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Palaeomagnetism and Magnetostratigraphy from the Early Miocene Lignite Opencast Mine Oberdorf (N Voitsberg, Styria, Austria)

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1 Text-Figure and 1 Table

Styria
Pannonian Basin
Styrian Basin
Lignite
Early Miocene
Palaeomagnetism
Magnetostratigraphy

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Palaeomagnetismus und Magnetostratigraphie im untermiozänen Braunkohlentagebau Oberdorf (N Voitsberg, Steiermark, Österreich)

Zusammenfassung

Im Rahmen einer multidisziplinären Studie über das Köflach-Voitsberger Kohlerevier, Steiermark, Österreich, wurden in Oberdorf paläomagnetische Untersuchungen durchgeführt, die Hinweise auf eine Rotation des Beckens von 20° im Gegenuhrzeigersinn ergaben. Die gesamten Sedimente der Liegendabfolge und Teile der Sedimente der Hangendabfolge bis 13 Meter über dem obersten Hauptflöz zeigen inverse Magnetisierung, der übrige Teil der Sedimente der Hangendabfolge zeigt normale Magnetisierung. Mit Hilfe einer reichen Wirbeltierfauna der Neogenen Säugetierzone MN4 aus den Sedimenten der höheren Hangendabfolge kann der normal magnetisierte Teil der Hangendabfolge biostratigraphisch mit dem Chron C5Dn und der liegende, invers magnetisierte Teil des Profils mit dem Chron C5Dr korreliert werden. Nach der GPTS ist das Alter des Polaritätswechsels C5Dr/C5Dn bei 17,6 Ma. Damit kann für die Abfolge ein ottnangisches Alter postuliert werden.

Abstract

In the frame of a multidisciplinary study of the Köflach-Voitsberg lignite mining district in Styria, Austria, palaeomagnetic analyses provided evidence for a 20° counterclockwise rotation of the basin with respect to present North direction. The entire sediments of the footwall sequence and parts of the hanging wall sequence sediments up till 13 meters above the uppermost main coal seam are reversely magnetized, the rest of the hanging wall sequence sediments are normally magnetized. The rich mammal fauna from the upper part of the hanging wall sequence, indicative of Neogene Mammal Zone MN4, allows a biostratigraphic correlation of the normally magnetized part of the section with Chron C5Dn and the lower, reversely magnetized part of the section with Chron C5Dr of the GPTS. The age of the polarity change C5Dr/C5Dn is according to the GPTS at 17.6 Ma. and indicates an Ottnangian Age of the section within the Central Paratethys Time Scale.

1. Introduction

For Mesozoic to Quaternary times, the geomagnetic polarity record is central to the construction of geologic time scales, linking biostratigraphies, isotope stratigraphies and absolute ages (OPDYKE & CHANNEL, 1996). Changes of the polarity of the earth's magnetic field are world wide phenomena, enabling correlation and dating of geological

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material. In the open cast mine of Oberdorf, a detailed magnetostratigraphic section of the coal bearing sequence was studied with the task of an age determination for the sediments. Palaeomagnetic results gave evidence for the palaeolatitude during the time of the sediment formation, as well as the tectonic development of the basin with respect to the North Pannonian Tertiary basin.

2. Methodology

The vast majority of the samples were taken by using nonmagnetic plastic cylinders with 25 mm diameter and 22 mm length, which were penetrated into the sediment surface, while only a few outcrops were suitable for drilling with diamond drill-bits. By means of an orientation table, the samples were oriented with standard palaeomagnetic techniques (TARLING, 1983). To prevent the sediments from drying, the samples were kept cool until laboratory measurements were finished.

All samples were progressively demagnetized with alternating magnetic fields of 140 mT in order to study the stability of different components of the natural remanent magnetization (SOFFEL, 1991). For most of the samples, thermal cleaning technique could not be applied, because the sediments disintegrated during heating. Viscosity of the magnetization, saturation behaviour and anisotropy of magnetic susceptibility (AMS) were studied on selected samples. All measurements were carried out in the Paleomagnetic Laboratory of the University of Leoben using a 2G three-axis cryogenic magnetometer and a KLY-2 magnetic susceptibility bridge.

The magnetic susceptibility of geological materials is a measure of the concentration of the magnetic minerals. Accompanying measurements of the anisotropy of magnetic susceptibility (AMS) can be used to describe the fabric of sediments so that their origin and evolution can be determined (TARLING & HROUDA, 1993).

The demagnetization behaviour gives information about the magnetic carriers and enables the discrimination between primary magnetization directions and magnetization components from magnetic overprints and chemical alteration (COLLINSON, 1983). Remanent magnetization is durable even for geological times, while viscose components represent relatively young magnetization ages, giving rise for chemical alteration of magnetic phases in the mineral assemblage. Viscose magnetization vectors are typically aligned parallel to the recent earth magnetic field and can be destroyed by magnetic cleaning with alternating fields. The nature and age of the secondary minerals was observed by application of a defined laboratory field to the demagnetized samples with measurements of the viscose magnetization over a period of two years (DUNLOP, 1973). Stepwise saturation with magnetic fields of 1.45 Tesla, measurements of the coercivity and demagnetization of the saturation magnetization helped to identify the magnetic minerals in the sediments.

3. Sampling

Several sampling campaigns were carried out from April 1995 until May 1997 together with sedimentologists and palaeontologists of the interdisciplinary research group. A total of 500 samples were taken from outcrops and also 350 samples from drill cores. Oriented samples were taken for magnetostratigraphic and paleomagnetic analyses from 13 outcrops in the open cast mine of Oberdorf, 3 outcrops in the open cast mine of Zangtal/Muttekogel and 1 outcrop in the open cast mine Barbarapfeiler. In the near vicinity of the mine, additional samples were taken from the basement rocks (Gosau) and overlaying tuffites, representing the geological frame. Every sampling site gave at least 6 individual samples, enabling statistical evaluation of the results (FISHER, 1953).

Due to recent land slide activity in the open cast mine, a proposed excavation for a magnetostratigraphic section of the coalbearing sequence was prohibited by the pit owner. Instead of the excavation, a drill core of 100 meters length, which originated from an exploration campaign in 1991 (BK 22; co-ordinates: x 216033.00, y –90049.00, altitude: 519.33 m), was subsampled in the drill core storage of the Graz-Köflacher Eisenbahn- und Bergbau-Gesellschaft (GKB). Correlation of susceptibility logs from different drill cores proved the completeness of BK 22, which is representative of the open cast mine of Oberdorf as a whole (LENZ & BERNHARD, 1993). The core provided over 300 samples for magnetostratigraphic analyses, with orientation parallel to the bedding strike direction. Sediments from the seam partings as well as parts of the footwall of the main seam were typically disintegrated and therefore excluded from sampling. Weathering was observed on the whole drill core.

Additionally, a drill core from 1995 (BJ 1) was subsampled for the study of viscose magnetization components. Due to the small diameter of the drill, all samples from drill core BJ 1 showed viscose magnetic overprints, which were related with coring. The drill cores for sedimentological studies in the frame of this project with a similar diameter were thereafter not studied for magnetostratigraphy.

4. Results

Measurements of low field susceptibility showed a weak, predominantly paramagnetic bulk susceptibility for the majority of the samples, indicating a limited ferromagnetic content in the mineral assemblage, while some specimen reached values of 5×10^{-4} SI units. Low field anisotropy of magnetic susceptibility of the sediments was typically insignificant, except for some isolated sites with poorly defined magnetic foliation parallel or sub-parallel to the sedimentary bedding planes. The magnetic fabric of the samples was evidently not affected by the post-depositional compaction of the sediments.

Stepwise acquisition of isothermal remanent magnetization and successional stepwise demagnetization with alternating fields gave evidence for the presence of magnetite with varying contributions of a secondary magnetic phase, while haematite was only observed in samples from the immediate hanging wall of the main coal seam. The remanent magnetization of most of the samples was dominated by a viscose component, which goes along with the presence of siderite and goethite in the sediments, as demonstrated by X-ray analysis (HAAS, this volume). Due to the influence of siderite, less than 20 % of the samples showed successful demagnetization behaviour with useful demagnetization paths. Consequently, two selection principles were applied for the exclusion of results prior to the statistical calculations: The occurrence of a viscose component carried by siderite, and directional instability of the demagnetization vector path in the range between 2mT and 10 mT. The direction of the characteristic magnetization for the remaining samples was defined by a stable demagnetization path towards the

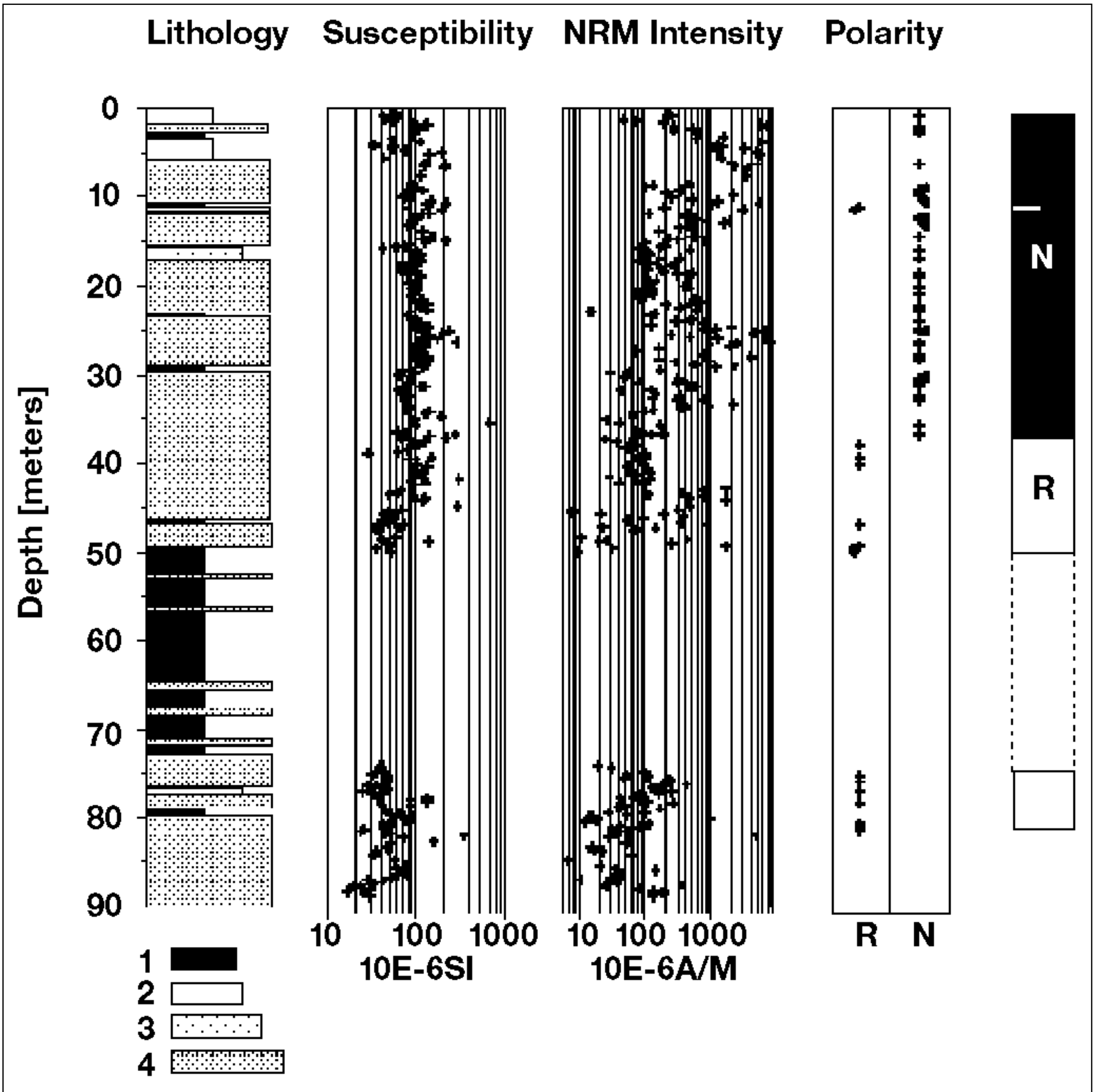

Fig. 1.
Combined magnetostratigraphic results for the coal bearing sequence in the open cast mine of Oberdorf.
Results from outcrops are projected into the according stratigraphic position in the drill core BK 22.
Lithology: 1 = coal, 2 = sandstone, 3 = sandy marl, 4 = marl.
Symbols: + = drill-core BK22, • = outcrops.
Polarity: R = reverse, N = normal.
The extension of the reverse chron over the coal seams is a hypothesis derived from estimated sedimentation rates.

origin in an interval between alternating fields of 5 mT and 30 mT.

The remaining results from outcrops and from the drill core provided a reliable magnetostratigraphy for the sequence under investigation (Text-Fig. 1). The footwall of the coal seams and the lower part of the hanging wall were reversely magnetized, while normal polarity occurred in the upper part of the hanging wall. The boundary between the polarity zones was observed in the drill core, 13 meters above the upper seam. In the uppermost part of the sequence, a sediment layer of 0,6 meters thickness in the drill core as well as samples from a corresponding site in the vicinity of the vertebrate site corresponding to the Neogene Mammal Zone MN4 (DAXNER et al., this volume) yielded reverse magnetization directions. Although these sediments showed alteration, there was no evidence found for a magnetic overprint in the samples. Thus the primary origin of the reverse component and the occurrence of a short reverse interval within the normal polarity zone could not be excluded.

The palaeomagnetic mean direction for the coal bearing sequence in the open cast mine of Oberdorf was derived from results of 31 samples in 9 different outcrops: Dec = 341°, Inc = 53°, $\alpha95$ = 5° (Tab. 1). Due to similar bedding planes, the fold test after MCELHINNY (1964) gave insignificant results. Both the counterclockwise rotation (19°±8°)

Table 1.
Mean palaeomagnetic directions for the open cast mine of Oberdorf and results from comparable Tertiary basins.
N = number of samples; D/I_{bc} = characteristic remanence direction before tilt correction; D/I_{ac} = after tilt correction; $\alpha 95$ = semi-angle of 95 % cone of confidence.

Locality	Age	N	D/I_{bc}	D/I_{ac}	α_{95}	Reference
Oberdorf open cast mine	Ottnangian	31	344 / 54	341 / 53	5.2	this paper
Lobmingberg, Tuffites	? Carpathian	10	160 / -49	160 / -49	18.6	this paper
Teiritzberg	Carpathian	19	3 / 55	340 / 49	5.6	Scholger, 1998
Obergänserndorf	Carpathian	39	336 / 56	336 / 56	3.7	Scholger, 1998
Little Carpathians	19 -16.5	74		341 / 59	3.3	Tunyi & Kovac, 1991
Bükk mountains	Ottnangian	23	337 / 56	334 / 45	4.5	Marton & Mauritsch, 1990
Matra mountains	Ottnangian	14	333 / 54	331 / 48	11.0	Marton & Mauritsch, 1990

N: number of samples. D/I_{bc} : characteristic remanence direction before tilt correction. D/I_{ac} : ..after tilt correction. α_{95} : semi-angle of 95 % cone of confidence.

and the palaeolatitude (34°±5°) agreed with results from comparable sediments of the Korneuburg basin in Austria (SCHOLGER, 1998), the Little Carpathians (TUNYI & KOVAC, 1991), and various Tertiary basins in Hungary (MARTON & MAURITSCH, 1990). Thermal treatment with temperatures of 700°C leads to a corresponding palaeomagnetic result for the tuffites from Lobmingberg, which overlay the coal bearing sequence (EBNER et al., this volume). The post depositional tectonics of the area under investigation compares with the development observed in the North Pannonian Tertiary basin as presented by MAURITSCH & MARTON (1995).

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