# Fault controlled evolution of the ALCAPA region

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Important role during the Neogene tectonic evolution of the Western Carpathians has played faulting. Brittle faults, mainly strike-slips allowed propagation of individual detached blocks to the realm of future Carpathian region. While Alpine units were stopped at the southern rim of the Bohemian massif, Carpatho/Pannonian microblocks have been decoupled and pushed northernly and eastwardly. Except the large block translations there are paleomagnetic and structural evidences of important CCW ALCAPA block rotation and CW Tisza-Dacia block rotation (Balla, 1987, Kováč et al., 1989) between the Early and the Middle Miocene. During A-subduction (sensu Mitchel and Reading, 1978) of oceanic/quasioceanic (Penninic) crust beneath propagating Carpatho/Pannonian units were outer Carpathian sediments scrabbled into the structure of the accretionary wedge. A-subduction gradually evolved into the oblique continent-continent (CC) collision during the Miocene (Jiříček, 1979). Dynamical evolution of the Western Carpathians resulted in genetical variability of the Neogene sedimentary basins. There are basins formed due to lithospheric extension, flexure and strike-slip related basins in the Western Carpathians (Vass 1998). The Tertiary evolution of the ALCAPA region can be divided to several tectonic events constrained by the age, character and orientation of stress field, related deformation style, sedimentation and paleogeographic position of lithotectonic units.

## Oligocene/Eggenburgian – Early Karpatian (23,4–17 Ma)

Due to CC collision of northwardly propagated Apulia with Bohemian massif process of the lateral extrusion combined with gravitational spreading of elastic Carpatho/Pannonian crustal units (Ratschbacher et al., 1991) started. This tectonic escape was controlled by strike-slip faults operating as border faults of crustal wedges moving to the east. The Early Miocene sedimentation of the E-W wrench furrows (sensu Montenat et al., 1987) took place within this zones in the regime of dextral transpression (Marko et al., 1991). To the end of this period strike-slips corridors un-bloc rotaded 15° CCW to ENE - WSW direction and dextral transpression within corridors converted to sinistral one.

## Late Karpatian – Lower Badenian (17–15,5 Ma)

Carpatho/Pannonian units began to move to the north between the Early and the Late Karpatian. While Alpine segment of orogene has been already stopped due to collision with Bohemian massif, extruded Carpatho/Pannonian units were pushed to the open space – to the bay of weak crust filled up by Carpathian paleogene flysch sediments. During the Late Karpatian ALCAPA invaded to the north, oceanic crust subduced underneath propagating continental Carpatho/Pannonian crustal blocks, was partially melted and produced early volcanic activity of the Western Carpathians. Separation of Carpatho/Pannonian segment from Alpine one and its propagation to the north was realized by N-S dextral strike-slips. One of them is expected in the basement of the Vienna basin (Krs and Roth, 1979, Balla, 1988). Distribution of the Vienna basin depocentres (Jiříček, 1988) shows dramatical change of structural plan during the Late Karpatian. Structural records point to change of compression direction from N-S to NNE-SSW direction, which resulted in change of fault kinematics controlled sedimentation. Former E-W trend of basins was overprinted by NE-SW. NE-SW faults were activated as dominant normal and sinistral strike-slip ones which controlled sedimentation in the Vienna basin and simultaneously allowed northeastward escape of detached blocks after their collision with platforma at the north. During the Late Karpatian first core mountains with exhumed crystalline basement emerged, what is recorded by FT ages (Král, 1977, Kováč et al., 1994) as well as by perifault debris sedimentation along uplifted Malé Karpaty Mts. (Vass et al., 1990). ENE-WSW wrench corridor was active as sinitral transtensional wrench zone. Former Early Miocene wrench furrows were broken up and separated remnants were rotated cca 30°–40° CCW (Kováč and Tunyi, 1995). These rotations were coeval with rotations described in Pelsö unit (Márton and Fodor, 1995).

During the Badenian due to the activity of major NE-SW sinistral strike-slips pull-apart Vienna basin has opened (Royden et al.,1982, Royden, 1985). Badenian depocentres of sedimentation has N-S trend due to normal faults which accomodated large magnitudes of strike-slip translations. While transtensional fore-arc basins were formed at the northern edge of the internides, extensional thermal back-arc basins due to lithospheric stretching and volcanism provoked by heat of rising Pannonian astenolith were formed at the Pannonian area.

## Middle – Upper Badenian (15,5–13,6 Ma)

For this period is typical NE-SW direction of compression and movement of the Carpatho/Pannonian lithospheric blocks. According paleomagnetic data the last CCW block rotations ceased in the western part of Western Carpathians in the Middle Badenian, while the last rotations in the eastern part of the Western Carpathians were recorded at Sarmathian (Orlický, 1996). In conditions of thermal crustal extension back – arc basins has been formed (Pannonian basin, Danube basin). Crustal stretching due to astenosphere heat was accomodated by extensional normal faulting (Tari et al., 1992, Horváth and Cloething, 1996).
Sarmathian - Pannonian (11,5–5,3 Ma)

Active front of orogene has already removed far from Western Carpathians area. NE-SW compresion gradualy inverted to NW-SE pure extension. Former tectonic regime has survived within these conditions. NE-SW normal faults played dominant role as sedimentation controlling structures. Carpathian lithospheric block propagated to the east. Due to the collision with East European Platform movement to the east stopped cca 9 Ma ago. This collision produced E-W compressional event (Decker and Pereson, 1996), which affected even such distal terranes as Western Carpathians. E-W normal faults has been reactivated within this stress period and controlled formaion of E-W trending morphostructures – horsts and depressions. Due to steepening of subducing oceanic plate (Royden et al. 1982, Doglioni et al., 1991) and related roll-back effect, E-W extension was induced in the Carpathian realm. Numerous N-S faults developed and were reactivated as normal ones within this youngest tensional event. These faults are the most frequent and conspicuous brittle features within the recent architecture of the Western Carpathians.

## Plio – recent (5,3–0 Ma)

The Pliocene period is typical by modest lacustrine sedimentation. Important regional tectonic stresses, generated by subduction/collision of large lithospheric plates ceased. Carpathian loop was already done including Pieniny Klippen Belt structure. There are structural records within Western Carpathians and Pannonian area, that cca N-S (NNW-SSE) compression affected orogen during the end of this period (Csontos et al., 1991, Hók et al., 1995) and continues up till recent as earthquakes focal mechanism analysis of seizmogenic faults.

## References


BALLA Z., l987. Tertiary paleomagnetic data for the Carpatho-Pannonian region in the light of Miocene rotation kinematics. *Tectonophysics*, l39: 67-98.

BALLA Z., l988. A Karpát-Pannon regió nagyszerkezeti képe a felsoeocénben és e kép hatása a mezozóos Tethys-rekonstruciókra. *Föld. Kozl. Bull. of the Hung. Geol. Soc*., 118: 11-26.

CSONTOS L., TARI G., BERGERAT F. and FODOR L., 1991. Evolution of the stress fields in the Carpatho-Pannonian area during the Neogene. *Tectonophysics*, 199: 73-91.

DECKER K. and PERESON H., 1996. Tertiary kinematics in the Alpine-Carpathian-Pannonian system: links between thrusting, transform faulting and crustal extension. In: G. WESSELY and S. LIEBL (Editors), Oil and Gas in Alpidic Thrustbelts and Basins of central and Eastern Europe, EAGE Special Publication, 5: pp. 69-77.

DOGLIONI C., MORETTI I. and ROURE F., 1991. Basal lithospheric detachement, eastward mantle flow and mediterranean geodynamics : a discussion. *Journ. Geodyn*., 13, 3: 47-65.

HÓK J., ŠIMON L., KOVÁČ P., ELEČKO M., VASS D., VERBICH F. and HALMO J., 1995. Tectonic of the Hornonitrianska kotlina Basin during Tertiary, *Geol. Carpath*., 46: 191-196.

HORVÁTH F. and CLOETINGH S., 1996. Stress-induced late-stage subsidence anomalies in the Pannonian basin. *Tectonophysics*, 266: 287-300.

JIŘÍČEK R. 1979. Tektogenetický vývoj Karpatského oblouku během oligocénu a neogénu. In: M. MAHEĽ (Editor), Tektonické profily Západných Karpát. *Konf., Symp., Semináre*, (GÚDŠ): 203-220.

JIŘÍČEK R., 1988. Stratigrafie, paleogeografie a mocnosti neogénních sedimentů ve Vídeňské pánvy. *Zem. plyn a nafta*, 33, 4: 583-622.

KOVÁČ M., BARÁTH I., HOLICKÝ I., MARKO F. and TUNYI I., 1989. Basin opening in the Lower Miocene strike-slip zone in the SW part of the Western Carpathians. *Geol. Zbor. Geol. Carpath*., 10, 1: 37-62.

KOVÁČ M., KRÁĽ J., MÁRTON E., PLAŠIENKA D. and UHER P., 1994. Alpine uplift history of the Central Western Carpathians: geochronological, paleomagnetic, sedimentary and structural data. *Geol. Carpath*., 45: 83-96.

KOVÁČ M. and TUNYI I., l995. Interpretácia paleomagnetických údajov zo západnej časti Centrálnych Západných Karpát. *Miner. Slovaca*, 27: 2l3-220.

KRÁL J., 1977. Fission track ages of apatites from some granitoid rocks in West Carpathians. *Geol. Zborn*. *Geol. Carpath*., 28: 269-276.

KRS M. and ROTH Z., 1979. Insubrický karpatský treťohorný blokový systém, jeho vznik a rozloženie. *Geol. zbor., Geol. Carpath*., 30, 1: 3-17.

MARKO F., FODOR L. and KOVÁČ M., 1991. Miocene strike-slip faulting and block rotation in Brezovské Karpaty Mts. (Western Carpathians). *Min. slovaca*, 23: l89-200.

MÁRTON E. and FODOR L., 1995. Combination of paleomagnetic and stress data – a case studies from North Hungary. *Tectonophys*., 242: 99-114

MITCHEL A. H. G. and READING H. G., 1978. Sedimentation and tectonics. In: H. G. READING (Editor), Sedimentary enviroments and facies. Elsevier, pp. 439-476.

MONTENAT CH., OTT D´ESTVOU and MASSE P., 1987. Tectonic-sedimentary characters of the Betic Neogene Basins evolving in a crustal transcurrent shear zone (SE Spain). *Soc. Nat. Elf Aquitaine*, (Pau): 1-22.

ORLICKÝ O., 1996. Paleomagnetism of neovolcanics of the East-Slovak lowlands and Zemplínske vrchy Mts.: A study of the tectonics applying the paleomagnetic data (W. Carpathians). *Geol. carpathica*, 47, 1: 13-20.

RATSCHBACHER L., MERLE G., DAVY P. and COBBOLD P., 1991. Lateral extrusion in the Eastern Alps. Part I: Boundary conditions and experiments scaled for gravity. *Tectonics*, 10, 2: 245-266.

ROYDEN, L.H., HORVÁTH F. and BURCHFIEL B.C., 1982. Transform faulting, extension and subduction in the Carpathian-Pannonian region. *Geol. Soc. An. Bull*., 93: 715-725.

ROYDEN L.H., 1985. Vienna Basin a thin skinned pull-apart basin. In: K. BIDDLE and N. CHRISTIE BLICK (Editors), SEPM, Spec. publ., 37: pp. 319-338.

TARI G., HORVÁTH F. and RUMPLER J.,1992. Styles of extension in the Pannonian basin. *Tectonophysics,* 208: 203-216.

VASS D., 1998. Neogene geodynamic development of the Carpathian arc and associated basins. In: M. RAKÚS (Editor), Geodynamic development of the Western Carpathians. GSSR, Dionýz Štúr Publishers, pp. 155-158.

VASS D., NAGY A., KOHÚT M. and KRAUS I., 1990. Granitoid clastics on the SE margin of the Vienna basin and basin genesis. In: D. MINAŘÍKOVÁ and H. LOBITZER (Editors), Thirty years of the geological cooperation between Austria and Czechoslovakia. ÚÚG Praha, pp. 179-184.