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MAGNETIC POLARITY OF UPPER TRIASSIC SEDIMENTS OF THE GERMANIC BASIN IN POLAND

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Abstract: Palaeomagnetic results are presented for 205 samples of cores from the Książ Wielkopolski IG-2, Woźniki K1 and Patoka 1 wells, drilled in the Polish part of Germanic Basin. The magnetic polarity stratigraphy is based on the inclination of the characteristic remanent magnetization, isolated in 60% of the total samples and found to be in general agreement with the expected Late Triassic inclination at the sampling sites. A total of 22 magnetozones from the integration of the three records correspond to about 25% of the published polarity zones for the Upper Triassic sediments that were combined in the worldwide composite polarity-time scale. The magnetic polarity pattern, defined for the Schilfsanstein, fits very well with the one defined in the Tethys area for the upper part of the Julian sub-stage. According to the magnetostratigraphic data, the uppermost part of the Upper Gypsum Beds (equivalent to the Ozimek Member of the redefined Grabowa Formation) and the lowermost part of the Patoka Member, containing the Krasiejów bone-breccia horizon, can be correlated with the latest Tuvalian (~228.5 Ma) or with the middle part of Lacian (~225 Ma). However, if the "Long-Tuvalian" option for the Late Triassic Time Scale is taken into consideration, the parts of these substages mentioned above should be correlated with ~221.5 Ma and ~218.5 Ma, respectively.

Key words: Magnetostratigraphy, Grabowa Formation, Upper Triassic, Germanic Basin, Poland.

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INTRODUCTION

The lithofacies of the Upper Triassic (Keuper) stratigraphic succession of the Germanic basin, including its Polish part, reflect alternating shallow-marine and continental environments and fluctuations between arid and humid climatic conditions. The layer-cake lithostratigraphy is broadly uniform throughout the basin; it resulted from the interplay between eustatic and climatic fluctuations, overwhelming the entire Western Tethys domain during Carnian–Rhaetian time. This created a sequence-stratigraphic framework linking the well established bio- and chronostratigraphy of the Alpine Upper Triassic records with its Germanic equivalent, which is without age-diagnostic fossils (Szulc, 2000). Also the regional extent of climatic variation (arid *vs.* pluvial conditions) supported the reliable correlation of the main Upper Triassic lithostratigraphic units with their Alpine time equivalents (Feist-Burkhardt *et al.*, 2008). Nonetheless, the scarcity of age-diagnostic fossils, limited to only a few units (see below), impedes more detailed bio- and chronostratigraphic study, with the result that magnetostratigraphy provides the only means of improving regional and global correlation of the Keuper succession. In the biostratigraphy of the Germanic Keuper, the main tool enabling chronostratigraphic correlation is palynostratigraphy. For the purpose of this paper, it is important to note the most important and accurate palaeobotanical data supporting the accuracy of the magnetostratigraphical correlation. This concerns in particular the Schilfsandstein (Stuttgart Fm), precisely dated as Julian by means of both palynonomorphs (Orłowska-Zwolińska, 1985; Fijałkowska-Mader *et al.*, 2015) and megaspores (Wierer, 1997). On the other hand, very careful and detailed study applying lithofacies examination, palaeozoological and palynological analyses and sequence-stratigraphy procedures unequivocally indicates a late Fassanian–Longobardian age of the Lower Keuper succession including the Grenzdolomit interval (Orłowska-Zwolińska, 1985, Szulc, 2000, Narkiewicz and Szulc, 2005) and Franz *et al.* (2015).

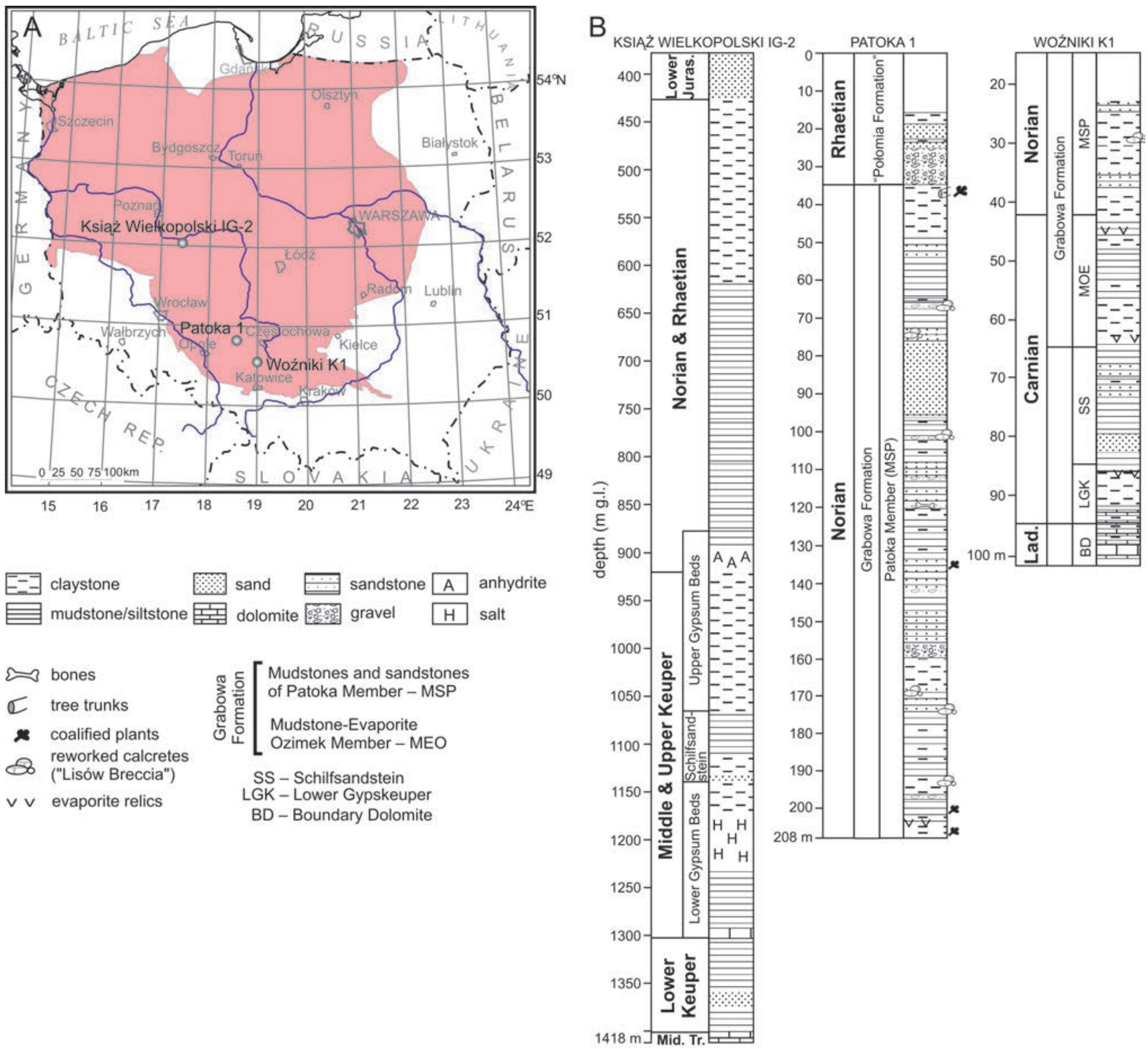

Fig. 1. The cores selected for palaeomagnetic investigation. **A.** Location of the cores studied on a sketch map of the distribution of the Upper Triassic sediments in Poland (after Fig. 52 in Deczkowski, 1997). **B.** Lithostratigraphy of the Upper Triassic deposits from the Książ Wielkopolski, Woźniki K1 and Patoka 1 cores.

The Late Triassic magnetic polarity scale has been developed in marine and nonmarine sections. The Late Triassic deposits of the Newark Basin allowed to reconstruct a cycle-scaled record of magnetic reversals in which the top of the youngest magnetozone E24 is as old as 202 Ma (Kent *et al.*, 1995; Kent and Olsen, 1999). This mixed magnetic polarity behaviour is characterized by quite long normal or reversed magnetozones alternating with short-lived ones.

Magnetostratigraphic correlation between the terrestrial Newark polarity scale and biostratigraphically calibrated scales from the Ladinian through Rhaetian marine sections from the Alpine area is difficult because of different sedimentation rates and tectonic deformations (Krystyn *et al.*, 2002; Channell *et al.*, 2003). On the other hand the magnetostratigraphy of terrestrial to shallow-water sediments from the St. Audrie's Bay section in the UK matches well with that found in the upper part of the Newark Supergroup succession (Hounslow *et al.*, 2004). Results of magnetostratigraphic correlation of Tethyan sections with the successions of the Newark basin reveal that the base of Rhaetian is placed between chrons E16n and E16r (Hüsing *et al.*, 2011). Gradstein *et al.* (2012) have presented the calibration of polarity patterns in relation to ammonite zones defined in magnetostratigraphy reference successions (Hounslow and Muttoni, 2010) where the ammonite zonal boundaries were adjusted to the Newark magnetic polarity scale. The Julian part of this synthetic scale was constructed according to the data obtained from the reference sections in the Alpine area and Turkey (Gallet *et al.*, 1992, 1998). The upper Carnian through Norian slice was mostly constructed by the means of the data from the locality at Pizzo Mondello in Sicily (Muttoni *et al.*, 2004) and the Silická Berezová succession of Slovakia (Channel *et al.*, 2003). The uppermost Norian to lowermost Rhaetian interval was correlated with conodont zones defined in Austrian sections (Gallet *et al.*, 1998; Krystyn *et al.*, 2007; Hüsing *et al.*, 2011). The middle Rhaetian through lowermost Hettangian part of the scaled polarity pattern was derived from the southern Alps (Muttoni *et al.*, 2010). Because of the deficiency of adequate correlation markers, Gradstein *et al.* (2012) presented two alternative versions of the Late Triassic magnetic polarity scale. According to a concept with a long-duration Tuvalian substage and presence of the Rhaetian gap in the Newark scale, the Late Triassic is subdivided into ~16-myr long Carnian and Norian of the same duration. The Rhaetian covers a 4 myr time span only. In the option with short-lasting Carnian and occurrence of Rhaetian in the Newark scale, the Late Triassic is subdivided into 8 myr long Rhaetian and 19 myr long Norian. In this model the Carnian Stage covers ~10 myr time span.

The Schilfsanstein of Western Europe sections was palaeomagnetically studied by Hahn (1984). The older part of this unit, sampled in the Weserbergland and Franken, displayed normal magnetization only. On the other hand, its younger part sampled in the Schwaben and N. Switzerland was magnetized in the reverse direction. Unfortunately, the samples studied were not linked with any geological profiles. Therefore, the possibility cannot be excluded that the two magnetozones distinguished there cover only a small part of the Schilfsanstein.

In this paper the authors present preliminary magnetostratigraphic data on the Upper Triassic sediments of the Germanic Basin in Poland, in its central and marginal (Upper Silesian) parts. Poor biostratigraphic documentation, stratigraphic frames that correspond mainly to lithological and environmental lines of evidence, and gaps in sedimentation (e.g., Szulc *et al.*, 2015) do not favour these rocks as very promising ones for regional magnetostratigraphic correlation. On the other hand, the succession contains red beds that provide a reliable primary palaeomagnetic signal, which also has been recognized in the underlying Buntsandstein sediments of the same basin (e.g., Nawrocki, 1997).

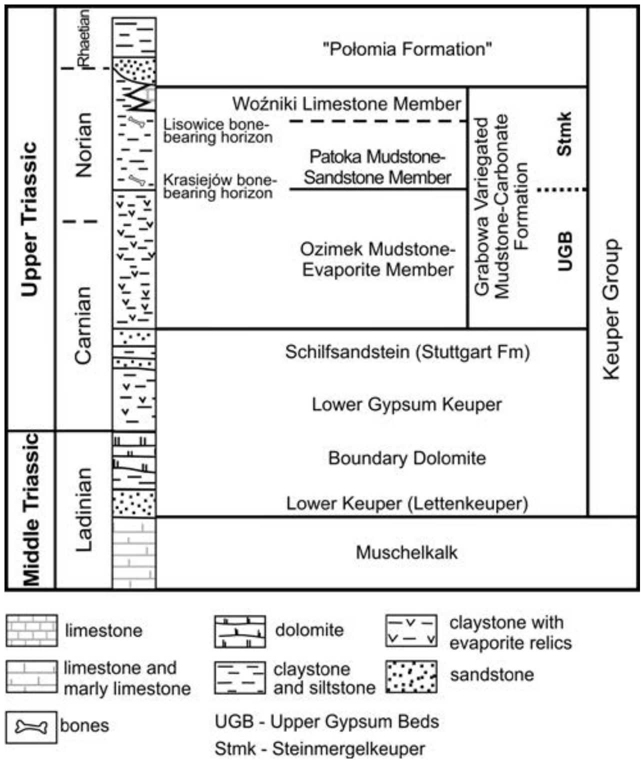

Fig. 2. Formal and informal lithostratigraphic units of the Upper Triassic in Upper Silesia. After fig. 2 in Szulc and Racki (2015), modified.

DRILL CORES STUDIED

For the present study, drill cores from the Książ Wielkopolski IG-2 (approximately 1,000 m long), Woźniki K1 (100 m) and Patoka 1 (208 m) boreholes were sampled (Fig. 1). The drill core from the Książ Wielkopolski IG-2 well contains very distinct Keuper horizons, starting from the Grenzdolomite and ending with the Upper Gypsum Beds. The Lower Gypsum Beds include about 60 m of salt. The Schilfsanstein (about 60 m thick) consists of sandstones, mudstones and siltstones in its upper part. The Upper Gypsum Beds terminate with an anhydrite horizon. A monotonous series of siltstones, claystones and clays about 500 m thick belong to the Norian and Rhaetian, which are not separated here.

The Woźniki K1 drill core begins at the bottom with a dolomite interval, corresponding to the Grenzdolomite horizon that is a widely distributed horizon across almost the entire Germanic Basin. The overlying interval, represented mainly by grey mudstones and claystones with anhydrite intercalations, corresponds to the Lower Gypsum Beds. These pass into the Schilfsandstein, which mainly consists of grey mudstones and sandstones with some coal seams. The grey sandstones and mudstones pass gradually into reddish mudstones with traces of roots. The Schilfsanstein is overlain by the Upper Gypsum Beds, included as the Ozimek Member in the revised Grabowa Variegated Mudstone-Carbonate Formation (Szulc and Racki, 2015; Szulc *et al.*, 2015; Fig. 2), developed as monotonous, multicoloured mudstones, containing gypsum intercalations and nodules. Above that, the Steinmergelkeuper can be distinguished. It consists mainly of variegated mudstones and claystones without gypsum intercalations. The thin horizons of vadose conglomerates, palaeosoils and beds with regolith are characteristic for this interval. The Steinmergelkeuper interval recently was defined for southern Polish Keuper lithostratigraphy as the Patoka Mudstone-Sandstone Member of the Grabowa Formation (Szulc and Racki, 2015; Szulc *et al.*, 2015; Fig. 2).

The core from the Patoka 1 well comprises a sedimentary succession, assigned to the Grabowa Formation (Upper Gypsum Beds, Steinmergelkeuper) and the uppermost Triassic – lowermost Jurassic clastic sediments ("Połomia Formation"). In contrast to the core from the Woźniki K-1 well, there is no clear evidence of Schilfsandstein facies. The Steinmergelkeuper is represented by variegated claystones and mudstones, as well as grey sandstones with a sharp erosional base. The distinct feature of this succession is the occurrence of pedogenic horizons, caliche, regoliths, debris flows and slump structures. The topmost part of the core an-

Table 1

Summary statistics of characteristic palaeomagnetic inclinations obtained from the Upper Triassic rocks drilled in the Książ Wielkopolski IG-2,Woźniki K1 and Patoka 1 wells

Locality	Number of samlpes N	Mean inclination I	Standard deviation SD
Książ Wielki IG-2			
– normal polarity	21	44.38	12.15
– reversed polarity	37	–38.59	14.09
– all	58	40.69	13.71
Woźniki K1			
– normal polarity	16	33.46	13.29
– reversed polarity	21	–37.41	13.85
– all	37	35.54	13.55
Patoka 1			
– normal polarity	23	38.91	12.83
– reversed polarity	4	–55.25	21.37
– all	27	41.33	15.06

alyzed is represented by grey and white conglomerates, and coarse sandstones, which represent the uppermost Triassic.

METHODS

A total of 205 fragments of cores were taken as hand samples, oriented only with respect to top and bottom. They were cut into a maximum of 6 cubic (8 cm^3) or cylindrical (11.3 cm^3) standard specimens for palaeomagnetic analysis, giving a total of 374 specimens. The clay horizons provided mainly cracked samples, not suitable for the preparation of specimens. Part (57) of the specimens fell to pieces very quickly in the first stages of laboratory heating.

The natural remanent magnetization (NRM) was measured on JR-5 and JR-6 spinner magnetometers (AGICO Ltd.) with a noise level of 5×10^{-5} A/m. A stepwise thermal demagnetization with maximum temperatures of up to 700 °C was performed, using a μ-metal shielded oven MMTD1 (Magnetic Measurements Ltd.), which reduced the ambient field to a few nT. After each steep of heating, the magnetic susceptibility was measured, using a KLY-2 susceptibility bridge (Geofyzika Brno). Characteristic remanent magnetization (CHRM) directions were calculated by principal component analysis (Kirschvink, 1980) using Remasoft (Chadima and Hrouda, 2006) and PCA (Lewandowski *et al.*, 1997) software. Late Triassic inclinations of the geomagnetic field for the study area calculated from existing data and not corrected for inclination shallowing, should be confined to between 39° and 60° (e.g., Torsvik *et al.*, 2012) and should differ from the present-day inclination in central Poland (67°) by up to 28° for the oldest Lower Keuper strata. Because of this difference, any geologically recent magnetic overprint directions should be distinguished, especially in the Lower-Middle Keuper part of the sedimentary sequence studied.

Direct studies of magnetic carriers were not performed. They were recognized during the thermal demagnetization of the palaeomagnetic specimens according to their spectrum of unblocking temperatures. It should be stressed that in the grey and red beds of the Buntsandstein a mixture of different ferric oxides was recognized, with hematite as the main carrier in the red beds and magnetite and/or maghemite carrying the remanence in the grey-coloured rocks (Nawrocki, 1997).

RESULTS OF DEMAGNETIZATION

Książ Wielkopolski IG-2

Generally, four types of palaeomagnetic behaviour can be distinguished. Part (~36%) of the samples revealed the dominance of one component with unblocking temperatures as high as at least 600 °C, and negative or positive inclinations of ~40–50° (Fig. 3, samples k36A and k62a). In these samples, most of the NRM initial intensity was usually lost during thermal demagnetization at temperatures between 400 and 550 °C. Because of this, it can be assumed that the CHRM is carried here by the hematite and magnetite grains together (e.g., Dunlop and Özdemir, 1997). Another set of samples (~52%), apart from that portion of the CHRM, was recognized as containing also the unstable low-temperature distinct component that was removed at temperatures not higher than 300 °C (Fig. 3, samples k25d and k30b). This component is probably of viscous origin and can be linked with the magnetite fraction, susceptible to such a kind of magnetization. Some grey-coloured samples have a similar structure of magnetization, but the most stable dual-polarity component was removed at lower temperatures of 470–560 °C (Fig. 3, samples k68c and k41b), which is typical of magnetite. The last set of samples contains a very distinct low-temperature component, often removed at temperatures not higher than 200 °C and probably carried by ferric oxyhydroxide (e.g., goethite). A stable dual-polarity component oftlinewas isolated at a maximum unblocking temperature of close to 400 °C (Fig. 3, sample k45a). Its inclination corresponds to the expected late Triassic value. Summary statistics for the characteristic inclinations at the sample level are presented in Table 1. The mean value of this parameter for the entire set of data amounts to 40.69° with a standard deviation of 13.71°.

The magnetic-polarity pattern, reconstructed for the core studied, against the background of the line-fit characteristic directions is very discontinuous (Fig. 4). Gaps occur in the places not suitable for sampling (e.g., clays destroyed during coring and core storage, salts) or where the samples were destroyed during the initial levels of thermal demagnetization. Four separate and distant parts of the Upper Triassic succession provided fragments with a continuous palaeomagnetic record. This amounts to about 35% of its total thickness. The magnetic polarity of the Lower Keuper strata is reversed at the bottom and mainly normal in the upper part. The uppermost part of the Lower Gypsum Beds and the Schilfsanstein were deposited mainly during a time of reversed-polarity geomagnetic field, interrupted by three intervals of normal polarity (Fig. 4). The lowermost part of the Norian sequence is similar to what was described for the Lower Keuper beds. Three magnetozones with the thickest

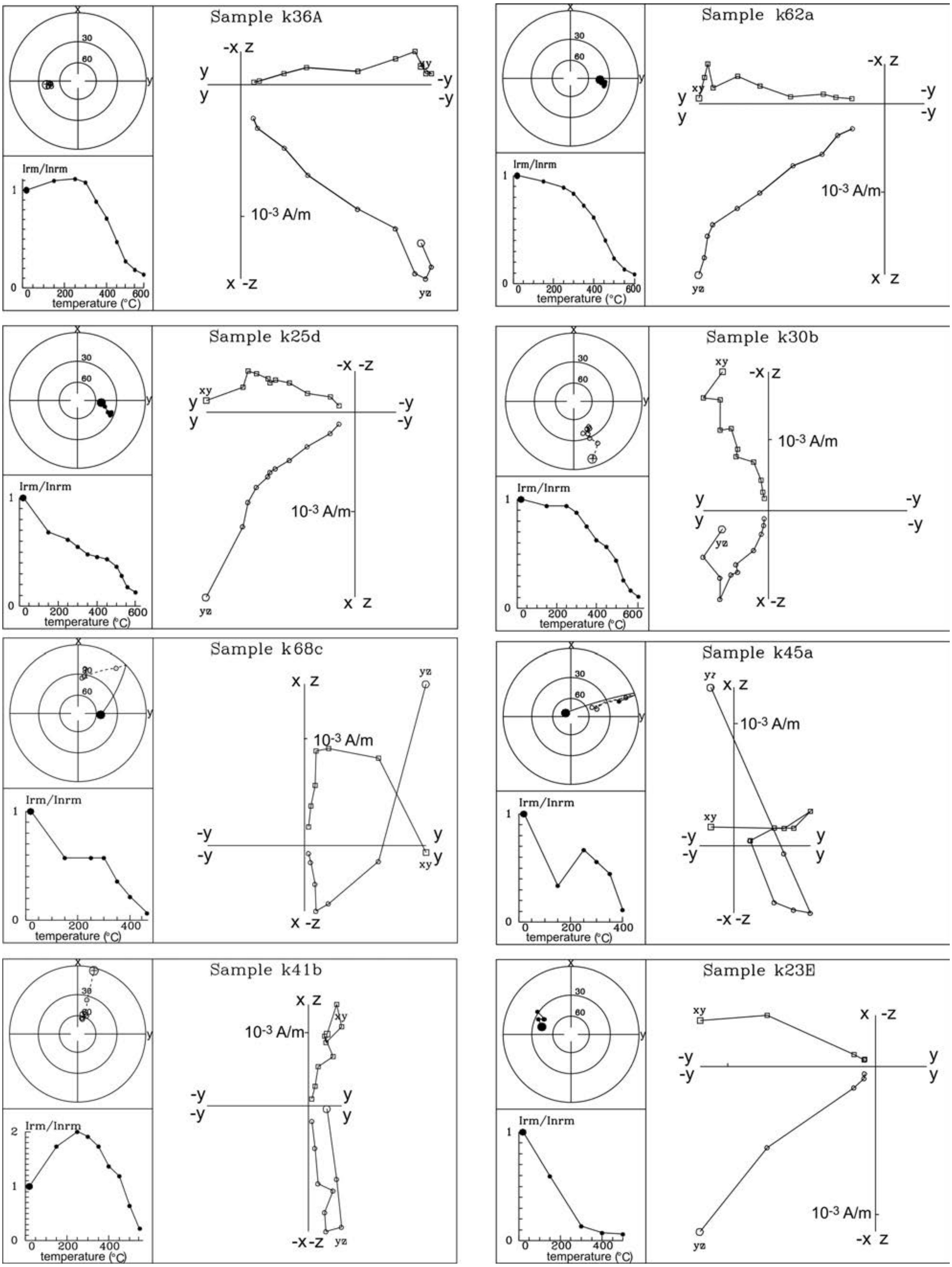

Fig. 3. Typical demagnetization characteristics (demagnetization paths, intensity decay curves and orthogonal plots) of' the Upper Triassic samples from the Książ Wielkopolski IG-2 core. Circles in the orthogonal plots represent vertical projections, squares represent horizontal projections. Irm – intensity of remanent magnetization, Inrm – initial intensity of natural remanent magnetization. The diagrams were prepared by the means of a computer package written by Lewandowski *et al.* (1997).

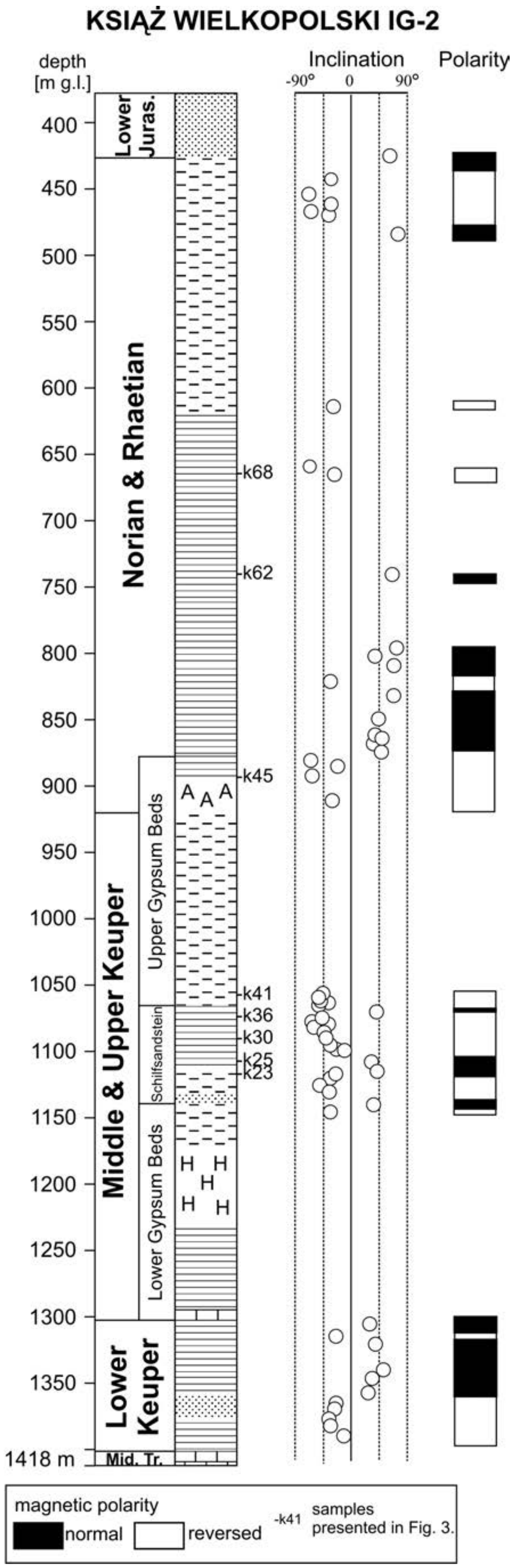

Fig. 4. Lithostratigraphy of the Upper Triassic deposits in the Książ Wielkopolski IG-2 core and the results of magnetostratigraphic investigations. On the right of the lithostratigraphic column, plots of characteristic inclination and magnetic polarities are presented. In the inclination plot, a single circle represents the characteristic direction isolated by the line-fit method from at least 2 specimens. For lithologic symbols, see Fig. 1.

zone of reversed polarity were distinguished in the topmost (i.e. late Rhaetian) part of the section.

Woźniki K1

Samples from the reddish sandstones and mudstones of the Woźniki K-1 core usually contain one distinct component carried by hematite, with unblocking temperatures higher than 600 °C (Fig. 5A, samples 1A, 40A, 12C). In some samples, the same component with a shallow negative or positive inclination also is carried by magnetite with unblocking temperatures of ca. 550 °C (Fig. 5A, sample 50A), or by magnetite and hematite together (Fig. 5, sample 16B). In addition, a very unstable low-temperature component of magnetization, carried most probably by the ferric hydrooxides, is typical for most of samples taken from the clays (Fig. 5A, sample 20A).

As might be expected, all directions isolated from samples oriented with respect to top and bottom on the stereonet form only a belt that is azimuthally dispersed and inclinations mainly between 30° and 60° (Fig. 5B).

The Woźniki K1 core contains sediments from the Carnian and Norian stages of the Upper Triassic (see Szulc *et al.*, 2015; Fijałkowska-Mader *et al.*, 2015), but their small thickness and different environments of deposition may indicate a discontinuous character of sedimentation. There are also several breaks in palaeomagnetic sampling and some places without good-quality data. The value of the mean inclination, calculated for characteristic directions at the sample level, is here about 5° lower than calculated for the directions obtained from Książ Wielkopolski IG-2 (Tab. 1). The middle parts of the Schilfsandstein and the Patoka Member were magnetized by the normal geomagnetic field (Fig. 6). The reversed-polarity record seems to be predominant in the lower parts of these units. Such a record is also displayed by single samples from the Ozimek Member (Upper Carnian).

Patoka 1

Most of the samples taken from the red beds of the Patoka Member contain two components of magnetization. A viscous component was removed at temperatures of up to 200 °C (Fig. 7). The sharp decrease of magnetization observed in some samples up to 150 °C probably reflects the presence of goethite (Fig. 7, sample P196-5A). The CHRM component was demagnetized at temperatures exceeding 600 °C (Fig. 7, samples P126C, P170B), indicating hematite as carrier. Some of the samples taken from the pink claystones were palaeomagneticaly unstable after a significant increase of magnetic susceptibility during heating (Fig. 7, samples P100C, P108C, P95-8B). This increase is probably due to transformation of ferric sulphides (at temp. ca. 350–400 °C) and/or clay minerals (at temp. >600 °C) to magnetite (e.g., Dunlop and Özdemir, 1997). Single samples taken from the red clays revealed the presence of well defined stable magnetization carried by hematite, but with very steep inclinations (Fig. 7, sample P60-8C). Such high values of inclination could indicate a secondary (Cenozoic) origin of the remanence. Very unstable palaeomagnetic directions accompanied with a huge increase in magnetic susceptibility were observed in the grey-coloured sediments. They did not provide any reliable characteristic direction. Because of this, the composite magnetic-polarity scale constructed for this core is very limited (Fig. 8). However, one can conclude that normal-polarity palaeomagnetic behaviour seems to be predominant in the Patoka Member, which was deposited during the Norian (see Środoń *et al.*, 2014; Fijałkowska-Mader *et al.*, 2015; Szulc *et al.*, 2015). Only single samples from the bottom and top parts of the section studied revealed the presence of a reversed-polarity record. However, two of these samples have a very steep inclination (~80°) with a characteristic component distant from the mean inclination, calculated for the rest of samples (Tab. 1), and because of this their reversed polarity cannot be of primary Triassic origin.

MAGNETOSTRATIGRAPHIC CORRELATION

Magnetozones covering relatively continuous fragments from the Woźniki K1 and Książ Wielkopolski IG-2 cores were numbered (Fig. 9). Integration of magnetostratigraphic results from both cores allowed the recognition of 22 numbered magnetozones, which correspond to about 25% of the magnetozones distinguished in the Upper Triassic of the Newark Basin or S Europe only (see Hounslow and Muttoni, 2010). The magnetozones defined in this paper cover not more than a third of the entire Upper Triassic succession of the Germanic Basin in Poland. The magnetic-polarity pattern, reconstructed for the Schilfsanstein (magnetozones SCHr1 to SCHr3) and the Lower Norian sediments (magnetozones NRr1 to NRn3) from the Książ Wielkopolski IG-2 core, is a good fit for the magnetozones defined in the coeval rocks of the Woźniki K1 core. The predominantly normal-polarity record obtained in the Patoka 1 core most probably in part corresponds to the magnetozones NRn2 and NRn3, distinguished in the Książ Wielkopolski IG-2 and Woźniki K1 cores (compare chemostratigraphic correlation of the Patoka 1 and Woźniki K1 sections in Środoń *et al.*, 2014, fig. 19; see also Szulc *et al.*, 2015).

The magnetostratigraphic scale compiled for the Germanic Basin in Poland was compared with the composite Late Triassic polarity-time scale, constructed against the background of the data obtained from coeval rocks in N America, S Europe, the United Kingdom and Turkey (see above), and the age was calibrated according to the "long-Rhaetian" option (Gradstein *et al.*, 2012). In this solution, the base of the Rhaetian is defined at 209.5 Ma and the base of the Norian is calibrated at 228.4 Ma (Fig. 10). The Lower Keuper part of the record in Poland fits well to the polarity zones distinguished in S Europe, close to the Fassanian and Longobardian boundary (Muttoni *et al.*, 2000). The palaeomagnetic data from the Schilfsanstein fits very well the upper part of the Julian sub-stage that contains the same conchostracans (Kozur and Weems, 2010). The early Tuvalian part of the composite scale is not covered by magneto- stratigraphy. According to the correlation by the present authors, it should contain at least one normal-polarity zone that was recognized in the bottom part of the Upper Gypsumkeuper (equivalent to the Ozimek Member). The supposed Early Norian part of this record with two distinct normal-polarity zones can be correlated with the coeval polarity pattern, documented so far in the Newark Basin and S Europe (Gradstein *et al.*, 2012). However, the uppermost part of the Ozimek Member and the lowermost part of the Patoka Member containing a reversed-polarity record, are most probably still of latest Tuvalian age (~228.5 Ma). Another possibility is to correlate them with the middle Lacian (~224.5 Ma) (Fig. 10). However, if the "Long-Tuvalian" option of the Late Triassic Time Scale (see above) is taken into consideration, the parts of these substages mentioned should be correlated with ~221.5 Ma and ~218.5 Ma respectively. The well-defined magnetozone URr1of reversed polarity in the top part of the Rhaetian can be correlated with the same polarity magnetozone SA5n, 1r was recognized in a similar position in St. Audrie's Bay (Hounslow *et al.*, 2004) or with the top part of the magnetozone E22 in the sequence of the Newark Basin (Kent and Olsen, 1999). This second solution implies that time-equivalents of the youngest Triassic rocks from the St. Audrie's Bay, i.e. the Lilstock Formation could not occur in the Książ Wielkopolski IG-2 core.

CONCLUSIONS

1. Some of the Upper Triassic samples from the German Basin in Poland revealed a good palaeomagnetic signal and provided characteristic directions of mixed polarity and inclinations, corresponding to those expected for that time interval.
2. A total of 22 magnetozones were distinguished and named in the rocks studied. They account for about 25% of magnetozones that were found in the Upper Triassic rocks of the Newark Basin, S Europe and Turkey and were used for the construction of the composite Late Triassic Polarity-Time Scale.
3. The magnetic-polarity pattern defined for the Schilfsanstein and the lower Grabowa Formation is almost the same in cores from the Książ Wielkopolski IG-1 and Woźniki K-1 boreholes. The predominantly normal polarity record defined for the Patoka 1 core corresponds most probably in part to the Early Norian magnetozones NRn2 and NRn3 specified in those cores.
4. The Schilfsanstein mixed magnetic polarity pattern corresponds very closely to the one recognized in the upper part of the Julian sub-stage of the Tethys area.

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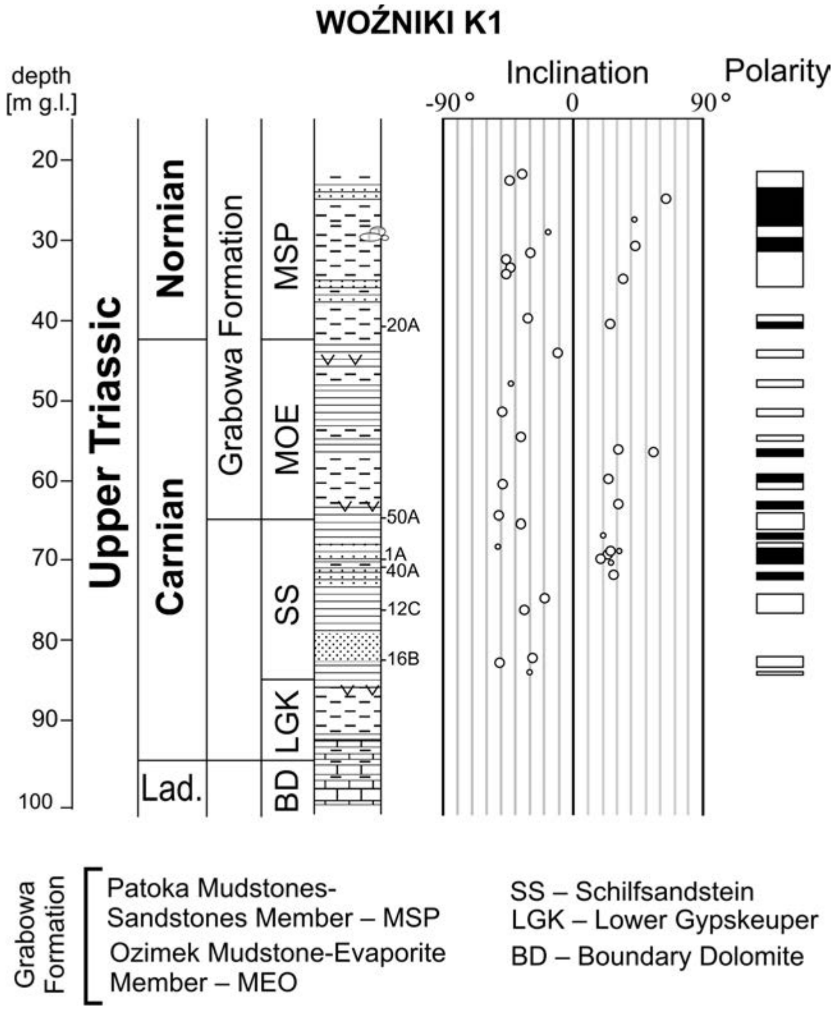

Fig. 5. Lithostratigraphy of the Upper Triassic deposits in the Woźniki K1 core and the results of magnetostratigraphic investigation of them. On the right of the lithostratigraphic column, the plots of characteristic inclinations and magnetic polarities are presented. In the inclination plot, the larger circle represents the characteristic direction, isolated by the line-fit method from at least 2 specimens. The smaller circle indicates the characteristic direction, isolated from one specimen only. For lithologic symbols, see Fig. 1.

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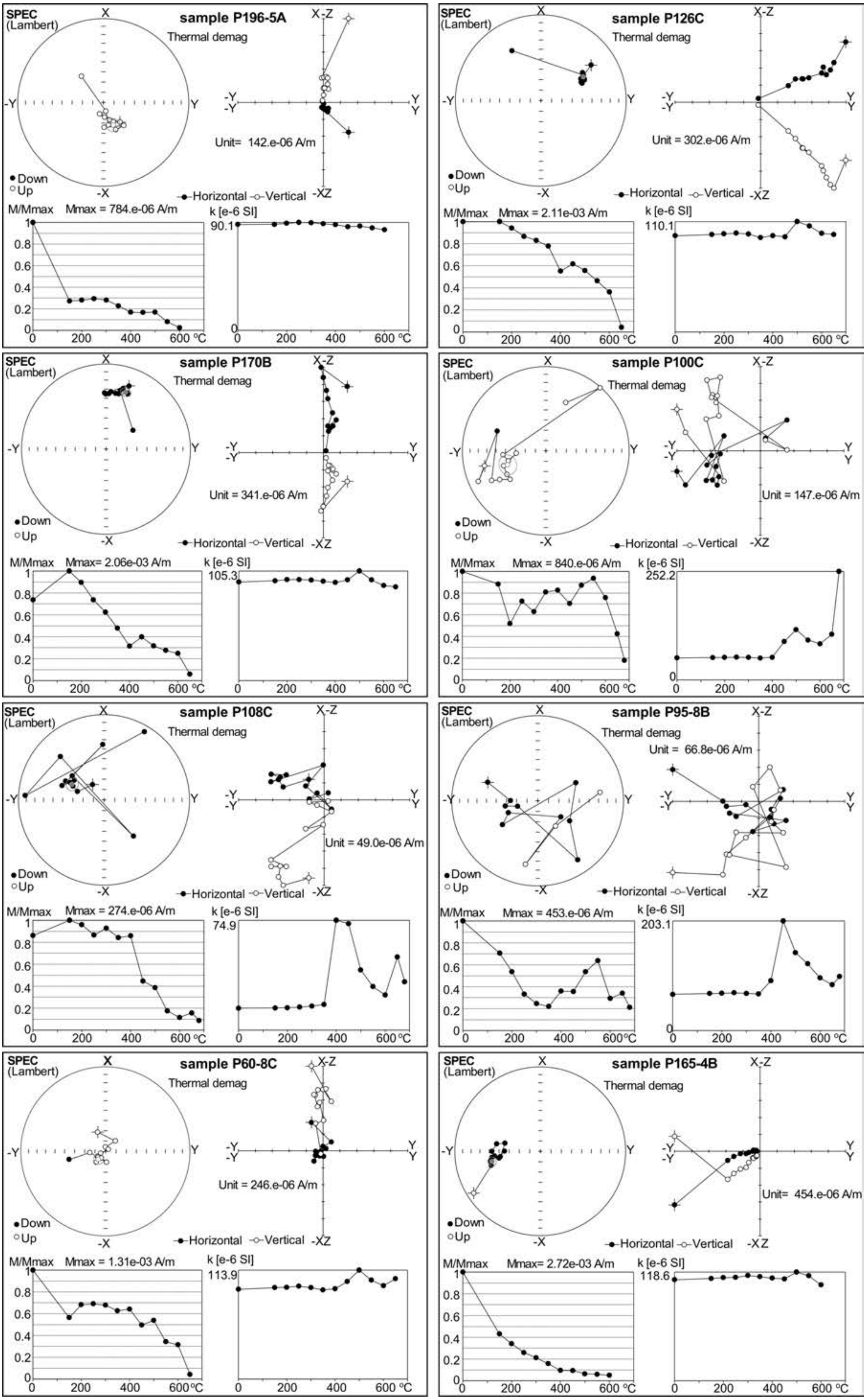
Fig. 6. Typical demagnetization characteristics (demagnetization paths, intensity decay curves, orthogonal plots and changes of magnetic susceptibility) of' the Upper Triassic samples from the Patoka 1 core. Open circles in the orthogonal plots represent vertical projections, full circles represent horizontal projections. M – intensity of remanent magnetization, Mmax – initial intensity of natural remanent magnetization. The diagrams were prepared by the means of a computer package, written by Chadima and Hrouda (2006).


SPEC (Lambert)
sample P196-5A
Thermal demag
Unit= 142.e-06 A/m
M/Mmax Mmax = 784.e-06 A/m
k [e-6 SI] 90.1
sample P126C
Thermal demag
Unit = 302.e-06 A/m
M/Mmax Mmax = 2.11e-03 A/m
k [e-6 SI] 110.1
sample P170B
Thermal demag
Unit = 341.e-06 A/m
M/Mmax Mmax= 2.06e-03 A/m
k [e-6 SI] 105.3
sample P100C
Thermal demag
Unit = 147.e-06 A/m
M/Mmax Mmax = 840.e-06 A/m
k [e-6 SI] 252.2
sample P108C
Thermal demag
Unit = 49.0e-06 A/m
M/Mmax Mmax = 274.e-06 A/m
k [e-6 SI] 74.9
sample P95-8B
Thermal demag
Unit = 66.8e-06 A/m
M/Mmax Mmax = 453.e-06 A/m
k [e-6 SI] 203.1
sample P60-8C
Thermal demag
Unit = 246.e-06 A/m
M/Mmax Mmax = 1.31e-03 A/m
k [e-6 SI] 113.9
sample P165-4B
Thermal demag
Unit= 454.e-06 A/m
M/Mmax Mmax= 2.72e-03 A/m
k [e-6 SI] 118.6
X -X Y -Y X-Z -XZ
Down Up
Horizontal Vertical
0 200 400 600 °C

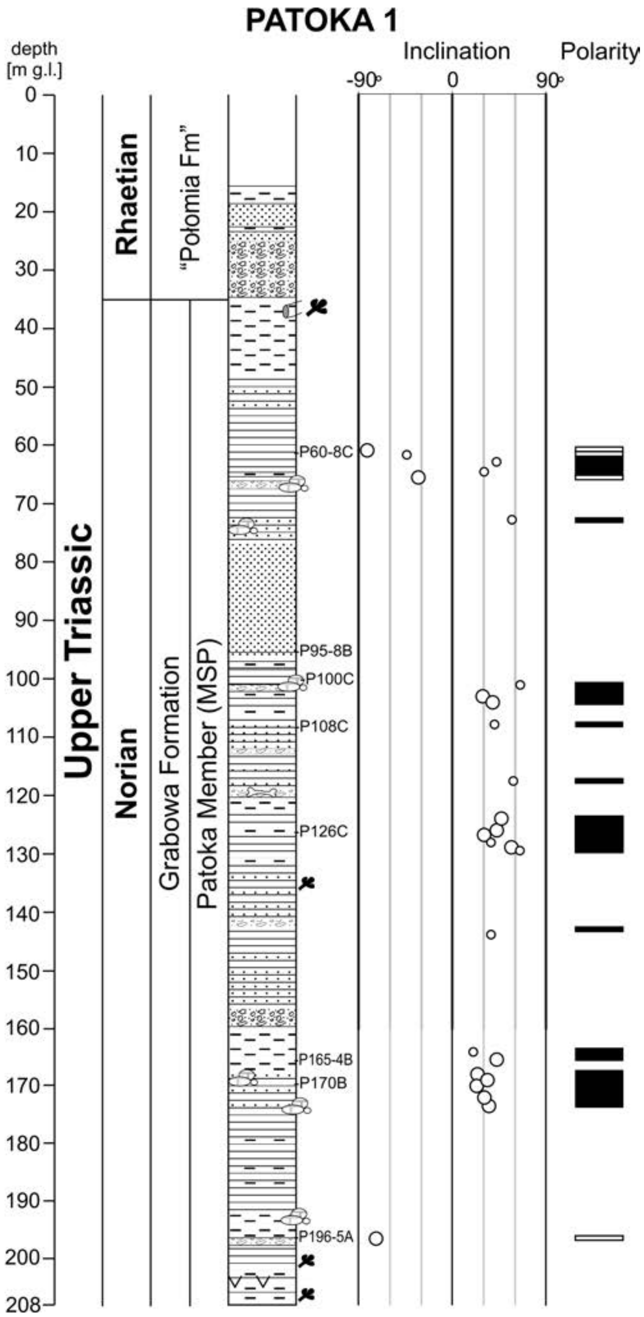


Fig. 7. Lithostratigraphy of the Upper Triassic deposits from the Patoka 1 core and the results of magnetostratigraphic investigation of them. On the right of lithostratigraphic column, the plots of characteristic inclination and magnetic polarities are presented. In the inclination plot, the larger circle represents the characteristic direction isolated by the line-fit method from at least 2 specimens. The smaller- circle indicates the characteristic direction isolated from one specimen only. For lithologic symbols, see Fig. 1.

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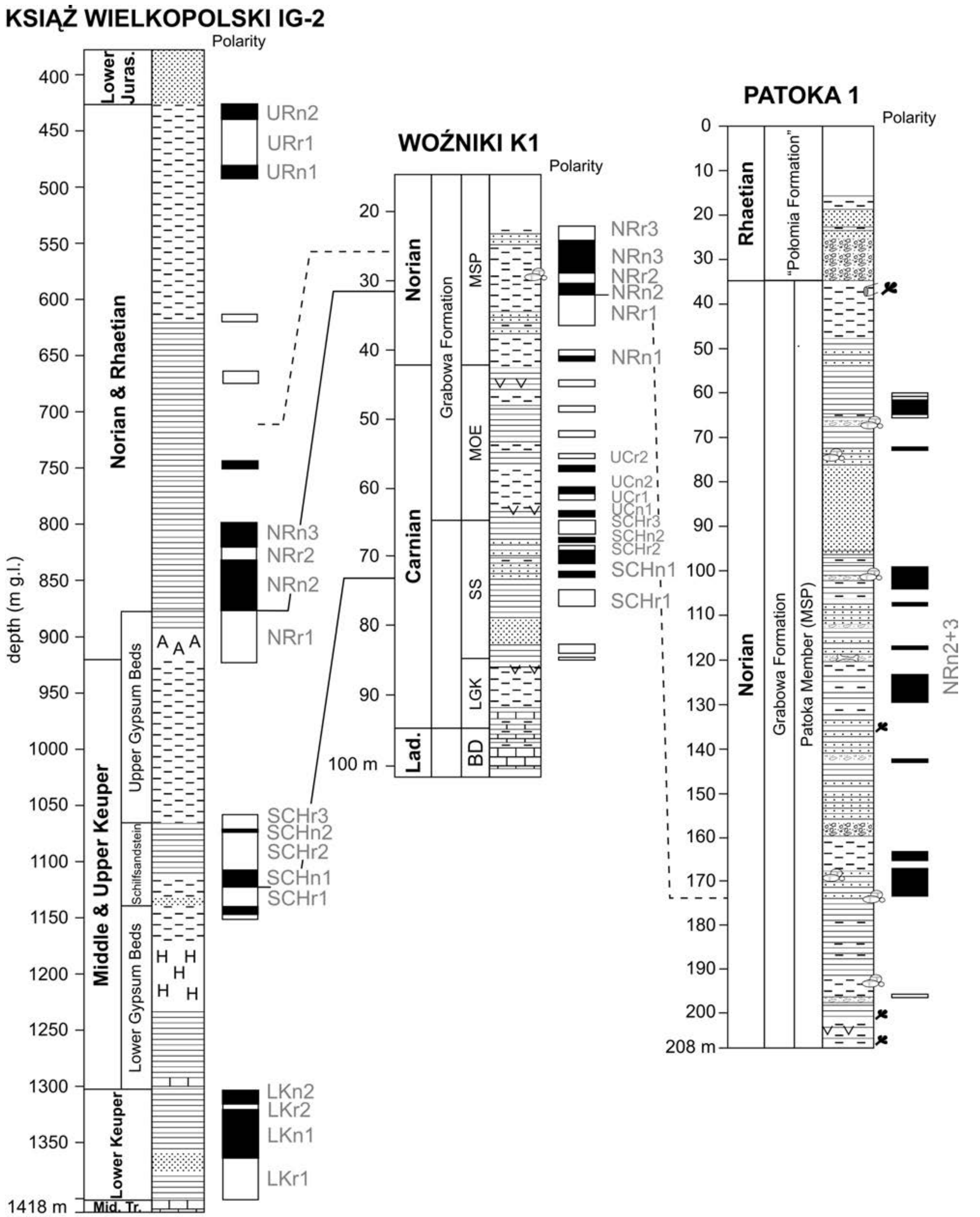

Fig. 8. Magnetic stratigraphy and correlation chart of the Upper Triassic sequences from the Książ Wielkopolski IG-2, Woźniki K1 and Patoka 1 cores. For lithologic symbols, see Fig. 1.

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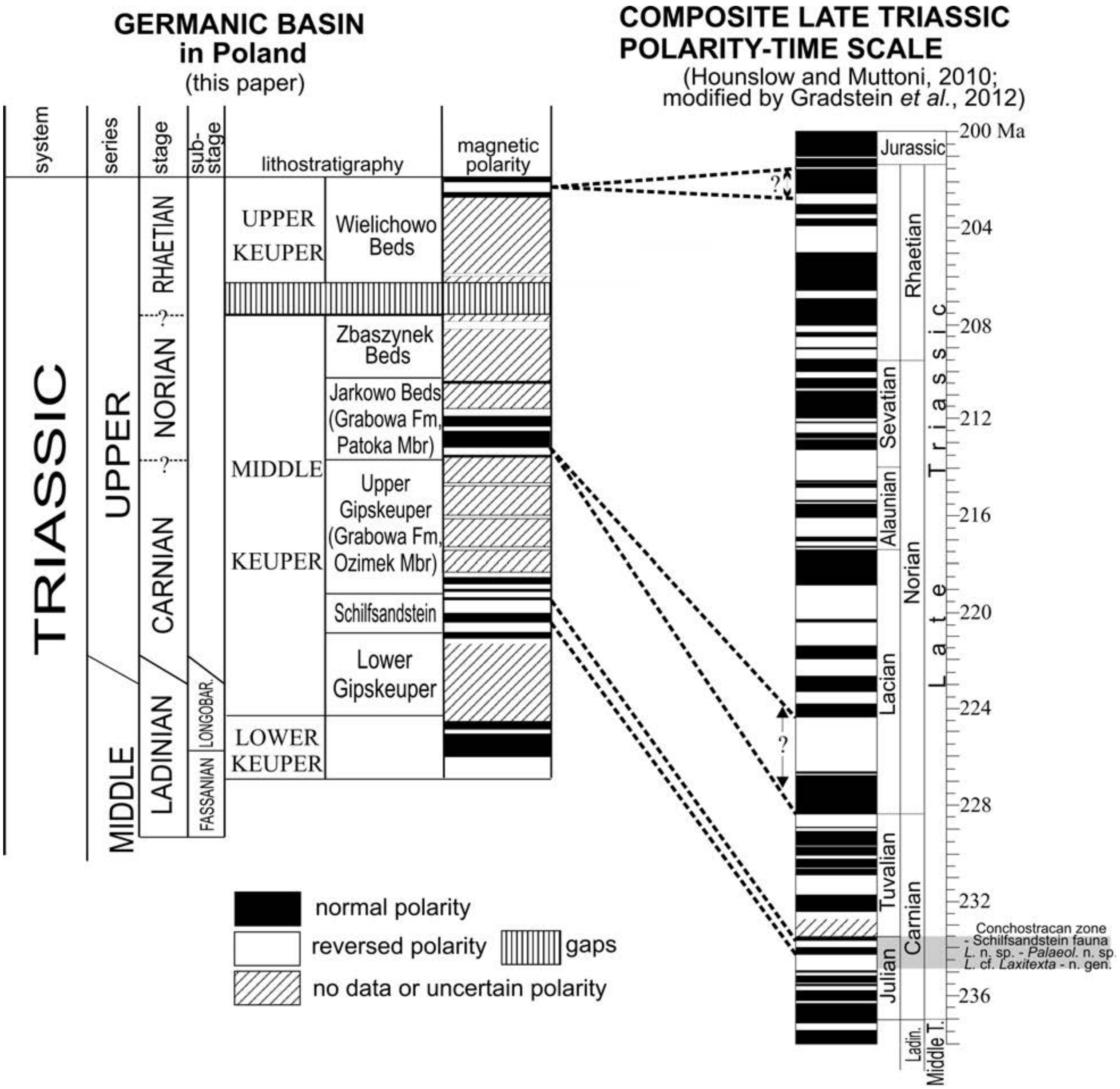

Fig. 9. Correlation of polarity pattern obtained in this study with the composite Late Triassic polarity-time scale, prepared according to a "Long-Rhaetian" option of stratigraphy (see Gradstein *et al.*, 2012, p. 709). Position of Conchostracan zone with Schilfsandstein fauna, according to Kozur and Weems (2010).

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