



ABSTRACT BOOK

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SCIENTIFIC PROGRAM

Wednesday (15.05) – **Short course on trend analysis** – pre-conference short course by **Dr. Manfred Mudelsee** (Venue: MTA PAB, Pécs Regional Committee of the Hungarian Academy of Sciences H-7624, Pécs, Jurusics Miklós str. 44)

09:30-10:00 **Registration**
10:00-11:30 **Course lecture**
11:30-11:45 **Coffee break**
11:45-13.15 **Course lecture**
13:15-14:00 **Lunch**
14:00-15:30 **Course lecture/exercises**
15:30-16:00 **Coffee break**
16:00-18:00 **Course lecture/exercises**

Thursday (16.05) –

09:00-10:25 **Registration**

10:00-10:25 **Coffee break**

10:25-10:30 **Opening ceremony** with speeches by:

Ferenc Fedor - President of the Geomathematical and Informatics Section of the Hungarian Geological Society

10:30-11:45 **Climate modelling past and future** – chair: István G. Hatvani

- Keynote speaker: **Manfred Mudelsee** - **Geological Climate Archives and Time Series Analysis**

- **Sándor Gulyás** Testing chronological precision and accuracy of age-depth models built with limited available dates using geomathematical tools
- **Izsák Beatrix** Spatial interpolation of the temporal trend of climatic elements
- **István G. Hatvani** Limitations of spectral analysis of time series with timescale error and variable temporal resolution

11:45-13:00 **Lunch**

13:00-14:00 **Quantitative methods in palaeontology**– chair: Attila Virág

- Keynote speaker: **József Palfy** - **From percentage to Procrustes: A historical review of the growing use of quantitative methods in Hungarian paleontology**

- **Gáspár Albert** Datamining the Santonian dinosaur bonebed of Iharkút, Hungary
- **Attila Virág** Automated landmark analysis: a new methodology

14:00-14:30 Coffee break

14:30-15:45 Agrarian- and environmental informatics & Geoinformatics– chair: Gábor Szatmári

- Keynote speaker: **Tomislav Hengl - Predictive Soil Mapping using ensemble Machine Learning: automation opportunities and remaining challenges**
- **Diego Magalhães Borges Santanna**
Mobility analysis of Arsenic and Lead in fluvial sediments. A study case in the Baiut Mining Area, Romania.
- **Péter Szabó** Investigation of geochemical-microbiological processes in the Drava River floodplain based on environmental geochemical data
- **István Elek** Redundancy-free topological data structures

15:45-17:00 Mathematical aspects of reservoir geology– chair: Marko Cvetković

- Keynote speaker: **István Nemes – Mathematical aspects of reservoir geology – a case study**
- **Szabolcs Borka** Insight into multiple-point simulation of a deep-water system, Algyő HC field, Hungary
- **János Geiger** Pore regimes and REV: a CT-based model for the BCF
- **Marko Cvetković** Lithology prediction in the subsurface using artificial neural networks on well and seismic data – a stochastic approach

18:00-22:00 Ice breaker dinner at the Nana Bistro (Pécs, Király str. 2)

Friday (17.05) –

09:15-10:00 Conquering space - remote sensing – chair: Ferenc Fedor

- Keynote speaker: **Mark McCaughrean - ESA's planetary missions – once explorers, always explorers**
- **Andor Németh** Geostatistical analysis of Raman spectrographic data of the Chelyabinsk meteorite

10:00-10:30 Coffee break

10:30-12:00 Analysis of monitoring time series– chair: Péter Tanos

- Keynote speaker: **Márk Molnár - Big Data in Geosciences – Challenges and Novelties**
- **Norbert Magyar** Assessment of the groundwater bodies in the vicinity of Lake Fertő/ Neusiedler See using multivariate data analysis methods.
- **Hervai András** The influence of Danube on the groundwater system in Mohács Island
- **Márton Barcza** Hydraulic characterization using water level monitoring time series on an example from Eastern-Hungary

- **Péter Tanos** Stochastic analysis of different homogeneous river sections at seasonal resolution on the River Tisza

12:00-13:00 Lunch

13:00-15:30 Data analysis in engineering geology– chair: Ákos Török

- Keynote speaker: **László Kovács - Data analysis in engineering geology**
- **Seyed Morteza Davarpanah**
Investigation of relationship between dynamic and static deformation constants of rocks
- **Jalal Zenah** Comparison of properties of porous limestone from different locations

14:00-14:30 Coffee break

- **Zsuzsanna Szabó** Predictors of concrete strength, porosity and permeability as suggested by data analysis and machine learning
- **Benedek Lógó** Parametric study of the Poisson's ratio
- **Alina Vattai** Effect of multi-stage shearing on shear strength of rock joint surfaces
- **Ákos Török** Geomathematical evaluation of surface strength tests of stone monuments

15:30-16:00 Assessment of geophysical datasets - interpretation & uncertainty – chair: Norbert Péter Szabó

- **Byambasuren Turtogtoh**
Application of the fuzzy c-mean cluster analysis over the Yamaat gold deposit in Mongolia
- **Armand Abordán** Reducing the uncertainty of parameter estimation for the interval inversion method using factor analysis

16:00-16:15 Break

16:15-17:15 Diverse faces of Geomathematics (posters) – chair: János Geiger

- **Sahar Saeidi** Analysing land use change and geomorphometric parameters in small watersheds
- **Lilla Hoffmann** Comparison of interpolation methods for Hungary
- **Artúr Kőhler** Probability distribution of concentration time series data
- **Kamilla Modrovits** Analysis of karst water recovery time series in a former mining area, Hungary
- **Dániel Erdélyi** Tritium isoscape of precipitation across the Adriatic-Pannonian realm
- **Péter Cseh** Preliminary data of the geoarchaeological analyses on the Vesszős-halom (mound) at Pusztaszer
- **Csaba Vágó** Late Pleistocene deglaciation and paleoclimate in the Rau Barbat Valley, Retezat Mountains, Southern Carpathians

- **Ana Kamenski** Estimating subsurface lithology distribution of a theoretical model by geomathematical methods
- **Réka Orsolya Tapody** Environment development of a Transylvanian peat bog derives from geochemical analysis
- **Attila Virág** Landmark analysis of *S. citelloides* (Sciuridae, Rodentia)
- **Attila Virág** Deer hunt in the Random Forest
- **István G. Hatvani** Interannual fluctuation of xylem cellulose content of three tree species (2012-2017; Romania)

17:05-17:30 Closing ceremony –

István G. Hatvani - Secretary of the Geomathematical and Informatics Section of the Hungarian Geological Society and the Geomathematical Sub-committee of the Hungarian Academy of Sciences

Ferenc Fedor - President of the Geomathematical and Informatics Section of the Hungarian Geological Society

18:30 Departure from the conference venue to the *Conference Dinner Programme*

18:40-19:25 Guided tour in the Cathedral of Pécs (meeting at the western entrance of Cathedral (from parking places))

19:30-20:00 Organ concert in the Cathedral

20:05-22:30 Conference dinner in the Magtár Restaurant (Pécs Dóm sqr. 2)

Saturday (18.05) –

10:00-12:00 Excursion – A step to Smartlab – automation in geology lead by Ferenc Fedor (meeting at 9.30 conference venue parking lot or at the laboratory site)

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- **Rock Study Ltd.**

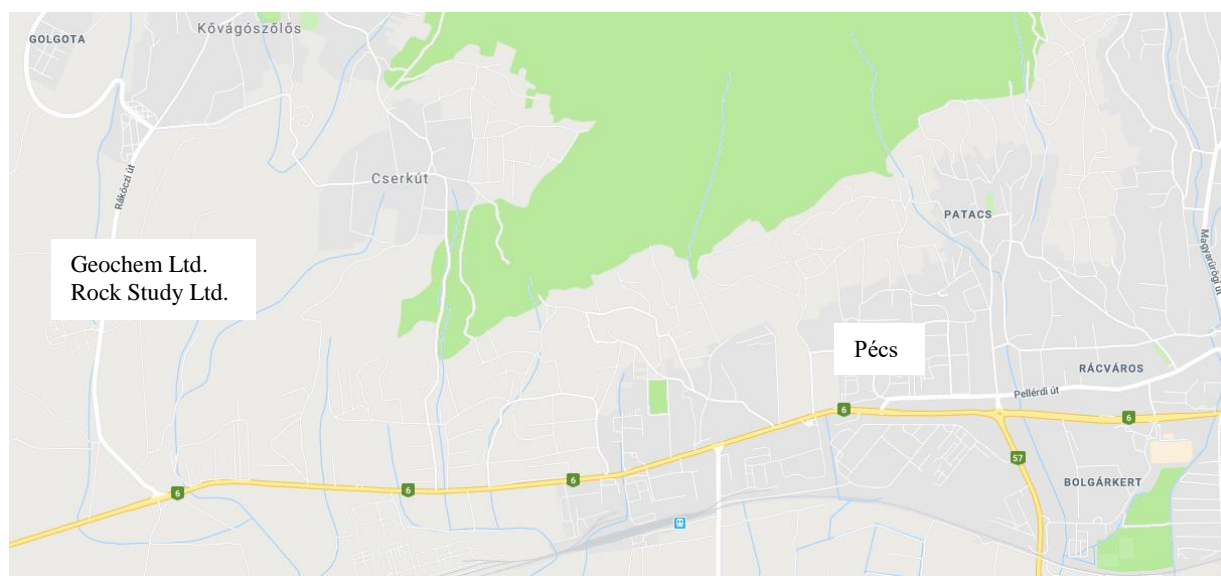


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Part I - Climate modelling past and future

Geological Climate Archives and Time Series Analysis

Manfred Mudelsee^{1*,2}

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Abstract

Geological archives, such as lake sediment cores or speleothems, provide information about past climates. Absolute dating techniques, such as layer counting or U/Th mass spectrometry, constitute the basis for the construction of the timescale of the climate archive. Measurements of properties of the archive material, such as grain size or oxygen isotopic composition, supply proxy information about the various climate variables (e.g., wind speed or precipitation). Geological knowledge about the archives is indispensable for a successful interpretation of climate proxy time series (Bradley, 1999). Climate models can be regarded as a certain type of archive, which enables to look back in time longer than what geological archives allow, and also into the future.

Statistical time series analysis, applied to climate records (instrumental, proxy, or model output), allows to test hypotheses about the climate and quantify climate parameters. There are three challenges imposed by climate time series. First, the random component often exhibits deviations from normal shape. Second, it usually shows persistence or memory effects. Third, timescale uncertainties constitute an additional source of uncertainty. Computer-age statistical approaches, such as bootstrap resampling or Monte Carlo simulations (Mudelsee, 2014), are indispensable to meet the challenges and deliver robust hypothesis test results and climate parameter estimates. This keynote illustrates computer-age statistical methods on paleoclimate proxy time series.

Key words: *Paleoclimate, Geological archive, Statistical time series analysis*

References

BRADLEY, R. S. (1999): Paleoclimatology. 2nd ed. Academic Press, San Diego, USA, 610p.

MUDELSEE, M. (2014): Climate Time Series Analysis. 2nd ed. Springer, Cham, Switzerland, 454 p.

Testing chronological precision and accuracy of age-depth models built with limited available dates using geomathematical tools

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Abstract

Quaternary paleoclimatic and paleoecological studies are focusing on the understanding of how major climate forcings translate to the regional level triggering feedback responses. This is done through comparing proxy results between records. Comparisons made at the millennial and centennial scales with the aim of tackling leads and lags in the responses require the construction of reliable chronologies. Age-depth model choice, dating density and quality significantly affect the precision and accuracy of our chronologies. Thus, assessing precision and accuracy of our models to make the best possible choice is inevitable. Precision can be improved by increasing dating densities on the one hand. But what if lack of funding hampers the inclusion of further dates in our analysis? In these cases, a comparison of the results of age-depth models can help. Classical age-depth models significantly underestimate uncertainty and are not improved in precision after a threshold in dating density is reached. Bayesian age-depth models considering chronological ordering on the other hand are more robust in providing realistic precision estimates. In this work age-depth models built using 14C AMS dates for late Quaternary paleoclimatic and paleoenvironmental records are presented. We aim to test changes in chronological precision and accuracy via changing the number of available dates from a minimum (5 for a 10 m profile) to a maximum available level (10, 15). Precision is tested through statistical comparison of the results. While „accuracy” is an arbitrary choice based on how well the model describes the observed sedimentological features of our profile. An attempt is made to see if the chosen model is “accurate” for our needs and how the inclusion of further dates improves precision and accuracy.

Key words: *age-depth modelling, uncertainty, accuracy, probabilistic approaches*

Acknowledgements

Research has been carried out within the framework of University of Szeged, Interdisciplinary Excellence Centre, Institute of Geography and Earth Sciences, Long Environmental Changes Research Group. Support of Grants 20391-3/2018/FEKUSTRAT and GINOP-2.3.2-15-2016-00009 ‘ICER’ are acknowledged.

Spatial interpolation of the temporal trend of climatic elements

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Abstract

Climate change studies require long term, high-quality, controlled, spatial and time-representative data series. The analytical trend analysis is the most commonly used method for quantifying the degree and direction of changes. The purpose of this study is to summarize the mathematical methods we use and to interpret the results obtained. We briefly describe our software developed for the homogenization, quality control, missing data completion and interpolation of meteorological time series. We review the basic concepts of the linear and exponential model, the applicability of the estimation obtained in this way for the trend function. For our study we used Hungarian time series of daily average temperature and precipitation sum for the period 1901-2017. We introduce the confidence interval which we calculated on a given confidence level for the point estimation to highlight beyond the most frequently used trend coefficient also the start and end point of the confidence interval. Besides, we examine in which cases the changes are significant, not only for the annual values, but also for the seasonal and monthly values as well. We interpolated the trend values at meteorological stations for the whole area of Hungary and we present them on maps. In the case of temperature increasing tendencies are appeared for the whole area of Hungary, while in the case of precipitation the trends are significant only in small regions.

Key words: *Linear trend estimation, Climate change, Interpolation*

Limitations of spectral analysis of time series with timescale error and variable temporal resolution

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Abstract

One of the most intriguing features of geochemical time series derived from sedimentary records (e.g. speleothems, ocean sediments) is their periodic characteristic. However, timescale error and variable temporal resolution as their common features challenges their spectral analysis (Mudelsee et al., 2009). Thus, the aim of the research was to stochastically model the spectral bias caused by timescale error and uneven temporal spacing on simulated time series resembling the characteristics of real-life sedimentary records. Time series (of 2000 timesteps) with known implanted period(s) (period time: 25, 50, 75, 100, 150, 200 step) known uneven spacing (avg. 5-35 step gaps) and timescale error (up to 250 steps) were modelled to mimic a sedimentary derived time series. An ensemble of potential timescales (500 for each model combination) was retrieved and their spectral characteristics explored with REDFIT (Schultz & Mudelsee, 2002) in R. Results suggest that timescale error is the bottleneck of such spectral analyses. However, increased accuracy and precision of the detection of the periodic components benefits from a higher average sampling resolution especially in the presence of larger timescale errors.

Key words: *Spectral analysis, Sedimentary records, Uneven spacing, Timescale error*

Acknowledgements

Authors thank the support of the Bolyai János Scholarship of the Hungarian Academy of Sciences.

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- MUDELSEE, M., SCHOLZ, D., RÖTHLISBERGER, R., FLEITMANN, D., MANGINI, A., & WOLFF, E. W. (2009). Climate spectrum estimation in the presence of timescale errors. *Nonlinear Processes in Geophysics*, 16(1), 43-56.

Part II - Quantitative methods in palaeontology

From percentage to Procrustes: A historical review of the growing use of quantitative methods in Hungarian paleontology

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Abstract

Paleontology has evolved from a largely descriptive branch of science to a discipline that applies increasingly sophisticated quantitative methods. Each of the basic questions of various subdisciplines are now routinely addressed by an array of mathematical methods. Taxonomists are concerned by distinguishing species, biostratigraphers attempt to establish the true temporal sequence of evolutionary first and last appearances of taxa, paleoecologists reconstruct the interaction of fossil organisms and their paleoenvironment, paleobiogeographers track spatial distributions in a framework of moving continents and changing ocean basins formed by plate tectonics. Evolution of life itself is tackled by revealing phylogenetic relationships and the history of biosphere is also assessed by reconstructing the history of biodiversity. For all of these scientific problems, many quantitative methods are borrowed from biologists studying similar questions of the modern biota. Other, more specifically paleontological issues stimulated methodological developments at the forefront of international paleontological research. In Hungary, paleontology for a long a time had remained a traditional, largely descriptive discipline, pursued by experts with a solid knowledge base but little inclination to experiment with novel, quantitative techniques. However, this started to change in recent decades and a new generation of Hungarian paleontologists is becoming swift to adapt new methodologies and embrace quantitative approaches. This presentation offers a brief survey of selected topical studies to showcase the growing application of mathematical methods in Hungarian paleontology.

Datamining the Santonian dinosaur bonebed of Iharkút, Hungary

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Abstract

From 2013 to 2018 the vertebrate site at Iharkút locality, provided 5,898 records of findings from the Upper Cretaceous bonebed Sz-6. Each record has 3D coordinates measured with high-precision geodesic surveying tools. The abundance of data and the temporal extent of the excavations make it difficult to see spatial relations and distributions without using 3D modelling and GIS technology. Our method for using such amount of spatially referenced data for taxonomy, taphonomy and paleoenvironmental analysis is without precedence. Although, a GIS-building workflow for the case of this site was already published (Albert et al., 2018), the full capacity of the available spatial database has not been evaluated yet. The 3D model of the bonebed and the GIS made it possible to easily execute fundamental statistics on the database such as findings per cubic meter, but their capabilities exceed such simple applications. The present study aims to show the results of the exploratory datamining techniques including clustering of data and spatial querying. With a self-developed spatial analyser program, possible connections among the isolated bones were also identified, suggesting the presence of further associated skeletal materials in the Iharkút assemblage.

Key words: *paleontological GIS, 3D palaeontology, datamining, fossil mapping*

References

ALBERT, G., BOTFALVAI, G., & ŐSI, A. (2018): Mapping the past: GIS and intrasite spatial analyses of fossil deposits in paleontological sites and their applications in taxonomy, taphonomy and paleoecology. *Palaeontologia Electronica*, 21, 3, 1-22.

Automated landmark analysis: a new methodology

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Abstract

The limitations of linear measurements resulted in the steadily rising popularity of landmark analysis among morphologists. The same anatomical points, however, are sometimes hard to find on each morphology studied in a given research. Consequently, we are focusing here on outline analysis with geometrically defined landmarks, which allow more flexibility when comparing shapes. We aimed to automate every step possible of the process by developing subroutines in the R software.

The first step is identifying outlines, which can be achieved automatically using high contrast images, or manually by registering the coordinates of shape descriptor points with the ImageJ software. The second step is to detect geometrical and/or equidistant landmarks on the defined shapes automatically using mathematical criteria. It allows objective and consequent point acquisition. After eliminating unnecessary variation in the size and orientation of the specimens, the third step is to execute a principal component or a canonical variate analysis on the coordinates. At this point, a visual representation of the existing morphogroups is generated. Group recognition can also be automated using a machine learning algorithm on the coordinates or on their ordination results.

The versatility of the subroutines will be demonstrated on morphologically different groups (including Late Triassic conodonts and Pleistocene mammals). Applying our protocol will give an efficient method into the hands of the researchers that can be used for a quick and objective morphological categorization of a wide variety of taxa.

Key words: *Landmark analysis, Automation, Point acquisition*

Acknowledgements

This study was funded by the NKFIH FK 128741 project.

Part III - Agrarian- and environmental informatics & Geoinformatics

Predictive Soil Mapping using ensemble Machine Learning: automation opportunities and remaining challenges

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Abstract

This talk aims to introduce both basic and new concepts in using ML in R for predictive mapping of soil classes and numeric soil properties. Machine Learning (ML) and data science in general are of increasing interest for soil modeling and mapping (Hengl and MacMillan, 2019). ML methods such as random forest, neural nets, deep learning and similar are now regularly used to generate soil maps. But unlike geostatistical techniques, such as various versions of kriging, spatial dependence structure in the data is often ignored in ML methods. If there is spatial structure in the cross-validation residuals of ML predictions, this indicates that the predictions are suboptimal and could be improved by taking spatial structure into account. To address this spatial autocorrelation issue, this talk introduces the use of the **Ensemble ML algorithms** (usually combination of random forest, gradient boosting, support vector machines and neural networks / deep learning) in combination with geographical distances to sampling locations, as additional covariates, to fit models and predict soil properties (Hengl et al. 2018).

Our recent experience shows that using EMLsp helps produce more accurate predictions. We anticipate that, in the coming 5–10 years, automated spatial prediction models will completely replace previous qualitative and subjective mental models; spatial modelling will be likely replaced with new methods of automated space-time modelling and prediction. Reichstein et al. (2019) have recently reviewed limitations of using ML to extract patterns and insights from geospatial data. The authors also agree that hybrid modelling approach, coupling physical process models with the versatility of data-driven machine learning, appears to be the best path toward producing decision-ready soil information.

Key words: *Ensemble Machine Learning, spatial interpolation, High Performance Computing, Predictive Soil Mapping*

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Mobility analysis of Arsenic and Lead in fluvial sediments. A study case in the Baiut Mining Area, Romania.

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Abstract

Sediment-associated transport can exert a key control on the transfer and fate of toxic substances within fluvial systems (Walling & Collins, 2016). The EU Water Framework Directive (EC, 2013) prescribes sediment quality monitoring and trend analysis, in terms of taking measures to ensure that the Hazardous Substances concentrations do not significantly increase in sediments and/or relevant biota. The mobility of total concentration of metal(oid) (As and Pb) and major elements (Fe, Al, Mn, S) were investigated in mine waste rock, stream sediment and floodplain sediment along the source-pathway-receptor chain in the catchment situated at the Baiut mining area in Romania. The total concentration of metal(oid) and major elements in waste rock, stream sediment and floodplain samples were determined by ICP-OES, in addition X-ray diffraction (XRD) analysis for the mineralogical composition and pH determination in floodplain sediments. The Kohn pipette method was applied to obtain the granulometric composition. Descriptive data analysis reported concentrations in the fluvial sediments between 0.6-2285 mg.kg⁻¹ As, 13.20-7990 mg.kg⁻¹ Pb, 35390-388,000 mg.kg⁻¹ Fe, 8,200-86,270 mg.kg⁻¹ Al, 30-21,530 mg.kg⁻¹ Mn and 600-393,000 mg.kg⁻¹ S. Arsenic had strong negative correlation with pH (0.76) and the clay fraction, while Pb had strong correlation with the silt fraction and no correlation with pH in the reducing floodplain sediments. This demonstrates that As is in a mobile form in the studied floodplain while Pb is immobile and most probably found in the physically weathered and transported original ore sulphide (eg. PbS) forms.

Keywords: *metal, contamination statistical analysis, potentially toxic element, sediment*

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Investigation of geochemical-microbiological processes in the Drava River floodplain based on environmental geochemical data

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Floodplains have received significant attention recently because they are densely populated areas, covered by fertile agricultural lands and act as diverse riverine habitats. At the same time, these important areas are sensitive receptors of PTE (Potentially Toxic Elements) contamination originating from upstream mining and industrial areas endangering food safety and the ecosystems. The large Drava River catchment has been impacted by industrial activities since historic times. Previous studies have shown that the alluvial sediments record the contamination from upstream mines and smelters (e.g. Bleiberg-Kreuth in Austria, Cave del Predil in Italy and Mežica in Slovenia). Floodplain topsoil (depth: 0-10cm) and subsoil (depth: 50-60cm) samples in the actively flooded alluvial plains and river terraces were collected along 10 cross-sections all along the Hungarian-Croatian border river Drava. In order to study the impact of contamination on soil microbiota, the samples were analysed with ICP-MS for chemical composition, in addition to FDA (Fluorescein Diacetate) tests for the microbial activity assessment. Data was modelled with data analysis methods including descriptive statistics, regression models and homogeneity tests, complemented by spatial visualisation with GIS based software. Results show that there is a significant difference between alluvial plain and river terrace sediment contamination, while soil depth (topsoil vs subsoil) seems to be an important factor for soil microbial activity.

Key words: *Floodplain, Contamination, Data analysis, Microbial activity*

Acknowledgements

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Redundancy-free Topological Data Structures

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Abstract

Open Geospatial Consortium Simple Feature Access standard defined the concept of the topology and the topological quality (<https://www.opengeospatial.org/standards/sfa>; OGC description, 2013), but this logic does not preserves the topology automatically, which is essential for spatial data quality (Rigaux et al., 2002). This paper introduces a data structure, which preserves topology coming from the logical construction of relational tables. This logic is redundancy-free, because nodes and polygons (or curves) are in separated tables. Only points contains coordinates. Polygons contain only references to points table, thus any changes in the points table are automatically transited to polygons. This logic guaranties the topology preserving property of this data structure (Elek, 2014, 2015). If a GIS software was based on this data structure, the topology would be a native property of a polygon/polyline data set.

Key words: *topology, data structure, data quality*

Acknowledgements

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Part IV - Mathematical aspects of reservoir geology

Mathematical aspects of reservoir geology – a case study

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Abstract

Following a workflow leading to the re-evaluation of potential, opportunities and risks belonging to a hydrocarbon field the crucial role of mathematics (including statistics, probability theory and logic) and basic programming skills will be presented, aiming to highlight the colourful world of modelling and the mindset related to it.

The oilfield - in the scope of the case study - was discovered and put on production in 1947, but based on its initial in-place volumes and comparison to average Russian hydrocarbon field sizes it was peripheral, so its development progressed at a very confined pace. This explains how and why it is reaching the plateau production only last year and still has low recovery and room for investment in re-development, and is still a significant member in MOL's portfolio. To support and make the base for these new approaches, conventional and "unorthodox" methods were needed while maintain the overall goal to arrive to a reliable output data set and recommendations. The emphasis shall be on the proposed work program including data gathering, development options, subsurface activities that can contribute to lifetime-extension of the field and optimize recovery.

Key words: *reservoir geology, geomodelling, geostatistics*

Insight into multiple-point simulation of a deep-water system, Algyő HC field, Hungary

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Abstract

The multiple-point simulation is a quite new method for facies modeling compared with indicator and object-based simulation. It is cell-based, but uses geometrical information (i.e. training image) instead of semivariogram to describe spatial heterogeneity. The aim was to apply this algorithm to model a deep-water submarine fan system and to visually compare its result with the result of indicator simulation.

The formation is located in the Algyő HC field, SE of The Great Hungarian Plain. It is described as a Pannonian (Late Miocene – Pliocene) deep-water submarine fan system belonging to the Szolnoki Formation. The data consists of faults derived from seismic, 163 well data (well logs: GR, RES, SP, POR, PERM etc.) and some core samples (7 wells). These were used to determine a simplified channel-lobe-background (architectural elements) system in each well. In lack of considerable diagenetic effect, they can be regarded as flow units.

The build-up of the structural model includes five sandy and five shaly zones. These are considered as sedimentary cycles. The geometrical parameters of facies elements were derived from result of indicator simulation. The channels are sinuous, the lobes show fan- or sheet-shapes with various sizes per zones.

The facies model of multiple-point simulation gave back the elements' geometries more efficiently than indicator simulation. If we can accept that the architectural elements are able to behave as flow units, this type of facies model may aid the accuracy of petrophysical modeling.

Key words: *deep water system, multiple-point simulation, architectural element*

Pore regimes and REV: a CT-based model for the BCF

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Abstract

In this study we would like to demonstrate the small scale textural and petrophysical heterogeneity of Boda Claystone Formation. For this purpose, three-dimensional images (CT-bricks) of Boda Claystone Formation drill cores were acquired by using a medical X-ray computed tomographic scanner. The 3D images were calibrated to the small-scale core description studies. The CT measurements carried out in two steps: (1) after vacuuming, (2) after water saturation. The effective pore structure was evaluated by subtracting the vacuum CT images from the saturated one. From this protocol we got three parameters for the textural and pore properties: CT number of the dry (vacuumed) state; CT number of the saturated state; and the calculated effective porosity. The spatial patterns of the voxels with similar porosity and textural characters were revealed by a generalized k-means clustering algorithm. We applied semivariograms and 3D gradient analysis to describe the spatial characters of the clusters. The Representative Elementary Volumes (REV) of effective porosity for different rock types were calculated by using a statistical process control approach.

Independently of both the rock types and the sedimentary structures, two clusters could be defined: one for the micro-porosity and one for the macro-porosity regimes. The former showed a continuous 3D spatial appearance, while the latter appeared in patches. These patches may also be connected, at least partly, to some local montmorillonite aggregates. These clay minerals could lose their structured water content during vacuuming and swell when adsorbing water during sample-saturation. In each rock types the micro-porosity regime could be related to low density rock fragments. The mean effective porosity of the micro-pore regime was about 0.02, which corresponds to the petrophysical core measurements. For the macro regimes the average was 0.1. Both the micro and the macro-regimens showed longer vertical and shorter horizontal continuity. The average REV calculated for the rock-types of the cores was 80-90 cm³.

Key words: CT, effective porosity, REV, Boda Claystone Formation

Lithology prediction in the subsurface using artificial neural networks on well and seismic data – a stochastic approach

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Abstract

Analysis of lithology and lithology related variables in the subsurface is a key component in exploration of subsurface. The conventional way is to use different mapping algorithms to determine the properties in the inter well area based solely on well data or using seismic explorations (attribute analysis; Radovich & Oliveros, 1998) in order to reduce uncertainty. Artificial Neural networks are also used for this purpose but more as a deterministic approach than a stochastic one (Brcković et al., 2017). For this purpose, a small volume of subsurface in the SW part of Pannonian Basin, representing an old small oil field which is covered by 3D seismic and several wells was selected. The artificial neural networks were first trained on a seismic attribute set belonging to the well traces and afterword the prediction was performed in the inter-well volume using 100 trained networks. The final result was obtained by P90 values of the categorical values that represent different lithologies. By this way the uncertainty of the lithology prediction in the inter well area has been significantly reduced, especially in this case where to few well point data were available to provide a variogram model for conventional deterministic and stochastic approaches.

Key words: *Artificial neural networks, stochastics, lithology, subsurface*

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Part V - Conquering space - remote sensing

ESA's planetary missions – once explorers, always explorers

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Abstract

The European Space Agency's solar system science and exploration missions have been much in the news in recent years, with the decade-long saga of the Rosetta comet-chasing spacecraft and its Philae lander, the arrival of the ExoMars Trace Gas Orbiter and Schiaparelli lander at the Red Planet, and the launch of the international BepiColombo mission to Mercury. I'll give you an insight into these missions and others in ESA's fleet, their challenges and some key scientific results, and tell you what's coming next in ESA solar system exploration, including new missions to study Mars, Jupiter and its icy moons, and perhaps out to the ice giants, Neptune and Uranus, and back to Venus.

Key words: *European Space Agency, solar system, planetary, space missions*

Geostatistical analysis of Raman spectrographic data of the Chelyabinsk meteorite

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Abstract

In case of adequate amount of data, using statistical methods analyzing a spectrographic database could provide profound information about unique petrographic features.

In this study, Raman spectroscopic analysis of shock induced melt-veins had been carried out on a thin section of the Chelyabinsk ordinary chondrite meteorite. The obtained raw spectra have been processed by a mathematical peak fitting analysis, where Gaussian deconvolution approach based on the Voigt-type curve fitting procedure was used. In 91 cases, from three shock melt-vein types, peak positions and full-width at half maximum (FWHM) values of the Raman-active bands of substance olivine have been tested by statistical methods. The distribution of the attributes was studied in histograms and scatter plots, additionally two-sample independent t-tests were carried out to examine the significant difference of population means in between olivine peak attributes from different melt-veins.

In the hypothesis test results two of the three optically separated melt-veins (Type 1 and 2) appearing in the thin section, shows significant difference ($p \leq 0,01$) between expected values of peak positions and FWHM values of the Raman-active bands of substance olivine, however in some peak attribute means the Type 2 melt-vein does not show significant difference with the other two vein type mean attributes ($p \geq 0.01$). Using this method, we can obtain information about the internal crystallite structure and crystallite size of the substance olivine, which can be used to infer the difference in the rate of solidification of the shock melt-veins.

Key words: *Geostatistical analysis, Raman spectrography, Chelyabinsk, shock-melt vein*

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Part VI - Analysis of monitoring time series

Big Data in Geosciences – Challenges and Novelties

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Abstract

The increase of ‘Big Data’ applications has been characterized by a dynamically growing availability and variance of data that is foreseen to have a key role in the future of geoscientific research. Without doubt other disciplines like economics, business sciences, medical and pharmaceutical research have advanced significantly in the widespread use of Big Data methodology, geoscience and geoinformatics is however slightly lagging behind, despite the ever-increasing amount of monitoring data obtained from campaigns and continuous monitoring. The goal is to provide an overview and raise some issues in this rapidly growing field with an outlook to other disciplines.

Key words: *big data, monitoring, economics, geoscience*

Assessment of the groundwater bodies in the vicinity of Lake Fertő/Neusiedler See using multivariate data analysis methods.

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Abstract

Lake Fertő/Neusiedler See and its surroundings are a part of the Neusiedlersee-Seewinkel National Park in eastern Austria. Its water quality and amount is highly influenced by the water quality of the groundwater bodies in the area. The groundwater quality- and levels are regularly monitored in the vicinity of the lake.

In this study the time series of the interval between 1997 and 2012 were analyzed using multivariate data analysis methods. The sampling sites were clustered based on the water quality data, with the distinguished groups indicating a spatial pattern. The groundwater levels were assessed using dynamic factor analysis to obtain the common trends in the time series. Based on the results it can be concluded that precipitation and evapotranspiration are the most significant driving factors of the water levels. In many cases the dynamic factor models were more efficient when estimating the water levels, than the ordinary linear regression models.

Key words: *groundwater, water quality, data analysis, dynamic factor analysis*

Acknowledgements

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The influence of Danube on the groundwater system in Mohacs Island

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Abstract

Mohacs Island is situated on the southern part of the Hungarian section of the Danube, its area is 275 km². The island was the floodplain of the Danube until the beginning of the 19th century when it was drained and blocked from the river by embankments during river regulations. Our aim was to explain soil development in the last hundred years for which the investigation of the influence of Danube on the groundwater system and understanding of the relationship between groundwater level and soil development are necessary.

Ten large flood waves were selected between January 2010 and June 2014. The lag-time and the strength of relationship between groundwater levels and the Danube flood waves were investigated with cross-correlation function (CCF) of R statistical software package.

Only the higher flood waves raised the groundwater level significantly. This raising-effect was observed mostly at the wells not too far from river bank (<1000 m). The affect size inversly related to the distance and it ceased at a distance of 2000 m from the Danube. We have concluded that strong co-factors in groundwater flow are drinking water producing wells and geology (elevated subterranean clay surfaces).

Key words: *Groundwater, Danube, CCF*

Acknowledgements

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Hydraulic characterization using water level monitoring time series on an example from Eastern-Hungary

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Abstract

Hajdúnánás area is located at the Eastern part of Great Hungarian Plan; it is a regional discharge area by hydrogeological aspect. The objective of our investigation was the hydraulic characterization of shallow zone (upper 30 m below ground). A five-years-long hydrodynamic investigation monitoring program was conducted which contains the one-hour frequency water level gaugement in selected wells and quarterly groundwater level measurements in each monitoring well. Data was analyzed using traditional tools e.g. potential maps, statistical analysis of hydrographs. Additionally, we calculated the one-hour frequency gradient time-series using geometrical method. This tool is useful to analyze the temporal variation of spatial variables (groundwater flow direction, connection between surficial water bodies and groundwater).

The following observations were used to refine the conceptual site model:

- the groundwater flow direction varies in 64° range.
- this variation of groundwater flow direction caused by spatially different amplitude of fluctuation. Significant spatial correlation was observed in fluctuation.
- this variation was most dominant in the shallow aquifer, but this variation decreases in downward.

Based on these results the investigated area is located on regional discharge area, but this situation is disturbed by a nested local scale unit basin.

Stochastic analysis of different homogeneous river sections at seasonal resolution on the River Tisza

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Abstract

Determining the ecological niche space occupied by planktic algae is important to sustain the biodiversity of surface waters. In the presented research, principal component analysis combined with the outlying mean index was applied to 14 water quality time series (1993-2005) derived from three previously determined homogeneous sections of the Hungarian part of the River Tisza. It was found that, in the first upper section, the seasonal niches (n dimensional hypervolumes) overlay each other, and no clear separation could be detected. In the middle- and lower reaches, however, a clear separation was observed between the seasons. The main idea of the study was to not only investigate the niches spaces as usually done in such ecological studies, but take into consideration the homogeneous characteristics of the sampling sites in the different river sections in the Tisza. The identification of these separate niches of the various seasons as the main indicators/drivers of certain ecological communities (e.g. phytoplankton) proved possible using the methodology presented.

Key words: *combined cluster and discriminant analysis, hydrochemical seasons, niche space, principal component analysis*

Acknowledgements

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Investigation of data structure in application of neural networks

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Abstract

In this study neural networks were applied to analyze parameters of ecological systems. The research targeted the parameters of Danube, with special focus on dissolved oxygen content. For the purposes of hydrological analysis, a reference model containing all sampling points on the river randomly allocated to either the training or the test set and a spatial configuration were developed. This latter assessed data from three alternative locations, two of them were homogenous stations and the third one as the last neighbouring station down the river was inhomogeneous. The objective was to define the most efficient data structure for the training set. Using results from the configuration implementing the spatial optimisation of Danube we justified that if the training set was of mixed structure (it contained data from both homogenous and inhomogeneous stations) then this yielded a more efficient estimation.

Key words: *Combined cluster and discriminant analysis, General Regression Neural Network, Radial Basic Function Neural Network, spatial forecasting, spatial optimisation*

Acknowledgements

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Part VII - Data analysis in engineering geology

Data analysis in engineering geology

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Abstract

The significance of data analysis in engineering geology has been increasing dramatically for the last decades. Besides the “traditional” geostatistical analyses of test data aiming mainly the optimization of exploration works, new challenges have arisen. The accelerated development of measuring methods or instruments requires deeper understanding of error sources and their contribution to composite error. By the remarkable growing of both the resolution of measuring instruments and the frequency of data logging the data-sets to be analyzed become continually larger and requires special data-managing and processing methods. According to the up-to-date in situ and laboratory measurements it is clear that the isotropic, non-rheological and linear elasticity approach of technical mechanics fails even for intact rocks, so it proved to be impracticable in more exacting projects. Nevertheless, that over-simplified solution is still dominant in everyday static design tasks, due to the complicated mathematical treatment of a realistic rock substance with its 21 independent variables, at least. Further rock mechanical and mathematical efforts with most likely thermodynamic approach are desirable for elaborating powerful methods on that field. The adequate mechanical description of real rock masses is even more challenging, multi-component task. Various useful empirical methods have been developed but sometimes they are weighted by site- or rock type-specific, non-unambiguous and subjective elements. New, more complex approaches (e.g. Discrete Fracture Network, fractal-based methods) are also used for the description of the geometry of discontinuities but their mechanical characterization is generally missing. Due to the mentioned problems, the numerical modelling, as one of the top-level evaluation methods of engineering geology, still has lots of uncertainties. The application of complex, irregular 3D geometries would be essential for getting reliable modelling results but it requires special GIS-based preparatory works. The presentation gives practical examples on the above-mentioned topics and makes an attempt to highlight some possibilities for stepping forward.

Key words: *Engineering geology, Data analysis, Numerical modelling, Geoinformatics*

Investigation of relationship between dynamic and static deformation constants of rocks

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Abstract

Determination of deformation constants of rock material is an essential part of any design in rock mechanics. Recently, the relationship between static and dynamic elastic moduli has got much attention in the scientific literature. The goal of this paper is to show, that there is a relationship between elastic and dynamic constant for Modulus of elasticity (E), Modulus of rigidity (G) and Bulk modulus (K). For this purpose, different data for igneous, sedimentary and metamorphic rocks were collected and analysed from literature. It was concluded that for Modulus of elasticity there is correlation ($R^2 = 0.9$), for Modulus of rigidity ($R^2 = 0.9$) and for Bulks modulus ($R^2 = 0.78$). The observed relations can be explained in a universal thermodynamic framework.

Key words: Static and dynamic, *Modulus of elasticity (E), Modulus of rigidity, Bulk modulus (K)*

Comparison of properties of porous limestone from different locations

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Abstract

The aim of this research is to evaluate the properties of porous limestone according to laboratory test results, which helps to understand the behaviour of this kind of rock as a host rock of underground cellar systems. The statistical evaluation results make easier to choose the input parameters for stability analysis of these underground structures. Porosity, density, water absorption, US wave propagation, uniaxial compressive strength and indirect tensile strength were measured in both air dried and saturated conditions according to ASTM and EN codes. The laboratory tests results represent the mechanical parameters of the studied porous limestone. Cylindrical specimens of Miocene limestone were obtained from cellar system in Budafok northwest of Budapest. There were 641 parameters determined from testing of 132 specimens. Statistical parameters and correlations of the laboratory test results are compared with previously determined database by Vásárhelyi 2005, and Dweirj et al. 2017. The results of the analyses indicate that small changes in lithology and the heterogeneous porous distribution cause variation in mechanical and physical parameters of the porous limestone.

Keywords: *porous limestone, laboratory tests, mechanical properties, statistical analysis*

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Predictors of concrete strength, porosity and permeability as suggested by data analysis and machine learning

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Abstract

Being able to predict the physical properties and integrity of differently prepared and exposed concretes is important in economic, environmental and human safety point of view. By the use of a neural network algorithm, the compressive strength of concrete is proven to be possible to estimate. In this work, a study case is reproduced and different machine learning algorithms are tested for the prediction of concrete strength. With the experiences collected, a new dataset is also analysed focusing on parameters determining the porosity and permeability of concrete. Analysis methods include data visualization both in Excel and R and machine learning in R. The concrete strength is estimated with an R^2 of 0.938 by the Random Forest algorithm, which suggest that the main predictors are concrete age and proportions of cement, water, slag and fine aggregate. Regarding the porosity-permeability dataset, the results are less conclusive due to the biased sampling. However, it is indicated, that the pressure applied on concretes during their preparation decreases both the porosity and permeability and that the proportions of cement, water and sand are the other important predictors. Prediction of concrete properties by data analysis and machine learning may help to reach better performance and easier experimental development.

Key words: *concrete, R, machine learning*

Acknowledgements

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Parametric study of the Poisson's ratio

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Abstract

The Poisson's ratio (Poisson, 1829) is one of the basic mechanical parameters for geomechanical calculations. When determining the various deformations and the associated tri- and biaxial stress, the Poisson's ratio plays a very important role. Thus, knowing this material constant is very important for any geomechanical calculations. In rock mechanics, the Poisson's ratio, depending on the rock material, it can be considered constant, although it is not necessarily true. However, the determination of this value is not clear – highly depend on the in situ stress conditions, rock mass quality, stress or strain rate, among the others. Selecting the value of the Poisson's ratio for a rock, from the values-range (Gercek, 2007) set for that rock, is an almost random process, which can significantly affect the result of the calculation.

This study presents a parametric study of changes in the value of the Poisson's ratio. It will be analysed the influence of the confining pressure and the rock mass quality for the Poisson' rate. The Geological Strength Index (GSI) is used for describing the rock mass quality.

Key words: *mechanics, stress, Poisson's ratio, rock mass*

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Effect of multi-stage shearing on shear strength of rock joint surfaces

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Abstract

Direct shear test method in laboratory conditions are commonly used for estimation the value of shear strength of rock joints. According to ISRM standards shear tests can be carried out on constant normal load (CNL), representing rock slope behaviour, or on constant normal stiffness (CNS), representing the behaviour of rock surroundings of a tunnel or other underground structures. ISRM standards recommend multi-stage shearing tests both with and without repositioning the sample in the shearing equipment. Due to the variability of natural joints and rock mass, and for making tests repeatable mortar specimens with the same qualities are usually tested.

This study focuses on the differences between the results of shearing tests with and without repositioning the samples. Specimens were made of cement (UCS was approx. 60 MPa) and plaster mortar (UCS was approx. 25 MPa) with sand aggregates with the maximum grain size of 0.5 mm. Surfaces of the specimens were copied from the same natural sandstone rock joint with joint roughness coefficient between 0 and 2 measured by Barton comb. Tests were carried out on three different CNL which were approx. 0.5, 1.0 and 1.5 MPa in case of cement mortar and 0.25, 0.375 and 0.5 MPa in case of plaster mortar. Each specimen was sheared five times and failure curves were approached by linear regression. Curves of results of tests with replaced specimens were compared with ones without replacing in case of every shearing.

Differences between result of the two methods in case of plaster mortar were relatively higher than in case of cement mortar although UCS and CNL values were closer to the natural conditions and qualities of the original rock joint.

Key words: *direct shear test, mortar, multi-stage shearing, linear regression*

Geomathematical evaluation of surface strength tests of stone monuments

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Abstract

The central building of Budapest University of Technology and Economics was constructed in 1909. It is a protected emblematic monument at the riverside of Danube in Budapest. The façade of the building was made of limestone that shows signs of severe deterioration. To assess the current state of preservation of the porous Miocene limestone and Pleistocene travertine, ashlar and external wall cladding elements were tested. The condition assessment is based on non-destructive tests, such as surface hardness (Schmidt hammer and Durosokop) and moisture content (GANN Hydromette UNI). All together 23 stone wall sections of the buildings were monitored representing different exposure conditions. On each section the moisture content was measured along two vertical profiles. The on-site measurements were made 6 times, representing one year period, with various weather conditions. More than 20,000 moisture data was collected. Schmidt hammer and Durskop tests provided more than 4000 and 8600 rebound data, respectively. The present study brings an example how these large data set of measurements can be evaluated by using geomathematical tools. Microsoft Excel and SPSS software was used to analyse the moisture and rebound data. The interpretation of these data sets allowed showing temporal changes in moisture content and also variations in surface strength of studied stone surfaces.

Key words: *Limestone, monument, surface strength, moisture content*

Acknowledgements

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Part VIII - Assessment of geophysical datasets - interpretation & uncertainty

Application of the fuzzy c-mean cluster analysis over the Yamaat gold deposit in Mongolia

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Abstract

This paper presents a result of Fuzzy C-mean clustering applied on the dataset of two physical properties (resistivity and chargeability) measured over the core sample in the gold deposit in the Yamaat area, Mongolia. In general, the mathematical statistic methods are essential for the geology modeling and analysis of rock physical properties dataset. Sometimes in practice, geostatistics are very difficult to apply to field data. The purpose of this research is to develop an advanced geostatistical technique for mineral exploration based on chargeability and resistivity of the core sample in the field. Our study has presented that, the optimized fuzzy C-means clustering analysis, helped us obtain clusters and new centers of the bedrocks distributed in the research area. This method is useful for the very quick processing of massive rock physical properties and may become an important technology in geophysical survey and mineral exploration

Key words: Chargeability, Resistivity, and Fuzzy C-mean clustering analysis.

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Reducing the uncertainty of parameter estimation for the interval inversion method using factor analysis

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Abstract

The accurate estimation of petrophysical parameters is of crucial importance in calculating the hydrocarbon reserves. An improved interval inversion approach is presented for the estimation of shale content, matrix volumes, porosity and water saturation using well logging data. First, the depth function of model parameters is expanded into series by using Legendre polynomials, which leads to a highly overdetermined inverse problem. To decrease the starting model dependence of the inversion procedure, the series expansion coefficients as unknowns of the inverse problem are first approximated by a metaheuristic approach using Particle Swarm Optimization. Then, their optimal values are searched by the Damped Least Squares method. The added advantage of the linear phase is that it allows the calculation of estimation errors of model parameters. For further increasing the data-to-unknown ratio, and thus improving the estimation accuracy, shale content is estimated independently by factor analysis applied before the interval inversion process. By incorporating the resultant shale volume log as a known quantity into interval inversion, the overdetermination of the inverse problem is increased. Through the example of Hungarian oilfield data, it is demonstrated that the uncertainty of the estimated model parameters can be significantly decreased, and the combined interval inversion method allows for a more reliable hydrocarbon reserve calculation.

Keywords: *Interval inversion, Particle Swarm Optimization, Factor analysis, Estimation error.*

Part IX - Diverse faces of Geomathematics (posters)

Analysing land use change and geomorphometric parameters in small watersheds

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Abstract

Land use and land cover changes have significant impacts on the environment, these changes might cause to modify the basin hydrology by affecting evapotranspiration, soil infiltration capacity and surface and subsurface regimes which ultimately can affect water quantity and quality. Moreover, land use change is one of the most critical and direct driving factors of changes in ecosystem functions and services. It can change the ecosystem productivity, modify the physical parameters of the surface, affect nutritional convey between soil and vegetation by changing biochemical cycles, and influence the elements and structures of ecosystems.

In this study, CORINE land cover maps of Hungary from five different time periods (1990, 2000, 2006, 2012, 2018) were used to analyze the trends of LULC changes and also detect the prominent changes in different classes of LULC maps within the catchments of Szilas and Rákos Streams near Budapest, Hungary. Additionally, geomorphometric analysis of the area has been implemented in order to assess possible relations between landforms and land use changes. Based on our analysis, increased area of urban fabric, industrial or commercial has led to a decrease in agricultural, semi-natural and forested areas.

Key words: *Land use change, CORINE, Hungary, geomorphometry*

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Comparison of interpolation methods for Hungary

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Abstract

Interpolation is one of the most frequent operations used in computational techniques. In this study, three different interpolation methods are carried out, using the weather stations data in Hungary. This study focuses on the temperature and precipitation averages derived for the 1981-2010 normal period. Some monthly, seasonal and yearly averages are investigated in this work.

In this work we compare two GIS interpolation methods such as Ordinary Kriging and Inverse Distance Weighting to the method MISH (Meteorological Interpolation based on Surface Homogenized Data Basis; Szentimrey and Bihari). The main difference between these methods is that in the case of geostatistical procedures the usable sample for modelling of the statistical parameters are only the predictors. In meteorology we have spatiotemporal data, namely the long data series which form a sample in time and space as well.

For each method, the prediction values and corresponding observed values were compared. By using Geostatistical Analyst in ArcGIS, 6 subsets were created in every single case and the results were averaged. The performance of the methods was assessed by identifying the Root Mean Square Error (RMSE) in the predictions. Higher values of RMSE obtained in case of Ordinary Kriging and Inverse Distance Weighting, while the slightest values of RMSE occurred with the MISH interpolation method.

Key words: *interpolation, MISH, Inverse distance weighting, Ordinary Kriging*

Probability distribution of concentration time series data

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Abstract

Many groundwater contamination problems are a persistent feature of the affected groundwater regime. Plumes are complex and dynamic entities. The behaviour of these contaminant plumes regularly monitored. Concentration data gained by repeated sampling of monitoring wells and subsequent laboratory analyses of the samples are used to assess the actual state and behaviour of the plume. Concentration data are ordered into time series and evaluated for trends. One of the most common trend evaluation methods is linear regression using least squares.

The significance of the regression line slope is often determined by F-test. F-test calculation requires the calculation of SSE (Sum of Squares Error), which in turn requires the use of data mean. Whether data mean is a representative (expected) value for the data set depends on data distribution. Data mean is representative for the data set if data are normally distributed, that is one of the reasons F-test is sensitive to data distribution.

Concentration time series data from a theoretical point of view can never be normally distributed, and their factual probability distribution is discussed on rare occasions. In addition concentration time series datasets are aggregating in time, so trends should be evaluated for each increment, as well as and data distribution. The result is a trend evolution and data distribution evolution in time.

Trends can change as new data is added to the time series, so instead of prognosis made on actual data trend persistence is more of a question. To assess trend persistence a hypothetical value is added to the actual dataset which would change the trend. The probability of this hypothetical value is then determined based on data probability distribution.

Key words: *groundwater, contamination, concentration time series, prognosis*

Analysis of karst water recovery time series in a former mining area, Hungary

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Abstract

From 1950 to 1990, a large amount of karst water was extracted in the Transdanubian Range because of the mining of coal and bauxite. At the beginning of the 1990s the mining was stopped, and the recovery process has begun, which caused technical-engineering problems as well. The goals of the study were (i.) to determine whether the time series can be grouped based on their patterns and their spatial distributions; (ii.) to assess whether the karst water levels can be forecast using “classical time series methods”, i.e. trend estimation and extrapolation and; (iii.) if they can be then, to identify which type of curves can appropriately describe the recovery process.

The 127 wells located in the area can be grouped into three groups by hierarchical cluster analysis. In the wells, situated nearer to the depression centers, the effect of the recovery is remarkable, and the time series weren't characterized by fluctuation. However, the water levels in the wells, situated further from the depression centers, have a significant fluctuation pattern. The long-term change of the water levels can be forecast by the estimation and extrapolation of the trend. Therefore, 10 different types of so-called growth curves were fitted in order to find the best fitting one and the water levels were forecast for January 2030. In most cases, the process can be modeled the most accurately by the so called “Richards” (28,35%) and “63%” (25,98%) functions.

Key words: *forecasting, growth curves, time series, karst water*

Tritium isoscape of precipitation across the Adriatic-Pannonian realm

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Tritium is an important natural tracer in hydrological sciences. The dataset used in the present study is compiled of ~7,700 monthly precipitation tritium activity values from 71 stations, covering the period from Jan 1961 to Dec 2017. As a pre-processing step, a sequential univariate outlier detection procedure was applied in which the time series of the stations were pairwise compared for each year. Variogram analysis was then applied to the precipitation amount weighted annual averages of tritium activity. Variograms applicable for interpolation were obtained from years 1977, 1982, 2007, 2010, 2011 and 2012. These were further on used as the reference years, and their variograms were used as the weights for kriging in the intermediate years. It suggests a decrease in spatial representativity of the precipitation monitoring stations from 590 km in 1977 to ~270 km in 2012, which might reflect the diminishing influence of broadly homogenous anthropogenic disturbance (i.e., global effect of bomb tests) on natural tritium levels of precipitation. Since ³H activity in the region approximated the natural level in precipitation by the early-1990s, it can be expected that the ~270 km range obtained for the 2012 reflects the natural ³H variability. The final product of the research was a database of the interpolated 1x1 km grids of each year's tritium activity.

Key words: *Tritium, Precipitation, Variography, Kriging*

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Preliminary data of the geoarchaeological analyses on the vesszős-halom (Mound) at pusztaszer

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Abstract

Mineralogical, geological and paleontological analyses of archaeological tools and features have started already in the 18th century. These sporadic investigations were followed by systematic geological analysis from the middle of the 19th century. Following the proposals of Flóris Rómer archaeologist at this time in Hungary in the 1860s, geoarchaeological research started at first by the analysis of obsidian stone tools and later by the analysis of kurgans. By the magnetic susceptibility and complex sedimentological analysis of Vesszős-halom (Pusztaszer/Ópusztaszer) we were able to separate three different phases of accumulation of the analysed kurgan. Furthermore, it was also possible to prove the formation of the bedrock and soils that cover the surface of kurgan (Vesszős-halom – Vesszős mound).

Keywords: geoarcheology, stratigraphy, vesszős mound, sedimentology, magnetic susceptibility,

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Late Pleistocene deglaciation and paleoclimate in the Rau Barbat valley, Retezat Mountains, Southern Carpathians

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Abstract

The topic of the study is the deglaciation history and the paleoclimate of the eastern, Rau Barbat valley system at the Retezat Mountain. Geomorphological mapping and digital elevation model were used to identify the glacial landforms in the valley system. The paleoglaciers were reconstructed with GIS applications (GlaRe toolbox, Pellitero et al., 2016) and the equilibrium line altitudes (ELA) were estimated using the accumulation-area ratio (AAR) method. Based on the reconstructed glaciers and their AAR ELA value six deglaciation phases were reconstructed: M1 (1800 m a.s.l.), M2a (1995±10 m a.s.l.), M2b (2045±10 m a.s.l.), M3a (2080±20 m a.s.l.), M3b (2150±20 m a.s.l.) and M4 (2220±7 m a.s.l.). The ELA-s of the reconstructed glaciers were compared to ELAs of reconstructed paleo-glaciers where ¹⁰Be surface exposure ages were available (Ruszkiczay-Rüdiger et al., 2016). On this basis tentative ages were assigned to the reconstructed glaciers of the Rau Barbat Valley. Using these indirect age estimates a tentative reconstruction of the paleo-precipitation values was carried out using a *Chironomidae*-based summer air temperature reconstruction (Tóth et al., 2012).

Key words: *glacier reconstruction, deglaciation, GIS, Southern Carpathians, paleoclimate*

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Estimating subsurface lithology distribution of a theoretical model by geomathematical methods

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Abstract

One of the key elements during regional geological subsurface explorations is a valid estimate of lithology distribution. Lithological properties of the rocks in the area between wells is conventionally estimated based on well data using either conventional deterministic approach or by stochastic algorithms. Because the uncertainty, spatial and time variability cannot be avoided in geology, the aim of this research is to determine theoretical lithological composition of rocks in the area between wells, as realistically as possible. Variogram, as a starting point, is a basic term of geomathematical analysis which presents random field structure and it can only depend on the distance between measured points and on the difference in value between them (Andričević et al., 2006). Indicator kriging is used as a main method for estimation the spatial distribution of the lithological composition. It builds the cumulative distribution function at each point, based on the behavior and correlation structure of indicator transformed data points in the neighborhood (Isaaks and Srivastava, 1989). Theoretical model which represents fluvial facies with five different lithologies was made in Petrel E&P software platform. The aim was to achieve "the most accurate" model that best shows real relations of facies to the original theoretical model, by using mentioned geomathematical tools as an introduction to the processes which will be performed on actual well data.

Key words: *Lithological composition, variogram, indicator kriging, subsurface explorations*

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Environment development of a Transylvanian peat bog derives from geochemical analysis

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Abstract

The Homoródszentpál Kerek-tó (Round Lake) is a Holocene peat bog deposition in the western foothill area of the Eastern Carpathians in Romania. The primary objective of this study was to analyse the geochemical composition of a 7500 year-long peat core. In order to understand the geochemical behaviour of elements in the peat deposit and to find the interaction between them and the environment. The elemental composition was examined by XRF and six elements (Fe, Mn, Ca, Mg, Na, K) were analysed in water extraction method using atomic absorption spectrometry AAS. We use multivariate statistical analysis for evaluation of the geochemical result in examining relationships among geochemical elements and the bog's environment changes. The purpose of this investigation is to explore the relationship between the observed elements and peat development. It is important to discover the effect of vegetation and erosion event on peat characteristics and what kind of processes stand behind the changes.

Key words: *peat sedimentology, geochemistry, multivariate statistical analysis, XRF, AAS*

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Landmark analysis of *S. citelloides* (Sciuridae, Rodentia)

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Abstract

Three ground squirrel taxa are known from the Pleistocene and Holocene of the Carpathian Basin. *Spermophilus primigenius*, *S. citelloides*, and *S. citellus*. The taxonomic validity and phylogenetic relationships of *S. citelloides* is under debate since 1915. Initially, it was regarded as a relative of the European ground squirrel (*S. citellus*). However, more and more evidence suggest that it is phylogenetically linked with the speckled ground squirrel (*S. suslicus*) endemic to eastern Europe. The present study aims to give some input on the above mentioned issue via the landmark analysis of 1,500 ground squirrel premolars and molars. The occlusal outline of each tooth was defined manually by a succession of shape descriptor points placed onto photographs using the ImageJ software. Geometrical landmarks and equidistant semilandmarks of these shapes were registered objectively and automatically by a program developed in the R software environment. The raw configurations were centered, scaled, and rotated until the minimum sum of squared distances between the landmarks and their corresponding average position was reached. Canonical variate analyses were performed on the resulting coordinates. Dendrograms representing morphological similarity were made by hierarchical clustering of the mean positions of the points belonging to a taxon along each canonical variate.

According to our results, *S. citelloides* is indeed a valid species that is somewhat distinct from other known ground squirrels regarding the occlusal morphology of its teeth. The majority of the resulting dendrograms suggest that it is closely related to *S. suslicus*, which agrees well with the most recent phylogenetic concepts.

Key words: *Landmark analysis, Canonical variate analysis, Hierarchical clustering, Sciuridae*

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Deer hunt in the Random Forest

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Abstract

The importance of machine learning algorithms is rising in almost every fields of natural science, however, there has been little to no sign of their application on paleontological data up to now. The current study aimed to establish a basis for implementing such a method on fossil vertebrates.

Sixteen parameters were measured on upper and lower premolars (P/p2-4) and molars (M/m1-3) of 81 extant ruminants. The specimens belonged to three species, namely the roe deer (*Capreolus capreolus*), the red deer (*Cervus elaphus*) and the fallow deer (*Dama dama*).

Based on the acquired dataset, species classification and tooth position identification was performed by the random forest algorithm within the open source R software environment. The algorithm worked almost flawlessly during the species determination by making correct taxonomic decisions with over 90% accuracy for each of the studied 12 tooth positions. However, it recognized tooth positions less successfully depending on which position was in question.

The advantages of using such methods in the field of vertebrate paleontology are vast. The most common remains found at fossil sites are isolated teeth, which sometimes are hard to identify on a species level. Similarly, recognizing the position of such a tooth within the dental row can also be difficult. A sufficient database of teeth belonging to extant and extinct species could make future identification less biased. With the necessary amount of comparative material and measured variables, questions concerning even the age or sex of the specimens could be answered.

Key words: *Machine learning, Random forest, Cervidae, Teeth*

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Analyzing the social networks of the Gunnison prairie (*Cynomys gunnisoni*) networks and their relations to environmental variables

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Abstract

In this study we used network data to analyze animal social networks. For animals where the interactions between individuals can be quite complex, studying the complex structure of social interactions can help to understand both individual behavioral patterns and group dynamics. In this case, social network analysis offers a toolkit to describe and quantify social structure. There is an increasing amount of data for the social organization of various species and it is an emerging question what determines the properties of these animal social networks. Factors can be both internal (parameters of sociality) and external (environmental parameters). We perform social network analysis in order to better understand how these external and internal network-independent variables correlate with some measures of network structure. We studied 14 groups of Gunnison's prairie dogs (*Cynomys gunnisoni*) and used the positive interactions among them (greet kisses) to build our social networks. We present correlations between three topological properties of the networks (centralization, clustering, average distance) and two network-independent variables (a social one: group size and an environmental one: total biomass). We found that larger group size is associated with smaller centralization, higher clustering and larger average distance, while higher total biomass is associated with higher clustering.

Key words: *social network analysis, prairie dogs, network variables*

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Interannual fluctuation of xylem cellulose content of three tree species (2012-2017; Romania)

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Abstract

Tree-rings are one of the most abundant annually resolved paleoclimate archives providing a wealth of xylem derived parameters (e.g., ring widths, density) for a retrospective view on past environmental history. Their chronological accuracy, wide availability, and the sensitivity of tree growth to local environmental factors, make them perfect candidates for such studies. An isotope dendroclimatological study was initiated for a deciduous (*Fagus sylvatica* L.), and two conifer species (*Pinus sylvestris* L., *Picea abies* (L.) H. Karst.) in the E Carpathians (Tab. 1.) for the years 2012-2017. Cellulose was separated using the Jayme-Wise method. Here we evaluate the between species/sites comparisons of tree-ring cellulose yields. The stable isotope data will be presented in a separate study. Results did not indicate any shared interannual variability between the species sampled at the same sites. There is a shared characteristic linear pattern between the pine populations at the different sites, with r mostly ≥ 0.52 , except for BZ vs. CR. The spruce populations' cellulose yield time series presented a weak negative correlation (RA vs. AND: $r = -0.23$). The beech populations from sites AND, BJ, and BZ showed a similar interannual variation ($0.62 \leq r \leq 0.97$). Interestingly, the interannual fluctuation of cellulose yield for both species (beech, pine) at the southernmost site (CR), showed a pattern unlike any other.

Table 1. Sites and species

site name	site code	species
Bistrita	BN	<i>Fagus sylvatica</i> , <i>Pinus sylvestris</i>
Blaj	BJ	
Buzau	BZ	
Craiova	CR	
Rarau	RA	<i>Fagus sylvatica</i> , <i>Picea abies</i>
Adancata	AND	

Key words: tree-ring, spatio-temporal evaluation, forest species, descriptive statistics

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Postscript

The **GEOMATES 2019**

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