basin. New data give further evidences for correlation of the sequences of the two parts of the basin (Jelen et al., 1998). Subsidence started in the latest Eocene and continued up to early Miocene, when the basin was filled. Source of magmatic clasts found in Eocene and Oligocene rocks of the Hungarian basin could be located in the Slovenian part, undelying their former closer position.

Physical continuation of the Slovenian Periadriatic line and the Mid-Hungarian zone is suggested by gravity and borehole data and analysis of seismic sections (Csontos and Nagymarosy, 1998). Haas et al. (in press) demonstrated that all Permo-Meosozoic units of northern Slovenia can be traced in narrow belts along the northern branches of the Mid-Hungarian zone. Also in this belt, isolated occurrence of Paleogene rocks are known (Kőrössy, 1990). Using the surface analogy, we suggest that both the Paleogene and the Mesozoic rocks occur in a series of strike-slip duplexes (Fodor et al., 1998). The age of formation is pre-Karpatian, because such sediments cover strike-slip structures.

Paleomegnetic data also demonstrate that the two parts of the basin separated during or before the first rotation of the Hungarian part, between 18 and 17 Ma. The ca. 45ş counterclockwise rotation was not affected the Slovenian basin part. On the other hand, the first dextral faulting at the northern tectonic boundary of the Slovenian basin part occured at the same time, between 22(?) and 17,5 Ma.

The continuity of the Hungarian and Slovenian basin parts up to the Eggenburgian or Ottnangian has major implication in extrusion tectonics. This shows that the northern Alcapa unit was not in connection with the Tisza-Dacia unit and their juxtaposition happened only later, within the late Early Miocene. The extruding East Alpine block did not imply the southern Tisza-Dacia only the Alcapa unit (Fodor et al., 1998).

Further separation of the two basin parts was realised by Karpatian-Middle Miocene synrift extension of the Pannonian basin. This extension was much larger north of the Periadriatic zone where metamorphic core complexes occurred (Tari, 1996). During this period, the Mid-Hungarian zone was already bended, thus it was not the structural continuation of the Periadriatic line. In addition, fault kinematics was different along the formerly unique fault zones, dextral and sinistral along the Periadriatic and Mid-Hungarian zones, respectively. Minor eastward displacement of the amalgamated Alcapa and Tisza-Dacia units was possible during this interval.

Due to continuous push of the Adriatic indenter, dextral separation of the Periadriatic zone renewed in late Miocene to Quaternary. The displacement was probably accommodated by folding and thrust faulting in Slovenia and Croatia.

References

Báldi, T. 1986. Mid-Tertiary Stratigraphy and Paleogeographic Evolution of Hungary. - Akadémia Press, Budapest.

Csontos, L. & Nagymarosy, A. 1998. The Mid-Hungarian line: a zone of repeated tectonic inversion. - Tectonophysics, 297, 51-72.

Fodor, L., Jelen, B., Márton, E., Skaberne, D., Čar, J. & Vrabec, M. (1998). Miocene-Pliocene tectonic evolution of the Slovenian Periadriatic Line and surrounding area – implication for Alpine-Carpathian extrusion models. Tectonics, 17, 690-709.

Haas J., Mioc, P., Pamic, J., Tomljenovic, B., Árkai, P., Bérczi-Makk, A., Koroknai, B., Kovács, S. & Rálisch-Felgenhauer, E. in press Continuation of the Periadriatic lineament, alpine and NW Dinaridic units into the Pannonian basin. - Geologische Rundschau.

Jelen, B. - Báldi-Beke, M. - Rifelj, H. 1998. Recent improvements in Slovenian Upper Paleogene and Lower Miocene time-rock stratigraphy. - XVIth CBGA Congress, Vienna, Abstracts, 248.

Kőrössy L. 1990. Geological results of hydrocarbon prospecting in the SE half of Transdanubia. - Általános Földtani Szemle (Budapest), 25, 3-53.

Premru, U. 1981. Tectonic evolution of Slovenia during the time interval from the upper Cretaceous to the Tertiary period. - Symposium on Problems of Danian in Yugoslavia, Ljubljana, Proceedings, 147-154.

Tari, G. 1996. Extreme crustal extension in the Rába river extensional corridor (Austria/Hungary). - Mitt. Ges. Geol. Bergbaustud. Österr. 41, 1-18.

Combination of Paleomagnetic and Paleostress data in the Alpine-Carpathian-Pannonian region

LÁSZLÓ FODOR AND EMŐ MÁRTON

During the last decade, a great number of paleomagnetic and paleostress data were obtained for the Pannonian basin and surrounding mountain chains (Márton, 1993; Fodor et al., 1999). As it is well known, both methods are very important in the tectonic reconstructions. It is less widely recognised however, that the combination of the two types of data sets can lead to a more correct interpretation. In our paper, we give a basin-wide comparison of paleomagnetic and paleostress data and try to integrate these data to a gedynamic model.

The Pannonian-Carpathian area can be divided into two larger microplates during the Paleogene-early Miocene time period. This subdivision is based on paleogeographical and paleomagnetic data (Márton, 1993) and kinematic analysis (Balla, 1984). Since Márton (1997) demonstrated a complicated rotational motion of the two microplates, further subdivision of these two units into several subunits is needed when comparing the independent paleostress and paleomagnetic data sets. This subunit-scale combination was performed following the method of Márton and Fodor (1995).

Paleomagnetic data clearly show that the Alcapa unit suffered moderate to large counterclockwise rotation during the Early to early Middle Miocene. When time constraints are good (in the central-eastern Pannonian basin), two steps of rotation can be differentiated, one between 18-17 Ma and one between 16,5-14,5 Ma.

The large counterclockwise rotation is reflected by an apparent clockwise change in the paleostress axes. Similarly to the rotation of rocks, two steps in change of stress axes can be differentiated. In general, the duration of rotation steps and stress field changes is the same, although small local discrepancies may occur. Considering the equal amount of block rotation, the (apparent) change in stress axes and the opposite sense of change of the two data sets we infer that rotation and brittle deformation of rocks happened in a stable stress field (N-S compression). Only a slight real change in maximal horizontal stress axes can be detected in clockwise sense, at the end of the second rotation step.

The steps of rotation and apparent changes of stress field can be connected to the eastward rotational extrusion of the Alcapa unit and its final emplacement onto the European foreland.

In addition to this microplate-like rotation, two other types of rotations can be demonstrated. One type of rotation is connected to large shear zones, a phenomenon we demonstrated for the Periadriatic fault zone in Slovenia. Within the shear zone, a local, apparent change in stress axes is due to the rotation. The other local deformation is a 30-40(CCW rotation, which affected the northeastern part of the Alcapa unit, from the Tokaj-Slanec, hills to the Gutii Mts. (Márton and Pécskay, 1995). This late Middle Miocene motion post-dates the microplate-like rotation of the Alcapa. The rotation can be connected to the final thrusting of the Northeastern Carpathians and back-arc opening of the Transcarpathian basin, due to the roll-back of the subducting slab.

A similar ("post-microplate") counterclockwise rotation affected the Mura basin and surroundings after Badenian. Post Middle Miocene clockwise and counterclockwise rotation occurred in eastern Slovenia and Croatia, respectively (Márton et al., in press). This deformation can be connected to renewed compression and inversion in the southern Pannonian basin and Southern Alps.

From the southern Tisza-Dacia unit we compared new paleomagnetic and stress data from the Mecsek hills and published data from the northern Apuseni Mts. and Transylvanian basin (Patrascu et al., 1990; Györfi and Csontos, 1994). In this latter area the general trend of change in the paleostress field corresponds to the CW rotation of the southern microplate. Although the exact timing is not clear, both the rotation and the change in paleostress axes occurred during the late Early to early Middle Miocene. In the southern Mecsek Mts. older paleomagnetic data suggested Early Miocene rotation (Márton, 1993) while new data would agree with late Miocene timing (Márton and Márton, in press). However, stress field does not reflect clearly this deformation.

Further complication is added by new observations on Ottnangian (18,5-17,5 ma) CCW rotation of the northern part of the Mecsek (Márton and Márton, in press). This rotation is also reflected by paleostress data and shows that the microplate rotation of the southern Tisza-Dacia unit was probably combined (or "overwrite") with other local deformations.

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References

Györfi, I. (Csontos, L. 1994: Structural evolution of SE Hungary, and Neogene basins of the Apuseni Mountains, (Romania) - Rom. J. of Tectonics and Reg. Geol. 75, suppl. 1, 19-20.

Fodor, L., Csontos, L., Bada, G., Györfi, I. (Benkovics, L. 1999: Tertiary tectonic evolution of the Pannonian basin system and neighbouring orogens: a new synthesis of paleostress data - in Durand, B., Jolivet, L., Horváth, F. (Séranne, M. (eds) The Mediterranean Basins: Tertiary extension within the Alpine Orogen. Geological Society, London, Special Publications, 156.

Márton, E. 1993: Paleomagnetism in the Mediterraneum from Spain to the Aegean: a review of data relevant to Cenozoic movements - in Boschi, E., Manotvani, E. (Morelli, A. (eds): Recent evolution and seismicity of the Mediterranean region, NATO ASI Series, C, 402, 367-402.

Márton, E. 1997: Tertiary paleomagnetic events in the PANCARDI region, type and timing of movements. Terra Nova 9, Abstr. Suppl. 1, 152.

Márton, E, (Fodor, L. 1995: Combination of paleomagnetic and stress data -a case study from North Hungary - Tectonophysics, 242, 99-114.

Márton, E. (Pécskay, Z. 1995: The Tokay-Vihorlát-Oas-Ignis Triangle: Complex Evaluation of Paleomagnetic and Isotope Age Data from Neogene Volcanics - Proc. XV. C.B.G. Cong., Spec Publ. Geol. Soc. Greece, 30

Márton, E. (Márton, P. 1999: Tectonic aspects of a paleomagnetic study in the Neogene of the Mecsek Mts. - Geophysical Transactions.

Márton, E., Pavelic, D., Tomljanovic, B., Pamic, J. (Márton, P. 1999: First paleomagnetic results on the Tertiary rocks from the Slavonian Mts. in the southern Pannonian basin (Croatia) - Geologica Carpathica

Patrascu, S., Bleahu, M (Panaioutu, C. 1990: Tectonic implications of paleomagnetic research into Upper Cretaceous magmatic rocks in the Apuseni Mountains, Romania - Tectonophysics, 180, 309-322.