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Late Variscan remagnetization of Devonian carbonates in the Moravo-Silesian zone (Czech Republic): implications for dating tectonic deformation

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Abstract: New paleomagnetic data from the Moravo-Silesian Zone (Eastern Variscides, Czech Republic) confirmed the presence of strong Late Variscan overprint. Data from four localities indicate syn-folding to post-folding age of remagnetization, which was acquired throughout a time span between 335-288 Ma. This implicates that deformation in the area started as early as the Visean (Lower Carboniferous) and continued to the lowermost Permian. Remagnetization was coeval with the same process reported from Ardennes and partially also Cantabrian arc.

Keywords: Moravo-Silesian Zone, paleomagnetism, remagnetization, Devonian.

The paleomagnetic method is widely used for paleotectonic reconstructions of fold-and-thrust belts. Investigations performed in the Moravo-Silesian Zone (MSZ) more than 10 years ago (Krs and Pruner, 1995; Tait *et al.*, 1996) proved a strong late Variscan remagnetization of the Devonian carbonate rocks. The remagnetization took place when the Variscan tectonic structures existed in their present shape. Secondary magnetizations of similar age were noted also in other parts of Variscan Europe, e.g. in Ardennes (Molina-Garza and Zijderveld, 1996; Marton *et al.*, 2000; Zegers *et al.*, 2003) and northern Spain (Weil *et al.*, 2001). In this paper we present new paleomagnetic results from MSZ, focused on more detailed dating of Late Variscan remagnetization in relation to deformations and timing of magnetic overprint in some other parts of Variscan Europe.

Geological setting

The Moravo-Silesian Zone (MSZ) is located at the eastern margin of the Bohemian Massif (Fig. 1), in the eastward extension of the Rhenohercynian and Subvariscan zones of the European Variscides. The main folding and thrusting events took place in the Late Carboniferous, most probably close to the Westphalian-Stephanian boundary ('Asturian phase'). The MSZ is considered to represent a Palaeozoic accre-

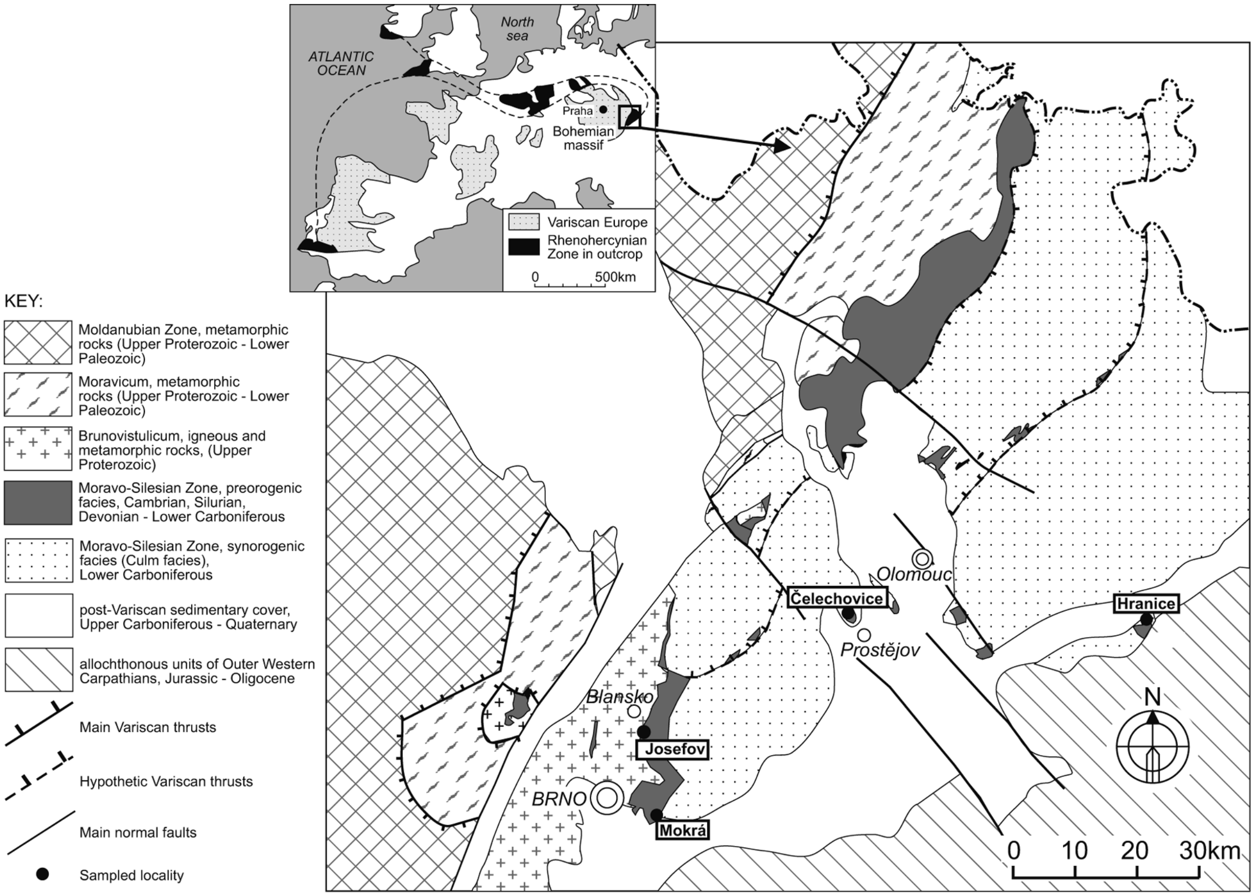

Figure 1. Geological sketch map of the Moravo-Silesian Zone with 4 sampling localities indicated.

tionary wedge, which developed between the overriding nappe stack of the Moldanubian and Tepla-Barrandian units, and the subducted Brunovistulian crystalline basement (Fritz and Neubauer, 1995).

Paleomagnetic data from four localities of Middle to Late Devonian carbonate rocks are presented (Fig. 1). Samples (total number of 46) were taken either from long, weakly deformed sections (Josefov, Celechovice) or well developed mesofolds of several meters of amplitude (Mokra, Hranice). The Devonian rocks in the MSZ rocks were moderately heated with CAI indexes from 3-3.5 in the Brno area through 4 in Josefov, to 5-6 in Hranice. The results must be considered as preliminary, since the project is still active and new paleomagnetic data will be obtained in the next few months.

Results

Paleomagnetism

Thermal demagnetization revealed the presence of two magnetization components in each locality. A low unblocking temperature component is a recent viscous remanent magnetization with no geological importance. The second component, labeled A, is demagnetized between 200 °C and 500 °C. It is well clustered with SW declination and shallow positive (Celechovice) or negative (other localities) inclination (Fig. 2). It corresponds to Late Variscan remagnetizations known from previous studies (Krs and Pruner, 1995; Tait *et al.*, 1996). The McFadden (1990) fold test was applied in order to determine the relative age of component A in sampled tectonic structures. The component A is post-folding in Josefov, late syn-folding (11% unfolding) in Mokra and early syn-folding (71% unfolding in Hranice). In Celechovice the component A is either post-folding or late synfolding (25% unfolding). We attempt to date the Late Variscan overprint in our study area in a more detailed way. This is usually done by comparison of the reference inclination curve with the observed paleoinclinations. Our reference curve in the interval 300-250 Ma was constructed using paleopole selection from well dated and demagnetized volcanic rocks from

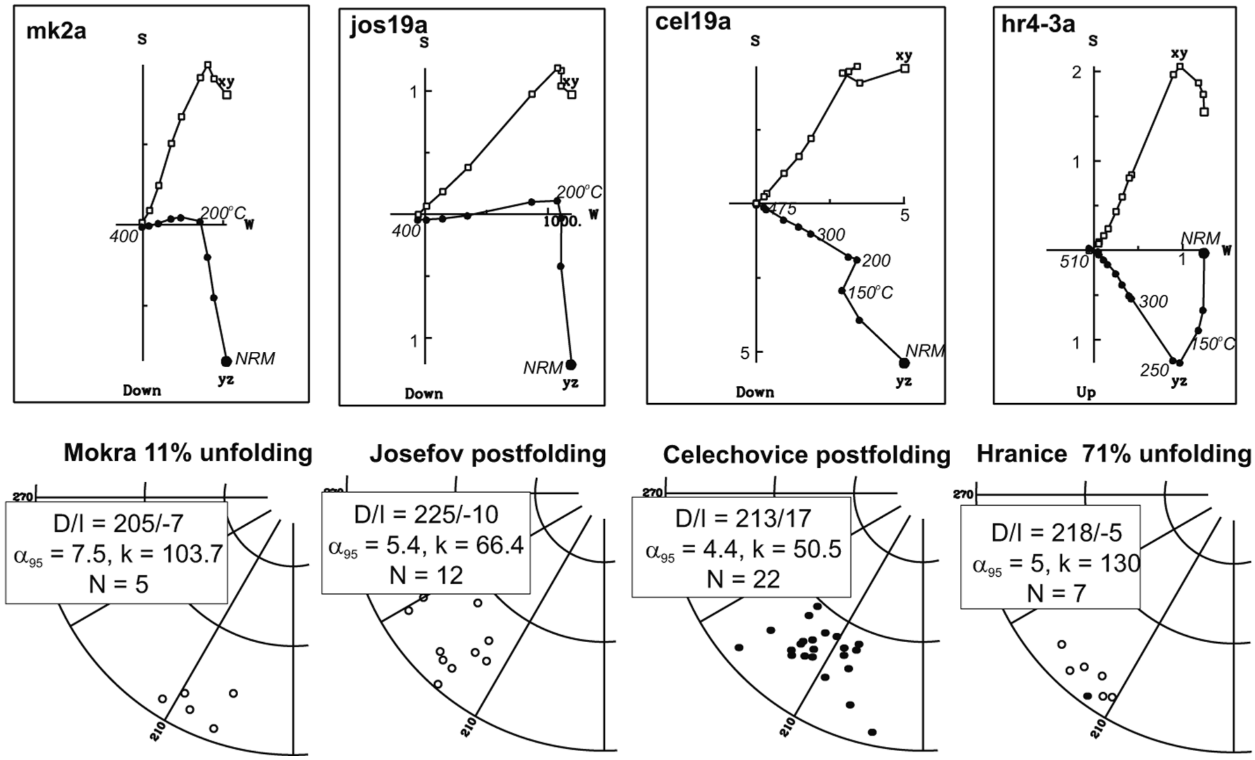

Figure 2. Upper row: orthogonal projection of thermal demagnetization path for typical specimens (before tectonic correction). Squares: horizontal plane projection; dots: vertical plane projection; NRM intensities in mA m[-1]. Lower row: stereographic projection of characteristic magnetizations. White (black) dots: upper (lower) hemisphere projection; D/I: declination/inclination; α_{95}, k: Fisher statistics parameters (Fisher, 1953); N: number of samples.

Baltica (Van der Voo and Torsvik, 2004), while between 350 and 300 Ma Baltic APW of Torsvik and Cocks (2005) was applied (Fig. 3). It appears that component A in Josefov, Hranice and Mokra

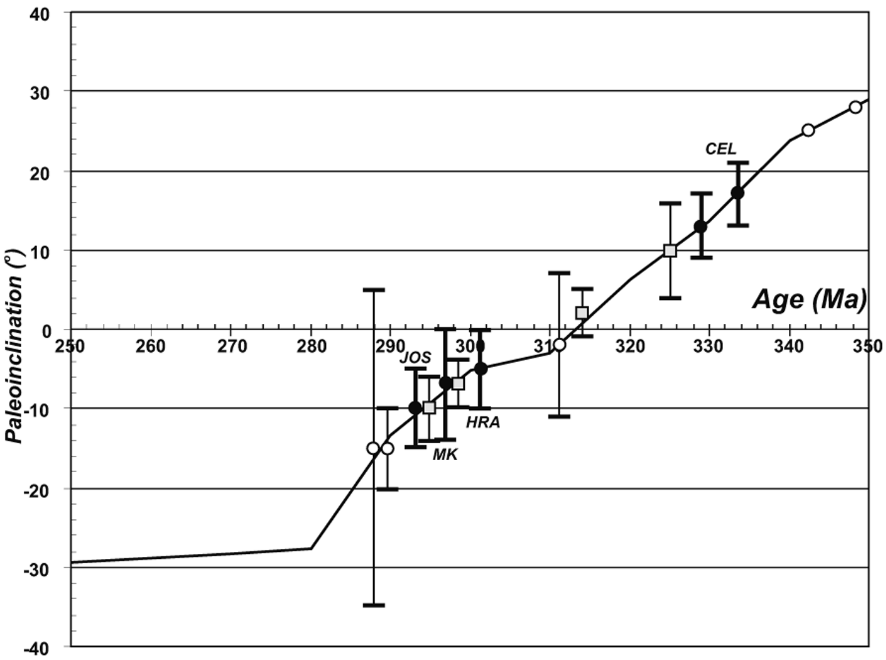

Figure 3. Paleoinclinations of the component A (this study – black dots) compared to the reference Carboniferous-Permian paleoinclination curve for Europe (recalculated from paleopoles for geographic coordinates 49°N, 17°E). Inclinations of Late Variscan remagnetization events in the MSZ after previous studies (Krs and Pruner, 1995 – white squares; Tait *et al.*, 1996 – white dots) are also indicated.

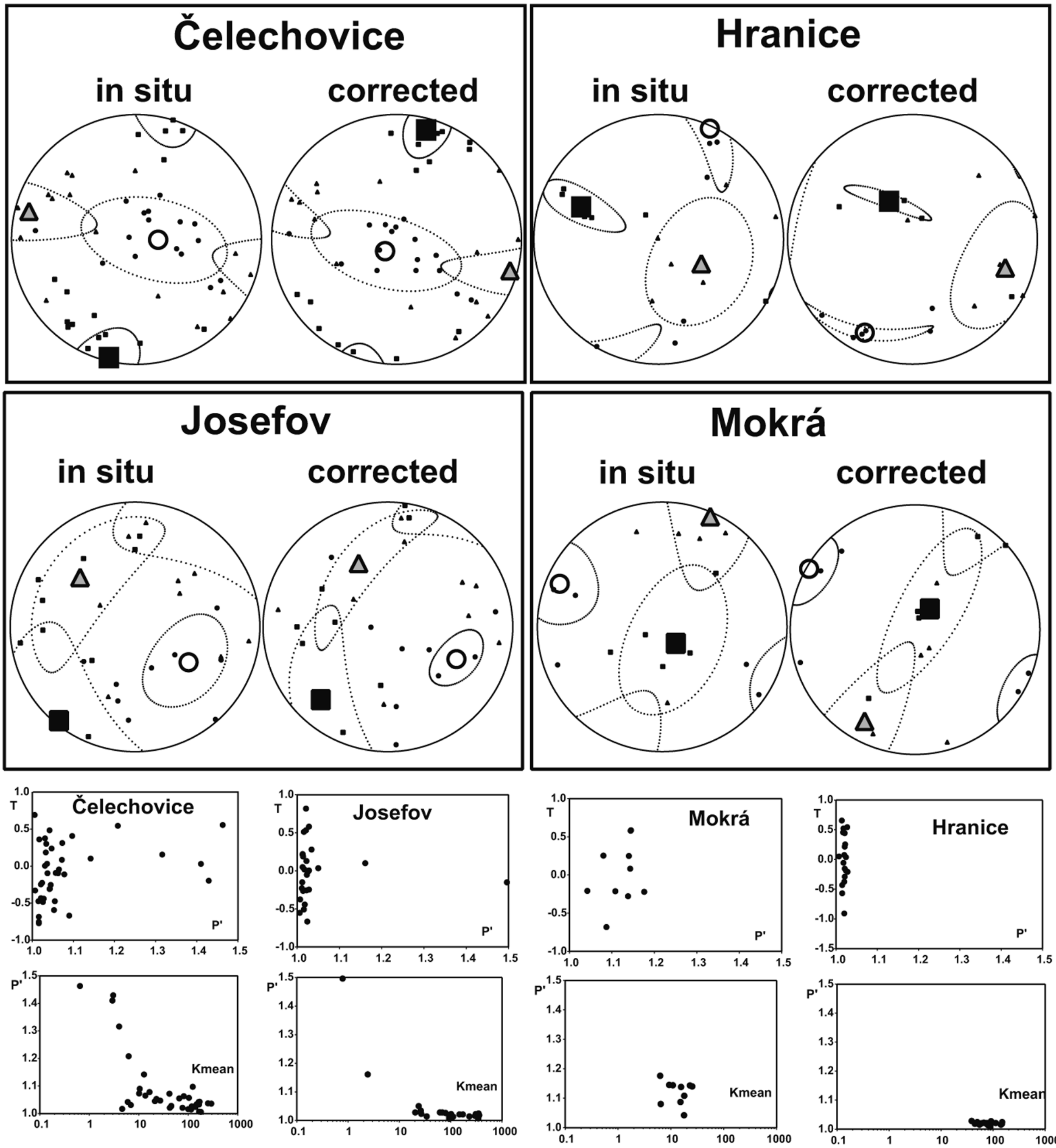

Figure 4. AMS fabric for 4 localities. Upper row: AMS mean axes (*in situ* and after tectonic correction, k_1-squares, k_2-triangles, k_3-dots). Jelinek's P' (T) diagram and P' (K_{mean}) diagrams below.

is roughly of the same age and might be dated as 300-294 Ma, which corresponds to the uppermost Carboniferous-lowermost Permian. Component A in Celechovice is apparently older and might be acquired at 330 Ma or even earlier. As component A in this locality is late syn-folding to post-folding, this implies that deformations of the Devonian carbonates in MSZ started as early as the late Early Carboniferous and they continued probably beyond the Carboniferous-Permian boundary.

AMS

In 4 localities in the vicinity of Brno (Fig. 4) the AMS fabric shows a moderately to well developed clusters of magnetic lineations (k_1). k_1 (for two exposures) and

k_2 (for one exposure) trend subhorizontally to NW-SW along the general trend of Devonian exposures. Magnetic foliation dip steeply in 3 sites and is rather subhorizontal in another one. The correlation of different AMS axes (k_1 and k_3 respectively) between sites (e.g. Hranice and Mokrá) can be due to multistage AMS fabric at given localities or due to mineralogical control (inverse fabric). The effects of local and regional deformation on the AMS and correlation with other AMS studies (Chadima *et al.*, 2006) need to be yet clarified. The 100% unfolding at the locality scale slightly improves the clustering of AMS although some more studies with partial unfolding are required. Anisotropy degree is strongly dependent on bulk susceptibility (P' is higher for more diamagnetic samples due to larger measurement errors). Rock magnetic studies revealed two phases of magnetite (SD+SP) and a high potential to growth of secondary magnetite upon heating. The AMS fabric rather seems not to affect the paleomagnetic record due to very low susceptibility mostly carried by para- and diamagnetic minerals.

Conclusions

Late Variscan remagnetizations in the MSZ, like tectonic deformations, were significantly extended in time spreading between 330 and 290 Ma. Two extreme results falling between 340 and 350 Ma are from Hady Limestone (Tait *et al.*, 1996) and are poorly constrained. We can not be sure if remagnetization was a continuous process. The presence of three phases might be postulated from figure 3: 1) between 335 and 325 Ma, 2) between 310 and 315 Ma, and 3) between 300 and 288 Ma. This might be an artifact resulting from paucity of data. However, the remagnetization phases distinguished in Ardennes (Fig. 5) seem to have their counterpart in MSZ. The first phase corresponds to magnetization A of Marton *et al.* (2000), the second might be compared to phases HT (Molina-Garza and Zijderveld, 1996) and C (Zegers *et al.*, 2003), while the third phase was distinguished by all the authors (B of Marton *et al.*, 2000; P of Zegers *et al.*, 2003; LT of Molina-Garza and Zijderveld, 1996). The second and third remagnetization phases are also present in Devonian rocks of the Cantabrian arc (component C and B, Weil *et al.* 2001).

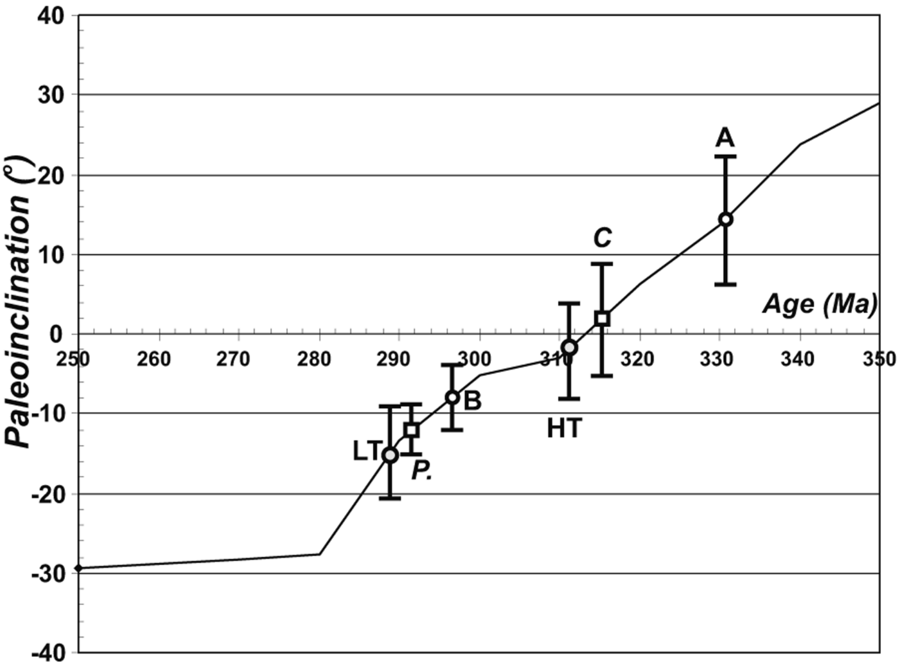

Figure 5. Paleoinclinations of the Late Variscan magnetization components from Ardennes (after various authors) recalculated for geographic coordinates 49°N, 17°E and plotted against reference Carboniferous-Permian paleoinclination curve for Europe. Grey dots: data after Molina-Garza and Zijderveld (1996); white dots: after Marton *et al.* (2000); squares: after Zegers *et al.* (2003).

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