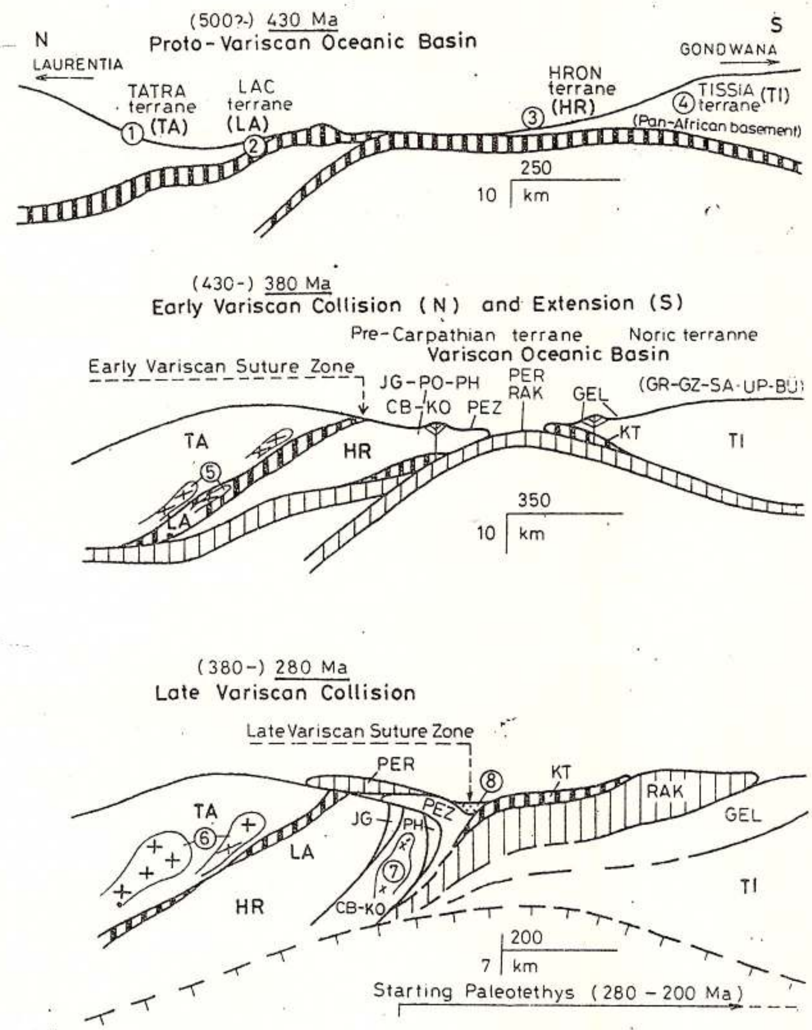

Fig. 1 - A preliminary interpretation of the Variscan tectonic evolution of the Western Carpathian basement (Putis 1993). Early Variscan terranes complexes (nappes): TA = Tatra complex (1 = passive, later active margin); LA = Leptyno-amphibolite complex (2 = active margin); H = Hron complex (3 = passive margin); TI = 4 = Pan-African basement of Tissia; 5 = granitic orthogneisses. Late Variscan Pre-Carpathian terrane complexes (nappes) mostly derived from the active margin of the northern plate: PER, RAK, KT = Pernek, Rakovec and Klatov (incomplete ophiolite) complexes; PH, JG, PEZ = Predna hola, Janov grun and Pezinok complexes; CB, KO = Cierny Balog and Kohut complexes; GEL = Gelnica (rifted passive margin ?) complex; 6, 7 = Late Variscan granitoid plutons (6 - older, mainly S-type, 7 - younger, I, S-type); 8 = Late Variscan collision flysch furrow. Noric terrane complexes (nappes) derived from the passive continental margin of the southern plate: GR, GZ, SA, U-B = Paleozoic complexes of Graz, Graywacke zone, Southern Alps and Upony-Bük zone.

unit (in biotite-garnet, or kyanite-chloritoid zone conditions) is bound to this deformation stage. Early Alpine extensional (master, detachment) Pohorelá and Lubeník faults changed to thrust faults.

The inverted Alpine metamorphic zoning in the Supratatric zone formed during the mid-Cretaceous thrusting of the uplifted metamorphosed Veporic unit over the Supratatric unit as a result of N-NW-ward thin-skinned tectonics (Fig. 2.).

Sinistral transpression along Čertovica, Pohorelá and Lubeník shear zones (top-to-ENE) was followed by-ESE-ward extensional sliding (late mid-Cretaceous - Early Paleogene) in the southern Supratatric and Veporic (and Gemeric) units due to the postcollisional uplift of the Tatric incl. Supratatric units.

The Meso-Alpine (post - Upper Cretaceous) thrusting is evidenced in the Infratatric zone (Putiš 1991).

Shear zone rheology and kinematics is also documented by the microstructures and patterns of quartz as well as the feldspar preferred orientation.

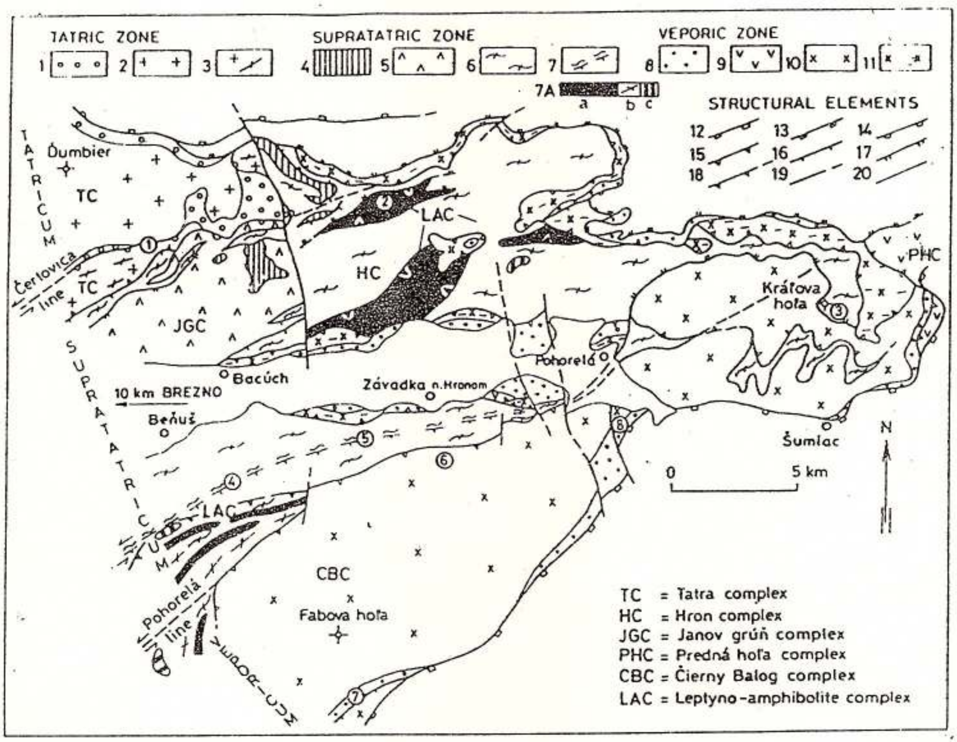

Fig. 2 – Geological - tectonic sketch - map of the Low Tatra Mts - E and the Slovak Ore Mts - NW (Putiš, 1993). Tatric zone: 1 - Tatric cover (Upper Carboniferous - Middle Cretaceous) rocks: Lower Triassic shales and quartzites, Middle Triassic limestones and dolomites, 2 - Tatra complex, 3 - Lubietova succession of the Tatra complex. Supratatric zone: 4,- Permian-Triassic remnants (roots) of the Velky bok (Supratatric cover) succession included into the Krizna Nappe, 5 - Janov grun complex, 6 - Hron complex, 7 - mylonitic schists (phyllonites), 7A - Leptyno-amphibolite complex (sensu Hovorka & Méres 1993): a = banded amphibolite, b = orthogneiss, c = serpentinite. Veporic zone: 8 - Veporic cover (Permian - Triassic) rocks: Permian arcoses, shales, acid volcanics and volcaniclastics, Lower Triassic quartzites, acid volcanics and volcaniclastics, Middle Triassic limestones and dolomites, Upper Triassic limestones, dolomites and dark calcareous shales, 9 - Predna hola complex, 10 - Cierny Balog complex (mostly late Variscan granitoids of the Vepor pluton wit gneisseous mantle, 11 - tonalite nappe (a part of Vepor pluton). Structural elements: 12 - thrust of the higher (non-metamorphosed) Mesozoic nappes (the Muran and Choc Nappes), 13 - thrust of the Krizna Nappe, 14 - mid-Cretaceous thrust of the Supratatric tectonic unit, 15 - Late Jurassic - mid-Cretaceous thrust of the Veporic tectonic unit, 16 - internal subhorizontal thrusts within the tectonic units, 17 - re verse fault-thrust, 18 - Variscan thrust, 20 - primary geological boundary.

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SINTECTONIC SEDIMENTATION HISTORY IN THE SOUTHERN CARPATHIANS FOREDEEP (GETIC DEPRESSION)

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Syntectonic sedimentation of post-Badenian deposits in the Getic Depression is modelled using sequential stratigraphy principles and restoration techniques, applied on seismic lines.

Through the seismic stratigraphy methods a series of seismic sequences, with more or less lateral continuity were recognised. From the Olt valley to the east there are less possibilities to separate seismic sequences, because of shoreline zone erosion in the frontal part of the main thrust, the Pericarpathian line. Thus, different types of reconstruction were made: in the western part of the area the methods are based on base level recognising, while in the eastern part of the sedimentary axis, deviation methods were used. The variation of local base level curve was made for both sectors and in the western part there is an attempt of its controlling features determination. In the eastern area we can see very well the forebulge evolution, using the truncation between the seismic reflections. Six Sarmatian peak deformation episodes, with determining influence on the 3D assemblage of the sedimentological major units in Sarmatian and Meotian can be seen.

There can be seen very well the time evolution of a dextral strike-slip system (duplexes), with main SE-NW direction, formed due to the Moesian Platform underthrusting on this direction, which determines a different tectonic evolution, from the western area, were the thrusting has low values in Sarmatian, and the dextral component is the main features, to the eastern areas, where the thrusting amplitude is greater, with a leading imbricated fan system, which gives a piggy-back type basin.

Sedimentation and tectonic evolution of the Getic Depression is the interference result of the NE-SW advancing of the Moesian Platform, an eastern uplifted area, an important sedimentary influx from the hinterland and an eustatic component. Sarmatian is less important, but Pliocene dominates.

VERY LOW -GRADE METAMORPHISM OF LATE- TO POST-VARISCAN SEDIMENTS OF THE EASTERN AND SOUTHERN ALPS

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This contribution provides a comparative view of the metamorphic overprint of some Late- to Post-Variscan strata of the Eastern and Southern Alps (Auernig-Formation of the Carnic Alps, Carboniferous of Nötsch and Remschnigg area). The comparison of the recognized metamorphic pattern in areas located near the Peri-adriatic lineament gives some information about the Pre-Alpine paleogeography at the eastern end of the South-Alpine/East-Alpine border zone and the significance of the Gailtalline, a segment of the Periadriatic lineament. The metamorphic data are based on illite crystallinity, coalification of organic matter, microthermometry of fluid inclusions and calculated thermal models.

The **Auernig-Formation of the South-Alpine Carnic Alps** was effected by two phases of very low-grade metamorphism, as deduced from the correlation between organic and inorganic parameters of metamorphism (coalification data, illite crystallinity and the distribution of temperature-sensitive minerals). The Upper Carboniferous sedimentation of the Auernig-Formation is characterized by an enhanced heat flow (diasthermal metamorphism). This can be explained by synsedimentary strike-slip tectonics which caused the opening of an intramontane pull-apart basin. The following thermal history is marked by a normal heat flow (app. 1.8 HFU) with minimum peak conditions of 270^0 C and 4 to 6 km subsidence.

Coalification data of the **Carboniferous of Nötsch**, a tectonically isolated unit at the southern margin of the Drau Range, reveal a syn- to posttectonic Alpidic coalification up to anthracitic coal ranks which is locally overprinted by shear stress to meta-anthracite.

In the **Remschnigg area**, south of the Neogene Styrian Basin, Carboniferous black shales and a Permian sequence of red shales and sandstones (ages given by lithostratigraphic correlation) overlie Early Paleozoic phyllites. The metamorphic overprint marks a continuous metamorphic section from epi- to higher anchizonal Early Paleozoic phyllites to lower-anchizonal Permian shales. This metamorphic picture resembles exactly the pattern within the Post-Variscan strata of the Gurktal thrust complex (GTC) in Middle and East Carinthia (SCHRAMM et al., 1982; GOSEN et al., 1987). The organic matter of the Carboniferous black shales is composed of semianthracitic coke-like transitional matter. This high rank of organic meta-morphism must be explained by effects of shearing.

The Post-Variscan sediments of the Drau Range are effected by an anchi-zonal metamorphic overprint with minimum metamorphic conditions of 5.5 to 7 km burial and a temperature of 270^0 C as determined by NIEDERMAYR et al. (1984). The Alpidic p-T conditions of the Carnic Alps show the same temperature and a slightly lower burial depth. The metamorphic overprint disappears in the Drau Range in the Middle Triassic, and in the Carnic Alps in the Permian.

The comparison of the South-Alpine Carnic Alps with the adjacent East-Alpine units of the Carboniferous of Nötsch, Drau Range and GTC (Carinthia and Remschnigg area) makes it evident that the Periadriatic lineament separates tectonic units which are effected by an Alpidic metamorphic overprint in the same intensity. This observation is opposed to the view of BÖGEL (1975) who stated that the missing Alpidic metamorphism inside the South-Alpine block, in contrast to the East-Alpine block, is a characteristic feature of the Periadriatic lineament.

According to EBNER et al. (1991) the eastward palaeogeographic continuation of the South-Alpine Carboniferous strata is given by the Hungarian Szendro-Uppony-Bükk-Range. The tectonic map of the Pannonian Pre-Neogene basement (FÜLÖP et al., 1987) shows the Igal-Unit (subunit of the Pelso-Unit) as interlink between South-Alpine (Carnic Alps and Karawanken) and Szendro-Uppony-Bükk. The comparison of the metamorphic overprint of the Carnic Alps with the metamorphic pictures of the Bükk-Range and the Igal-Unit shows a similar pattern and confirms the paleogeography of EBNER et al. (1991). Both units are metamorphosed by an Alpidic anchizonal metamorphism (ARKAI, 1983, 1991; ARKAI et al., 1991) which is the distinctive feature of the other Pannonian terranes.

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ON THE GRAVITY OF THE SOUTH CARPATHIANS FOREDEEP

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The image of the South Carpathians Foredeep is represented by a remarkable low. Modelling of this low along 3 profiles crossing the foredeep has been performed, on the basis of the corresponding geological cross-sections prepared for the whole Romanian territory by Mihai Ştefănescu and collaborators. Density data used for this attempt have been provided by samples and seismic waves velocities (Nafe, Drake, 1959; Woolard 1968; Rădulescu, 1989).

During the modelling process, it turned out that densities having to be assigned to the profound formations filling the foredeep, in order to reproduce the gravity low, might be hardly or not at all accepted. Actually the difficulties encountered when one tries to model the South Carpathians Foredeep low, where noticed even by the very first attempt (Airinei, 1971), when a strange density inversion had to be presumed in order to achieve modelling. Therefore, the presented models are rather a proposal discussion basis then an usual geological interpretation of a physical image.

The first point of such a discussion might be the " granites model ". Granites are definitely low density rocks as compared to most of other crystalline formations or deeply buried sediments. Extension into depth and even laterally can be easily presumed. The " granite model " is the commonplace solution for regional gravity low sources.

But for the South Carpathians Foredeep low, for many reasons, an alternative to this banal model has to be sought. Such an alternative might be represented by the " over-all " density of the carbonate rocks at great burial depths. A possible explanation for unusual low densities one has to use for deep layers when modelling a foredeep gravity low, when carbonates are located in that foredeep, is the preservation of karst-type voids, obviously fluids filled up, at very deep levels, especially in the Mesozoic and Paleozoic Moesian Platform underthrusted formations. As an argument to such an explanation, the presence of a geothermal anomaly (Veliciu, 1985) in the area where the Bouguer map shows even the lowest value for the whole Romanian territory, is advocated. It is suggested that the geothermal anomaly might be explained by an unusual upward flow of deep crustal fluids, favoured by a karst-type pervious system, represented mainly by platform and nappes carbonites, present in the foredeep.

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STRESS FIELD MEASUREMENTS IN EASTERN EUROPE AND LOGGING IN SEISMICALLY ACTIVE AREAS

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The World Stress Map does not contain much information about eastern Europe between the Elbe river and the Ural mountains. Filling this knowledge gap would be of fundamental importance for the understanding of the geodynamics of the area and Europe as a whole. It is not clear whether the stress field is homogeneous and mainly determined by the surrounding plate driving forces or significantly influenced by regions of different crustal thickness, by provinces formed in different orogenic phases or by other features. The contact zones between these regions might be of special interest: At the Trans-European-Suture-Zone the relative young western Europe with thinner crust and lithosphere is in contact with the old Russian craton, where heat flow density and viscosity are changing too; the Urals as well as the Carpathians with neighboring mountain chains might also affect the stress field. Thus, in the framework of the International Lithosphere Program and the EUROPROBE program in-situ measurements to determine the stress field at intermediate depth and great depth in eastern Europe will be an important step towards an answer to the open questions and towards a data base so that the stress field can be traced between the existing data from

Scandinavia to the Caucasus, from western Europe beyond the Urals. A logging truck is sent out to field campaigns like a "continental research vessel". Borehole breakouts as stress indicators are measured mainly with 4-arm calipers/dipmeters and acoustic borehole televiewers (BHTV). If not yet available, ancillary logs, as sonic logs, spectral gamma ray logs etc., can be run. Scientists from the Karlsruhe University, the new GeoForschungsZentrum (GFZ) Potsdam, Stanford University, the USGS at Menlo Park, the University of Alberta, the Russian "Nedra", the Academy of Sciences of Belarus, the Geological Surveys of Lithuania and Romania started to conduct such logging campaigns putting together their scientific knowledge and experience as well as software and hardware. It is intended to co-operate with other institutions on this research, too.

The equipment consists of a borehole logging truck (GFZ) with various tools:

- 2-Arm Calipers,
- 4-Arm Dipmeters,
- a digital Borehole Televiewer for hostile environment (170 MPa, 250C),
- televiewers for standard temperatures and pressures (Karlsruhe and Stanford);
- a Spectral Gamma Ray tool,
- a Dual-Induction Latero Log tool,
- a Micro-Spherically Focused Log tool,
- Compensated Sonic Log tools,
- Gamma Ray tools. To the truck belongs a 7000 m high temperature cable (260^0 C) with seven conductors. The equipment is completed by processing software and digitizing facilities (Stanford, Edmonton etc.). Specialists, boreholes, drilling rigs/cranes, logging data, geological data etc. are supplied by the eastern European partners. The first joint field campaign was run in 1993 with borehole breakout measurements in two Russian superdeep wells, Vorotilov (VGS) and Uralskaja (SG4). Borehole VGS is about 500 km east of Moscow. It is 5375 m deep, the bottom hole diameter is 21.5 cm and the uncased section extends down from 689 m. BHTV logging was possible down to 4800 m. Examples of the original data are shown along with a compilation of all the breakouts picked. A first examination of the data shows an average breakout direction of 35^0E $\pm$ 16^0 with respect to magnetic North. Some longer sections show a slightly different angle. Excluding these and sections with rotating breakout directions, we obtained 40^0E $\pm$ 10^0. Correcting for the magnetic declination and taking into account that borehole breakouts should point in the direction of the minor principal horizontal stress, we obtain as a preliminary result for the maximum horizontal stress direction: 135^0E $\pm$ 16^0 or 140^0E $\pm$ 10^0, respectively. In addition to this project, it would be very interesting to use deep boreholes in seismically active areas to monitor changes before and after earthquakes by repeated logging. As there is little experience about this, a variety of methods should be tested. These include: borehole breakout measurements, sonic logs, maybe also density and porosity logs. Thus, the gap between seismic source parameters from the hypocenter and surface or near-surface observations could be reduced.

VERY LOW TO LOW GRADE METAMORPHISM IN THE PALEOZOIC OF GRAZ, AUSTRIA

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The thrust system of the Upper Austroalpine Graz Paleozoic consists of different nappes of very low - to low - grade metamorphosed sediments of Silurian to Carboniferous age which are sheared off from their basement (FRITZ & NEUBAUER, 1990). Each of the nappes is characterized by different sedimentary sequences. In general the basal parts of the sedimentary column is built up by Silurian metavolcanics, followed by Late Silurian to Early Devonian carbonatic to clastic sediments (EBNER et al., 1980; GOLLNER et al., 1982; TSCHELAUT, 1985). Alpidic orogeny in the Paleozoic of Graz concerns Early Cretaceous compression and thrusting followed by Late Cretaceous extension. The upper limit of the thrusting is given by a Late Cretaceous overstep sequence, the Kainach Gosau. The extension is connected with the formation of this basin. Northeast to southwest striking steep shear zones are the expression of this deformational regime in this area (FRITZ et al., 1991 cum lit.).

The Paleozoic of Graz was investigated with tools of coal petrology and clay mineralogy in order to estimate the metamorphic conditions, in particular: vitrinite reflectance, Conodont Colour Alteration Index (CAI), illite crystallinity (IC) and the distribution of temperature sensitive minerals (HASENHÜTTL & RUSSEGGER, 1992; RUSSEGGER, 1992 cum lit.).

The sediments of the Graz Paleozoic are very poor in phytoclasts. Only about half of the samples could be used to estimate the coal rank. Apart from the "truth coaly particles" there are found very thin phytoclasts called "graphitic phytoclasts". Another group is represented by the so-called coke-like "transitional matter" which is characterized by specific internal structures.

The coalification spectrum ranges from low volatile bituminous coal to meta-anthracite (according to the ASTM-classification). There is no relation between coal rank and stratigraphic age of the strata. The trend surface map grade 4 displays a coalification picture of the maximum vitrinite reflectance with a north to south trend, an increasing coalification to the north.

The CAI within the highest nappe group ranges between 3 and 8. This enormous spread inside this group has no relation to the stratigraphic age. Even within one sample different stages of conodont alteration can be found.

The illite crystallinity as defined by the half-height peak width of the first illite basal reflection (cf. FREY, 1987) ranges from the diagenetic zone up to the epizone. Again, there is no relation to the stratigraphic age. The regional distribution points out an EW trending isocryst pattern, with increasing crystallinity towards the east. The 0.20^0 $\Delta 2\Theta$ isocryst follows the nappe contacts in the north and in the east.

The correlation table for the investigated area displays the following: It is not useful to build a direct correlation between vitrinite reflectance and illite crystallinity. The vitrinite reflectance is correlated to the other parameters of organic metamorphism whereas the illite crystallinity is correlated to the temperature sensitive minerals.

The poor correlation of illite crystallinity to vitrinite reflectance points out that two different metamorphic events must have taken place. The following synthesis of the metamorphic succession within the Paleozoic of Graz can be drawn:

- An Early Alpidic (Low Cretaceous) thrusting in the Paleozoic of Graz determines the illite crystallinity pattern as a syntectonic thermal event.
- Short timing and enhanced geothermal gradients related to the Upper Cretaceous extensional tectonics are responsible for the coalification and graphitization of the organic matter.
- The anomalous high and scattering CAI-values in the highest nappe group are interpreted as the result of hydrothermal activity related to the extensional - or/and compressional tectonics in the Paleozoic of Graz.

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COALIFICATION OF TERTIARY SEDIMENTS IN EASTERN SLOVENIA

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Tertiary subbasins in eastern Slovenia form part of the Pannonian Basin System. They are situated at the triplejunction between the Eastern Alps, Southern Alps and the Pannonian realm. The basin filling consists of a sedimentary sequence comprising Eocene to Quaternary sediments (Jelen et al., 1992). The thickness of the basin filling reaches more than 5000 m near the Hungarian border. The major structural element is the Periadriatic Line and its assumed continuation into the Balaton Line. This major fault zone is accompanied by magmatic rocks of Oligocene and/or early Miocene age. Miocene (Ottnangian to Karpatian) dacites are genetically related to magmatic activity in the Styrian Basin and occur in the Pohorje area.

A compilation of maturity data reveals a complex coalification pattern including coalification maxima in Paleogene sediments in the vicinity of the Periadriatic Line and highly coalified Ottnangian sediments in the Benedikt well (Sachsenhofer, 1992 cum lit.).

The aim of this contribution is to present a more detailed coalification map of Slovenia and to reconstruct the thermal history. Coalification patterns of three areas will be discussed:

1) Miocene sediments along the northern and eastern margin of the pre-Tertiary Remschnigg Mountain in northern Slovenia
(Fig. 1);

2) Miocene sediments in the Ribnica-Selnica fault trough (Fig. 1);

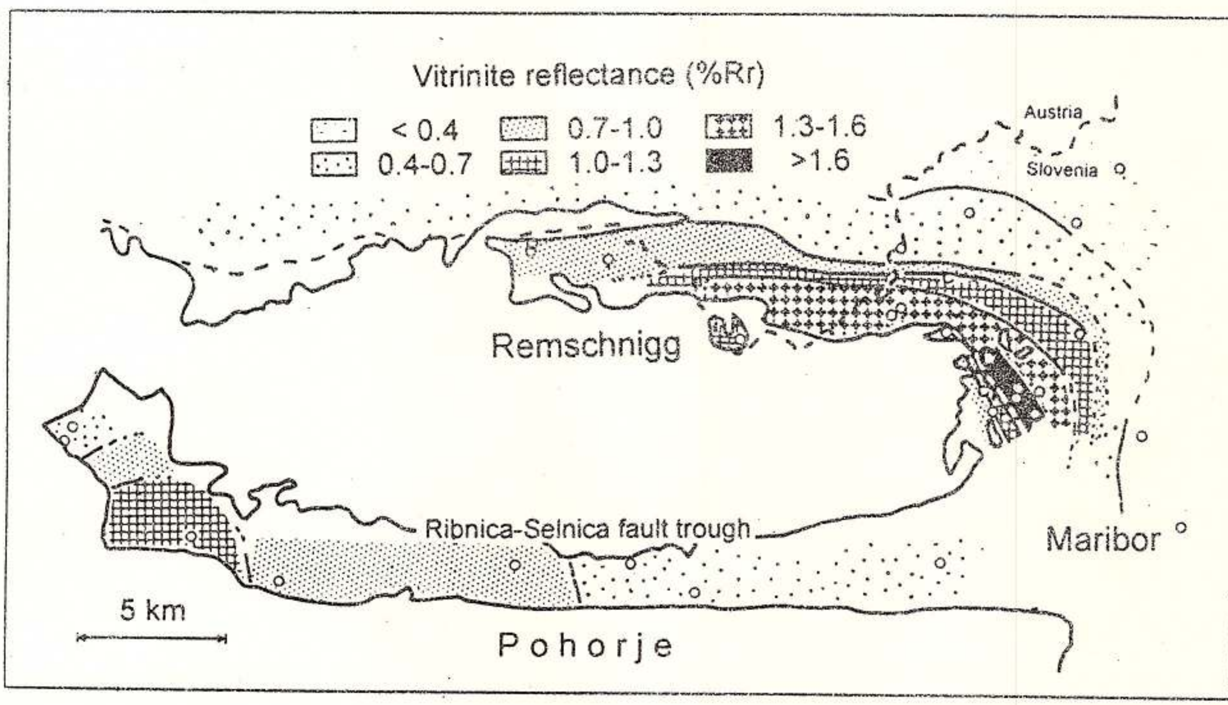

Fig. 1 Coalification of Tertiary sediments in northern Slovenia.

3) Eocene and Karpatian sediments between the Donat Line and the Periadriatic Line.

1) Karpatian and Ottnangian sediments along the northern and eastern margin of the **Remschnigg Mountain** are characterized by very high coalification and very high lateral coalification gradients (Fig. 1). Vitrinite reflectance reaches 2.0 %Rr (Sv. Urban, northwest of Maribor) and decreases to 0.4 % at

a distance of five kilometers. Vitrinite reflectance of outcrop samples northeast of Maribor is <0.4 %Rr. However, highly coalified Ottnangian sediments are known from the Benedikt (> 2.0 %Rr) and Radkersburg (> 1.0 %Rr) wells, which are located in the eastern continuation of the described coalification maximum. Although no Miocene magmatic rocks are known from this part of Slovenia, the coalification maximum may be caused by subvolcanoes. Numeric modelling techniques were used to reconstruct the Karpatian heat flow in the Radkersburg well. In order to obtain a good fit between measured and calculated vitrinite reflectance data, a very high heat flow of 400 mW/m has to be assumed. Most probably, heat flow was similar high along the eastern end of the Remschnigg Mountain.

2) Coalification of Miocene sediments in the **Ribnica-Selnica fault trough** (Fig. 1) shows the great thermal influence of dacitic magmatism in the western Pohorje Mountains. Vitrinite reflectance of studied samples ranges from 0.40 to 1.25 %Rr. The coalification maximum is situated south of Sv. Anton in close vicinity of the center of this magmatic activity.

3) Coalification of Eocene and Karpatian sediments from three profiles (**Dobrna, Konjiska Gora, Makole**) has been studied. (It has to be stressed that the age of sediments from the Makole profile is still under question). Vitrinite reflectance of both Eocene and Karpatian sediments incerases from the western (Dobrna; 0.40 - 0.55 %Rr) to the eastern (Makole; 1.40 - 1.50 % Rr) profile. Vitrinite reflectance of Eocene coals is 0.1 (Dobrna) to 0.28 %Rr (Konjiska Gora) higher than vitrinite reflectance of Karpatian mudstones from the same profiles. At present, it is not clear whether this indicates a coalification break or it is simply a facies effect. In any case, the W-E coalification trend in Miocene sediments and the extremely high vitrinite reflectance of Miocene (?) sediments at Makole, which is situated close to the postulated continuation of the Periadriatic Line, may indicate a Karpatian heating along this lineament. Additional investigations (stratigraphy, coalification studies, apatite fission track analysis) are needed to test this preliminary result.

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PALEOZOIC PALEOMAGNETISM OF THE SOUTHERN ALPS IN AUSTRIA

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New paleomagnetic results from Paleozoic rocks in the southernmost part of Austria contribute to the geodynamic reconstruction of the alpine region. Rotational and latitudinal movements of the Southern Alps in Austria have been investigated in Ordovician throughout Permian rocks.

Pre-variscoan plate movements are poorly constrained by paleomagnetic data in the Alpine Mediterranean region. Several authers observed a late Paleozoic magnetic overprint. The magnetisation history of the alpine Paleozoic is not yet clear, but there is evidence for a regional thermal event of undefined age with temperatures of about 350C. Armorica in the North and Africa in the South provide a paleomagnetic reference frame for alpine Paleozoic.

350 cores were drilled and oriented by standard paleomagnetic techniques. Additionally, some 20 oriented hand samples were taken, where drilling was impossible. Laboratory experiments included analyses of the remanent magnetisation by thermal- and alternating field-demagnetisation, magnetic fabric analyses and various rock-magnetic methods.

Preliminary results:

The Permian formations of the Reppwand section reflected counterclockwise (ccw) rotation with respect to present magnetic North position. Inclinations of 20 degrees indicated a sedimentation area in the close vicinity of the equator, still in the southern hemisphere.

The Carboniferous formations at Auernig, Plattner, Nafeld, Zollneralm, Straninger Alm and Rattendorf consistently confirmed ccw rotation, with evidence for a setting at a southern latitude of about 15 degrees.

The Devonian to Ordovician of the Cellonetta section and two additional sites (Rauchkofel and Oberbuchach) gave several well-defined magnetisation directions. Laboratory experiments are in progrss and will be finished for presentation at the ALCAPA meeting.

TECTONIC SETTING OF TWO CONTRASTING TYPES OF PRE-ALPINE BASEMENT: NORTH VERSUS CENTRAL DOBROGEA

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In the Carpathian foreland, pre-Alpine basement rocks are exposed in two areas with distinct geological evolution: the Alpine orogenic belt of North Dobrogea and the Cadomian fold belt of Central Dobrogea - joined during the Jurassic-Lower Cretaceous by translation along the Peceneaga-Camena dextral strike-slip fault.

The pre-Alpine basement of North Dobrogea represents a segment of the Variscan chain reactivated in the Alpine orogeny, when it was deformed by shearing along extensional faults related to Lower Triassic rifting and by thrust-folds during Kimmerian compressional events.

The Variscan history of the pre-Alpine basement exposed in the western part of North Dobrogea starts with marine sedimentation on a stable pre-Variscan sialic basement. This older basement includes two terranes showing different lithology and polyphase metamorphic history; their Early Caledonian or Cadomian age is still controversial in the absence of reliable geochronological evidence.

Lower Palaeozoic sedimentation starts in the Silurian with pelagic limestones deposited in an euxinic basin. It continues during the Lower Devonian with neritic sequences deposited at increasingly shallow water depths. In the Upper Palaeozoic, southward directed subduction creates a continental margin magmatic arc, with alluvial fan-fluvial sedimentation in retro-arc and intra-arc settings.

In the retro-arc basin, the beginning of sedimentation is controlled by the active tectonics of the source area, uplifted along thrust-faults. Terrigenous sedimentation changes progressively upsequence to volcaniclastic, due to the development of an explosive subaerial rhyolitic volcanism.

Paleozoic deposits belonging to the fore-arc basin are not exposed, but they include detrial sequences known from borehole drillings in the North Dobrogean Promontory. Another piece of Variscan basement, exposed discontinuously along the western border of North Dobrogea, consists of pelagic deposits and deep water turbidites which could possibly represent underplated sequences of the accretionary prism.

Central Dobrogea is the only area where the basement of the Moesian Platform crops out. This part of the Moesian basement consists of a thick turbiditic sequence deposited in mid-fan and distal-fan environments, showing a very-low grade Cadomian metamorphism connected to gentle folding at shallow crustal levels. Structural style and clast petrography suggest a possible forearc setting for deposition and deformation of this sequence. The Cadomian folded basement underlies a platform cover beginning with the Ordovician.

In the Jurassic-LowernCretaceous, North and Central Dobrogea were joined by dextral slip along the Peceneaga-Camena fault system. A large shear zone developed at the northern margin of Central Dobrogea, with greenschists facies mylonites formed on Cadomian basement rocks. In North Dobrogea, dextral shear occurred along pre-existent reactivated faults and secondary strike-slip faults developed in places. Cataclastic rocks connected to this deformation suggest that shearing in North Dobrogea occurred above the cataclastic/ductile transition.

DUPLEX INTERPRETATION FOR THE STRUCTURE OF THE DANUBIAN THRUST SHEETS

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In the South Carpathians, Laramian events resulted in a major nappe structure consisting of upper (Getic) plate basement units. The large window created by partial erosion through the Getic Nappe in the West and Central South Carpathians is a duplex window exposing a stack of thin cover nappes above Danubian basement imbricates.

Cover nappes involve oceanic plate ophiolites and pelagites, as well as various turbidites and mélange formations, showing subduction related low-temperature metamorphism in prehnite-pumpellyite facies; these nappes were emplaced by underthrusting of oceanic and trench sediments beneath the upper plate during formation of the accretionary prism. Internal structure of cover nappes in Mehedinţi Mountains suggest an antiformal stack with a passive roof thrust represented by the main overthrust in the footwall of the Getic Nappe.

The Danubian Nappes include at least four upper and two lower Danubian thrust sheets, most of them with a basement-cover stratigraphy. Internal geometry of the Danubian units indicates that they are individual horses of two duplexes developed by piggy-back thrusting. Within each horse, alpine metamorphism decreases progressively upsequence, from green-schist facies mylonites in the prealpine basement to illite-chlorite facies at the tops of the covers. Individual horses show elongate folds (anticline-syncline pairs) with bedding locally parallel with the footwall fault. The roof thrust of the Danubian duplex is the major overthrust from the footwall of the Getic and cover nappes. The floor thrust is not exposed, but it may possibly be the very low-angle overthrust juxtaposing the South Carpathians over the Moesian Platform. The major overthrust separating the Danubian thrust-sheets is a break-back thrust which emplaced the Upper Danubian hindward dipping duplex on top of the Lower Danubian antiformal stack. Post-nappe deformation is related to orogen-parallel extensional faults and dextral strike-slip systems, as well as to Miocene compression.

PRE-ALPINE AND ALPINE SHEAR ZONES IN THE CENTRAL SOUTH CARPATHIANS

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The Sebeş-Lotru series, covering a large area in the central South Carpathians (Sebeş, Cibin and Lotru Mts) has a tabular structure achieved during the last prealpine metamorphic event (M2). It consists of three petrographic complexes lying subhorizontally (from lowest to highest): (1) augen gneisses with tonalite cores, (2) mica gneisses with a lithological assemblage of amphibolites and quartzo-feldspathic gneisses at the upper part, and (3) micaschists that cover the highlands in the Sebeş-Cibin massif. During the alpine tectogenesis, this pile has been affected by large faults with E-W axial trend. In the north- eastern Cibin Mts. the folds are tight to isoclinal and their trend changes into a NW-SE one.

The gneisses and the micaschists display two coarse-grained parageneses that point out two regional medium-grade metamorphic events (M1 and M2). During the M2 event, numerous lithological boundaries behaved as ductile shear zones, when the less competent rocks along them were highly strained by slip on discrete shear planes, parallel to the developing S2 foliation. The most extended shear zones of this type coincide with the boundaries between the complexes of the Sebeş-Lotru series. Their strict lithological control, and therefore their areal discontinuity, as well as the similar overall metamorphic history of the three complexes, exclude the possible interpretation of these subhorizontal shear zones as overthrusts.

Margarite-bearing blastomylonites containing a fine-grained paragenesis of muscovite + margarite sillimanite outcrop on the boundary between micaschists and quartzo-feldspathic gneisses, especially in the Cibin Mts. They were formed under physical conditions varying from one microscopic domain to another, within a PT field of 3.7-6 Kb and 500-620o C. Biotite-bearing blastomylonites within which the M1 paragenesis of the gneisses (biotite + oligoclase) have synkinematically recrystallised under PT conditions, similar to those of the M1 event, outcrop on the limits between the mica and the augen gneisses.

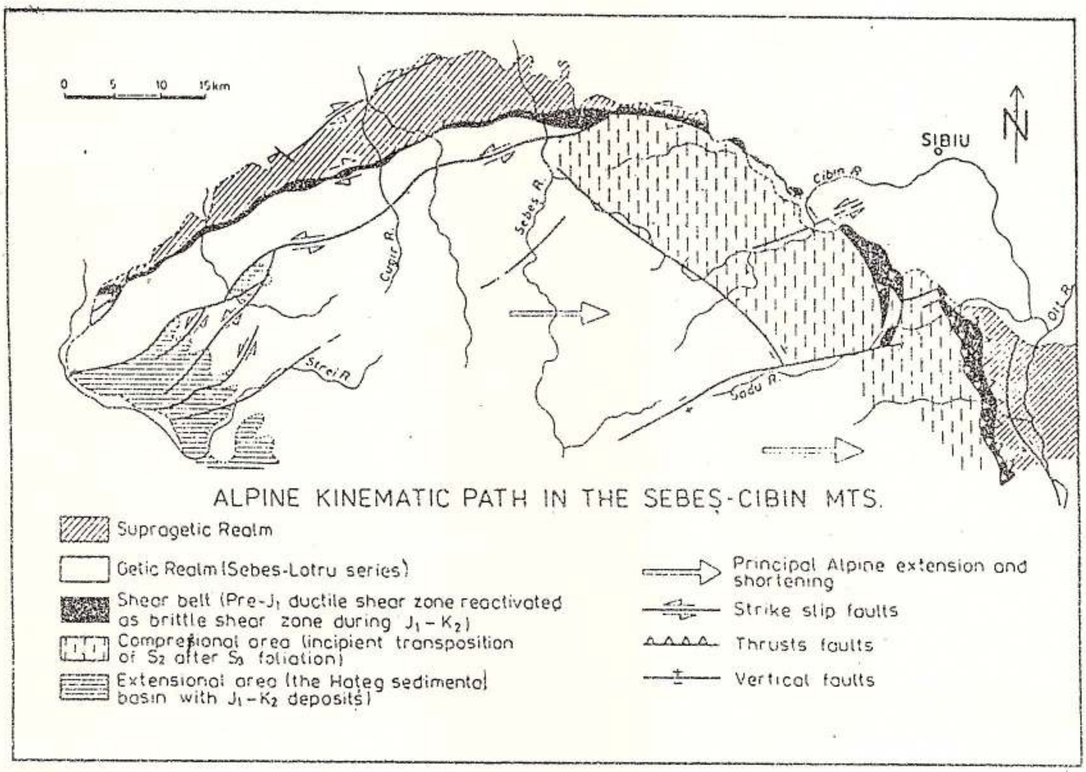
The alpine metamorphic event (M3) is nonpenetrative on regional scale and is mainly related to a shear belt that surrounds the central South Carpathians on their northern and eastern sides. The belt separates the Getic (Sebeş-Lotru series) and the Supragetic Realms (figure) and along it, the mesometamorphic rocks have been altered to greenschists both by ductile (early stage) and brittle deformation (late stage).

The ductile shearing has generated blastomylonites in which biotite, hornblende and oligoclase have sinkinematically recrystallised. Their metamorphic grade is similar to that of the blastomylonites outcropping on the limits between the mica and the augen gneisses. During this stage the contact with the country rocks was gradual, without any faults. The superposed brittle shearing is related to strike-slip faults (on the SW-NE segment) and to thrust faults (on the NW-SE segment). Mylonites and cataclasites with syn- and postkinematic low-grade recrystallisation (chlorite, actinolite, zoisite, fine-grained muscovite, albite and calcite) have been generated during this stage. Sometimes, the more competent pre-existent rocks are preserved as boudins within the shear belt.

Sygmoidal deflection in the trend of the S2 foliation, induced by the motion of the tectonic blocks, show dextral displacement on the major shear zone accompanied (or followed) by an important displacement in the opposite sense on subparallel faults. The senestral slip on the northern Sebeş-Cibin massif was accommodated by shortening on the eastern extremity of the massif (Olt Valley thrusts) and by extension in the western extremity (Haţeg sedimentary basin).

A lot of porphyric granodiorite dykes have penetrated the shear belt as well as the wall rocks on either sides, on the vertical planes of the strike-slip faults. Their K/Ar ages ranging from 90 to 200 Ma, show heterochronous emplacement that is consistent with the deformation grade of the magmatic rocks which varies from one dyke to another. As this long period (J1-K2) corresponds to the brittle shearing stage, the ductile shearing and therefore the Getic/Supragetic tectonic contact, must be older than Lower Jurassic, possibly syn-M2 event, if the metamorphic grade of the blastomylonites is taken into account.

The alpine reworking of some pre-alpine shear zones appears to be common in the central South Carpathians. The shear zones along the contact between the micaschists and the quartzo-feldspathic gneisses also underwent a weak reactivation in Alpine when the micaschists and the interlayered blastomylonites were crenulated. Subsequently, chloritoid recrystallised as porphyroblasts. No effects of the alpine movements have been observed on the mica gneisses / augen gneisses boundary.



ALONG-STRIKE NAPPE CORRELATION IN THE ALPS: HOW FAR DOES IT WORK?

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In the heyday of nappe correlation, between 1920 and 1935, each nappe was defined not only by its geometry and position, but also by its distinct facies assemblage. This approach was based on Argand's concept of embryo-tectonics, i.e. on the prefiguration of major nappes at least since Jurassic time. When this theory became discredited, in the fifties, correlation encountered growing and sometimes exaggerated criticism.

Correlation is based on eight criteria, four of structural and four of paleotectonic character:

1) Direct connection of folds and thrusts
2) geometry of nappe bodies (1 and 2 including borehole and geophysical evidence)
3) position within the edifice, relation with other units,
4) structural style, related to the grade of Alpine metamorphism,

5) pre-Triassic evolution, including the type of basement,

6) Triassic facies belts,

7) Jurassic - Cretaceous, eventually Paleogene paleotectonic elements,

8) age of deformation(s) and of metamorphism.

Criteria 2, 3, 7 and 8 are the most widely used ones. The eight sets of characteristics are partly independent from each other, partly interdependent.

Alpine structures occur in two different settings. On the European side (External Zone 4s of the Western Alps); Helvetic units of the Central Alps) and on the Apulian side (Southern Alps) we find coherent folds and nappes, cut out of single prism of basement and cover rocks. Construction of balanced sections and of palinspastic maps can be attempted with a reasonable degree of confidence. The Penninic and Austroalpine nappes, on the contrary, are incoherent ("terrane") nappes: considerable pieces of the original prism have disappeared by subduction or erosion, or they have been shifted by Jurassic to Miocene lateral displacements.

Two examples are discussed in more detail:

A) the relation between the Subalpine Chains sand the Helvetic nappes, where the interplay between Mesozoic paleogeography and Tertiary structures can be well understood;

B) the Jurassic-Cretaceous Brianconnais rise, where almost all the correlation criteria change along-strike between the Mediterranean and easternmost Switzerland.

The author ends with a plea for an interdisciplinary approach to the problems of mountain ranges, all the more necessary in the age of specialization.

"PRELIMINARY ESTIMATIONS OF THE P-T CONDITIONS OF THE METAMORPHISM IN THE SOUTHERN PART OF THE FĂGĂRAŞ MTS"

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The metamorphic rocks that build up the Făgăraş Massiv are assigned to the upper (Supragetic) unit of the Getic-Supragetic Realm of the South Carpathians. In the southern part of the massif outcrops the Argeş Nappe, the lowest one of the Supragetic Unit. The basement of the Argeş Nappe is the Cumpăna lithogroup which includes predominantly migmatites, gneisses, amphibolites, some bodies of meta-ultrabasites and eclogites, and to the upper part carbonate rocks (Balintoni & Pană, 1994).

The analysed samples are from the gneisseous and amphibolitic rocks of the Argeş Nappe. In order to determine the P-T conditions of the metamorphism several mineral analyses were performed using the electron microprobe at the Geological Institute of Salzburg.

Several experimental calibrations were used for the thermo- and barometry calculations, i.e. the Al-in-hornblende barometer (Schmidt, 1992), the phengite barometer (Massone & Schreyer, 1987), the garnet-biotite geothermometer (Ferry & Spear, 1978).

The presence of the epidote in the analysed amphibolite sample indicates that the rocks evolved under the epidote-amphibolite facies conditions. The pressure estimations using the Al content in hornblende indicate low values for the cores of the amphibole grains, i.e. 5.1 kbar, while the rims of the grains show high values of the pressure, i.e. 7.5 kbar.

The Si content in the phengite (from the orthogneiss) was used in order to determine the evolution of the pressure from the core towards the rim of the white mica grains. The core pressure values are higher than the rim values indicating a decrease of the pressure from 7.5 kbar down to 4.0 kbar.

The Grt + Bt assemblages founded in some orthogneisses allowed to use the partitioning of Fe and Mg between Grt and Bt as geothermometer. The calculated temperatures range between 361–416^0 C. In the same sample the white micas were also analysed. The phengite barometer corroborate with this temperatures gave pressure values that vary from 4.9 kbar (core) down to 2.9 kbar (rim) - a further decrease of the pressure.

All this results suggest that these rock sequences underwent first a prograde evolution, within the epidote-amphibolite facies, while the pressure increased from 5 up to 7.5 kbar (temperature range 500–650^0 C). A cooling down to 300–350^0 C followed, as revealed by the $^{40}Ar/^{39}Ar$ mineral ages presented by Dallmeyer et al. (1993; 1994). The prograde limb of the P-T path is localized within the greenschist facies, from 7.5 kbar/300–350^0 C to 2.9 kbar/360–415^0 C.

PEBBLES OF GRANITIC ROCKS FROM CRETACEOUS TO PALEOGENE FLYSCH OF THE PIENINY KLIPPEN BELT: GEOCHEMISTRY AND AGE

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Granitic rocks occur systematically in pebbles of conglomerate bodies within proximal facies of turbidite (flysch) sequences of Middle Cretaceous (Albian) to Paleogene (Middle Eocene) age in the Slovak, Polish and Ukrainian section of Pieniny Klippen Belt (PKB). The granitic rocks occupy in average 4 % of all material of pebbles on the West-Slovak segment of PKB (Marschalko 1986); however, over 20-50 % of granites occur in some localities. The pebbles with granitic rocks are the most widespread in the region between Ilava and Zilina, and in the Orava region (NW Slovakia). I present a study of the whole Slovak segment, from Podbranc in the west to Inovce in the east (ca. 350 km length). Three principal types of granitic rocks could be distinguished:

1. The UPOHLAV TYPE "exotic" leucocrate granites, granitoic porphyries and rhyolites with pink K-feldspar and green biotite are the most widespread and conspicuous. These granitc rocks rocks exhibit clearly post-orogenic A-type geochemical trend with increase contents of SiO_2, K_2O, Rb, but also Ga, Zr, REE, Y, Nb, Zn, and lower contents of CaO, MgO, P_2O_5, Ba and especially Sr and V. The U-Pb zircon isotope dating gave Lower Permian ages: 274 ± 13, and 294 ± 21 Ma respectively. All above mentioned data indicate the post-Variscan mildly alkaline granitic suite with numerous analogies in the Western Mediterranean and ALCAPA area (e.g. Tauern window, Velence Mts, Western Carpathians: Turcok and Hroncok granite). Consequently, these results contradict older opinions about the Jurassic-Cretaceous calc-alkaline suite connected with the subduction of oceanic ctust beneath "Andrusov exotic rigde or cordillera" (e.g. Birkenmajer 1988, Mišík and Marschalko 1988).
2. The KRIVÁ TYPE represent biotite to two-mica leucotonalites, granodiorites, granites and pegmatites. On the basis of geochemical, mineralogical and petrographical study, they resemble the Lower Carboniferous calc-alkaline orogenic S>I-type granites in the Tatric and Veporic Units of the Western Carpathians (mainly the monazite series).
3. The LUBINA TYPE is very rare, up to now it occurs only at one locality. It is a coarse-grained biotite leucogranite with porphyric pinkish K-feldspar phenocrysts. This type could be compared with some Variscan calc-alkaline I-type granites which occur in the Western Carpathians and Eastern Alps.

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THE ALPINE-CARPATHIAN FLYSCH-ZONE: HOW DOES IT FIT INTO THE PALEOGEOGRAPHIC PUZZLE?

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The Flysch Zone of the East Alps and the Carpathians represents a prominent tectonic unit within the Alpine Carpathian orogeny. The continuity of both sides is evident through the bore holes under the Miocene of the Vienna Basin and the stratigraphic and sedimentological identity of the Greifenstein Nappe in the Wienerwald with the Raĉa Subunit of the Magura Nappe (Luhaĉovice Zone) in the Western Carpathians.

However, strikingly evident differences are the width and the different stress and history during the young alpidic movements.

The Alpine-Carpathians Flysch Zone is a rootless Mega-Nappe in the frontal position of the orogeny between the autochthonous foreland to the North, on which it is overthrust, and the Austroalpine Nappe and the Central Carpathians to the South. It comprises thick Flysch formations of Cretaceous and Paleogene age. Despite its enormous importance for the tectonic history of the Alpine orogeny and evolution, little really reliable facts are known concerning its previous depositional area and its basement.

The Alpine Flysch Zone (Rhenodanubic Flysch – RDF) is widely considered to be part of the Penninic realm. Its previous position, North or South Penninic, is in the West closely related to the comparable Swiss flysches. New data point rather more towards a South Penninic origin, since the Gurnigl-Schlieren Flysch complexes are put into an "ultrabrianconnais" (South Penninic/Piemontains/Ligurian) position.

New investigations of the RDF appear to support this indication. The Ybbsitz Klippen Zone in Lower Austria with a Jurassic sequence with radiolarites along with strongly tectonized mafic/ultramafic rocks, seems to be a remnant of the primary substratum of the RDF. The RDF, at lest in its southern parts, may thus have been deposited on a basement of Jurassic oceanic crust similar to South Penninic sequences.

This touches on the relationship of the RDF to the Penninic sequences in the tectonic windows of the Central Alps (Tauern and Rechnitz), which is of particular importance for the tectonic evolution of the entire Eastern Alps. According to many authors, the South Penninic domain has been subducted under the Austroalpine during the Lower Cretaceous. In this case RDF in its entirety can by no means be assigned to a South Penninic domain, in the sense of a Ligurian/Piemontais one, which was terminated during Early Upper Cretaceous times in this segment. The secret lies hidden either below the Northern Calcareous Alps or in the steep tectonic borderline between the Northern and Central Alps. The continuation of the Brioconnais rise to the East, essential for defining the South and the North Penninic realms, becomes enigmatic.

In the Wienerwald the homogeneous Flysch Nappe of the East Alps splits into at least three Nappes, different in facies and stratigraphic range. It is the Greifenstein Nappe, which has congruencies with either the Western Main Flysch Nappe and the Magura Nappe of the West Carpathians and this can be taken as one of the few well-established links of the two segments. The Kahlenberg Nappe, dismembered into imbricated thrust sheets, again displays a remnant of the pre-Cretaceous basement in the St. Veit Klippen Zone. Continental and epicontinental development in the Late Triassic and Early Jurassic ("Keuper", Kössen beds" and "Gresten beds"), pelagic development from the Middle Jurassic onward (including radiolarian chert and Aptychus limestone) underline a flysch-sequence from mid-Cretaceous up to Maastrichtian times. Picritic volcanism in the mid-Cretaceous is noteworthy. The continental facies in the Triassic/Lower Jurassic rather points to a more southern location (Apulian) than to a northern (European) one. In respect to the substratum of the Flysch Zone this only shows that this flysch has been deposited on a thinned continental crust, developed during the Middle Jurassic. The Kahlenberg Nappe has no equilvalents in the Carpathians, at least on the surface.

The Cretaceous to Oligocene Flysch of the Carpathians comprises a huge area of sedimentation. Based on sedimentological features several hypothethical swells ("cordilleras") were reconstructed to furnish the detritus. The width including the hypothetical ridges must have been of the order of at least 400 km, presuming that the basins and swells were arranged from North to South. In any case this area must have been located north of the Pieniny Klippen belt, in the external zones of the Carpathians.

Despite this huge space, very little is known of the substratum. The Grajcarek unit along the southern rim of the Magura Nappe in the Polish sector is the only locality where Jurassic to Lower Cretaceous sequences give a slight indication on a more or less oceanic basement. The detritus itself merely gives indications of the source rocks along the margin and not of the basement. In the Upper Cretaceous, the increase of Cromite in the heavy mineral spectra toward the South, from the Bilé Karpaty Unit (Southern Magura Nappe) into the Pieniny Klippen successions gives evidence of considerable masses of obducted oceanic crust along the southern active margin of the Flysch trough. Consequently the concept of the basement of the Flysch successions in the paleogeographic models differs according to the various interpreters. In some models considerable oceanic crust is presumed, in others (the majority) it is superimposed on a more or less thinned continental crust along the labile Southern Continental Margin.

The dilemma of the use of terms such as "Helvetic", "Penninic" plus all the derivatives from the Western through the Eastern Alps into the Carpathians is particularly shown when trying to assign the Flysch-Zone to one of these domains. From West to East the depositional area seems to strike obliquely over the classic domains, rooting in the Penninic, possibly the southern Penninic realms to the West, continuing to more and more Northern positions in the East Alps and "going external" in the Carpathians.

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