*GEOLOGICA CARPATHICA, 46, 4, BRATISLAVA, AUGUST 1995*
*191 - 196*

# TECTONICS OF THE HORNONITRIANSKA KOTLINA DEPRESSION IN THE NEOGENE

JOZEF HÓK[1], LADISLAV ŠIMON[1], PETER KOVÁČ[1], MICHAL ELEČKO[1], DIONÝZ VASS[1], JOZEF HALMO[2] and FRANTIŠEK VERBICH[2]

[1] Dionýz Štúr Institute of Geology , Mlynská dolina 1, 817 04 Bratislava, Slovak Republic
[2] Upper Nitra Mine, Baňa Nováky OZ, 972 71 Nováky, Slovak Republic

*(Manuscript received September 20, 1994; accepted in revised form December 12, 1994)*

**Abstract:** Brittle deformation analysis of the Tertiary depression fill and surrounding area of the Hornonitrianska Kotlina Depression permited the reconstruction of the paleostress-field orientation. Compression axis rotated clockwise from NW-SE (Early Miocene) to NE-SW (Middle Miocene). After Middle Miocene (Middle Sarmatian) compression axis rotated counterclockwise to the NNW-SSE position in Quaternary. During the Early Miocene the marine sedimentation predominated. The marine conditions appeared again during Early Badenian, but later continental conditions prevailed.

**Key words:** Western Carpathians, intramontane (back arc) basins, brittle deformation, paleostress-field.

## Introduction

The origin and development of the Tertiary molasse basins of the Western Carpathians is connected with the collision of the North Pannonian Block with the North European Platform. The Paleogene to Early Miocene escape of units, extruding the present Central and Inner Western Carpathians from the area of the Central Alps played a certain role in this. A mantle diapir or astenolith, which influenced the origin and development of back arc basins in the Middle Miocene, and as a result also during the Late Miocene and Pliocene, also played a part.

The Hornonitrianska Kotlina Depression belongs to a group of small, intra-montane back arc basins in the Western Carpathians. Their specific characteristics are as follows:

- small area (tens to hundreds of $km^2$);
- polygenetic structure;
- sedimentary filling formed mostly in continental conditions;
- a prevalence of fault tectonics, which produced a simple block, often of asymmetrical structure, or with rotated blocks (Vass in press).

The filling of the basin is divided into two structural stages. The older, Early Miocene stage, originated as part of a marine back arc basin, formed to the south of the Klippen Belt, during the Eggenburgian. The basin is genetically connected with subduction at the front of the Carpathians, by which the roll over effect of subduction created tension in the over thrust lithospheric plate, or oblique convergence caused a transpressional effect, and strike-slip faults generated the back arc basin.

During the Middle Miocene, a mantle diapir caused heating and rifting of the crust, as a result of which a graben-horst structure was formed, not only in the area of the Pannonian Basin, but also in the Central Slovak area. Although the area of the present Pannonian Basin communicated with the sea, transgressions of the sea into the grabens of the Central Slovak area were sporadic, probably because of a barrier of volcanites. The filling of these graben basins occurred in continental conditions.

The origin of basins, their character and the spatial distribution of sediments was controlled by the changing direction of paleostress in space and time.

In the past, the Hornonitrianska Kotlina Depression was the subject of intensive geological research, mainly in connection with the presence of coal seams at the Handlová and Nováky (Čechovič 1959).

Works on structure were concerned with the fault tectonics of this depression or its immediate surroundings (e.g. Gašparik 1974; Rakús et al. 1984) or the relation of tectonics to coal seams (Brodňan 1970), or thermal waters (Biely & Fusán 1985). The development of the horst-graben structure in the area of the Central Slovak basins was evaluated on the basis of modern structural analysis by Nemčok & Lexa (1990).

In the next chapter we reconstruct the development of the Hornonitrianska Kotlina Depression from the point of view of the analysis of brittle deformations, the rotation of axes of paleostress and the character of sedimentation.

## Structural analysis of brittle deformations and discussion of the results obtained

Reconstruction of the sedimentary area of Paleogene (Eocene) clastics in the Hornonitrianska Kotlina Depression is made more difficult by the weak structural record and the lack of an adequate amount of information. The basal clastics of the Paleogene (Borová Formation) represent the northernmost spurs of sedimentation of the Buda Development. After the following subsidence, connection with the northern Inner Carpathian sedimentary area occurred, probably in the area of the Hornonitrianska Kotlina Depression (Gross 1978).

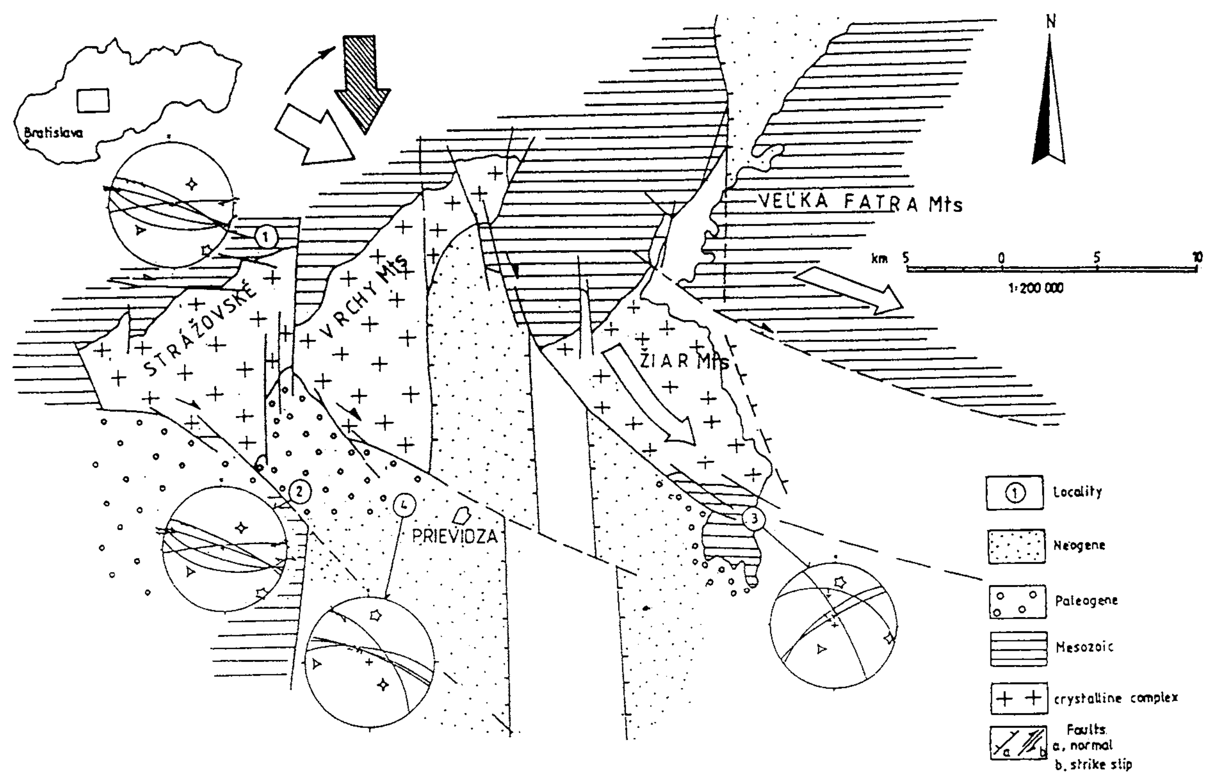



**Fig. 1.** Schematic geological map of the Hornonitrianska Kotlina Depression and surroundings. The surfaces of slickensides are represented in Lambert's projection, in the form of large arcs with an indication of movement along the lineation. Five point star - direction of main compression. Three point star - direction of main extension. A description of the localities is given in Table 2. The arrows indicate the rotation of compression from the Early Miocene (Early Badenian) to the Late Badenian.

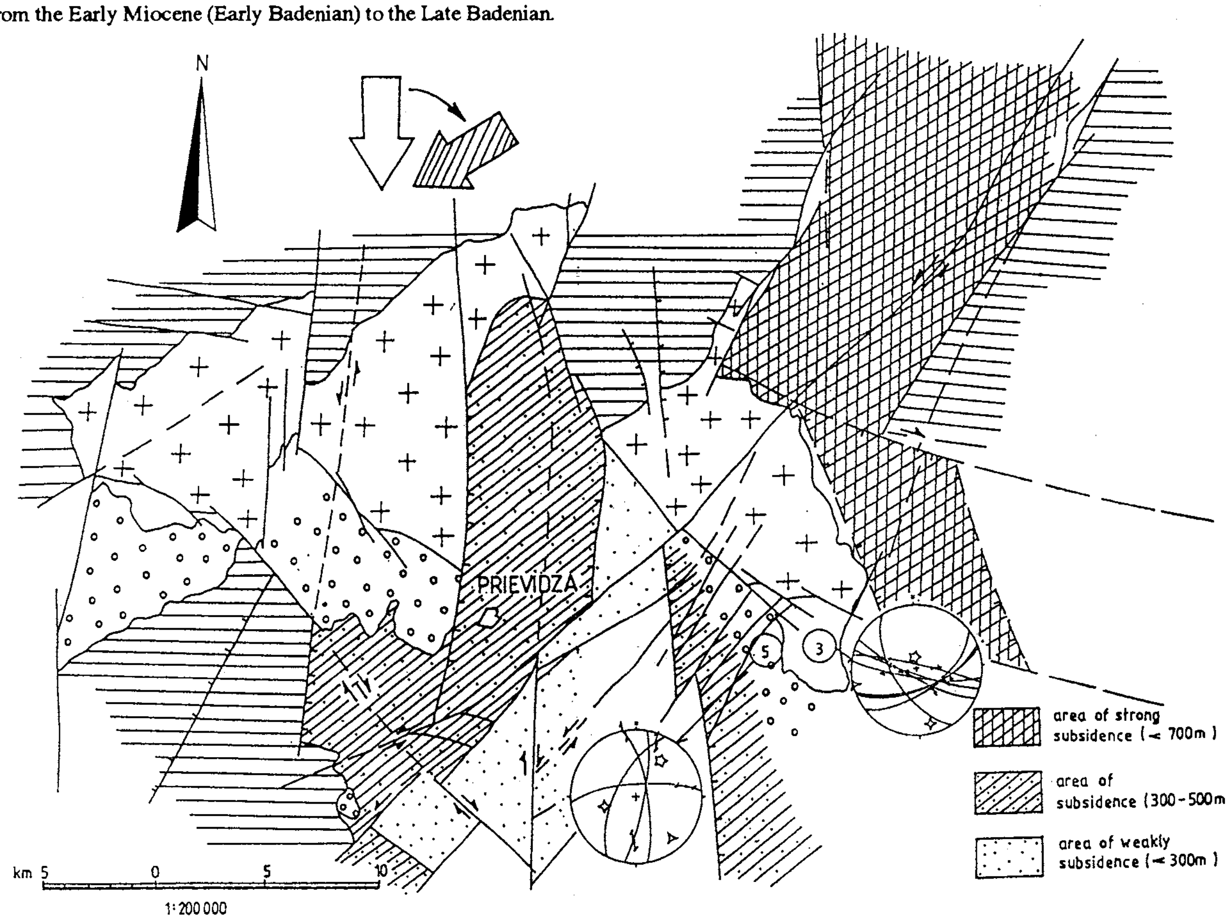



**Fig. 2.** Rotation of compression and assumed development of the basin from the Late Badenian to Middle Sarmatian.

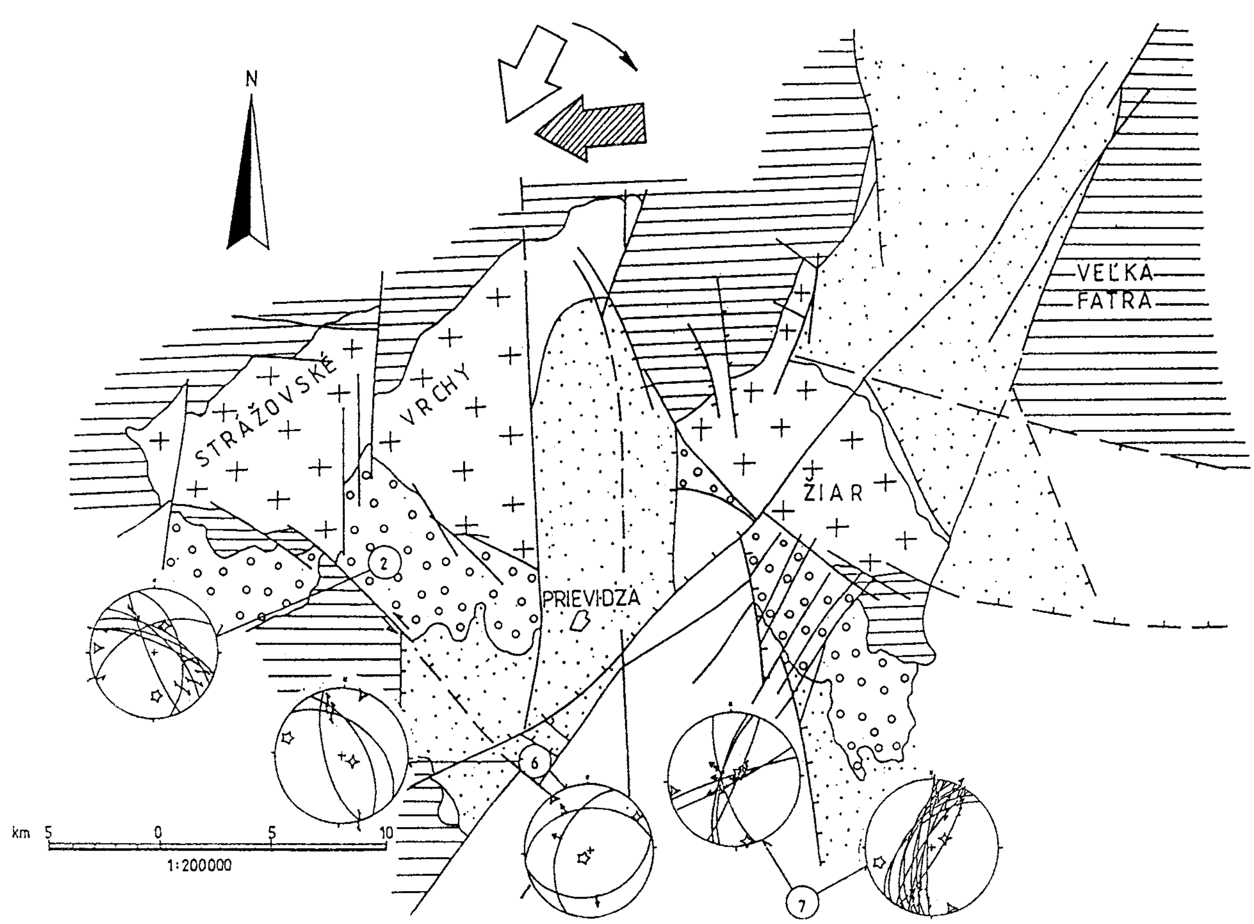



**Fig. 3.** Rotation of compression from Middle Sarmatian to Late Sarmatian - Early Pannonian.

Sediments of the Oligocene to Egerian (Biely Potok Formation) lie discordantly on the Eocene clastics, and on crystalline and Mesozoic rocks. Thus the position of the Biely Potok Formation conserves the state at the end of the Eocene, when rocks of the Eocene and pre-Tertiary complexes were found on the same level, and faults with a NW to SE direction (according to present day geographical co-ordinates) associated with their contact. It is probable that these faults were also active synsedimentarilly, and the axis of the Eocene Basin in this area had a NW to SE direction, and could have caused communication or connection of the sedimentary areas of the Buda and Inner Carpathian Paleogene. Data on the FT ages of apatite Kováč et al. 1994), and the presence of crystalline pebbles in sediments of the Upper Eocene (Gross in Šimon et al. 1994), also indirectly point to the possibility of the synsedimentary activity of the NW to SE oriented faults in this period.

Sedimentation of the Čauša Formation (Eggenburgian) indicates a new transgressive cycle. The development of the sedimentary area is probably connected with the activization of the transpressional shear zone continuing from the area of the Brezovské Karpaty Mts. through the Bánovská Kotlina Depression to the Hornonitrianska Kotlina Depression, which also indicated a connection with the area of the Vienna Basin (Kováč et al. 1993a). The coastal facies of the Eggenburgian sedimentation area (Kľačany Conglomerate and Veľka Čauša Member, Vass in press) are localized on the south-west margin of Žiar Mts. (Čechovič 1959), which again points to an active function for the fault line oriented NW-SE (the Pravno Fault). Their basinal equivalents are calcareous claystones and siltstones with a marine fauna, which points to the gradual degradation of a normal marine environment, changing into a gulf with inadequate aeration and limited communication with the open sea (Čechovič 1959). In the area of Prievidza, the greater part of the basinal facies is formed by sediments of the distal part of the turbidite or mass flows with features of a prograding delta (Elečko et al. 1994). At the end of the Eggenburgian, sedimentation in the area of the Hornonitrianska Kotlina Depression temporarily ended, and during the Ottnangian it was probably dry land (it lacks any sedimentary record).

The compressional component of the paleostress in the Early Miocene was oriented in the direction NW-SE (Fig. 1) and is in good agreement with the possible function of the normal faults of this same direction, and also with the sedimentation of the marine Lower Badenian and Kamenec Formation.

On the basis of the overall configuration of the pre-Tertiary basement of the basin (c.f. Killény & Šefara 1989), and the results of geophysical investigations (Lanc et al. 1994), we suppose that the axis of the sedimentational area of the marine Lower Badenian and Kamenec Formation had a NW-SE direction. The sedimentary area of the Lower Badenian was connected, through the transtensional Central Slovak fault system (Kováč & Hók 1993), with the Želiezovce Depression (c.f. Kováč et al. 1993a), and represented the northernmost embayment of the Lower Badenian sea into the area of the Central Slovak neovolcanites. This gulf communicated with the Badenian sea in the Želiezovce Depression, through a system of grabens and horsts obliquely oriented to the north - south course of the Central Slovak fault system (c.f. Vass et al. 1993).

The Lower Badenian sediments of the studied area are known only from the borehole HV-9 (Jánová Lehota), where lagunal sediments with coaly intercalations alternate with sediments of a basin type (calcareous pelites) with rich as-

**Table 1**: Lithostratigraphic column of the Tertiary fill of the Hornonitrianska Kotlina Depression.

| | | | | | | |
|---|---|---|---|---|---|---|
| TERTIARY | NEOGENE | MIOCENE | PONTIAN | LELOVCE FORMATION | gravels. sands. clays | 0 - 180 m |
| TERTIARY | NEOGENE | MIOCENE | SARMATIAN | VTÁČNIK FORMATION | volcanites and volcanoclastics | 0 - 400 m |
| TERTIARY | NEOGENE | MIOCENE | SARMATIAN | KĽAKOVSKÁ DOLINA FORMATION | volcanoclastics and volcanites | 0 - 100 m |
| TERTIARY | NEOGENE | MIOCENE | UPPER BADENIAN-LOWER SARMATIAN | LEHOTA FORMATION | gravels. conglomerates | 0 - 250 m |
| TERTIARY | NEOGENE | MIOCENE | UPPER BADENIAN-LOWER SARMATIAN | PLEŠINA FORMATION | volcanites | 0 - 150 m |
| TERTIARY | NEOGENE | MIOCENE | UPPER BADENIAN-LOWER SARMATIAN | KOŠ FORMATION | clays, claystones and sandstones | 0 - 350m |
| TERTIARY | NEOGENE | MIOCENE | UPPER BADENIAN | HANDLOVÁ AND NOVÁKY FORMATION | clays, coal. tuffs | 0 - 50 m |
| TERTIARY | NEOGENE | MIOCENE | LOWER BADENIAN | KAMENEC FORMATION; MARINE L. BADENIAN; COMPLEX OF ANDESITES WITH GARNETS | volcanoclastics, gravels, conglomerates, clays, volcanites | 0 - 700m |
| TERTIARY | NEOGENE | MIOCENE | EGGENBURGIAN | ČAUSA FORMATION | claystones and sandstones | 0 - 400m |
| TERTIARY | NEOGENE / PALEOGENE | MIOCENE / OLIGOCENE | EGERIAN | BIELY POTOK FORMATION | sandstones | 1000m 70m |
| TERTIARY | PALEOGENE | OLIGOCENE | KISCELIAN | HUTY AND ZUBEREC FORMATION | claystones and sandstones | 300 - 500m |
| TERTIARY | PALEOGENE | EOCENE | ?PRIABONIAN | MARGINAL FORMATION | claystones, breccias, conglomerates | 60 - 70m |
| TERTIARY | PALEOGENE | EOCENE | ?PRIABONIAN | BOROVÉ FORMATION | breccias, conglomerates, sandstones | 50m |

sociations of foraminifers and nannoplankton of the open sea (Gašpariková in Blaško et al. 1987). Volcanic activity begins in this period. Volcanism produces extrusive bodies of andesites with garnets and products of the Kamenec Formation (Šimon et al. 1994).

From the Middle Badenian to the Late Badenian, the compressional axis of paleostress progressively rotated to a N-S direction (Fig. 1). In the Middle Badenian, the structural and sedimentary arrangement of the Hornonitrianska Kotlina Depression began to be reconstructed, with the depression losing its junction with the open sea. Faults with a mainly NW to SE direction were activated, and after this a right-side offset with rotation of the blocks of the Strážovské Vrchy Mts. and Žiar Mts. occurred. At the same time, space opened in a N-S direction for the continental sedimentation of the Upper Badenian-Lower Sarmatian formations.

The origin of swamps and coal formation (the Nováky-Handlová Formations) was conditioned by the closing of the basin to the south by products of older volcanism. Swamp sedimentation alternated in time with lacustrine sedimentation (Koš Formation). Local extrusive bodies of rhyolites and amphibol-pyroxenic andesites (Nová Lehota and Plešina Formations) represent the younger volcanism (Šimon et al. 1991).

From the Late Badenian to Early Sarmatian the compressional component rotated to a NE-SW direction (Fig. 2). During this tension, the N-S faults were activated as strike slips. The western part of the Cígeľ Basin is probably amputated on one of these faults.

The sedimentation of the Koš Formation was followed by tectonic disturbance with the resulting volcanic activity (Kľakovská Dolina Formation, Šimon et al. 1991). Its result was the break up of already deposited sedimentary and volcanic formations, which is very well documented in the Handlová coal mine (Šimeček 1980). The tectonic disturbance caused uneven erosion of individual blocks, and the Lehota Formation lies on various formations of the Upper Badenian to Lower Sarmatian. The Lehota Formation originated in a river environment, in paleo-valleys with a N-S direction (Fig. 3).

The final change of paleostress is recorded in the volcanic rocks of the Vtáčnik Formation, which is dated to the Middle Sarmatian (Tabs. 1, 2). This means that after the Middle Sarmatian, the compressional component of paleostress rotated

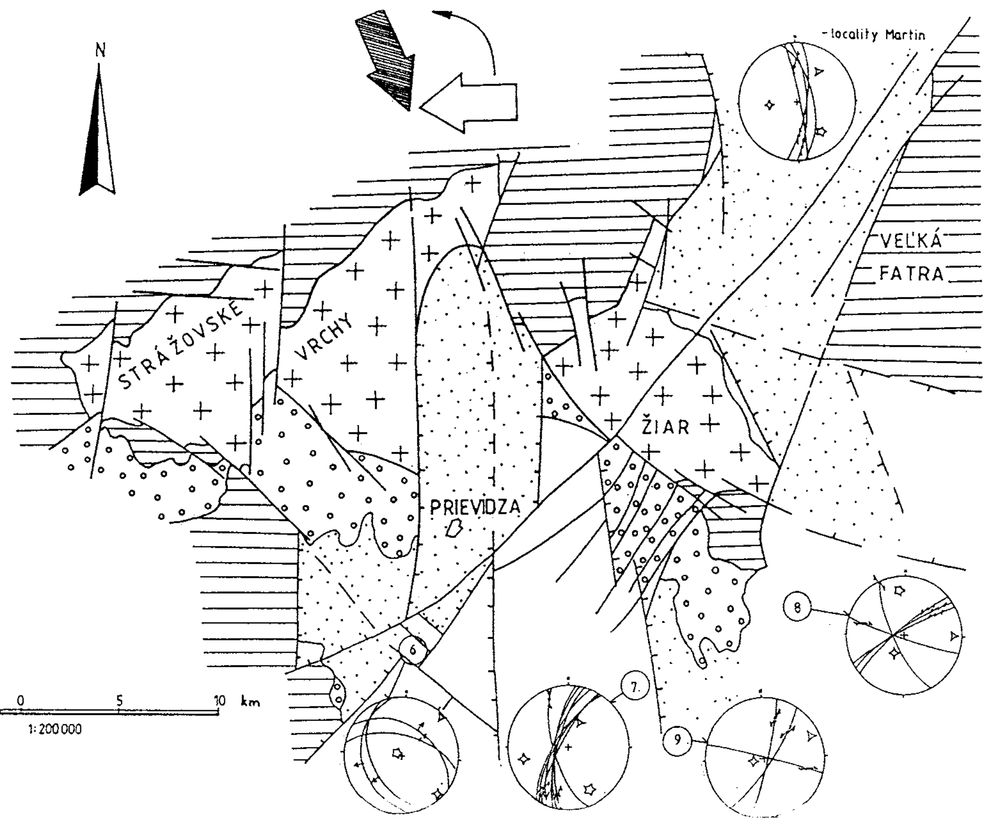
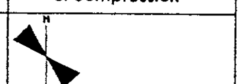
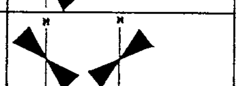
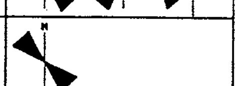
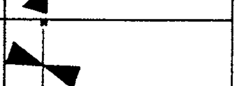
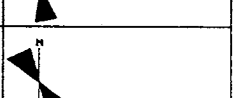



**Fig. 4.** Rotation from the Middle Sarmatian - Early Pannonian to Pliocene - Quaternary.

**Table 2:** Direction of compression (dark sectors), obtained by analysis of brittle deformations at individual localities.

| locality No. | locality | type of rocks | direction of compression |
|---|---|---|---|
| 1 | ABANDONED QUARRY VALASKÁ BELÁ | LUŽNÁ FORMATION L.TRIASSIC ENVELOPE UNIT |  |
| 2 | QUARRY NITRIANSKE RUDNO | TRIASSIC DOLOMITES CHOČ NAPPE |  |
| 3 | QUARRY REMATA | LIMESTONES, DOLOMITES AND SHALES - KRÍŽNA AND CHOČ NAPPES |  |
| 4 | ABANDONED QUARRY KOCÚRANY | CONGLOMERATES, PALEOGENE |  |
| 5 | OUTCROPS RÁZTOČNO | ČAUSA FORMATION EGGENBURGIAN |  |
| 6 | NOVÁKY MINE | NOVÁKY FORMATION L.BADENIAN-E.SARMATIAN |  |
| 7 | ABANDONED QUARRY HORNÁ LEHOTA | KLAKOVSKÁ DOLINA FORMATION L.BADENIAN-E.SARMATIAN |  |
| 8 | OUTCROPS ŠECHVALDSKÁ VALLEY | KLAKOVSKÁ DOLINA FORMATION L.BADENIAN-E.SARMATIAN |  |
| 9 | QUARRY ČIERNY POTOK VALLEY | VTÁČNIK FORMATION MIDDLE SARMATIAN |  |

from the direction NE-SW to the general direction NNW-SSE (Fig. 4). More exact dating of this orientation of compression enables comparison with data obtained in the Turčianska Kotlina Depression. At the locality Martin-brickyard, compression was found, with the direction NE-SW, and with synistral movements and subsequent slumps to N-S oriented faults (Fig. 4). The rocks are palynologically dated to the Late Sarmatian-Early Pannonian (Planderová 1988). The tectonic deformation is therefore younger than Early Pannonian.

Compression with a NW-SE direction is the youngest deformation described from the territory of Hungary (Csontos et al. 1991) and from the northern part of Austria and western part of Hungary (Gerner 1992), where it is similarly dated to the period of the Pliocene to Quaternary. From the above mentioned facts, it follows that compression with the direction NNW-SSE to NW-SE influenced development in the area of the Hornonitrianska Kotlina Depression during the Late Pannonian to Quaternary.

In this period, the whole area was again broken up by normal faults, generally with a N-S direction and individual blocks were tilted in a westerly direction (Lanc et al. 1994). The distribution of river and land sediments of the Lelovce Formation of Pontian age near the western margin of the Hornonitrianska Kotlina Depression is also evidence of this.

No doubt the occurrence of volcanic rocks between the Hornonitrianska Kotlina Depression to the west and the Žiarska Kotlina Depression to the east, which resulted in tilting of the sedimentary filling of the Žiarska Kotlina Depression in an easterly direction, also played a significant role in this process (c.f. Nemčok & Lexa 1991).

During the whole Neogene, the emplacement of the Central Slovak neovolcanites was controlled by the transtensional character of the Central Slovak fault system (Kováč & Hók 1992).

The Quaternary activity of the N-S faults, e.g. the Malá Magura fault at the west end of the Strážovské Vrchy Mts. is evidence of the continuing uplift of this area in the Pliocene and Quaternary (Brodňan 1970; Gross et al. 1970).

## Conclusion

The Hornonitrianska Kotlina Depression was influenced by regional paleostress, which controlled sedimentation by means of active faults.

In the Eocene to Early Badenian, the compressional component in the area of today's Hornonitrianska Kotlina Depression was oriented in the direction NW-SE. In this period normal faults with a NW-SE direction were active. They mediated the connection of the sedimentary areas of the Paleogene, and later controlled the distribution of Eggenburgian sediments, volcanites and Lower Badenian sediments.

From the Middle to Late Badenian, compression continually rotated to a N-S direction. There were conditions for the deposition of sedimentary and volcanic formations in this period.

In the Late Badenian, the rotation of compression in a clockwise direction continued due to accretion in the Outer Carpathians.

From the Late Pannonian to Pliocene, and probably into the Quaternary, the compressional component of paleostress rotated from a NE-SW (ENE-WSW) direction to a NNW-SSE (NW-SE) direction.

## References

Biely A. & Fusán O., 1985: Structural-tectonic scheme of the pre-Tertiary basement of the Hornonitrianska kotlina Depression 1:100,000. *Manuscript, Archive of Geology Institute of D. Štúr,* Bratislava, (in Slovak).

Blaško D. et al., 1987: Final report on Handlová East VP brown coal, situation up to 1. 5. 1987. *Manuscript, Archive of Geological Research,* Spišská Nová Ves, (in Slovak).

Brodňan M., 1970: Geological structure of the Nováky coal deposit. *Geol. Práce Spr.,* 52, 35-59 (in Slovak).

Csontos L., Tari G., Bergerat F. & Fodor L., 1991: Evolution of stress fields in the Carpatho-Pannonian area during Neogene. *Tectonophysics,* 199, 73-91.

Čechovič V., 1959: Geology of the Tertiary strata of the northern margin of the Handlová Coal Basin. *Geol. Práce, Zoš.* 53, 5-58 (in Slovak).

Elečko M., Vass D., Gross P., Šimon L., Lexa J., Šoltésová E. et al., 1994: Final report on the geological evaluation of borehole Š-1 NB III. *Manuscript. Archive of the Geology Institute of D. Štúr,* Bratislava, (in Slovak).

Gašparik J., 1974: Classification of the faults of the Upper Nitra and Turiec Basins. *Manuscript archive Geology Institute of D. Štúr,* Bratislava, 1-35 (in Slovak).

Gerner P., 1992: Recent stress field in Transdanubia (Western Hungary). *Földt. Közl.,* 122/1, 89-105.

Gross P., 1978: The Paleogene under the Central Slovak neo-volcanites. Materials from the seminar: *"Paleogeographical development of the Western Carpathians". Geology Institute of D. Štúr,* Bratislava, 121-145 (in Slovak).

Kilényi E. & Šefara J., 1989: Pre-Tertiary basement contour map of the Carpathian basin beneath Austria, Czechoslovakia and Hungary 1:500,000. *Eötvös Loránd Geophysical Institute of Hungary.*

Kováč M. & Hók J., 1993: Central Slovakia fault system - field evidence of strike-slip. *Geol. Carpathica,* 44, 3, 155-159.

Kováč M., Nagy A. & Baráth I., 1993b: The Ruskovce Formation - sediments of gravitational flows (NW part of the Bánovce Basin). *Miner. slovaca,* 25, 117-124 (in Slovak).

Kováč M., Nagymarosy A., Soták J. & Šutovská K., 1993a: Late Tertiary paleogeographic evolution of the Western Carpathians. *Tectonophysics,* 226, 401-415.

Kováč M., Kráľ J., Márton E., Plašienka D. & Uher P., 1994: Alpine uplift history of the Central Western Carpathians: geochronological, paleomagnetic, sedimentary and structural data. *Geol. Carpathica,* 83-96.

Lanc J., Šefera J., Filo M., Kubeš P., Husák L., Szalaiová V., Grand T., Komora J., Valušiaková A., Pavlíková S., Galková A. & Orlický O., 1994: Map of the geophysical indications and interpretations of the region of Vtáčnik and the Hornonitrianska kotlina Basin. *Final report. Manuscript, Archive of the Geology Institute of D. Štúr,* Bratislava, 1-101.

Nemčok M. & Lexa J., 1990: Evolution of the Basin and Range structure around the Ziar Moutain Range. *Geol. Zbor. Geol. Carpath.,* 41, 3, 229-258.

Planderová E., 1988: Ecostratigraphy of the Tertiary of the Turiec Basin. *Manuscript, Archive of the Geology Institute of D. Štúr,* Bratislava, 1-41 (in Slovak).

Šimeček M., 1980: The tectonic structures of the Handlová Deposit and their relation to the volcanism of Vtáčnik. In: Maheľ M. (Ed.): *Significant problems of the geological development and structure of Czechoslovakia, key territories and methods of solution. Geology Institute of D. Štúr,* Bratislava, 283-303 (in Slovak).

Šimon L., Lexa J., Halouzka R. et al., 1991: Explanations of the geological map (Janova Lehota). *Manuscript, Archive of Geofond,* Bratislava, 36-311, (in Slovak).

Šimon L., Elečko M., Gross P., Kohút M., Miko O., Pristaš J., Lexa J., Mello J., Hók J. et al., 1994: Explanations of the geological maps 36-133 (Handlová), 35-244 (Prievidza-4), 36-131 (Ráztočno). *Manuscript, Archive of Geofond,* Bratislava, (in Slovak).

Vass D., in press: Molasse basins of the Western Carpathians. *Geology Institute of D. Štúr,* Bratislava, (in Slovak).

Vass D., Hók J., Kováč P. & Elečko M., 1993: The sequence of Paleogene and Neogene tectonic events in the south Slovak basins in the light of tension analysis. *Miner. slovaca,* 25, 79-92 (in Slovak).