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ON AGE OF THE „WITÓW SERIES" IN THE LIGHT OF PALAEOMAGNETIC STUDIES

INTRODUCTION

Despite considerable progress made in stratigraphic investigations, contemporaneous geologists are not always able to define precisely the age of certain formations. As far as Poland is concerned, this applies particularly to the Permo-Triassic and Neogene-Quaternary deposits. Recently, palaeomagnetic studies have gained in popularity when applied to deposits devoid of paleontological record. Magnetostratigraphic correlation consists in comparing of the obtained palaeomagnetic readings with the magneto-polarity scale. The range of changes of paleopole (or paleodirection) positions, plotted on geographic coordinates, is also used when dealing with more general stratigraphic problems.

MATERIAL AND METHODS

Our studies concentrated on a nearly 30 m thick series of clastic deposits, called the Witów series (Łyczewska 1948). The area under study is situated at Witów, 50 km east of Cracow, within a gravel pit cut into the northern escarpment of the Vistula river valley (Fig. 1).

These studies aimed at determination of palaeomagnetic parameters in order to define stratigraphic position of the series in question. The latter has been a subject of numerous and, usually, controversial elabora-

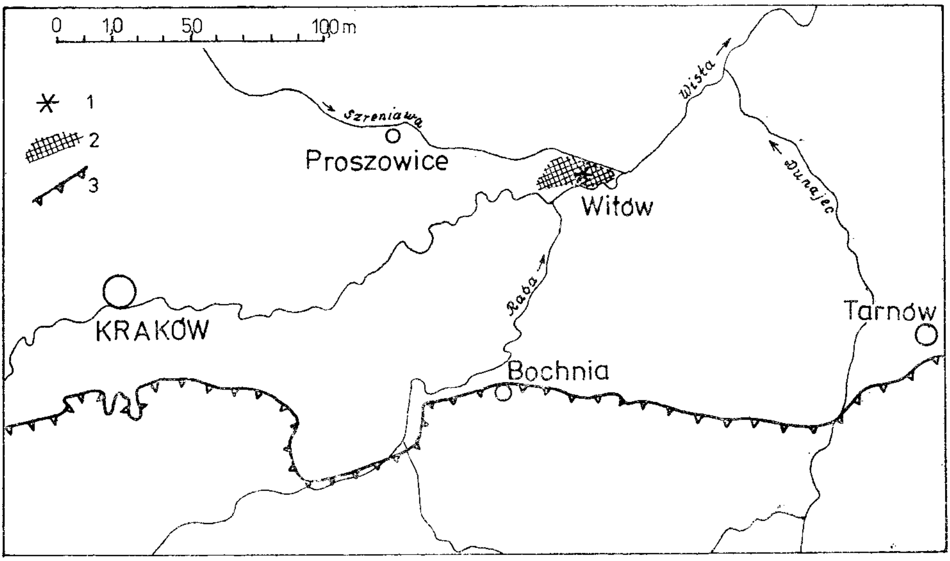

Fig. 1. Localization sketch of the gravel pit at Witów. 1 — localization of the section studied, 2 — extent of the Witów gravels, 3 — Carpathian frontal thrust

Ryc. 1. Szkic lokalizacyjny żwirowni w Witowie. 1 — położenie badanego profilu, 2 — obszar występowania żwirów z Witowa, 3 — czoło nasunięcia Karpat

tions, placing the formation of the series within a time span extending from the Upper Miocene up to the South-Polish glaciation (cf. Łyczewska 1948; Gradziński and Unrug 1959). This series is composed of gravel layers, built up chiefly from Carpathian rocks, intercalated by vari-grained sands, muds and clays. Basing on the occurrence of Miocene microfauna within clay interlayers, Łyczewska (1948) considered them to represent marine deposits, laid down in littoral zone of the Lower Sarmatian (Upper Tortonian) sea, close to the mouths of Carpathian rivers. Rühle (1957), however, put forward an hypothesis of an preglacial age of these deposits, whereas Gradziński and Unrug (1959) thought them to represent fluvial deposits, laid down during an interstadial of the South-Polish Glaciation. The last concept based on the presence of pebbles of crystalline rocks. In subsequent elaborations it has been found that the alleged erratic pebbles represent egzotic rocks, occurring within those flysch complexes which build the Raba river drainage basin (Dżułyński *et al.* 1968; Dżułyński *et al.* 1974). Kucia-Lubelska (1966), in turn, documented the presence of resistant heavy mineral assemblages, forming spectra being distinctly different from those of erratics-bearing deposits of the South-Polish stage. She concluded that the Witów series represents fluvial deposits laid down in a furrow, cut into the underlying Miocene clays, and filled between the Upper Miocene and the South-Polish glaciation.

Dżułyński *et al.* (1968) considered these deposits to have been supplied by the ancient Raba river during the Early Quaternary, at the time of increased tectonic activity in the Carpathians. Such an age estimation was also confirmed by the results of palynological studies by Oszast (cf. Dżułyński *et al.* 1968). Nevertheless, Tyczyńska (1978) following Łyczewska's (1948) ideas, expressed an opinion of the Miocene age of the Witów series, treated as a delta-fan deposited within a shallow embayment of the Volhynian sea, at the time of shaping of the foothills planation level in the Carpathians. Top part of these deposits was thought to represent subaerial delta plain. Recently, Rutkowski (1987) has underlined palaeogeographic situation of the Witów series which overlies unconformably, as do the equivalent Majdan gravels, different Miocene complexes.

Oriented samples for palaeomagnetic studies have been collected from poorly cemented sandstones and mudstones, forming intercalations within the Witów gravels. We obtained 7 samples which have subsequently been subdivided into 28 cubic samples. Moreover, 24 cylindrical samples have been collected from a claystone layer at the top of the series. Every sample has been demagnetized by alternating magnetic field. Each successive demagnetizing step has been followed up by measuring (by the use of a rotational magnetometer JR-4) of the intensity of remanent magnetism components. The results of measurements have been analysed numerically in order to specify the most stable and genuine position of paleopoles. The stable magnetic components have been calculated by the use of an analysis of orthogonal projections, showing the behaviour of horizontal and vertical components of the vector of remanent magnetization. In addition, a criterion of the greatest coincidence of the mean paleodirection has been applied to 4 samples.

RESULTS

The results of demagnetization of rocks in question display a complex character of the vector of natural remanent magnetization (NRM). The coure of changes of horizontal and vertical components of NRM, following demagnetization, is shown best on the orthogonal projection. Projections plotted for selected samples (Figs. 2, 3) point to considerable role being played by the nonstable vector within total magnetism. Only under high demagnetizing fields (500 Oe and more). the directions of NRM components do become more stable. Minor oscillations of these components should be linked with small intensities of magnetism of the remanent vector (several per cent of the initial values of NRM intensity); leading to a relative increase of measurement errors, associated with the precision of laboratory equipment.

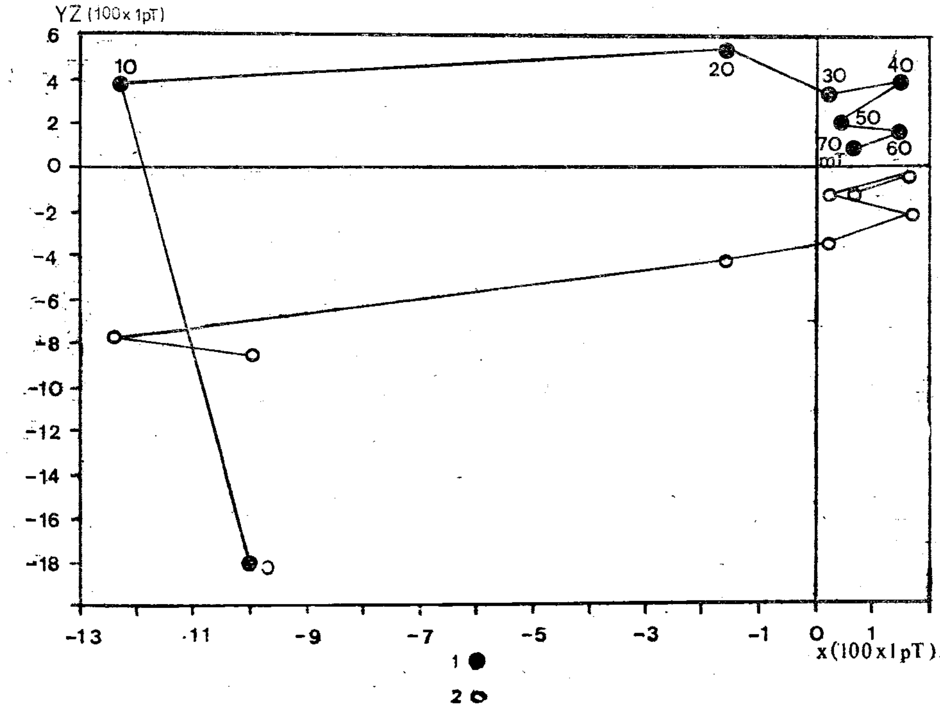

Fig. 2. **Orthogonal diagram** showing the course of demagnetization of the sample W-2b by a **alternating** magnetic field. 1 — projection on the XZ plane, 2 — projection on the XY plane

Ryc. 2. Diagram ortogonalny przedstawiający proces rozmagnesowania polem zmiennym **próbki** W-2b. 1 — projekcja w płaszczyźnie XZ, 2 — projekcja w płaszczyźnie XY

The results of analyses of orthogonal projections of magnetic components, as well as the estimation of the degree of coincidence (under a given demagnetizing field) of paleodirections, calculated for four specimens of mudstone-sandstone deposits, enable one to separate stable (?original) paleodirections. Deposits of the Witów series are characterized by variable magnetic polarity. The process of demagnetizing of a typical sample showing normal polarity (cf. specimen W-2b within sample W-2) is presented in Fig. 2; whereas Fig. 3 portrays demagnetization of a selected sample showing reverse polarity (cf. specimen W-5c within sample W-5). Only two (W-2 and W-3) from seven paleopoles calculated for mudstone-sandstone samples do reveal normal polarity, whilst the remaining ones display reverse polarity. Taking into account the position of individual samples within the section, we observe that the zone of normal polarity separates a broad reverse zone (Fig. 4). Within a clay interlayer occuring at the top of the series, a number of changes of magnetic polarity have been preserved; therefore, we call this zone the zone of mixed polarity (Fig. 4).

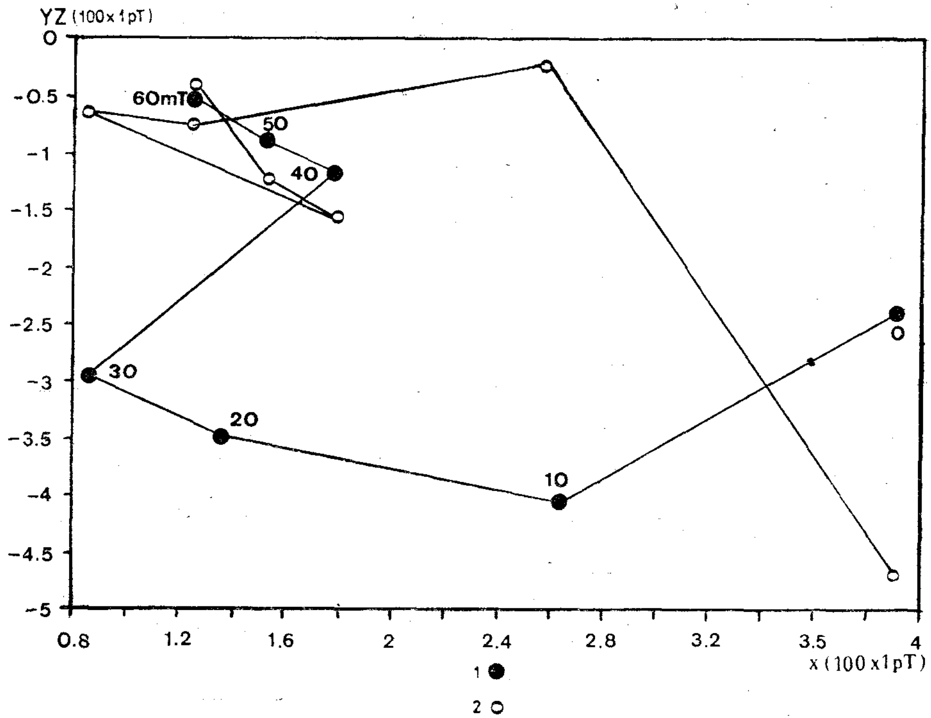

Fig. 3. Orthogonal diagram showing the course of demagnetization of the sample W-5c by a alternating magnetic field. For explanations — see Fig. 2

Ryc. 3. Diagram ortogonalny przedstawiający proces rozmagnesowania polem zmiennym próbki W-5c. Objaśnienia jak na Ryc. 2

CONCLUSIONS

Lithological properties of the Witów series are not suitable for palaeomagnetic investigations; hence, continuous sampling was not possible. Nevertheless, we succeed in obtaining a set of samples, the analysis of which makes possible palaeomagnetic description of the deposits under study. Taking into account exclusively the results of palaeomagnetic analyses, we can conclude that:

— natural remanent magnetism of clastic deposits of the Witów series is of a multicomponent character resulting, most probably, from intensive chemical alterations of magnetic carriers;

— the rocks under study display a changing magnetic polarity, the reverse one being predominant, and

— a comparison of the magnetic polarity record of the Witów section with the standard polarity scale (Fig. 4) allows one to suppose that this series could not originate during the Brunhes epoch, i.e. during the past 700—740 ka.

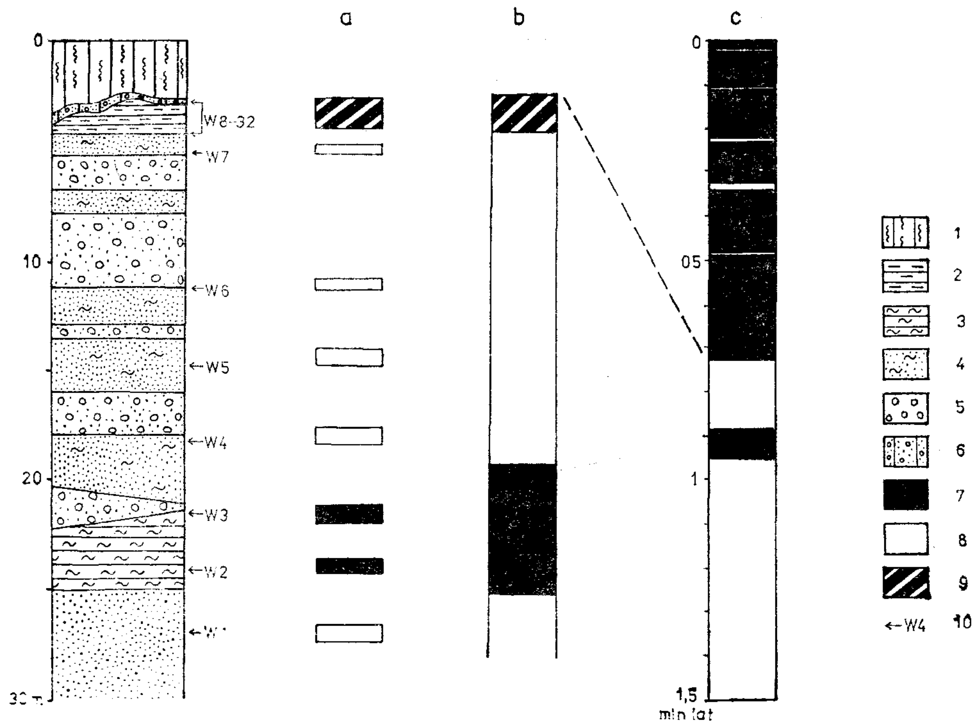

Fig. 4. Schematic lithological log of the Witów series, together with real (a) and interpreted (b) records of magnetic polarity changes, shown versus magnetostratigraphic scale of the last 1.5 Ma (s), compiled after Cox (1969) and Tretyak (1983). 1 — loess, 2 — clays, clayey muds, claystones, 3 — mudstones, 4 — sands and poorly comented sandstones, 5 — pebbles, sands and poorly cemented conglomerates, 6 — sandy loams containing pebbles and cobbles of crystalline rocks (residual till), 7 — normal polarity, 8 — reverse polarity, 9 — mixed polarity, 10 — sampling sites

Ryc. 4. Schematyczny profil litologiczny serii witowskiej oraz rzeczywisty (a) i interpretowany (b) zapis zmian polarności magnetycznej w jego obrębie wraz ze skalą magnetostratygraficzną dla ostatniego 1,5 mln lat (c) zestawioną na podstawie danych Coxa (1969) i Tretjaka (1983). 1 — lessy, 2 — iły, mułki ilaste, iłowce, 3 — mułowce, 4 — piaski i słabo scementowane piaskowce, 5 — żwiry i piaski oraz słabo scementowane zlepieńce, 6 — gliny piaszczyste ze żwirami i głazikami skał krystalicznych (residuum gliny zwałowej), 7 — polarność normalna, 8 — polarność odwrotna, 9 — polarność mieszana, 10 — miejsca opróbowań

The data obtained point to an age older than that estimated by the TL method. The latter led Lindner (1988) to infer that deposits comprised between residual till at the top and the gravels at the bottom should be of the South-Polish (Sanian-2) age. The underlying sediments were thought to represent the Narewian(?) glacial stage. The upper TL date of Lindner (467 ± 70 ka BP) is nearly two-fold rejuvenated, as compared to the results of palaeomagnetic analyses. The top part of the section at Witów displays several changes in magnetic polarity; a feature being indicative of the Brunhes/Matuyama boundary. The reverse magnetic polarity indicates that the Witów series could have been deposited during the Matuyama reverse epoch (Fig. 4). The section of normal polarity occurring within this epoch may be correlated with the Jaramillo event. The lower TL date (952 ± 142 ka BP), quoted by Lindner (1988), corresponds with palaeomagnetic determinations far more better than the upper one.

The results of palaeomagnetic studies seem to confirm suggestions put forward by Dżułyński *et al.* (1968), estimating the time of deposition of the Witów series for the earliest Quaternary.

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STRESZCZENIE

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Wiek „serii witowskiej" w świetle wyników badań paleomagnetycznych

Przedmiotem analizy paleomagnetycznej były klastyczne osady serii witowskiej (Łyczewska 1948), których powstanie wiązano z różnymi okresami mieszczącymi się w przedziale od górnego miocenu do zlodowacenia południowopolskiego włącznie (Łyczewska 1948; Gradziński, Unrug 1959; Rühle 1957; Dżułyński i in. 1968; Kucia-Lubelska 1966; Tyczyńska 1978; Lindner 1988). Porównanie zapisu zmian polarności magnetycznej w obrębie badanego profilu ze skalą zmian polarności (Ryc. 4) wskazuje na to, że seria witowska nie mogła powstać w czasie trwania epoki magnetycznej Brunhes.

Dla stropowej części badanego profilu utrwaliło się kilka zmian polarności magnetycznej, co jest charakterystyczne dla granicy Brunhes/Matuyama. Odwrotna polarność magnetyczna pozwoliła przyjąć, że akumulacja serii witowskiej następowała w czasie trwania epoki paleomagnetycznej Matuyama. Otrzymane dane z badań paleomagnetycznych są najbardziej zbieżne z wynikami badań przeprowadzonych przez Dżułyńskiego, Krysowską-Iwaszkiewicz, Oszast i Starkla (1968), którzy przyjęli że seria ta została osadzona w okresie najstarszego czwartorzędu. Przeprowadzone badania paleomagnetyczne wskazują, że seria ta jest starsza prawie dwukrotnie w stosunku do oznaczeń wieku metodą TL (Lindner 1988).

РЕЗЮМЕ

Я. Навроцки, А. Вуйцик

ВОЗРАСТ „ВИТОВСКОЙ СЕРИИ" В СВЕТЕ ИТОГОВ ПАЛЕОМАГНЕТИЧЕСКИХ ИССЛЕДОВАНИЙ

Предметом палеомагнетического анализа являлись кластические отложения витовской серии (Лычевска 1948), возникновение которых относили к различным периодам: от верхнего миоцена до южнопольского оледенения включительно (Лычевска 1948; Градзиньски, Унруг 1959; Рюле 1957; Джулыньски *и бр.* 1968; Куця-Любельска 1966; Тычиньска 1978; Линднер 1988). Сопоставление записи изменений магнетической полярности в пределах исследуемого профиля со шкалой изменений полярности (Рис. 4) свидетельствует о том, что витовская серия не могла возникнуть в период магнетической эпохи Бруньес.

В кровельной части исследуемого профиля сохранилось несколько изменений магнетической полярности, характерных для рубежа Бруньес/Матуйяма.

Обратная магнетическая полярность позволила принять, что аккумуляция витовской серии имела место в палеомагнетическую эпоху Матуйяма. Полученные в результате палеомагнетических исследований данные наиболее близки к результатам исследований, проводившихся Джулыньским, Крысовской-Ивашкевич, Ошаст и Старкелем (1968), считавшими, что данная серия была отложена во время самого старшего четвертичного периода. Проведенные палеомагнетические исследования показывают, что эта серия почти в два раза старше по сравнению с обозначениями возраста по методу ТЛ (Линднер 1988).