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IUGS UNESCO 580 IGCP

Application of Magnetic Susceptibility on Palaeozoic sedimentary rocks

Miroslav Krs Conference: Time, Magnetism, Records, Systems and Solutions

The 2011 Annual IGCP 580 Meeting, October 12 – 18 Prague, Czech Republic

Abstract Volume

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Editors:

Leona Koptíková, Jindřich Hladil, Jiří Adamovič

Geologický ústav AV ČR, v.v.i.
Institute of Geology AS CR, v.v.i.

Prague 2011

Content

Venue

Geologický ústav AV ČR, v.v.i.
Institute of Geology AS CR, v.v.i.

Conference topics

- applications of magnetic susceptibility on Palaeozoic or younger rocks
- magnetic methods in environmental research
- material science
- magnetism in biology, medical science
- records of processes, analyzing the signal and understanding the behaviour of complex systems

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Volume dedication to Miroslav Krs

Miroslav Krs

born on 17 October 1928 in Bučany, district Hlohovec (83) – is an eminent (palaeo)magnetist and magneto-mineralogist, recognized with F. Posepny Medal in 2000, and founder of the Průhonice Paleomagnetic Laboratory (Institute of Geology ASCR, v. v. i.). Although being from WW-II generation, his counts in WoS are 50, with 384 citations (298 citing papers), where the most cited papers relate to greigite or greigite-smythite/ pyrrhotite and also paleomagmetism in service to orogenic and tectonic studies .
He is suffering from severe chronic disease now, and the Conference pays homage to him.

Conference programme

October 12 – Wednesday – 1st day

Registration of participants: 8:30-9:00

Opening of the meeting: 9:00-9:30

Block 1 – chairman Thomas Suttner

9:30-9:50
Petr **PRUNER** — *Miroslav Krs – a pioneer of palaeomagnetism in the Czechoslovakia*

9:50-10:20
Anne-Christine **DA SILVA** — *Magnetic susceptibility evolution in the Eifelian-Givetian Baileux section (Belgium): complex origin of the magnetic susceptibility signal*

10:20-10:40
Xavier **DEVLEESCHOUWER** — *The Givetian-Frasnian boundary at the GSSP (Puech de la Suque, Montagne Noire, France): a multi-proxies approach. Is there a need to search for another GSSP section?*

Coffee break: 10:40-11:10

Block 2 – chairman Anne-Cristine da Silva

11:10-11:30
Frédéric **BOULVAIN** — *Preliminary study of MS-facies relationship in Bajocian-Bathonian carbonates from eastern and north-eastern Paris Basin*

11:30-11:50
Michael T. **WHALEN** — *Controls on magnetic susceptibility during the Late Devonian punctata Event in the Western Canada Sedimentary Basin: insight from trace element paleoceanograhic proxies and factor analysis*

11:50-12:10
Daizhao **CHEN** — *Carbonate platform development and biotic recovery during the Late Devonian Famennian, South China: constraints from cycle and sequence stratigraphy*

12:10-12:30
Ulla **PREEDEN** — *Magnetic susceptibility of Ordovician sedimentary succession in Pakri drill cores, NW Estonia*

12:30-12:50

Jacek **GRABOWSKI** — *Complex origin of magnetic susceptibility in the Eifelian dolostones of Zachełmie Quarry (Holy Cross Mts, Poland): implications for stratigraphical and palaeoenvironmental interpretations*

Lunch: 13:00-14:00

Afternoon special topic lectures & training courses

Prof. Ing. Ivo **ŠAFAŘÍK**, PhD., DrSc. 14:00-15:30
Institute of Nanobiology and Structural Biology of GCRC, ASCR, v. v. i.

Magnetic particles for bio- and environmental applications

Coffee break: 15:30-16:00

RNDr. Eduard **PETROVSKÝ**, CSc. 16:00-17:00
Institute of Geophysics ASCR, v. v. i.

Magnetic particles in different environments: identification and significance

Poster session: 17:00-18:00

Didem TANIK **DENIS** & Ali **AYDIN** — *Pollution distribution of and around Denizli City by using magnetic susceptibility measurements*

Erika **KIDO** — *Magnetic susceptibility as tool for high-resolution correlation of pelagic and distal slope facies of the Middle Devonian in the Carnic Alps: preliminary results*

Otakar **MAN** — *The common cycles recorded by magnetic susceptibility observed in distant magnetostratigraphic sections*

Damien **PAS** — *Sedimentology and magnetic susceptibility on a continuous Middle Givetian to Lower Famennian fore-reef succession (Sauerland, Germany): A new example of MS study for long-distance correlations (Germany, Belgium and Moravia)*

Mehrdad **SARDAR ABADI** — *Sedimentology and magnetic susceptibility of Mobarak Formation (Lower Carboniferous in central and eastern Alborz Mountains, North of Iran)*

František **VACEK**	*Upper Silurian (Ludfordian) Lau event viewed by magnetic susceptibility and gamma-ray spectrometry (Prague Synclinorium, Czech Republic)*
YAICH Chokri	*Application of magnetic susceptibility to tidal flats environment and cyclostratigraphy of the late Hauterivian Bouhedma formation using time-series analysis, Khanguet Aicha area, Eastern junction of the Northern Chotts range, Tunisia*

Roasted pig & wurst evening garden barbecue: 18:00-??

October 13 – Thursday – 2nd day

Block 3 – chairman Xavier Devleeschower

8:30-8:50
Laurent **RIQUIER** — *Eustatic and climatic variations at the Frasnian-Famennian boundary in the Rhenish Massif (Germany): New insight from magnetic susceptibility microfacies, clay assemblages and elemental concentrations*

8:50-9:10
Katarzyna **SOBIEŃ** — *Late Silurian $\delta^{13}C$ excursion event in the light of rock magnetic analyses: a case study form Mielnik IG-1 borehole, E Poland*

9:10-9:30
Vasudeva Kaimal **PRASANNAKUMAR** — *Magnetic Susceptibility Analysis of upper Cretaceous marine sediments of Trichinopoly, South India*

9:30-9:50
David **DE VLEESCHOUWER** — *Cyclostratigraphic calibration of the Frasnian (Late Devonian) time-scale (Western Alberta, Canada)*

9:50-10:10
Jacek **GRABOWSKI** — *Magnetic susceptibility variations at the Jurassic-Cretaceous boundary (Pośrednie III section, Tatra Mts., Western Carpathians, Poland): correlations with geochemical proxies and sea-level changes*

Coffee break: 10:10-10:40

Block 4 – chairman Katarzyna Sobień

10:40-11:00
Tomáš **NAVRÁTIL** — *Recent occurrence and properties of suspended solid particulate material at Prague-Suchdol, Czech Republic*

11:00-11:20
Jaroslav **KADLEC** — *Environmental magnetic record in the Late Holocene floodplain deposits – A key study from the Strážnické Pomoraví (Morava River catchment, Czech Republic)*

11:20-11:40
Thomas **SUTTNER** — *Magnetic susceptibility research in the Carnic Alps*

11:40-12:00
Günther **KLETETSCHKA** — *Heat, magnetic field and wind analysis from the samples that have experienced the Tunguska blast in Siberia, Russia*

12:00-12:20
Jaroslav **KADLEC** — *Rock magnetism and magnetic fabric of Cypris Formation as indicators of paleoenvironmental changes in the Sokolov Basin (NW Bohemia)*

12:20-12:40
Lenka **LISÁ** — *New results on the paleoclimate record of the Late Pleistocene cave sediments (Moravian Karst, Czech Republic); the case study based on mineral magnetic properties and facial analyses*

Lunch: 13:00-14:00

Afternoon special topic lectures & training courses

RNDr. Aleš **KAPIČKA**, CSc. 14:00-14:50
Institute of Geophysics ASCR, v. v. i.

Magnetic properties of soils - a basis for pollution mapping

Prof. RNDr. František **HROUDA**, CSc. 14:50-15:50
Agico Ltd.; Charles University in Prague

Identifying ultrafine magnetic particles in rocks and soils using frequency-dependent magnetic susceptibility and out-of-phase susceptibility

Coffee break: 15:50-16:20

Mgr. Martin **CHADIMA**, PhD. 16:20-17:10
Agico Ltd.; Institute of Geology ASCR, v. v. i.

Processing rock magnetic data acquired by Agico Ltd. instruments

October 14 – Friday – 3rd day

The conference field trip to the Barrandian area (Silurian, and Lower, Lower-Middle Devonian):
Koněprusy Area – Čertovy schody Quarry (Lower Devonian)
Klonk section (Devonian GSSP)
Branžovy Quarry (Lower Devonian)
Kosov Quarry (Silurian)

Departure from the hotel "Wienna Galaxie" at 8:00 A.M.

October 15 – Saturday – 4th day

IGCP 580 business meeting in the morning, free afternoon for sightseeing in Prague etc.

October 16-18 – Sunday to Tuesday

Working days in the Barrandian Area and parallelly in the Moravian Karst.

Barrandian working group:	departure from the hotel "Wienna Galaxie" at 8:30 A.M.
Moravian Karst working group:	departure from the hotel "Wienna Galaxie" at 8:00 A.M.

Abstracts

Carbonate platform development and biotic recovery during the Late Devonian Famennian, South China: constraints from cycle and sequence stratigraphy

Daizhao CHEN[1], Maosheng JIANG[1], Maurice E. TUCKER[2] & Hairuo QING[3]

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ORAL PRESENTATION

During the early Middle Devonian in South China, a complicated pattern of carbonate platforms and interplatform basins was shaped and persisted throughout the Devonian as a result of accelerated crustal extensional activity. In the Upper Devonian Famennian, carbonate successions are characterized by widespread microbialites and fenestral limestones generally barren of normal marine macrofossils, although recovering in the uppermost Famennian, due to the mass extinction at the end-Frasnian. Five depositional facies, including peritidal, restricted shallow subtidal, semi-restricted subtidal, intermediate subtidal and deep subtidal facies, are recognized from three measured sections on three isolated platforms. These deposits are arranged into metre-scale, upward-shallowing cycles, capped by either peritidal or subtidal facies, which resulted from high-frequency (fourth- to fifth-order) sea-level fluctuations. The vertical cycle stacking patterns are well displayed by the Fischer plot, which illustrates the long-term changes in accommodation space.

In the Famennian successions, eight third-order sequences (S1 – S8) are identified from changes in cycle stacking patterns, vertical facies, and stratigraphic distribution of subaerial exposure indicators. These sequences mostly consist of a lower transgressive part and an upper regressive part. Transgressive packages are dominated by thicker-than-average subtidal cycles, and regressive packages by thinner-than-average peritidal cycles. Sequence boundaries are transitional zones composed of stacked, high-frequency, thinner-than-average cycles with upward-increasing intensity of subaerial exposure, rather than individual, laterally traceable surfaces. These sequences can be well correlated with the Famennian sequences proposed by Haq and Schutter (2008), indicating a eustatic control.

However, the correlation of long-term accommodation changes indicated by the Fischer plots shows that an increased accommodation loss occurred both on platforms and in interplatform depressions (or basins) during the early Famennian (S1 – S3). However, an opposite pattern in accommodation change took place between the two settings during the middle Famennian (S4 – S6) as the increased accommodation loss took place on platform interiors, whereas an opposite trend in accommodation change occurred on more open shelves (or in interplatform basins). This suggests that the movement on faults (or block-tilting) resulted in the relative uplift of platforms and in the subsidence of interplatform basins. This scenario also points towards an intensified extensional activity by which differential variations in accommodation space took place across platforms during this time. During the late Famennian (S6 – S8), the accommodation changes in different settings approximately followed a similar increasing trend. Therefore, to a longer-term interval and broader extent, the development and evolution of the Devonian carbonate platforms in South China were mainly controlled by episodic extensional rifting, superimposed with eustatic sea-level fluctuations.

Sequence stratigraphic correlation further reveals that the biotic recovery after the Frasnian-Famennian mass extinction was diachronous, early in the nearshore intrashelf basin, and gradually expanding seawards to offshore cleaner platforms. This scenario implies that biotic refugia may have existed during the Frasnian-Famennian crisis near the terrestrial – marine transition.

Magnetic susceptibility evolution in the Eifelian-Givetian Baileux section (Belgium): complex origin of the magnetic susceptibility signal

Anne-Christine DA SILVA[1], Mark J. DEKKERS[2], Cédric MABILLE[1] & Frédéric BOULVAIN[1]

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ORAL PRESENTATION

The Eifelian – Givetian section from Baileux (near Couvin, close to the French Border) is composed of very argillaceous limestones with crinoids and brachiopods (top of Jemelle Formation), followed by argillaceous carbonates alternating with carbonates with crinoids and stromatoporoids (Hanonet Formation) and by carbonates with crinoids, corals and stromatoporoids (base of Trois Fontaines Formation). These facies are interpreted as corresponding to a fore-reef setting, characterized by a strong influence of storm events within the deepest facies. Crinoidal meadows constitute the intermediate facies, developed within the fair-weather wave base. In even shallower position, the shallowest facies observed are still from a fore-reef setting, and are characterized by a high proportion of crinoids, mixed with clasts or peloids coming from the reef or back-reef zone. The link between Magnetic Susceptibility (MS) and facies evolution is different in the lower part and the upper part of the section. The lower Jemelle and Hanonet Formations are characterized by an alternation of facies with "background" distal characteristics and facies with a more proximal input. The major process controlling the facies evolution is considered here as being the carbonate influx, interpreted as relatively independent of bathymetry (Mabille & Boulvain, 2008). This makes the bathymetrical trends difficult to interpret and could explain the observed lack of relationship between MS and microfacies. Concerning the Trois-Fontaines Formation, the MS and microfacies curves show a clearly parallel trend, similar to what is observed elsewhere in the Frasnian of Belgium (da Silva & Boulvain, 2006), with an increase in MS with the shallowest facies.

Considering this complex relationship between MS and palaeoenvironments and the fact that the main Variscan remagnetization event was recognized in the Devonian rocks of the Ardennes (Zegers *et al.*, 2003), a full understanding of what is driving the magnetic susceptibility signal is critical to a better understanding of its origin. To further investigate the link between magnetic parameters, facies and diagenesis, an extended rock-magnetic characterization was performed on a selection of 24 samples from Baileux. This magnetic property data set, consisting of hysteresis measurements and IRM (isothermal remanent magnetization) acquisition curves, both at room temperature, serves to explain the origin of the magnetic susceptibility signal in these sediments. Furthermore, geochemical analyses (XRF) are carried out, mostly analyses of elements such as Zr, Rb, Ti and Al acknowledged detrital proxies. This allows a better understanding of the link between magnetic properties and detrital inputs.

References:

DA SILVA, A.-C. & BOULVAIN, F., 2006. Upper Devonian Carbonate Platform Correlations and Sea Level Variations Recorded in Magnetic Susceptibility. Palaeogeography, Palaeoclimatology, Palaeoecology, 240, 373-388.

MABILLE, C. & BOULVAIN, F., 2008. Les Monts de Baileux section: detailed sedimentology and magnetic susceptibility of Hanonet, Trois-Fontaines and Terres d'Haurs formations (Eifelian/Givetian boundary and lower Givetian, SW Belgium). Geologica Belgica, 11, 93-121.

ZEGERS, T.E., DEKKERS, M.J. & BAILY, S., 2003. Late Carboniferous to Permian remagnetization of Devonian limestones in the Ardennes: Role of temperature, fluids, and deformation. Journal of Geophysical Research, 108, 5/1-5/19.

Cyclostratigraphic calibration of the Frasnian (Late Devonian) time scale (Western Alberta, Canada)

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ORAL PRESENTATION

Currently, only few U-Pb isotopic dates constrain the Devonian geological time scale, hampering a detailed understanding of the rates of sedimentation processes, environmental changes and key-events in the evolution of life on Earth. One possible way to reduce uncertainties in the Devonian geological time scale is the recognition of astronomical cycles in its stratigraphy. Therefore, this study reports frequency analyses of high-resolution (10 – 20 kyr) magnetic susceptibility (MS) data of the Frasnian (Late Devonian), derived from carbonate-platform and surrounding slope and basin deposits in western Alberta, Canada. Previous studies demonstrated the generally consistent pattern of MS change across the Alberta basin and demonstrated the utility of MS stratigraphy as a refined regional correlation tool, compared to biostratigraphy. In the present study, it is shown that the MS stratigraphy of the Frasnian in western Alberta is significantly influenced by astronomical forcing. Cyclicity in the studied sections is ascribed to different Milankovitch astronomical parameters. The astronomical interpretation of the observed periodicities is supported by the presence of several amplitude modulations consistent with astronomical theory, and by average sedimentation rate patterns that agree with the existing lithostratigraphy. Sixteen 405kyr long eccentricity cycles are recognized in the Frasnian MS stratigraphy. By using these cycles as a geochronometer, a Frasnian astronomical time scale is constructed. This time scale indicates a duration of 6.5 ± 0.4 Myr for the Frasnian. Calibrating this duration to the Kaufmann (2006) Devonian chronology, the absolute age of the Givetian-Frasnian boundary is recalculated to 383.6 ± 3.0 Ma and the age of the Frasnian-Famennian boundary to 376.7 ± 3.0 Ma. These new absolute ages take into account the astronomically derived duration of the Frasnian, and yield a narrowing of the error margins of the absolute ages by several hundred thousand years. Therefore, this study demonstrates that the recognition of astronomical cycles can also significantly refine the Paleozoic geological time scale.

References:

KAUFMANN, B., 2006. Calibrating the Devonian Time Scale: A synthesis of U – Pb ID–TIMS ages and conodont stratigraphy. Earth-Science Reviews, 76, 175-190.

Preliminary study of MS-facies relationship in Bajocian-Bathonian carbonates from eastern and north-eastern Paris Basin

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ORAL PRESENTATION

This preliminary study concerns different sections in the Mâconnais area (East of France, between Lyon and Dijon) and in the Rumelange area (South of Luxemburg). These sections are representative for the south-eastern and north-eastern parts of the Paris Basin, respectively, during the Jurassic Period. More precisely, this work was focused on the geological context of the Azé caves, included in Bajocian and Bathonian carbonated rocks. Seven sections were described and sampled to cover the whole stratigraphic range of the caves. Among these, the main section covering a large stratigraphic interval was studied along a water adduction tunnel and compared with the Luxembourg section.

In addition to a better knowledge of regional geology, the main goals of the study were (1) to propose a sedimentological model of the Middle Jurassic ramp in the Eastern Paris Basin, including the well-developed reef complexes, (2) to understand lateral facies changes, specially between reefs and others sediments, (3) to integrate the sections into a sequential canvas and (4) to evaluate magnetic susceptibility (MS) signal changes both at short and long distances. Petrographical study of more than 250 thin sections allowed us to define twelve microfacies, grouped together in six facies associations (external ramp, distal storm deposits, proximal storm deposits, internal ramp, substrate colonizing and reef building). Two sedimentological models were considered: a relatively smooth carbonate ramp with oolitic shoals, extending from below the storm wave base up to the shoreface, and a multiclinal carbonate ramp with reef complexes, extending from the storm wave zone to the littoral area. MS signal is partly related to facies and partly to general evolutions of the sedimentary basin. The facies dependence of the MS signal seems to be mainly related to changes in carbonate productivity: oolitic facies and reef complexes show the lowest signal, while storm deposits are characterized by higher values (da Silva *et al.*, 2009). Moreover, all the reef facies show the same low MS signal, independently from the bathymetry of the buildups. On the opposite, MS signal from storm deposits is related to bathymetry, with proximal tempestites having higher values than distal ones (Ellwood *et al.,* 2000).

The use of facies curves, together with MS curves, showed at least seven successive third-order sequences included in a second-order sequence which was replaced in a regional context (Durlet & Thierry, 2000). The Rumelange section showed additional 4^{th} to 5^{th} order parasequences which were imperfectly registered in the Azé area. Finally, this study allowed us to propose detailed correlations between the Mâconnais and the Luxembourg area.

References:

DA SILVA, A.-C., MABILLE, C. & BOULVAIN, F., 2009. Influence of sedimentary setting on the use of magnetic susceptibility: examples from the Devonian of Belgium. Sedimentology, 56, 1292-1306.

DURLET, C. & THIERRY, J., 2000. Modalités séquentielles de la transgression aaléno-bajocienne sur le sud-est du Bassin parisien. Bulletin de la Société géologique de France, 171, 327-339.

ELLWOOD, B.B., CRICK, R.E., EL HASSANI, A., BENOIST, S.L. & YOUNG, R.H., 2000. Magnetosusceptibility event and cyclostratigraphy method applied to marine rocks: detrital input versus carbonate productivity. Geology, 28, 1135-1138.

The Givetian-Frasnian boundary at the GSSP (Puech de la Suque, Montagne Noire, France): a multi-proxies approach. Is there a need to search for another GSSP section?

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ORAL PRESENTATION

The stratotype of the basal boundary (GFb) of the Upper Devonian and the Frasnian stage is exposed at Puech de la Suque section (Montagne Noire, France).

Sedimentological analyses revealed a highly-condensed sequence underlined by numerous reddish hardgrounds and pointed out a hemipelagic environment partly affected by distal storms (Casier & Préat, 2007).

Low-field magnetic susceptibility (XLF) values ranging from 1.52 to 59.47 x 10^{-8} m³/kg are high for carbonate rocks. The highest XLF value is observed 0.83 m before the GFb. The signal could be subdivided into six magnetic sequences (MSE). MSE 1, 3, 4 and 6 represent increasing XLF trends while MSE 2 corresponds to a long stable interval with low XLF values (<4 x 10^{-8} m³/kg). MSE 5 is characterised by several large fluctuations towards high XLF values before the GFb.

Gamma-Ray spectrometry logging was obtained on the field each 25 cm. K and Th concentrations are relatively constant and weak, ranging respectively between 0.4 – 0.8% and 2 – 4 ppm. U concentrations fluctuate mostly between 0.5 and 1.5 ppm along the section with only minor trends. U/Th ratios are mostly below 0.7 indicating oxic conditions. K and Th are moderately positively correlated (r = 0.80) indicating a fine-grained siliciclastic admixture in carbonate rocks. Th and K concentrations usually relate to the presence of aluminosilicates in carbonates. K, Th and U concentrations are negatively and moderately correlated with XLF (respectively, r = 0.48, r = 0.40 and r=0.38) indicating that stronger XLF values correspond to a lesser amount of fine-grained siliciclastic admixtures in the carbonates. These aluminosilicates correspond to paramagnetic minerals indicating that higher XLF values are mostly controlled by ferromagnetic *s.l.* minerals.

Clay assemblages are mostly dominated by illite and chlorite with traces of kaolinite and interstratified mixed-layers. These paramagnetic minerals are not the main carriers of the XLF fluctuations along the section and indicate a strong diagenetic overprinting.

The presence of hematite in the beds is observed, close to the GFb, by the reddish colour of the limestones. The percentages of yellow and red spectral reflectances reveal the presence of red (hematite) and yellow (goethite) chromatophores in three different levels of the section. Low concentrations of these chromatophores are observed at the base. An increasing trend towards the

highest concentrations in yellow and red chromatophores in the last 20 samples across the GFb is clearly identified.

The presence of large amounts of viscous grains (nanometric particles of diagenetic origin) in the rocks straddling the GFb suggests that the primary origin of the MS signal and its interpretation is thus questionable. The different proxies used here indicate that the GSSP section cannot be used as a high-resolution stratigraphic tool for intra- and inter basinal correlations or for calculating eccentricity bands based on raw MS data.

Complex origin of magnetic susceptibility in the Eifelian dolostones of Zachełmie Quarry (Holy Cross Mts., Poland): implications for stratigraphical and palaeoenvironmental interpretations

Jacek GRABOWSKI [1], Marek NARKIEWICZ[1] & David DE VLEESCHOUWER[2]

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ORAL PRESENTATION

Zachełmie Quarry (northern Holy Cross Mts.) exposes a ca. 100 m thick succession of the Eifelian restricted-marine marly dolomite mudstones and wackestones grading upwards into fossiliferous crystalline dolomites of a more open-marine carbonate platform (Narkiewicz & Narkiewicz, 2010). Recently, the earliest tetrapod trackways were found in the lower part of the section (Niedźwiedzki *et al.*, 2010). The current follow-up project aims to constrain the depositional environment of the track-bearing sediments, in order to better understand the ecological context of the evolutionary fish-to-tetrapod transition. Within the framework of the project we performed a set of rock magnetic analyses in the lower part of the section (ca. 30m) to evaluate the suitability of petromagnetic parameters as tools for stratigraphic and palaeoenvironmental applications. The analyses include field magnetic susceptibility (MS) measurements in close steps of ca. 10 cm, as well as laboratory measurements of low field MS, anhysteretic remanent magnetization (ARM), isothermal remanent magnetization (IRM) and frequency dependence MS, performed on 30 samples taken from the section with ca. 1 m resolution. A good agreement is found between results from field and laboratory measurements of MS. Magnetite and hematite occur in the rocks in various proportions and they both contribute to the MS. In samples with magnetite predomination, a relatively low S-ratio, and a good correlation of MS with ARM are observed. Conversely, where magnetite was virtually absent, a high S-ratio and a good correlation of MS with IRM in 1T occurred. The question if MS might be used as a proxy for detrital input into the basin is not yet fully resolved. Two subsections from distant parts of the quarry correlate quite well but there are some MS peaks which possibly result from late diagenetic hematite redistribution. Preliminary spectral analyses of the MS signal reveal the presence of a strong and persistent cyclicity, characterized by a period of 1.1 – 2 m which might be interpreted as the result of astronomical forcing by climatic precession, with a period of ~18 kyr (Berger *et al.*, 1992). Moreover, a low-frequency spectral peak was identified, tentatively interpreted as the result of 100kyr eccentricity forcing. This would indicate that primary depositional MS record was essentially preserved and not affected by a pervasive oxidation of unknown age. Further geochemical tests, focusing on the verification of the primary nature of the MS signal, are planned.

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Magnetic susceptibility variations at the Jurassic-Cretaceous boundary (Pośrednie III section, Tatra Mts., Western Carpathians, Poland): correlations with geochemical proxies and sea-level changes

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ORAL PRESENTATION

Deep water Jurassic – Cretaceous (J/K) boundary sections in the lower Sub-Tatric (Fatric) unit of the Tatra Mts. provide an excellent possibilities to test magnetic susceptibility (MS) as a high-resolution stratigraphical tool on the background of well-established bio- and magnetostratigraphy (Grabowski & Pszczółkowski, 2006). The stratigraphic range of the Pośrednie III section (ca. 45 m thick), spans between the base of Chitinoidella Zone (Lower Tithonian, magnetozone M20r) and Oblonga Subzone (Upper Berriasian, magnetozone M16n). MS, field spectral gamma-ray (SGR) as well as CaCO3, total organic carbon (TOC), δ13C measurements and selected elemental analyses were carried out. MS reveals excellent negative correlation with CaCO3 content as well as positive correlation with Al, Zr, Ti and other lithogenic elements concentrations. Therefore it might be treated as a proxy of detrital input into the basin. MS reveals increasing trend between magnetozones M20r and M20n2n (lower to Upper Tithonian), followed by a decrease with minimum values in the magnetozone M17r (Middle Berriasian). Definite increasing trend is observed again in the magnetozone M16n (Upper Berriasian). MS log has been correlated to an established reference curve of sea-level changes and major sequence boundaries (SB) for Tethyan realm. MS lows and highs correlate with transgressive and regressive intervals respectively. SBs in the Tithonian and lowermost Berriasian are significantly enriched in fine grained terrigenous material and marked by the presence of hematite, which is in the contrast with overall magnetite-dominated magnetic mineralogy of the section. Geochemical data and TOC contents indicate increase in the productivity and slight oxygen deficiency in the Lower and Middle Berriasian, which corresponds to MS low values and calpionellid limestone sedimentation. A broad positive δ13C plateau is also related to that interval. MS and geochemical trends show correlative patterns with climate variations in the Tithonian and Berriasian, documented in the Tethyan and NW European sections (see Schnyder *et al.*, 2006; Tremolada *et al.*, 2006).

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Environmental magnetic record in the Late Holocene floodplain deposits – A key study from the Strážnické Pomoraví (Morava River catchment, Czech Republic)

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ORAL PRESENTATION

The study area, Strážnické Pomoraví, is located in southern Moravia along the lower course of the Morava R. west of the town of Strážnice. The river catchment area upstream of the Strážnické Pomoraví is 9146 km^2. The central segment of the Morava R. catchment has been affected by intense agricultural activity since medieval times and especially after WW II when large field tracts were cultivated during agrarian collectivization. The thickness of the Morava R. floodplain deposits exposed in the erosion banks ranges between 400 and 600 cm. Three vertical pilot sections were sampled. At each section, triplicate samples were collected at each stratigraphic level using plastic boxes (6.7 ccm) with a vertical separation of less than 0.5 cm. Mineral magnetic parameters such as mass specific susceptibility (χ), ARM, ARM susceptibility, IRM, SIRM and their intraparametric ratios (ARM/SIRM, S-ratio) all show similar variations from section to section. The values of magnetic susceptibility are highest in the upper 50 cm of the sections. χ values then show a noticeable decrease downward in the section to the depth of 200 cm and then stay low throughout the rest of the section. Based on hysteretic data gained at room temperature we knew that paramagnetic or high hysteretic components dominate especially in the lower portions of the sections. Both low and high temperature VSM measurements verified a significant paramagnetic contribution to χ. The most Lakeshore results also indicate a predominance of paramagnetic component in the magnetic signal. This paramagnetic component, carried by clay minerals containing Fe, often masks the ferrimagnetic signal. However, the paramagnetic susceptibility variations are rather flat documenting an elevated ferrimagnetic content in horizons where χ record shows distinct peaks. High temperature-dependent magnetic susceptibility variations follow a pattern common in young soft sediments. Maghemite formed from lepidocrocite (?) after heating to 280 °C is later converted to hematite, which is then reduced to magnetite between 480 and 510 °C. To diagnose the magnetic carriers in the sediments, we used MPMS measurements. RTSIRM-ZFC sweeps show the presence of an oxidized magnetite in the upper 50 cm in all sections and in several underlying coarser horizons. Drops in RTSIRM-ZFC magnetizations at 120 K indicate a suppressed Verwey transition suggesting the presence of low temperature oxidation of magnetite to maghemite. However, goethite starts to appear at depths greater than 50 cm in the ZFC-RTSIRM and FC-ZFC-RTSIRM sweeps, and becomes the dominant magnetic phase below the depth of 200 cm in the sections. The causes of magnetic enhancement in the uppermost 50 cm of the floodplain sequences were studied in sediments deposited between flood dykes constructed along the Morava R. channel in late 1930s. The magnetic enhancement is connected with changes in magnetic grain size and mineralogy. The ARM susceptibility variations indicate an increased content of superparamagnetic particles formed during field soil cultivation. Anthropogenic spherical magnetic particles present in the sediment also significantly contribute to the enhancement. Based on persistent organic substances (DDT, PCB) and radioactive ^{137}Cs peak determined in the sediments we suppose that the magnetic enhancement is a result of soil erosion triggered by agriculture activities conducted in the river catchment since 1950.

An interpretation of gained mineral magnetic data allows us to sketch the following conclusions:

1. The clay mineral paramagnetic influence dominates in the flood sediments through sections often masking the ferrimagnetic signal.

2. Goethite is a common iron oxyhydroxide present in the floodplain sediments. The concentration of goethite increases downward in the sections. Goethite could be a product of dissolution of iron oxides and consequential iron precipitation under changing redox conditions in the floodplain environment.

3. Detrital magnetite grains are partly oxidized to maghemite. We surmise that cultivation of arable soil exposed magnetite grains which became later oxidized during erosion, transportation and re-sedimentation in the flood sequences. The gradual increase of χ and other magnetic parameters in the uppermost 200 cm of each section is the consequence of more intense erosion caused by agriculture activities, which was triggered by medieval colonization in the central Europe and dramatically accelerated during the last 60 years of very intensified land use.

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Rock magnetism and magnetic fabric of the Cypris Formation as indicators of paleoenvironmental changes in the Sokolov Basin (NW Bohemia)

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ORAL PRESENTATION

The Sokolov Basin is located in western Bohemia as a part of the Eger Rift Zone which belongs to the European Cenozoic Rift System. The basin is filled with Eocene to Early Miocene lake sequence containing several coal seams. Lacustrine deposition was terminated by clays called the Cypris Fm. reaching a thickness up to 180 m. The formation possibly represents an interval of 3–4 My in the late Early Miocene. The depositional rate was affected by several events of the lake level drop and drying-up, especially in the late stages of the Cypris Fm. sedimentation. The lake deposits became a subject of multidisciplinary research including rock magnetic, magnetostratigraphic and cyclostratigraphic approach which should provide a detailed chronometer for the correlation of the local paleoclimate record with other continental as well as deep-ocean archives.

Rock magnetic data were used to understand the depositional as well as post-depositional processes in the lake. Two drill cores (first at the basin edge and second close to the basin centre) representing 70 and 94 m deep sections above the coal seam roof were continuously sampled. Based on bulk magnetic susceptibility (MS) and anisotropy of magnetic susceptibility (AMS) data, the studied sections can be subdivided into three segments showing distinct changes in magnetic mineralogy. The upper segments reveal low to medium MS, very high AMS degree and dominating oblate magnetic fabric. Middle segments are characterized by elevated MS values, relatively lower AMS degree and oblate magnetic fabric. Unlike the upper segments, sediments in lower segments show very low MS, lower AMS degree and inverse magnetic fabric most probably carried by siderite. The natural remnant magnetization (NRM) signal is noisy in the upper and middle segments whereas the NRM values are usually very low in the lower part of the section.

Post-depositional diagenetic formation of paramagnetic siderite caused a deformation of primary magnetic fabric in the lower segments of the sections. The dominance of greigite in the middle segments of both sections document a lake level drop accompanied by insufficient water ventilation. Sulfur produced by organic matter in the lake reacted with iron, forming greigite. This sulfide is present in a very fine form in the lake sediments. A common size of the greigite pigment is about one micrometer. An elevated sulfur concentration near the top of the middle segments is documented by paramagnetic pyrite formation. The lake level rise and a drop in sulfur concentration during the upper segment deposition were connected with pyrrhotite formation as documented by microprobe data. This rock magnetic paleoenvironmental interpretation is in good agreement with other geochemical as well as sedimentological data.

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Magnetic susceptibility as a tool for high-resolution correlation of pelagic and distal slope facies of the Middle Devonian in the Carnic Alps: preliminary results

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POSTER

Following Schönlaub *et al.* (2004), a horizon with dark-stained (phosphoritic?) lithoclasts of an interval known as “unit 3” within the pelagic succession at Mt. Freikofel is related to the Kačák Event or the Eifelian/Givetian boundary. This event was also recognized in the section at Oberbuchach, which is considered a more distally deposited lateral unit of the succession at Mt. Freikofel. In “Oberbuchach II”, Schönlaub *et al.* (2004) reported a lower and an upper Kačák level within the kockelianus-ensensis conodont biozones, which correspond to an interval of lydites and black shales. In the Wolayer Glacier section near Valentintörl, deposits ranging from the Emsian to Famennian are assigned to the Findenig, Valentin and Pal limestones. These limestones represent highly condensed sediments which were accumulated in a pelagic environment. Based on a detailed biostratigraphic study, the upper part of the Eifelian (documented conodont zone: australis Zone) is unconformably overlain by beds of Givetian age (latifossatus Zone) in the Valentin Limestone, with the boundary located between samples Nos. 70 and 71 (Schönlaub, 1985).

We collected 15 bulk-rock samples at distances of ca. 2 cm (in total, an interval of about 25 cm) across the Eifelian–Givetian boundary within gray bioclastic wacke- and packstones of the Valentin Limestone (Nos. 69 to 72; compare Schönlaub *et al.*, 2004) and prepared them for magnetic susceptibility analysis under a KLY-3 kappabridge device in the Institute of Geology AS CR. In the Wolayer Glacier section we observed a decrease in values between sample numbers 69 top and 70 top ranging from 47.45 to 27.71.

In order to correlate the MS-log across the Eifelian–Givetian boundary of the above mentioned section, we also collected 64 rock samples from a 10 m interval of the Hoher Trieb Formation (Eifelian to Frasnian) exposed in the Lanza area. This unit is characterized by gray to dark gray flaser and platy limestone with black shale and chert layers which are interpreted as distal slope deposits (Pondrelli *et al.*, 2011). The MS-log obtained from this section shows a negative trend from 55.73 to -0.88 (sample numbers: “ZMB 34 middle2” to “ZMB 20”), just below the Eifelian–Givetian boundary, which might be related to the Kačák Event.

The next step of our study will be the correlation of MS patterns across the Eifelian–Givetian boundary with neritic carbonate deposits.

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Heat, magnetic field and wind analysis from the samples that have experienced the Tunguska blast in Siberia, Russia

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ORAL PRESENTATION

More than hundred years ago an unknown object impacted in Siberia, Russia. Today this region is know as Tunguska region and created a seismic signature 100-1000 times stronger that the Hiroshima explosion at the end of the World War II. To this day, nothing has been found to suggest a foreign material (e.g. meteoritic) dispersion during this event. Various hypotheses were put forward, for example: Comet impact, Kimberlite Pipe explosion, but also Dark Matter interaction with our atmosphere. We collected samples of black chert, conglomerate and wood from 5 different locations within 2 km from the epicenter. We used these samples for magnetic analysis and searched for any evidence of magnetic contamination that may date the Tunguska blast. All samples, wood, chert, and conglomerate showed sufficient content of magnetic material that should be capable of recording strong magnetic pulse. We now have the evidence that the heat during the explosion did not play the role in decimating the trees and was insignificant both below the explosion as well as 12 km away from the explosion. Magnetic analysis of the wood point towards 90 degree deflection of the magnetic signal during the explosion. Since the temperature increase was in significant the nature of the magnetic acquisition must be Isothermal remanent magnetization.

New results on the paleoclimate record of the Late Pleistocene cave sediments (Moravian Karst, Czech Republic); the case study based on mineral magnetic properties and facial analyses

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ORAL PRESENTATION

Kůlna Cave is a classical Neanderthal cave locality, situated in the northern part of Moravian Karst a relatively small karstic area northerly from Brno, eastern part of the Czech Republic. The cave itself is situated on lower part of the valley slope in the altitude of 464 m a.s.l. The cave infilling was well archaeologically studied by K. Valoch during 1961-1976 (Valoch, 1988) years and 1995-1997 years (Valoch, 2002). Stratigraphically continuous sequence was described in the entrance part of the cave (sector D) where more than 14 metres of sediments was exposed. In this part of the cave was during the 2011 exposed more than 4 meters of sediments which were included in this study.

According to today accepted chronostratigraphy of Kůlna, the sedimentary sequence in the entrance part covers the time spam of MIS6/5 - MIS2 (Valoch, 2002): the oldest findings (layer 14) of Kůlna sequence, interpreted as Mousterian with Levallois method, are correlated with MIS 6/5. Second archaeological unit is represented by Taubachian findings of layers 11 and 10. According to biostratigraphy are those layers dated as the end of last Interglacial (Eem, MIS 5e), but the OSL dating of layer 11 indicated different chronological position around 70 ka BP (Nejman *et al.*, 2011). The most complex upper 4 meters of exposed sediments with the complicated stratigraphy and with the rich findings were devoted to Micoquian culture (layers 9 – 6a). Layer 9b is correlated to Interstadial Odderade, layer 7c to Glinde, and layer 7a to Moershoofd (Valoch, 2002). Only ESR dating of layer 9b (Rink *et al.,* 1996) was accepted as well as results for layer 7a because calibrated ^{14}C data (Mook, 1988; Neruda & Nerudová) are comparable with ESR ones (Rink *et al.*, 1996). For a long time the position of layer 6a was unknown. The result of ^{14}C dating for the youngest Micoquian layer is older than data for layer 7a (Neruda & Nerudová). The key question is the chronostratigraphic position of layer 7b that was correlated with MIS 4 due to absence of archaeological finds, but this problem should be solved in future because of the datation of the first glacial maximum and layers 9b and 7a (Neruda & Nerudová ; Neruda *et al.*, 2011). Analyses of magnetic susceptibility (Šroubek *et al.*, 2001) compared the layer 9, central part of layer 8 and layer 7b to the warmer climatic oscillations, which doesn´t correspond to the archaeological interpretations.

In this paper we would like to concern to the importance of magnetic and non magnetic proxy. It seems that an alternative chronostratigraphy of Micoquian layers (11 – 6a) can be suggested. Our chronological conception is based mainly on the available dating and magnetic proxy compared with the facial and microfacial analyses. It seems that while the layer 11 is the relict of warm period (probably Eemian Interglacial), the layers 9b and 8 are typical by the continuous stable input of provenance material with no signs of warming. This period could be the record of glacial maximum of MIS4 developed inside the cave. Simultaneously a loess dune was accumulated close to the entrance. Layers 7d, 7c, 7b, 7a and 6a should be devoted to the MIS3 period with the warmer

phase at the base (layers 7d and 7c) and the record of the transitional phase above. A relatively quickly redeposited loess dune (which aggraded during the end of MIS4) infilled the space in the entrance of the cave at the end of warm phase of MIS3. The result of this redeposition is thick loess like layer 7b with the lenses of redeposited soil. High magnetic susceptibility peaks reflects redeposited soil lenses, the low magnetic susceptibility reflect the lenses of coarse quartz grains sorted during the loess redeposition. The end of this transitional phase is probably reflected by the layer 7a. The uppermost sediments in the entrance part of the cave were redeposited during some colder phase of the transitional phase of MIS3. Younger sediments corresponding to the Visla interpleniglacial and to the end of MIS3 period are missing.

The data presented doesn´t correspond in every aspects to the recently accepted chronostratigraphy of the Kůlna cave deposits and must be further studied and compared with additional data from the paleoecological analyses and dating.

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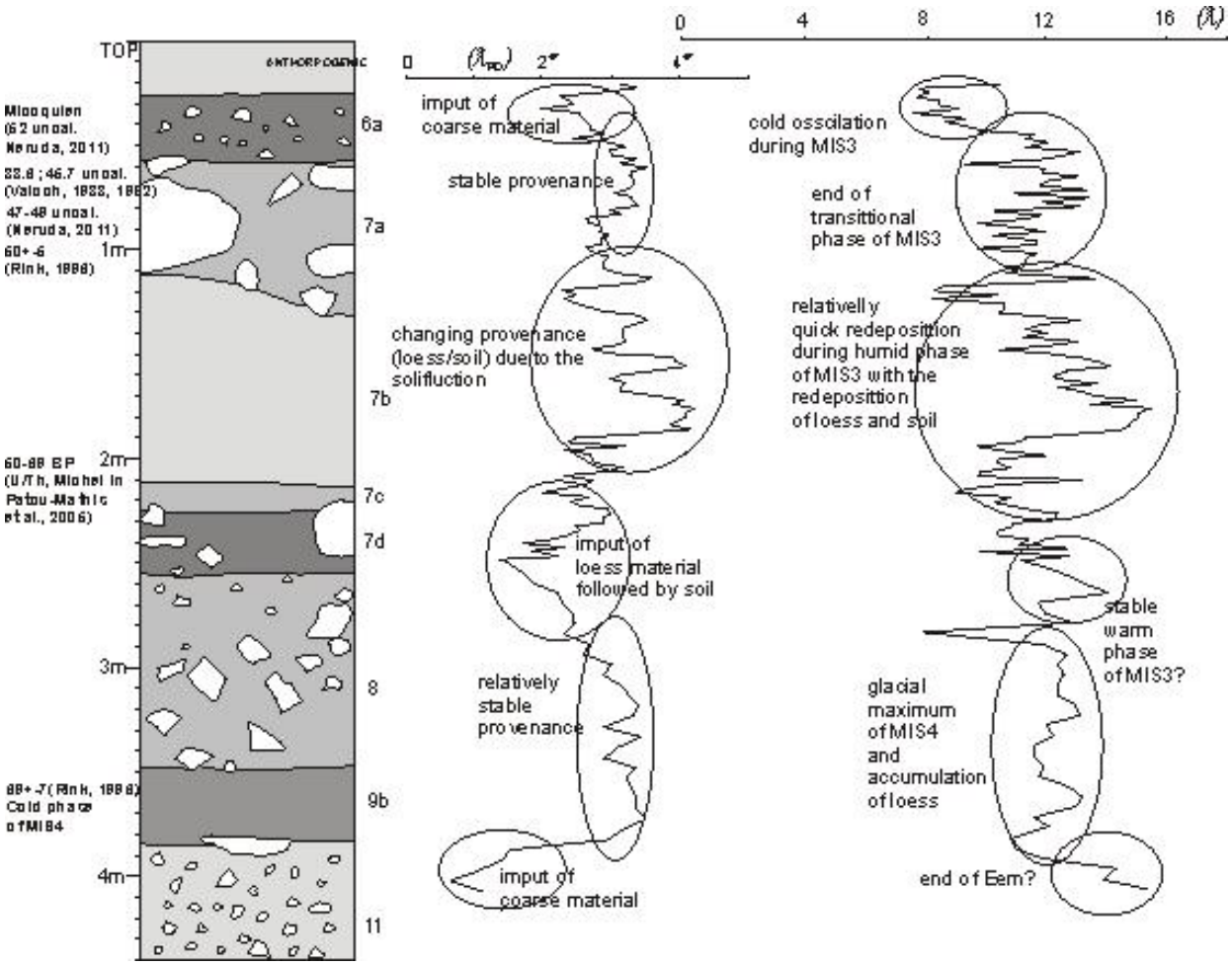
Tab.1 – the chronostratigraphy of Kůlna Cave sediments based on magnetic proxy and facial interpretations;

The indexes used are: λ_{FD} – magnetic susceptibility, λ – frequency-dependent magnetic susceptibility.



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The common cycles recorded by magnetic susceptibility observed in distant magnetostratigraphic sections

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POSTER

Rock properties observed along magnetostratigraphic sections of the same age can be easily correlated. Since the measurement of magnetic susceptibility is regularly included in magnetostratigraphic studies, we can detect common cycles or episodic events recorded by this medium in distant sections. Having compared both the frequency and phase of the detected cycles, we can test the hypothesis of their random coincidence. This way, we studied the magnetic susceptibility of the sections of Brodno (NW Slovakia) and Puerto Escaño (S Spain), located about 2200 km apart. Both sections are formed by deep-sea carbonate sediments of Jurassic to Cretaceous age, whose susceptibility is mostly borne by magnetite, possibly of bacterial origin. Because of the uneven sampling, the power spectra of the susceptibility record were estimated by the standard Lomb-Scargle technique and the phases of the cycles corresponding to the power spectra maxima were assessed by least-squares fitting of the data in the time domain. The hypothesis of random coincidence had to be rejected at a significance level of 0.05 with seven pairs of detected cycles. Moreover, the frequencies of most of these cycles nearly coincided with the present frequencies of variations of the Earth's orbit eccentricity.

Recent occurrence and properties of suspended solid particulate material at Prague-Suchdol, Czech Republic

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ORAL PRESENTATION

Particulate material (PM) present in the atmosphere has been a subject of research due to its potential environmental and human health impacts. It was observed that urban and industrial settings represent areas with low air quality caused by various activities such as combustion processes of various kind, increased levels of road transport and construction works. Low air quality has been usually attributed to increased levels of pollutants such as SO_2, NO_x, heavy metals and particulate matter (PM) suspended in the air – usually referred to as PM10.

The atmospheric pollution in Prague and in the whole Czech Republic has improved considerably over the past 20 years, due to improvements on emission budgets. Annual values of mean passive dust deposition in Prague have decreased significantly from 0.716 $g.m^{-2}.day^{-1}$ in year 1986 to 0.142 $g.m^{-2}.day^{-1}$ in 2006, when the measurements were unfortunately discontinued. The reduced dustiness was most likely because of the fact that former large scale industrial sources within Prague were significantly diminished or abolished during the past twenty years. The mean PM10 concentrations in Prague for period 1996 to 2009 have also decreased significantly from ~50 to ~25 $ug.m^{-3}.day^{-1}$, but remain relatively high due to rising quantity of vehicles and connected rising level of road traffic.

Prague-Suchdol area represents sub-urban background part of the city unaffected by increased road traffic or industrial activities. By simple method of dry filtration we acquired two simultaneous samples of the PM per week in period from June 2010 to September 2011. These samples were subject to measurement of magnetic susceptibility (MS) and other properties, which may provide information or indices on the source.

The mean PM concentrations calculated for the particular intervals of the studied period ranged from 9.5 to 114.0 $ug.m^{-3}.day^{-1}$. The range for mean assorted PM measured by dry filtration was not very different from the PM10 concentrations ranging from 11.5 to 86.2 $ug.m^{-3}.day^{-1}$ measured on nearby AIM station of Czech Hydrometeorological Institute. The weekly concentrations of PM at Suchdol statistically correlated ($n = 69$, $p < 0.01$) positively with PM10, SO_2 and NO_x ($r = 0.76$, 0.56 and 0.52), while with MS the correlation was statistically significant but negative ($r = -0.34$). The magnetic susceptibility of weekly PM samples at Prague-Suchdol varied from 1182 to 6959 x $10^{-9}.m^3.kg^{-1}$. Mean monthly values of MS lower that the overall mean (3728 x $10^{-9}.m^3.kg^{-1}$) were typical for period from December to April, while MS values in period from May to November were greater (Fig. 1). The statistically significant negative correlation of MS ($n = 69$, $p < 0.01$) was also found with SO2 and PM10 (-0.40 and -0.37). Thus the decreased MS values of the atmospheric PM connected with greater PM concentrations in the air during cold months (Dec-Apr) could result from thermal inversion situations rather than from increased combustion of fossil fuels by the local small emission sources (households) for the heating purposes.

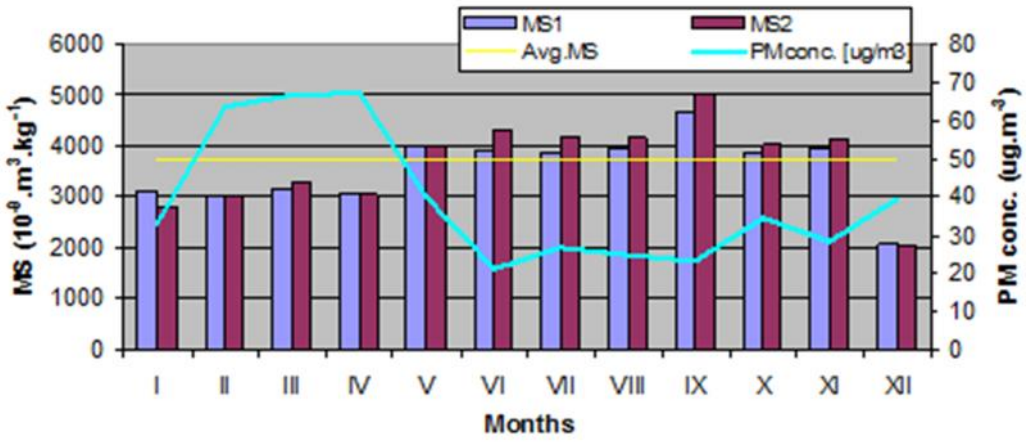

Fig. 1 Mean monthly MS values for both simultaneously sampled PM and overall average MS (left axis) and mean dust monthly concentration (right axis).

Sedimentology and magnetic susceptibility on a continuous Middle Givetian to Lower Famennian fore-reef succession (Sauerland, Germany) : A new example of MS study for long-distance correlations (Germany, Belgium and Moravia).

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POSTER

This study focuses on the continuous Givetian – Frasnian section of the abandoned Burgberg quarry (Messinghausen Anticline, northern margin of the Rhenish Mountains). The exposed section (102 m thick) covers a well constrained stratigraphic interval starting in the Middle of the Givetian (Stritzke 1991; Aboussalam *et al.*, 2003) and – according to Stritzke (1991) and our new datings – ending within the Lower Famennian.

The Middle – Upper Devonian shelf edge within the Rheinisches Schiefergebirge can be traced from the supposed position along the southern rim of the Dinant Syncline and the Eifel Synclines, northwards along a line connecting the southern margin of the Devonian reefal outcrops of Attendorn and Brilon (Krebs 1967, 1974). The depositional setting of the investigated section corresponds to complex slope and basinal environments where reworked material from the proximal Brilon platform (located to the north) and basin deposits coexist. Thus, this section allows to follow the evolution of the Givetian – Frasnian Brilon platform (e.g., Machel, 1990; Stritze, 1990, 1991) in a deeper setting. Petrographic analysis of more than 330 thin sections leads to the identification of 7 microfacies which are integrated into a palaeoenvironmental model. Microfacies curve evolution shows two main trends. A shallowing-upward trend ending within a typical proximal slope setting (dismantling of the platform) followed by a deepening upward trend which is characterized by several meters of pelagic mudstone within the upper part of the studied section.

Magnetic susceptibility variations in sedimentary rocks have been commonly interpreted as related to variations in detrital inputs through climatic or sea level changes (Crick *et al.*, 1994). The magnetic susceptibility (MS) study of more than 330 samples from this long-time fore-reef carbonate succession is an opportunity to better constrain our sedimentological interpretations. To do so, we propose a comparison between general MS trends and some parameters such as microfacies and relative sea level fluctuations interpreted on the basis of the sedimentological study. The relatively long stratigraphic interval covered by the Burgberg section offers a good opportunity to compare our data with the time-equivalent Devonian sections of the Ardennes (Belgium) and Moravian Karst area (Czech Republic; Boulvain *et al.*, 2010). This permits to test the magnetic susceptibility tool for long-distance correlation between stratigraphically well constrained sections.

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Magnetic susceptibility analysis of Upper Cretaceous marine sediments of Trichinopoly, South India

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ORAL PRESENTATION

The Cauvery Basin, the southernmost in the Indian peninsular shield was formed during the fragmentation of the supercontinent during late Jurassic to early Cretaceous period. It continued to evolve until the end of Tertiary through rift, pull-apart, shelf sag and tilt processes and witnessed many cycles of transgression, regression, erosion and deposition. A more or less complete succession of Upper Cretaceous – Paleocene sediments is exposed in the Ariyalur-Pondicherry depression of the Cauvery basin. The sedimentary sequence exposed in the erstwhile Ariyalur district hosts unique geological record of the Upper Cretaceous sedimentation history.

Cretaceous marine sedimentary sequence, in Ariyalur area, marks three major groups which are Uttathur (Albian – Turonian in age), Trichinopoly (Turonian – Coniacian in age), Ariyalur (Campanian- Maastrichtian in age) and Niniyur formation (Danian in age). Most of the rocks are calcareous in origin and possess considerable faunal assemblages. The Uttattur Group is made up of limestone, mud, clay and lenses of sandstone bodies, while the Trichinopoly Group is composed of sandstone, clay, shell limestone, calcareous limestone, shale, silt, and bands of calcareous grit. The Ariyalur Group rests over the Trichinopoly Group with an unconformity and is essentially made up of sandstone, limestone and shale. The Niniyur Formation, which conformably overlies the Ariyalur Group, is composed of limestone, calcareous shale/mud, clay and sandstone of Palaeocene age. Core samples were collected from all representative formations within the groups of the entire stratigraphic sequence and subjected to detailed analysis using anisotropy of magnetic susceptibility (AMS). The results obtained from this study provided indicative signatures about the sedimentary environments that prevailed during the Cenomanian marine transgression period.

Most of the samples from Ariyalur area show both prolate and oblate fabrics except Uttathur which shows a prolate dominancy. The magnetic foliation (F) and degree of anisotropy (*Pj*) are more or less uniform and the result suggests that the calcareous formations preserve the primary sedimentary fabric. Magnetic mineralogy is dominated mainly by calcite and paramagnetic grains; hence it is very feeble in comparison to the crystalline rocks. The Uttathur Group and Niniyur Formation show considerable variation in the K_{mean} value and it ranges from -8.895 to 1598 E-06 SI. This could be due to the lopsided climatic shifts experienced within the major Cenomanian transgression episode. But K_{mean} values higher than 100 only is found in the Ariyalur and Trichinopoly Groups indicating minor stages of terrigenous supply. The horst-graben configuration formed during late Jurassic had maintained its tectonic set up till the end of Eocene during which all basement highs were peneplained. As a result of this, the basement lows (sub basins) were filled up with sediments derived from the erosion of adjoining horsts. The present analysis of the anisotropy of magnetic susceptibility of the sediments also reveals that the sedimentation history of the basin was dominated by marked sea level changes engraved with several phases of transgression and regression. It is felt that the sedimentation occurred in a shallow epicontinental sea which has been punctuated with terrigenous supply more often.

Magnetic susceptibility of Ordovician sedimentary succession in Pakri drill cores, NW Estonia

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ORAL PRESENTATION

The aim of current study has been to test the suitability of magnetic susceptibility (MS) for correlation of the lithostratigraphic units of Ordovician sedimentary succession and to describe the origin (primary or secondary) of magnetization. The studied samples belong to Lower (O1) and Middle (O2) Ordovician, revealed in four Pakri drill cores, NW Estonia. The rocks are represented by (i) various types of carbonates: form pure limestones and dolostones to clay/pyrite/glauconite/goethite rich carbonates, (ii) sandstones, and (iii) argillites.

The MS measurements with sampling interval of ~ 10 cm were made on core sections with hand-held MS meter SM-30, and they were corrected for the curvature of the core. Then representative samples were taken for the measurements of petrophysical properties (density, porosity, seismic velocity). Mass-normalized MS measurements in two frequencies were performed with a MS meter SM100 (0.5 and 8 kHz) to discover possible influence and extent of remagnetization.

Magnetic susceptibility shows similar trends along all four core sections. The overall trend is a decrease of susceptibility from below to top. On a large scale the MS log can be divided into two segments: (i) Tremadocian to Dapingian interval (limestones and sandstones with high content of glauconite and clay, and argillites) with higher MS values (~ 5×10^{-8} $m^3.kg^{-1}$) and (ii) Darriwilian to Sandbian interval (limestones with upward increasing content of clay) with lower (~ 1.5×10^{-8} $m^3.kg^{-1}$) values. Between these segments, at the boundary between Dapingian and Darriwilian Stages, a prominent drop in MS occurs. The lowest MS values correlate with the earliest Darriwilian Stage sandy limestone. Within the upper Darriwilian to Sandbian Stages the MS values increase upwards.

The ratio between high and low frequencies (χfd %; Jackson *et al.*, 1993) is generally low (≤ 5 %) in glauconite-rich sedimentary rocks (carbonates of the Floian and Dapingian Stages, and sandstones of Tremadocian Stage). It indicates the primary synsedimentary origin of the MS carriers and suitability of limestones for studies of primary palaeomagnetic component (Plado *et al.*, 2010). Other intervals have generally χfd ≥ 5 % hinting the presence of ultrafine particles that are diagnostic for chemically remagnetized carbonates.

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Miroslav Krs – a pioneer of paleomagnetism in Czechoslovakia

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ORAL PRESENTATION

We are pleased to dedicate this conference, the 2011 IGCP 580 Annual Meeting, to our colleague and friend Miroslav Krs, who has recently retired and will reach the age of 83 years. This collection of abstracts represents practically all the themes of time records, magnetism, paleomagnetic and rock-magnetic records also explored by Miroslav Krs. Our primary intention is to pay tribute to his dedication to science, friendliness and contribution to our past and present work. In 1962 he started his interest in palaeomagnetic research and became a pioneer of paleomagnetism in former Czechoslovakia. From the very beginning, Miroslav Krs was well aware of the need for complex approach, combining paleomagnetic, rock-magnetic and mineralogical studies, complemented by proper data processing and tests. From the early 1970s he participated in developing petrophysical methods using spinner magnetometers, magnetic susceptibility bridges, astatic magnetometers and alternating-field and thermal demagnetizers, among which especially the MAVACS (Magnetic Vacuum Control System) is of special significance. This system enabled a considerable extension of palaeomagnetic studies to minerals with metastable properties. Between 1973 and 1992, Miroslav Krs concetrated on the development of the Paleomagnetic Laboratory at Průhonice including new instruments and laboratory techniques, and on the study of palaeomagnetism of Phanerozoic rocks in Czechoslovakia and abroad (Jordan, Egypt, Austria, Germany, Tanzania), and of magnetism of different minerals (natural ferrites) and different types of rocks. After 1992, as a senior researcher in the Institute of Geology of the Academy of Sciences in Prague, he was running projects aimed at the interpretation of global tectonics, magnetostratigraphy and petrophysical studies, or rocks containing micro-organic matter. The evaluation of palaeomagnetic data for the Alpine-Carpathian-Pannonian Zone resulted in the development of a theoretical model simulating palaeotectonic rotations, typical for collisional zones (e.g. Alpine, Variscan, etc.). Ferrimagnetic minerals greigite and smythite, of bacterial origin, and their metastability were studied in relation to the process of carbonification of rocks with micro-organic matter. He participated in magnetostratigraphic studies focused on Miocene rocks in western Bohemia (Sokolov Basin) and on Jurassic-Cretaceous boundary strata in Moravia (Štramberk), Slovakia (Brodno near Žilina), Spain (Río Argos, Puerto Escaño) and Italy (Bosso Valley, Umbria). During his professional career, he authored or co-authored more than 250 papers in national and international journals (four of them in Nature), and numerous technical (or technical-development) reports, the majority of which are kept in Geofond in Prague and in the United Nations in New York.

Fig. 1 Miroslav Krs.

Fig. 2 Miroslav Krs sampling the J/K section in Rio Argos, Spain.

Eustatic and climatic variations at the Frasnian-Famennian boundary in the Rhenish Massif (Germany): New insight from magnetic susceptibility microfacies, clay assemblages and elemental concentrations

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ORAL PRESENTATION

The Late Devonian was a period of many biological events associated to environmental changes like the Lower and Upper Kellwasser (KW) Events (upper Frasnian) and the Nehden Event (early Famennian). Among the triggering mechanisms proposed to explain these changes, the relationships between detrital inputs, sea-level variations, climatic fluctuations and their impacts on the marine environments are still debated. To better understand these relationships, a detailed record of rock magnetism measurements, microfacies observations, clay mineralogy analyses and elemental concentration have been performed from the Beringhauser Tunnel section (Rhenisch Massif, Germany), one of the reference sections for the Late Devonian period. The aim of this multiproxy study was to reconstruct the paleo-environmental conditions from the late Frasnian up to the middle Famennian period.

Beringhauser Tunnel is one of the few sections that record the Frasnian-Famennian (F-F) boundary but does not show the well-known black, organic carbon-rich facies of the KW horizons. Nevertheless, the occurrence of equivalent beds has been demonstrated thanks to redox markers, like the U/Th ratio.

From the magnetic susceptibility signal, several evolution sequences can be highlighted. The Late Frasnian (from *jamieae* to *linguiformis* zone) corresponds to a period of gradual detrital input decrease punctuated by 2 negative peaks in the levels corresponding to the KW-equivalent beds, whereas the base of the Famennian (from lower *triangularis* to lower *crepida* zone) records an increase of detrial rock fraction. Then, the magnetic signal slightly decreases up to the *rhomboidea* zone. This decrease of detrital input is perturbed by a noticeable short-term negative pulse corresponding to the Nehden Event.

The clay mineral assemblage mainly dominated by illite and chlorite, indicates that this section has been submitted to significant burial (close to anchizone). Nevertheless, the occurrence in noticeable content of kaolinite (up to 25 %). and inter-stratified clays are punctually observed. within the two KW horizons, as well as the sedimentary level of the Nehden event. These peaks could thus indicate more humid climatic conditions during these 3 events.

Lastly, the thin section analyses allow to recognize 6 microfacies organized along a standard sequence recording a shallowing upward evolution from deepest (MF1) to shallowest (MF3C) open-

marine environments. This analysis has also confirmed that the upper KW horizon corresponds to the deepest environment.

The multi-proxies used here indicate that the F-F boundary is marked in the Rhenish Massif by significant variations of detrital input, mainly recorded during the lower and upper KW and the Nehden events. These changes are mainly linked to climatic evolution toward more humid conditions associated to sea-level rise. Such environmental perturbations probably triggered increased continental weathering and the onset of O_2-depleted conditions.

Sedimentology and magnetic susceptibility of Mobarak formation (Lower Carboniferous in central and eastern Alborz Mountains, North of Iran)

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POSTER

The Mobarak formation (lower Carboniferous) corresponds to a carbonate platform which was located in the northern margin of Gondwana. This work is focused on the two stratigraphic sections located in central and eastern Alborz Mountains: the Aruo and Shahmirzad sections. Palaeoenvironments are corresponding to a carbonate ramp platform with frequent storm deposits. Different facies have been observed and are from proximal to distal: (1) crinoid banks and lagoonal facies with abundant peloids and oncoid; (2) in-situ bioherms, mainly constituted by accumulations of tabulate corals, shell fragments and crinoids steams; (3) distal to proximal tempestites and (4) bioturbated dark argillaceous mudstone. The main sedimentological evolution is a shallowing-upward trend corresponding to the transition from distal to proximal tempestites, bioherms, crinoids banks and lagoonal facies.

Magnetic susceptibility data are also provided in order to get a better understanding of sedimentary dynamics and correlation between the two sections. It appears that MS values are the lowest for the more energetic environments which corresponds to the trends observed in the Devonian carbonate ramp in Belgium (da Silva *et al.*, 2009).

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Controls on magnetic susceptibility during the Late Devonian punctata Event in the Western Canada Sedimentary Basin: insight from trace element paleoceanograhic proxies and factor analysis

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ORAL PRESENTATION

The western Canada sedimentary basin, surrounding the Devonian isolated Miette carbonate platform, was a mixed carbonate-siliciclastic system where the mineralogy, magnetic susceptibility (MS), and organic and inorganic geochemistry varied with relative sea-level change. Geochemical proxies for redox conditions (Mo, U, V), productivity (Ba, Cu, Ni, Zn), and detrital input (Al, K, Si, Ti, Zr) were examined using x-ray fluorescence spectroscopy and along with MS and organic-content were measured at half meter intervals from samples collected along the southeast margin of the Miette platform. We report here the results of analyses on samples that span the Middle Frasnian *punctata* zone event that records a transient increase in detrital input that appears to be linked to high productivity and development of low oxygen conditions in the western Canada sedimentary basin and a global perturbation of the carbon cycle

Deciphering the controls on the MS signature of these carbonate-dominated rocks is difficult due to the fine grain size and small proportion of the non-carbonate fraction. We applied factor analyses in an attempt to better understand the relationship between MS and the various geochemical proxies examined. Factor analysis discerned two dominant drivers of MS and trace element proxy excursions during the Late Devonian *punctata* event. Our initial hypothesis was that silicilastic detrital input is a main control on MS variability and that redox conditions influenced the accumulation of organic matter and redox-sensitive trace metals. When viewed within a sequence stratigraphic framework, excursions of organic carbon, detrital input and redox-sensitive trace metal proxies occurred during third order sea level lowstand and subsequent transgression. During lowstand detrital input to the basin appears to have increased and this influenced the MS, biological productivity, and oceanographic conditions. Increased detrital input appears to have spurred high productivity that resulted in eutrophication and anoxic bottom waters. Anoxia facilitated organic matter preservation and the sequestration of redox sensitive trace metals in the sediment. Factor analysis indicates that at least 67% of variance of the MS data can be explained in terms of detrital proxies.

Late Silurian $\delta_{13}C$ excursion event in the light of rock magnetic analyses: a case study form Mielnik IG-1 borehole, E Poland

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ORAL PRESENTATION

Upper Silurian periplatform succession of the Mielnik IG-1 borehole (eastern Poland) with a precise graptolite-based stratigraphy has a great potential for advanced sedimentological studies. Magnetic susceptibility (MS) and other petromagnetic proxies (such as IRM, ARM and S-ratio) were measured to evaluate magnetic mineralogy in the core interval, where detailed analyses revealed positive mid-Ludfordian Carbon Isotope Excursion (CIE) during prolonged sea-level lowstand.

Laboratory measurements along the section show relatively low magnetic susceptibility values. Poor interplay between MS and ARM, together with a moderate positive correlation with potassium content (from spectral gamma ray survey), implies that a major contribution to the magnetic susceptibility is due to paramagnetic? illite, diluted by quartz pelite and carbonates. However in the low MS samples ferromagnetic admixture is significant (high MS vs. ARM correlation). Close to 1 S-ratio suggests soft magnetic mineralogy (magnetite) presence in the whole section.

A progressive magnetic susceptibility negative shift coincides with the main positive carbon isotope excursion, gradual decrease in total gamma intensity, as well as with gradual domination of varved-like texture of sediments and ingression of dolomitic siltstone facies, respectively. A clear increase in S-ratio is noted, after the *N. kozlowskii* extinction, with a positive shift coeval with the main δ_{13} C anomaly. It records reduced coercivities interpreted as significant admixture of coarser magnetite grains of detrital (aeolian) origin.

In the sedimentary environments with depleted clastic influx, changes in concentration, mineralogy and grain size of magnetic fraction are believed to reflect climatically induced variations. Contemporary appearance of negative excursion in total gamma and magnetic susceptibility, coarser magnetite fraction and decrease in magnetic grains concentration (general ARM-IRM depletion) together with abundant wind derived detritus, occurring strictly in CIE interval, suggest important changes in sediment source area and/or transport processes. Rock magnetic pattern of the studied interval in the Mielnik IG-1 section shows significant coincidence with a record of enhanced aeolian influx in low-latitudes during the Pleistocene glacial intervals, therefore may support the hypothesis of short-lived glaciation in the mid-Ludfordian time.

Application of magnetic susceptibility to tidal flats environment and cyclostratigraphy of the late Hauterivian Bouhedma formation using time-series analysis, Khanguet Aicha area, Eastern junction of the Northern Chotts range, Tunisia

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POSTER

It has been obviously proven that past climate changes are recorded in marine sedimentary sections as well as on tidal flats. Nevertheless, the difficulty is how to extract the climate signature. Thus, to evaluate climate fluctuation, magnetic susceptibility (MS) data could be measured on field samples and chosen as a proxy to characterize climate cyclicity. This cyclicity is characterized by alternations of weathering and erosional variations that are recorded as the detrital components that dominate the MS due to climate change.

We have sampled the Late Hauterivian Bouhedma Formation interval at Khanguet Aicha area (Eastern Northern Chotts range junction), Tunisia, in order to test the utility of MS to yield climate proxies in tidal flats sediments showing major changes in lithology. This section represents a spectacular, fast lithologic variation from Late Hauterivian carbonate-dominated limestone/dolomite – marl/shale couplets with scarce interbedded gypsum to a detrital-dominated marl-shale to sandstone sequence in the Barremian, indicating a relative regression-erosional event obvious towards the upper limit of the Bouhedma Formation.

Our results indicate that MS measurements reflect changes in detrital sediment, evident with (1) high-frequency stromatolite-bearing limestone-marl couplets, (2) with a large, rapid shift toward higher MS values near the top of the section resulting from a relative major regression, and (3) with low-frequency climate-controlled variations within these tidal flats.

Six short-term MS sequences grouped within four long-term sequences were developed in this study from the cyclicity observed throughout. Time-series analysis using Fourier transform (FT) method (PAST Software) was applied to the MS results, exhibiting obvious Milankovitch cyclicities in the precessional (18.3 – 22.3 kyr), obliquity (38.7 – 49.8kyr) and eccentricity bands (106 – 413kyr) for the first time in Tunisia (for the Hauterivian).

Supported with the MS data set and time-series analysis results, average sedimentary rates and the duration of the studied section were estimated. The fluctuations in MS data set can be related mainly to both precessional (ca. 20 kyr) and eccentricity (100 and 400 kyr) cyclicity suggesting that changes in surface water fertility were linked to climate changes in the Milankovitch frequency band

Our test of the utility of MS data sets in these lagoonal tidal flats, marsh, intertidal flats and tidal channels and keystone vugs varying depositional setting demonstrated that these data can provide a climate proxy that is not represented by large lithologic changes.

Magnetic susceptibility research in the Carnic Alps

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ORAL PRESENTATION

The Carnic Alps represent an ideal area for application of Magnetic Susceptibility. On the one hand because of the advanced study of micro-facies from different depositional settings (e.g. shallow marine, slope and pelagic environments) recorded in that region (e.g. Kreutzer, 1992), and on the other hand because of the long history of Carnic Alps-research which produced many biostratigraphically well-constrained sections throughout the entire Palaeozoic sequence (e.g. Schönlaub *et al.*, 2004). Earlier investigations for example on pelagic sections like Oberbuchach II were performed by Hans Peter Schönlaub and Brooks Ellwood. The area of Mount Freikofel and Mount Pal Grande, belonging to the so called Transitional Facies (Kreutzer, 1992), was partly studied for MS within the diploma mapping of Mathias Höcker (2003 – 2004, unpublished).

Due to the establishment of IGCP 580, a revival of MS-research in the Carnic Alps was initiated. Primary, sections of Silurian to Devonian age were chosen especially for correlation of shallow marine with pelagic deposits, which in a way could not be achieved solely based on biostratigraphic data, hence the resolution of biostratigraphic zones (for example of conodonts) recorded from shallow marine deposits is too low (e.g. Hohe Warte Lst, Lambertenghi Lst, Spinotti Lst, *Amphipora* Lst). Apart from using MS as method for stratigraphic correlation, we started to sample distinctive event intervals (S/D-boundary, *pesavis* Event, Kačák Event) of different depositional settings for bathymetric reconstructions (Fig. 1). Further comprehensive sampling of the Silurian-Devonian sequence of the Carnic Alps shall contribute to a better understanding of the general paleoenvironmental development of that area.

This is a contribution to IGCP 580. Financial support by NAP0017 and FWF P23775-B17 is gratefully acknowledged.

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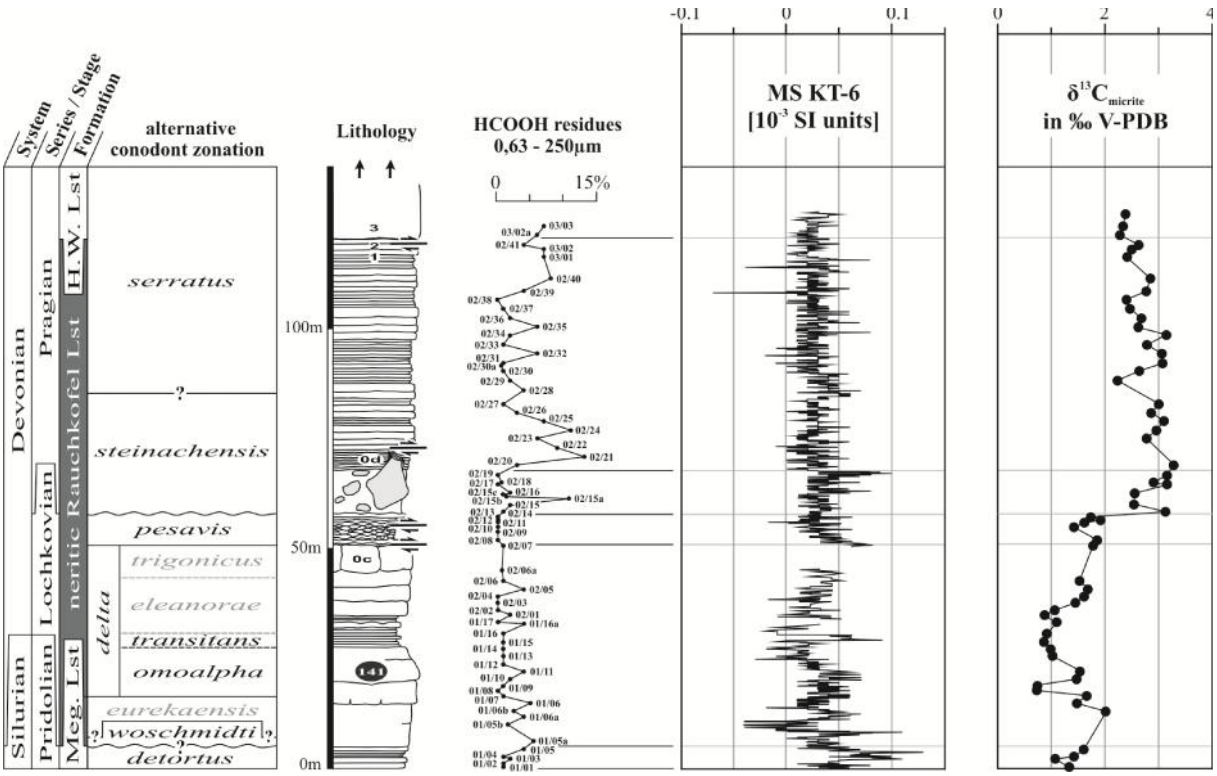

Fig. 1 Seewarte.

Pollution distribution of and around Denizli city using magnetic susceptibility measurements

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POSTER

In this study, we showed the relation between the contents of heavy metals and the magnetic susceptibility; and also the distribution of the pollution in the surface soil collected from industrial, residential and agricultural zones, and around of traffic roads in part of Denizli city, Turkey. We attempted to investigate correlations between the concentration of selected heavy metals and the MS from 553 sample sites around Denizli. We saw that the dimensions of pollution sources distributions which came from car exhausts are one of the most important environmental threats. These investigations let us quantify and standardize MS method, which might have consequences for long term monitoring of anthropogenic pollution, especially in urban areas. Magnetic susceptibility measurements were carried out by using a MS2B dual frequency sensor. The mass magnetic susceptibility (χ), low frequency magnetic susceptibility (χlf) and high frequency magnetic susceptibility (χhf) were measured by using a dual-frequency Bartington MS2 magnetic susceptibility meter. Xfd % of samples ranges from 0.1 % to 12.5 % with a mean value of 1.4 %. It was showed the pollutant distributions after mapping the data of magnetic susceptibility near and along the roads and around the city to assess environmental threats. We used the Tomlinson pollution load index (PLI) which showed a significant correlation with the magnetic susceptibility. The magnetic susceptibility measuring techniques was successfully applied in showing heavy metal pollution of soils on the city territories. Good correlations of magnetic susceptibility with Cr, Pb, Zn and Cu observed in the soils collected from the industrial sites, residential zones and around of traffic roads. We put forward that it is only enough that using field magnetic susceptibility measurements could provide the distribution of heavy metal pollution in residential areas. Furthermore this method is cheaper and less time-consuming against chemical methods and also showing the dimensions of distribution of the heavy metal pollution.

Upper Silurian (Ludfordian) Lau event viewed by magnetic susceptibility and gamma-ray spectrometry (Prague Synclinorium, Czech Republic)

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POSTER

A 22-m-thick sequence in the disused Mušlovka Quarry in Prague, Czech Republic (50°1'52.898"N, 14°19'59.486"E) has been sampled for study of stratigraphic variations in magnetic susceptibility (MS; samples taken with 0.1 m step) and gamma-ray spectrometry (GRS; measurements carried out with 0.5 m step). This section comprises the upper part of the Kopanina Formation (Fm.) that represents the Ludfordian Stage with transition to overlying Požáry Fm. that approximately represents the Přídolí Series. Major part of the studied succession consists of massive coarse-grained bioclastic (brachiopod, cephalopod and crinoidal) packstones/grainstones, transition from the Kopanina to Požáry Fm. is characterized by fine-grained wackestones/packstones/shales facies. The middle part of the studied interval (section 11.0–13.6 m) represents an interval of carbon isotope positive excursion referred as the Lau Event (described from this locality by Lehnert et al., 2007). These authors associated positive carbon excursion with emergence of this area and partial erosion of underlying limestones, which caused that only the upper part of the typical Lau interval known from other areas (e. g., Gotland) is present here.

The interval representing Lau Event is characterized by slightly increased MS values in contrast to underlying beds. They show considerably high variability. This increase in MS is accompanied by only slightly enhanced K a Th concentrations (in contrast to values directly below the event interval). Uranium concentrations, on the other hand, tend to rapidly decrease in Lau interval. Thus, both MS and GRS (K and Th) indicate an increase in amount of non-carbonate impurities in limestones. This may be related to recycling of eroded material from underlying strata during sea-level lowstand.

However, we realize that further detailed studies involving more sections are required for better understanding of the depositional history in this time interval.

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