PALEOMAGNETIC INVESTIGATIONS ON LATE CRÉTACEOUS - CENOZOIC SEDIMENTS FROM THE NW PART OF THE PANNONIAN BASIN

EMÓ MÁRTON¹, PAVEL PAGÁČ² and IGOR TÚNYI²

¹ Eötvös Loránd Geophys. Institute, Columbus ut. 17-23, 1145 Budapest, Hungary
² Geophysical Institute, Slovak Academy of Sciences, Dúbravská cesta 9, 842 28 Bratislava, Czecho-Slovakia

(Manuscript received June 10, 1992; accepted in September 15, 1992)

Abstract: The article presents results of paleomagnetic investigation of the NW part of the Pannonian Basin. More than 170 independently oriented sedimentary samples from 10 localities from Hungarian and Slovak sides were subjected to the AF and thermal demagnetization. They were sandstones, siltstones, marls and limestones and their age is late Cretaceous-late Miocene. The results gave counterclockwise rotation with angles of declination between an important common component to the Cenozoic movements affecting the present NW part of the Pannonian Basin.

Key words: paleomagnetic direction, Cenozoic movements.

Introduction

The area we studied is situated within the North Pannonian Block (bordered by the Outer Western Carpathians in the north and the Mid-Pannonian mobile belt in the south) in the vicinity of the Bohemian Massif, close to the Eastern Alps-Western Carpathians junction, on both, West and East sides of the Danube Basin (Fig. 1).

The NW part of the Pannonian Basin was the subject of paleomagnetic investigations from the sixties on. The first results were obtained on mid-late Cenozoic volcanics (Pagáč 1976; Márton & Márton 1971; Andért et al. 1977; Halas & Márton 1978; Kris et al. 1979; Orlicz et al. 1982). These studies, although primarily aimed at the behaviour of the Earth's magnetic field in the geological past, contain important information concerning the tectonic history of our study area. Namely, that the significant horizontal movements had ended before the calc-alcaline volcanism started (Márton E. 1981).

Unfortunately, the subsequent studies did not proceed back in time methodically, but having left out a considerable time interval, dealt with Paleozoic (Kris et al. 1982) or Mesozoic (Márton & Márton 1981) rocks.

However, it became clear soon that the North Pannonian Block must have been subjected to important horizontal movements also in the Cenozoic. The evidence for such movements was provided by paleomagnetism, which indicated that the Transdanubian Range continued its rotation in the Cenozoic (Márton & Márton 1983; Márton E. 1984, 1986).

North of the Northern Pannonian unit, in the Outer Western Carpathians, paleomagnetic evidence was obtained for counterclockwise rotation matching that of the Transdanubian Range on both Cretaceous (Kris et al. 1982) and Eocene (Kris et al. 1982, 1991) sediments.

Between the Outer Western Carpathians and the Transdanubian Range paleomagnetic work was not initiated on the post-Paleozoic until recently, when the analysis of microtectonic fea-

Fig. 1. Paleomagnetic sampling localities (1 - 10). Key to the geology: 1 - Pech torrent; 2 - Pestany Cliffs Belt; 3 - Inner Western Carpathians; 4 - Bakony and Bukk Mts.; 5 - Neogene volcanics. Locality: 1. Ro- Rohmot; My- Myjava; Kr- Krajné; 2. Esztergom Castle Hill; 3. Nyerge-

sádplóda.
364

MARTON, PAGAC and TUNYI

ures lead to the recognition of the importance of Cenozoic tec-
tonics (Kovács et al. 1989; Marton et al. 1991).

According to the microtectonic studies, the critical interval for
tectonic movements in the Inner Western Carpathians must have
been the early-mid Miocene. Thus the first samples for paleomag-
netic study were collected from the youngest stratigraphic horizons,
still showing evidence for important strike-slip motion.

In the MátraKarpathy Mts., where the investigation started in
1985, 8 localities were sampled. Four of the localities yielded
statistically well-defined paleomagnetic directions as a result of
AF cleaning (Tuny i & Kovács 1991). Sampling was extended in
the meantime to the BrezovskéKarpaty Mts. as far as the Pieni-
ny Clippen Belt. On the eastern side of the Danube Basin one
locality (Kovác) was sampled in the south and one in the north
(Podmanitski pahekární Mts.).

By combining microtectonic and paleomagnetic information
it was concluded that paleomagnetically indicated declination
rotations and the orientation of the stress field were related.

Close relationship between Cenozoic paleomagnetic declination
rotations and the orientation of the stress field was also
suggested to explain paleomagnetic and microtectonic observa-
tions at the southern margin of the Bílky Mts. (Marón E. 1990).

Surprisingly, the timing of the rotations in the Bílky Mts. and in
the Mátra/BrezovskéKarpaty Mts. were also in harmony.

A Slovak-Hungarian joint project in the field of paleomag-
netism started in 1991 with the aim of investigating the possibility
of coordinated movement of the two areas. In order to ensure
the highest degree of compatibility, cooperation was close du-
ring all stages of the paleomagnetic investigation.

Sampling and laboratory experiments

We collected more than 170 independently oriented sedimen-
tary samples at 10 localities (Fig. 1). Most of them were drilled
and oriented independently in the field. However, hand samples
were also taken and drilled in the laboratory. Half of the collec-
tion comes from Slovak, the other from the Hungarian side.

The age of the sediments (sandstone, shale, marl, lime-
stone) is late Cretaceous - late Miocene.

The natural remanence (NRM) of sister specimens of a smal-
er pit collection was measured in the laboratory of ELGI in
Budapest and in Bratislava GFI. Then each laboratory sub-
jected one specimen per sample to detailed thermal (ELGI) or
AF demagnetization (GFI). These experiments showed that
ertains of the localities were unsuitable for tectonic evaluation.

Those with good magnetic signal were revisited and additional
samples collected with the aim of improving the precision of the
paleomagnetic locality mean directions.

Results

It is well known that the remanent magnetization of sedi-
ments, especially clastic sediments, is sensitive to secondary al-
tention. The magnetic signal of depositional origin may be
modified or completely reworked by early to late diagenetic pro-
cesses as well as processes connected to tectonic events, expo-
sure etc.

Since the rocks exposed in the study area mostly clastics, it is
not surprising that a considerable proportion of the collection
did not yield tectonically valuable result, despite of the very care-
ful selection of samples in the field and exhausting laboratory
processing. This chapter will concisely present the most import-
ant types of paleomagnetic behaviour, for successful as well as
for unsuccessful localities.

The Eocene flysch from Négyerdőüli is an example of rocks
with complex remanence. Each sample possesses a NRM which
is fairly stable or moderately unstable on thermal demagnetiza-
tion (Fig. 2).

However, the individually well behaved NRMs do not allow
to characterize the locality by a mean paleomagnetic direction.

Due to the large within-locality scatter (Fig. 3), exhibited by both
siltstone and sandstone <location> samples, the locality is not suitable for
tectonic evaluation.

The NRM at Sfelechna (Eocene limestone) is also composite.

Nevertheless, thermal demagnetization has the power to separate
the components (Fig. 4). The majority of the samples define a mean
demagnetization direction with reasonably good statistical par-
ameters (Fig. 5).

Occasionally the overprint magnetization is of very different
stability in different samples at the same locality. For instance, at
Estergom, Castle Hill secondary magnetization is the only de-
formable NRM in some specimens, while in others it is easily
removable (Fig. 6). The characteristic magnetizations of the
samples define two groups: one close to the actual field direc-
tion, an other far away from it. Three samples out of twenty-six
fall in neither: these preserve the composite nature of the NRM
during demagnetization (Fig. 7). Rejoining the latter, mean
demagnetization can be estimated for the two groups separately.
However, the one coinciding with the actual field direction
cannot be interpreted in terms of tectonics.

The NRM of the samples from Kovács (siltstone) define a
mean paleomagnetic direction close to the actual field with
excellent statistics.

AF demagnetization hardly influences this position. Thermal
demagnetization, however, destroys the consistency. With in-
creasing temperature, the mean direction moves away from the
actual field towards CCW rotated direction (reversed polarity),
but the increasing scatter prevents the definition of a charac-
teristic ancient magnetization (Fig. 8).

Fig. 2. Négyerdőüli, Eocene flysch. Thermally cleaned NRM direc-
tions. Stereographic projection. Positive inclinations: dots, negative
inclinations: circles.
PALEOMAGNETIC INVESTIGATIONS

Fig. 3. Nyergesijahua. Eocene flysch. Typical demagnetization behaviour. Modified Zijderveld diagrams (D and I curves) and susceptibility (dots)/intensity (circles) versus temperature plots.

Fig. 4. Sololnica. Eocene limestone. Typical demagnetization behaviour. Top left and right: thermal cleaning, modified Zijderveld diagrams. Intensity (circles) drops at low temperatures (middle, from top to bottom: first and second) while susceptibility (dots) remains fairly stable. AF-demagnetization fails to separate the two components of NRM, although intensity versus demagnetizing field curves (in the middle of the diagram, third and fourth) exhibit a behaviour similar to the thermal characteristics.

Fig. 5. Sololnica. Eocene limestone. Termally cleaned NRM directions on stereographic projection. All inclinations are negative. Top left: all directions with locality mean declination (D), inclination (I) and statistical parameters; bottom right: the same after rejecting two directions situated far from the cluster.

Fig. 6. Esztergom, Castle Hill. Oligocene siltstone. Typical demagnetization diagrams. 677A: secondary magnetization, partially overprinted. Below the modified Zijderveld diagrams showing declination (D) and inclination (I) versus susceptibility (dots)/intensity (circles) versus temperature plots are shown.
Overprint (convergent domain high intensity) present in one third of 12 samples.

Low intensity, negative inclination 8 samples (5/2 negative incl.).

Interpreted as origin.

Fig. 7. Esztergom, Castle Hill. Thermally cleaned NRM directions on stereographic projection. Dots: positive; circles: negative inclination. Top: all directions at the optimal cleaning step; bottom: sample 675A at different cleaning steps. The latter shows how the NRM direction moves along a great circle containing the actual field direction (asterisk), never reaching stable end point.

Fig. 8. Košátkov (near Štúrovo). Ommangian siltstone. Present work: mean direction of 8 samples on successive demagnetization (1: NRM; 2: AF 10 mT; 3: TH 250 °C; 4: TH 450 °C; 1-3: positive; 4: negative inclination) with φθ increasing on demagnetization. Earlier work: directions NRM after AF demagnetization (dots) and mean direction (cross) with φθ, asterisks show the direction of the actual field.

Fig. 9. Roh motel (near Stará Turka). Eocene flysch. Typical demagnetization behaviour on modified Zijderveld (D and I) and susceptibility (dots)/intensity (circles) versus temperature diagrams.

Fig. 10. Esztergom, Basa u. Oligocene marl. Typical demagnetization behaviour on modified Zijderveld (D and I) and susceptibility (dots)/intensity (circles) versus temperature diagrams.
Overprint caused less problem when the ancient remanence had normal polarity (Figs. 9, 10), although the change in direction is clearly seen on progressive demagnetization. To summarize the results, we accept as tectonically significant those yielding statistically reasonably well defined mean paleomagnetic direction, as a result of thermal cleaning. The palaeomagnetic mean directions must lie at a significant distance from the direction of the actual field, before tilt correction is applied (Tab. 1).

### Table 1: Summary of tectonically significant palaeomagnetic results.

<table>
<thead>
<tr>
<th>Sampling locality</th>
<th>N/N</th>
<th>Dec</th>
<th>Inc</th>
<th>Nc</th>
<th>k</th>
<th>a95</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solotinsa</td>
<td>3/16</td>
<td>168</td>
<td>62</td>
<td>13</td>
<td>13</td>
<td>13</td>
</tr>
<tr>
<td>POH Motel</td>
<td>6/12</td>
<td>21</td>
<td>6</td>
<td>29</td>
<td>13</td>
<td>13</td>
</tr>
<tr>
<td>Esztergom</td>
<td>9/25</td>
<td>99</td>
<td>43</td>
<td>24</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>Castle Hill</td>
<td>113</td>
<td>38</td>
<td>38</td>
<td>7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Esztergom, Basa utca</td>
<td>10/10</td>
<td>303</td>
<td>38</td>
<td>44</td>
<td>7</td>
<td></td>
</tr>
</tbody>
</table>

**Key:** N/N: number of used/collected samples. Dec: inclination before tilt correction, Inc: inclination after tilt correction. Nc, k: statistical parameters of the mean palaeomagnetic directions. * - corrected for overturned position.

### Discussion and conclusions

After tilt correction, the paleomagnetic directions of the successful localities exhibit counterclockwise rotation (two with normal, two with reversed polarity). The angle of declination rotation is high, between 50 and 110 degrees (Fig. 11).

Despite of the large distance, different tectonic setting, the locality mean directions of rocks of similar ages suggest that there must have been an important common component to the Cenozoic movements affecting the present NW part of the Pannonian Basin.

The overall declination rotation of the study area seems to be larger than that of the SW part of the North Pannonian Block. It matches better the magnitude of the post-Oligocene net CCW declination of the Máté-Bükk area (Fig. 12).

In the light of the large CCW rotation of Cenozoic age, the equally large declination rotation observed on Permian rocks in the Choł Nappe (Müller & Vizir 1978) might have to be reinterpreted as counterclockwise rotation. Since the Permian paleomagnetic directions have extremely shallow inclinations it is a matter of subjective decision whether the sense of rotation is considered as CW (as the authors of the paleomagnetic directions did) or CCW. However, once the second possibility is accepted, Cenozoic movements alone can account for the declination deviation observed on the Permian. Thus nappe displacement during the Mesozoic as the mechanism causing rotation, will become subordinate compared to mid-late Cenozoic tectonism.

Concerning the details, it would be early, especially in the light of the inclination scatter, to suggest that the existing declination differences between localities are tectonically significant. Our strategy for the future is laid down so that the problem of differential movements within each arc(s) of the studied region could be better approached.

### References
