Institute of Geodesy and Geoinformatics, Wrocław University of Environmental and Life Sciences

Institute of Rock Structure and Mechanics, Czech Academy of Sciences

Institute of Geodesy, Brno University of Technology

Committee of Geodesy, Polish Academy of Sciences

Association of Students and PhD Students "Zenit-Nadir"

20th CZECH–POLISH WORKSHOP

ON RECENT GEODYNAMICS OF CENTRAL EUROPE

and

the 2nd Symposium of the Committee on Geodesy of the Polish Academy of Sciences

ABSTRACTS

Szklarska Poręba — Jakuszyce, Poland
October 24–26, 2019

Scientific and Organizing Committee of the 20th Czech–Polish Workshop
ON RECENT GEODYNAMICS OF CENTRAL EUROPE
and
the 2nd Symposium of the Committee on Geodesy of the Polish Academy of Sciences
Szklarska Poręba — Jakuszyce, Poland
October 24–26, 2019

Institute of Geodesy and Geoinformatics
Wrocław University of Environmental and Life Sciences, Poland

Institute of Rock Structure and Mechanics
Czech Academy of Sciences, Prague

Institute of Geodesy,
Brno University of Technology, Czech Republic

Committee of Geodesy
Polish Academy of Sciences, Warsaw

Association of Students and PhD Students "Zenit-Nadir", Wrocław, Poland

SCIENTIFIC COMMITTEE

Prof. Bernard Kontny [1, 4] Chairman
Prof. Janusz Bogusz [4]
Prof. Andrzej Borkowski [1, 4]
Prof. Jarosław Bosy [1, 4]
Prof. Aleksander Brzeziński [4]
Prof. Stefan Cacoń [1]
Prof. Wiesław Kosek [4]
Prof. Jan Kryński [4]
Assoc. Prof. Lubomil Pospíšil [3]
Dr. Zdenka Schenková CSc. [2]
Dr. Vladimír Schenk Dr. Sc. [2]
Prof. Otakar Švábenský [3]
Prof. Paweł Wielgosz [4]

ORGANIZING COMMITTEE

Dr. Olgierd Jamroz [1]
MSc. Wojciech Sowa [1] Secretary
MSc. Adrian Kaczmarek [1]
MSc. Wojciech Dach [1]

[1] Institute of Geodesy and Geoinformatics,
Wrocław University of Environmental and Life Sciences
[2] Institute of Rock Structure and Mechanics, Czech Academy of Sciences, Prague
[3] Institute of Geodesy, Brno University of Technology
[4] Committee for Geodesy, Polish Academy of Sciences

Typesetting – Wojciech Dach, MSc. | Graphics – Adrian Kaczmarek, MSc..
Wrocław University of Environmental and Life Sciences, Poland, Institute of Geodesy and Geoinformatics
Print in 55 copies

ABSTRACTS

Invited Speaker

Contents
(in alphabetical order)

GLACIAL ISOSTATIC ADJUSTMENT IN EUROPE – OBSERVATIONS, MODELLING AND ITS EFFECTS SOUTH OF THE BALTIC SEA

Holger Steffen[1], Rebekka Steffen[1], Christian Brandes[2], Lev Tarasov[3]

[1] *Geodetic Infrastructure, Lantmäteriet, Lantmäterigatan 2, 80182 Gävle, Sweden, holger.steffen@lm.se*

[2] *Institut für Geologie, Leibniz Universität Hannover, Callinstr. 30, 30167 Hannover, Germany, brandes@geowi.uni-hannover.de*

[3] *Department of Physics and Physical Oceanography, Memorial University of Newfoundland, St. John's, NL, A1B 3X7, Canada, lev@mun.ca*

ABSTRACT

Keywords: Glacial isostatic adjustment, land uplift, geodetic measurements, forebulge, modelling

Glacial isostatic adjustment (GIA) describes the response of the solid Earth to the waxing and waning of ice sheets and corresponding changes in ocean loads that affect the Earth's shape, geopotential, rotation and stress. Most of these changes can be accurately observed with dedicated geoscientific methods.

Fennoscandia is the major GIA-affected area in Europe. Since the 1970s efforts are made to precisely model GIA and its signals. We will highlight the major steps since then and review the current state of the art. Finally, we will focus on effects at the edge and surrounding of the former ice sheet, which can be observed, for example, south of the Baltic Sea in Germany and Poland.

SUDETIC BOUNDARY FAULT'S DEEP STRUCTURE AS REVEALED BY MAGNETOTELLURIC SOUNDING

Paweł Aleksandrowski[1], Joanna Figuła[2], Marek Sada[2], Łukasz Sito[3], Marek Wojdyła[3]

[1] *Państwowy Instytut Geologiczny – Państwowy Instytut Badawczy, Oddział Dolnośląski, Al. Jaworowa 19, PL 53-122 Wrocław, pawel.aleksandrowski@pgi.gov.pl*

[2] *Przedsiębiorstwo Badań Geofizycznych Sp. z o.o., ul. Wadowicka 8A, PL 30-315 Kraków, pbg@pbg.com.pl*

[3] *Geopartner Sp. z o.o., ul. Skośna 39B, PL 30-382 Kraków, biuro@geopartner.pl*

ABSTRACT

Keywords: SW Poland, Sudetes, neotectonics, brittle tectonics

The Sudetic Boundary (Marginal) Fault (SBF) constrains the uplifted Sudety Mts. block from the NE and is manifested in the topography by the most prominent fault scarp in Poland, c. 200 km long and up to 600 m high. In terms of structural geometry, the fault is a steep to vertical feature of originally strike-slip, Carboniferous, origin, reactivated in end-Cretaceous and late Miocene to Pleistocene times as a dip-slip event of a recurrent polarity of throw (first throwing its SW and, subsequently, NE side). Magnetotelluric (MT) sounding was carried out along three profile lines from c. 2 to 7.5 km long, crossing the SBF at different locations. The MT profiles show the gross structure of a complex fault zone down to 4.5–5 km depth in terms of electroresistivity variation image, where zones of lowered resistivity of the rock medium likely correspond to deep-reaching (saline and, possibly, thermal) water-filled conduits along damage zones of major fault discontinuities. The investigated damage zones locally achieve as much 400–500 m in width and, usually, two or more of them can be seen on profiles of the SBF.

TOWARDS ESTIMATES OF PRESENT-DAY VERTICAL DEFORMATIONS USING GPS AND GRACE OBSERVATIONS

Janusz Bogusz[1], Anna Kłos[1], Jürgen Kusche[2]

[1] *Military University of Technology, Faculty of Civil Engineering and Geodesy, Sylwestra Kaliskiego Str., 00-908 Warsaw, Poland, anna.klos@wat.edu.pl*

[2] *University of Bonn, Institute of Geodesy and Geoinformation,17 Nußallee Str., 53115 Bonn, Germany*

ABSTRACT

Keywords: GPS, vertical displacements, GRACE

Recently, the vertical deformations of Earth's crust are estimated employing modern satellite systems, as GPS (Global Positioning System). These deformations are then used to interpret and verify both large-scale and local phenomena. Among others, the Post Glacial Rebound (PGR)-related uplift or human-induced subsidence should be mentioned. Modern demands to integrate available observations require that deformations derived from hydrology changes and estimated with GRACE (Gravity Recovery and Climate Experiment) and GRACE Follow-On gravity missions are also verified using GPS observations. Number of more than 17 000 permanent GPS stations distributed globally, 4 500 of which are located in Europe, answers this broad range of applications. However, one needs to be aware that GPS has also its disadvantages, as systematic or multipath errors, mismodelling in orbits and clock, misestimates of atmospheric (ionosphere and troposphere) impact; all narrowing the usefulness of GPS observations. Moreover, GPS position time series are also biased by broad range of signals that are registered. In this presentation, we will focus on the requirements that GPS position time series need to fulfil to be employed for the task of validation of hydrology-induced displacements, pointing on advantages and limitations of GPS estimates to evaluate present-day hydrology-induced vertical deformations. To this task, GRACE observations in a form of spherical harmonic to d/o 90 are employed and filtered using DDK3 filter. Then, they are converted to Earth's crust vertical displacements, estimates provided for Europe. To compare the GRACE-derived hydrology-induced deformations, geophysical model is employed, namely global hydrological LSDM (Land Surface Discharge Model) model produced by GFZ (GeoForschungsZentrum) group. For validation purposes, GPS-derived vertical changes, available from NGL (Nevada Geodetic Laboratory) are utilized.

VIRTUAL GEOLOGICALOUTCROPS – NEW APPROACHES IN SEDIMENTOLOGY, STRUCTURAL GEOLOGY, TECTONOPHYSICS

Ihor Bubniak, Kornyliy Tretyak

Lviv Polytechnic National University, Bandera Str. 12, 79053 Lviv, Ukraine, ihor.m.bubniak@lpnu.ua, kornel1958@gmail.com

ABSTRACT

Keywords: digital photogrammetry, laser scanning, virtual geology outcrop

In this work we present the results of research into the use of new technologies – digital photogrammetry and terrestrial laser scanning for sedimentology, structural geology and tectonophysics. For researches we have selected representative outcrops in different tectonic settings, in the Ukrainian Carpathians on the Eastern European Platform. The choice of technology depends on the specific conditions. First of all, it is the size of the outcrop, its type, its accessibility. For each case, we have developed a workflow of surveying. The result is a cloud of points, which is used for further processing.

The resulting point clouds and 3D surfaces are used to extract a variety of information, namely, the top and bottoms of layers, the spatial location of joint and faults, fold axes etc.

As a result of our work, we have processed 10 outcrops in the territory of Western Ukraine.

The advantages of using digital photogrammetry and laser scanning to obtain spatial information for various fields of geology are demonstrated. The high accuracy of the obtained results is also demonstrated in comparison with the classical approaches of structural geology and tectonophysics with the use of a conventional compass.

The proposed approaches can be used in other regions where a detailed studies of outcrops are required.

The resulting models will be used to visualize attractive geological objects for geotourism purposes and to create virtual geological excursions.

PROCESSING OF SATELLITE LASER RANGING TO GNSS SATELLITES

Grzegorz Bury, Radosław Zajdel, Krzysztof Sośnica

Wrocław University of Environmental and Life Sciences, C. K. Norwida 25, Wrocław
grzegorz.bury@upwr.edu.pl

ABSTRACT

Keywords: GNSS, Precise Orbit Determination, Satellite, Laser Ranging, Galileo

Satellite Laser Ranging (SLR) is a precise geodetic technique that provides range measurements to artificial satellites equipped with laser retroreflectors. The International Laser Ranging Service (ILRS) unites and coordinates all laser stations and their activities in terms of tracking satellites. Due to the fact that almost all the Global Navigation Satellite System (GNSS) satellites are equipped with the laser retroreflector arrays, SLR measurements are performed with cm-accuracy. As a result, the SLR technique can be used for the validation of GNSS-derived products as well as for the independent GNSS orbit determination.

SLR serves as an independent validation technique for the GNSS-derived orbits due to the fact that SLR uses optical wavelengths in contrast to GNSS which is based on the microwave observations. Since March 2017, a new Associated Analysis Center (AAC) of the ILRS has been established at Wroclaw University of Environmental and Life Science (WUELS) who runs an online platform GOVUS for the SLR validation of microwave-based orbit products. The web-service GOVUS allows the users to perform fast and advanced online analyses on the stored SLR validation results which are calculated automatically.

Apart from the independent validation tool, SLR solely may serve for the determination of the GNSS satellite orbits. We calculated the boundary conditions for the precise Galileo orbit determination using at least 60 SLR observations provided by 10 homogenously distributed SLR stations within 5 days. Based on solely SLR data we obtained Galileo orbits with the accuracy at the level of 4 cm.

The SLR constitutes a valuable tool for both the accuracy assessment as well as an independent orbit product provider. However, based on the two techniques it is possible to provide the combination of two types of observations whose preliminary results are shown in this contribution.

VERTICAL MOVEMENTS OF THE LAND ON THE ODER ISLANDS IN THE AREA OF SZCZECIN, NW POLAND

Stefan Cacoń[1], Wojciech Milczarek[2], Marek Zygmunt[1]

[1] *Institute of Geoinformatics of the Maritime University in Szczecin, 46 Żołnierska Street, 71-250 Szczecin, tel. 91 48 77 107*

[2] *Department of Geoengineering, Mining and Geology, Wrocław University of Technology, 15 Na Grobli Street, 50-421 Wrocław, tel. 71 320 4862*

ABSTRACT

Keywords:

Vertical displacements of the Oder islands in Szczecin have been the subject of research for years. They were confirmed by the analysis of archival materials of precise levelling of lines I and II class from the years 1975–2000. The calculated values of the velocity of changes in the height of benchmarks on the islands in Szczecin reach 2.5 mm/year. They correspond to the unstable geological structure of the island region. Organic soils (peats, gyttjas) are commonly found. In the rest of the city there are geologically stable formations – sands and sands overlapped with clays. Calculations made at present on spatial data obtained using Satellite Radar Interferometry (InSAR, Small BAseline Subset method) in the years 2014–2019 show vertical displacements on the islands in Szczecin reaching several dozen cm. The calculations were based on 129 SAR images (Sentinel 1A satellite), based on which 324 interferograms were calculated. In the rest of Szczecin no significant movements were recorded. In addition to the unstable geological structure of the island area, an additional factor contributing to the increase in settlement is the increased load on the quays of the port expansion areas and other investments. Continuing interdisciplinary research will help to identify areas where vertical movements on the oder islands pose a serious threat to construction.

THE UAS LANDSLIDE SURVEY AND DEFORMATION ANALYSIS IN COMPARISON TO HISTORICAL DATA ON EXAMPLE SIEDLĘCIN LANDSLIDE

Bartłomiej Ćmielewski

Labscan3D, Department of History of Architecture, Art and Technology,
Faculty of Architecture, Wroclaw University of Science and Technology,
ul. Bolesława Prusa 53/55, Wroclaw, Poland, bartlomiej.cmielewski@pwr.edu.pl

ABSTRACT

Keywords: UAS, photogrammetry, lidar, ISOK, landslide, deformation

Landslides are a big threat to human activity. It often has an impact on the existing infrastuctre like roads, railway, building, pipelines, etc. Due to its nonpredictable and nonlinear activation and movements it generates a significant threat. So in the case of its appearance a big lose. There are several ways to collect spatial data and monitoring such phenomena, starting from traditional geodetic surveys, thrue airborne lidar, ending on satellite imagines or interferometric scenas. Also due to high technological progress there is possibility to use small drones for creating digital surface models and use it for spatial analysis to determine the range and volume of moving masses. Also, the progress in miniaturisation allows for developing the small lidar survey devices which mounted under the unmanned aerial vehicles providing high-quality data. Such equipment can be very interesting tool in high-density spatial analysis on small areas – like landslides.

The research object where the survey methods were testes is located in the Lower Silesia near the Siedlęcin village. The central part of colluvium cumulate in the proximity of the road number 2491D (Pławna–Wleń–Jelenia Góra).

COMPARISON OF VERTICAL DISPLACEMENTS OBTAINED USING GRACE DATA AND GNSS DATA OVER POLAND

Walyeldeen Godah, Małgorzata Szelachowska, Jagat Dwipendra Ray, Jan Kryński

Institute of Geodesy and Cartography, Centre of Geodesy and Geodynamics, 27 Modzelewskiego St., 02-679 Warsaw, Poland, walyeldeen.godah@igik.edu.pl, malgorzata.szelachowska@igik.edu.pl, jagat.ray@igik.edu.pl, jan.krynski@igik.edu.pl

ABSTRACT

Keywords: GNSS, GRACE, vertical displacements

The development of knowledge on geodynamic processes is one of the most important issues in the Earth's science. Over decades, geodetic techniques have been applied to study the geodynamics. The Global Navigation Satellite System (GNSS) has been reliably used for monitoring geodynamic processes. The satellite gravimetric missions such as GRACE (Gravity Recovery And Climate Experiment) and GRACE Follow-On (GRACE-FO) missions provide numerous valuable information concerning the Earth's surface deformation induced by temporal mass variations within the Earth's system. The main aim of this study is to compare vertical displacements of the Earth's surface over the area of Poland obtained from GNSS data with the corresponding ones determined from GRACE data.

The GNSS data from permanent GNSS stations operating in Poland and the latest release of GRACE-based Global Geopotential Models (GGMs) were used. GNSS data and GRACE-based GGMs were processed with the GAMIT/GLOBK and the IGiK–TVGMF (Instytut Geodezji i Kartografii – Temporal Variations of Gravity/Mass Functionals) packages, respectively. The main findings were presented and analyzed. The agreement between vertical displacements of the Earth's surface over the investigated area obtained from GNSS and GRACE data was discussed.

This work was supported by the Polish National Science Centre (NCN) within the research Grant No. 2017/26/D/ST10/00422.

STATION TO TESTING OF VERTICAL DIGITAL INCLINOMETER SISGEO

Piotr Gołuch[1], Kazimierz Ćmielewski[1], Janusz Kuchmister[1], Bartłomiej Ćmielewski[2], Izabela Wilczyńska[1]

[1] *Institute of Geodesy and Geoinformatics, Wroclaw University of Environmental and Life Sciences, Grunwaldzka 53, 50-357 Wroclaw, Poland, piotr.goluch@upwr.edu.pl, kazimierz.cmielewski@upwr.edu.pl, janusz.kuchmister@upwr.edu.pl, izabela.wilczynska@upwr.edu.pl*

[2] *Labscan3D, Wroclaw University of Science and Technology, Bolesława Prusa 53/55, 50-317 Wroclaw, Poland, bartlomiej.cmielewski@pwr.edu.pl*

ABSTRACT

Keywords: inclinometer, landslide monitoring, deformation measurement, instrument testing

Inclinometers are widely used in civil and geotechnical engineering to monitor soil movements and structural deformations. The main applications are: monitoring slope and landslide movements; monitoring subsurface lateral movements, inclinations and settlements of embankments, dams, open cut excavations, etc. and monitoring the deflection of piles, diaphragm, retaining walls and structures.

Surveys consist of the measurement of the variation in inclination with respect to the vertical at specific elevations. From the inclinations measurement it is possible, through the use of numerical integration methods, to evaluate the displacement. The measurement results show the changes of inclination in relation to the vertical at specific heights of the tested object. Based on the measurement of slopes, displacement can be assessed using numerical integration methods. The purpose of inclinometric measurements is to determine whether and to what extent the test object is subject to deformation. In the case of landslide testing, measurements are carried out in holes made on endangered natural or artificial slopes to determine the size and speed of deformation.

Inclinometric measurements are carried out cyclically (e.g. 2 times a year), therefore there is a need, in accordance with applicable law, to carry out periodic examination of measuring equipment, including the probe. Calibration of the inclinometer probe carried out by the producer in laboratory conditions consists in recording by the probe the results of reference inclinations in two series and in two mutually perpendicular directions.

The article presents the developed and made prototype of the measuring station for testing the Sisgeo inclinometer probe and the results of experimental and research works. The measuring station allows for functional and accuracy assessment of the inclinometer measuring set in laboratory conditions, similar to real field conditions. The reference measurements for inclinometric measurements are measurements carried out by two geodetic methods: optical plumbing and angular-linear intersection and photogrammetric method.

RECENT GEODYNAMIC BEHAVIOUR OF MOLDANUBICUM FAULTS

Filip Hartvich

Institute of Rock Structure and Mechanics, V Holešovičkách 41, Prague
hartvich@irsm.cas.cz

ABSTRACT

Keywords: fault monitoring, microdisplacement, tectonics, seismicity, TM-71, Moldanubicum

The high accuracy 3D optical-mechanical extensometers TM-71 were installed across tectonic fault in selected caves and rock faces in southern Bohemia, geologically belonging to the crystalline massif of the Moldanubicum unit. The monitoring is placed in Chýnov cave (1 device, since 2007), at an outcrop near Vyšší Brod (1 device, since1989), in Strašín cave (2 devices, since 2007), in Sudslavice cave (1 device, since 2011), in Malenice cave (1 device, since 2011) and in Fík cave (1 device, since 2013). The datasets thus contain time-series 30 to 6 years long.

While the region is considered geologically stable and no significant activity is expected, the observed data indicate several events of higher dynamics of the tectonic displacements throughout all observed sites.

However, the most significant phenomenon, that can be observed on most devices (and numerous other in other regions) is a very prominent and significant overall change in the dynamics of movement behaviour after 2013/14. While before this time we have observed irregular behaviour, marked with relatively large displacement steps and/or irreversible trends, after 2013/14 we witness dramatic change, the step-like displacements practically do not occur, all trends disappear, and even the yearly thermal sinusoid is in some cases attenuated ion of the displacements.

Moreover, similar behaviour has been recorded on other devices throughout Europe. To find a reliable explanation of this rather curious phenomenon is difficult, but it seems likely that the cause is not in regional or local stress field, as the similar behaviour is found in unrelated fault systems in various geological units.

PREDICTION OF GEOCENTRIC CORRECTIONS DURING COMMUNICATION LINK OUTAGE

Joanna Janicka[1], Dariusz Tomaszewski[1], Jacek Rapiński[1], Renata Pelc-Mieczkowska[2]

[1] *Institute of Geodesy, University of Warmia and Mazury in Olsztyn, ul. Oczapowskieo 2, 10-719 Olsztyn, Poland, joannasuwm@gmail.com*

[2] *Institute of Geoinformation and Cartography, University of Warmia and Mazury in Olsztyn, ul. Oczapowskieo 2, 10-719 Olsztyn, Poland, renata.pelcmieczkowska@uwm.edu.pl*

ABSTRACT

Keywords: GNSS, SSR orbit corrections, prediction

International GNSS Service (IGS) real-time service (RTS) provides access to real-time precise products. State Space Representation (SSR) products are disseminated through Internet using the Networked Transport of RTCM via Internet Protocol (NTRIP) protocol. However almost every day there are some communication outages caused by loss of communication link or corrupted ephemeris. Unfortunately, any break in providing precise orbit and clock corrections affects the possibility to perform precise point positioning. To eliminate this problem various methods were developed and presented in the literature.

The solution proposed by the authors is to directly predict geocentric increments. This manuscript presents the results and the analysis of geocentric corrections prediction between each IODE value change and refer to out of date navigation message.

MONITORING OF HIGHWAY STABILITY USING SENTINEL-1 DATA AND INTERFEROMETRIC TECHNIQUES – A CASE STUDY OF A DOBKOVIČKY LANDSLIDE AREA, CZECH REPUBLIC

Jan Jelének, Kateřina Fárová, Veronika Strnadová, Petr Kycl

Czech Geological Survey, Klárov 3, Prague 1, Czech Republic,
jan.jelenek@geology.cz

ABSTRACT

Keywords: DInSAR, vertical displacement monitoring, PSI, radar interferometry, infrastructure

Surface instability caused by either land sliding or land compaction is among major problems occurring during infrastructure construction which can cause significant problems in construction costs or be potentially dangerous after construction completion. In the presented study, we have demonstrated deployment and capabilities of both single-pair differential synthetic aperture radar interferometry (DInSAR) and more advanced persistent scatterer interferometry (PSI) methods for surface vertical displacement detection in highly vegetated landscape. The area of major landslide, which occurred in June 2013 during construction of the D8 highway near Dobkovičky, České středohoří mountains was used as a test site for comparison of the two abovementioned techniques. Freely available Sentinel-1 data were used for both DInSAR and PSI approaches; moreover the conventional single-pair DInSAR workflow was processed using freely available SNAP software. Both techniques proved to be reliable in detecting vertical displacement "hotspots", however only PSI proved to be able to provide absolute value accuracy, validated by the in-situ measurements (using geodetic measurements, 3D inclinometers and laser scanning). Presented study also shows that free data and software provided under the Copernicus program brings a great potential for monitoring vertical displacements and developing SAR-based applications.

HOW CAN GRAVIMETERS IMPROVE THE DETERMINATION OF THE EARTH'S MANTLE STRUCTURE?

Kamila Karkowska[1,2], Monika Wilde-Piórko[1]

[1] *Institute of Geodesy and Cartography, Centre of Geodesy and Geodynamics, 27 Zygmunta Modzelewskiego St., 02-679 Warsaw, Poland, kamila.karkowska@igik.edu.pl,monika.wilde-piorko@igik.edu.pl*

[2] *Faculty of Geodesy and Cartography, Warsaw University of Technology, Pl. Politechniki 1, 00-661 Warsaw, Poland*

ABSTRACT

Keywords: tidal gravimeters, earthquakes, structure of the Earth

The physical properties of tidal gravimetric instruments allow recording surface waves of very long period, which are generated by the earthquakes. Superconducting gravimeters are able to detect periods of seismic surface waves even up to 400–500 s, while typical broad-band seismic sensor can measure them up to a period of 120–150 s due to its transfer function limitation. This is of great importance for structure studies, because waves of longer periods carry valuable information for studying directly deeper structure of the Earth.

The gravimetric and seismic data had been downloaded from IRIS (USA) data-base. There are three stations, which have available gravimeter transfer function and are useful to these analyses. They are located in Europe; two of them are in Belgium (Membach and Rochefort) and one is in Germany (Black Forest). The collected tidal records were post-processed, i.e. tidal, barometric pressure and polar motion effects were removed and then the signal was filtered and deconvolved with the instrument transfer function. In the case of seismic records, the signal was filtered, differentiated and deconvolved with the instrument transfer function to obtain a consistent database of earthquakes recorded by gravimeters and seismometers.

The perspectives of application of seismic methods to the recordings of tidal gravimeters will be presented. Group dispersion curves of Rayleigh waves will be determined from series of monochromatic signals separated from surface waves using the method of constant relative resolution filtering. The obtained results will be verified with the values computed on the basis of the records of seismometers, located close to gravimeters. Finally, a basic forward modelling will be performed to calculate a distribution of shear-wave seismic velocity with depth in the Earth's mantle.

This work was done in the research project No. 2017/27/B/ST10/01600 financed from the funds of the Polish National Science Centre.

CAN WE BLINDLY TRUST GPS ESTIMATES? A COMPARISON TO ENVIRONMENTAL LOADINGS

Anna Kłos, Janusz Bogusz

Military University of Technology, Faculty of Civil Engineering and Geodesy, 2 Sylwestra Kaliskiego Str., 00-908 Warsaw, Poland, anna.klos@wat.edu.pl

ABSTRACT

Keywords: GPS, GRACE, environmental loading

Global Positioning System (GPS) position time series evidence on local and large scale phenomena. Their estimates are often employed to examine the atmosphere, ocean and continental hydrosphere loading and compared to geophysical models' estimates. At the same time, various satellite missions, as GRACE (Gravity Recovery and Climate Experiment), have been employed to estimate real mass changes related to water cycle, in a so-called "Earth system". Whether the GPS is able to infer environmental elastic loading is mostly presented for seasonal signal's amplitudes, leaving the relative contribution of environmental loading on the GPS position time series in shorter time-scales unanswered. In this analysis, we examine the sensitivity of the European GPS position time series to non-tidal atmosphere, non-tidal ocean and continental hydrosphere loadings at various time scales. We show that the direct removal of environmental loading brings a 60% improvement in the root-mean-square values of the GPS position time series, causing a reduction in the time series power for frequencies between 4 and 80 cycles per year. We also focus on advantages and drawbacks of GPS position time series, trying to answer the question whether GPS estimates can be blindly trusted and applied to geodynamical interpretations.

DETECTION OF HARMONIC SIGNALS IN GNSS POSITION TIME SERIES USING FREQUENCY DEPENDENT AUTOCOVARIANCE

Wiesław Kosek, Anna Kłos, Janusz Bogusz

Military University of Technology, Warsaw, Poland

ABSTRACT

Keywords: autocovariance, Fourier Transform, GNSS position time series

The frequency dependent autocovariance function is defined in this paper as the autocovariance function of a wideband oscillation filtered by the Fourier transform band pass filter (FTBPF). First, the frequency dependent autocovariance estimations were computed for the model time series which consist of the signal composed of harmonic oscillations and noise with different standard deviations. In this test, different kinds of power-law noise were used including white and flicker noises with spectral indices of 0 and -1, respectively. For such noise time series the highest maximum of the frequency dependent autocovariance estimates occur for time lag equal to zero and the next maxima occur for an integer multiples of an oscillation period. All these maxima for noise decrease quickly with time lag. In the case of time series composed of harmonic oscillations and noise, the decrease of all maxima with time lag is much slower than for noise-only data. It was shown that the frequency dependent autocovariance estimation is a useful algorithm to estimate mean amplitudes of oscillations in very noisy time series as the next maxima of this estimation are equal to half of amplitudes square. The frequency dependent autocovariance estimations applied to the Global Navigation Satellite System (GNSS) position time series enable detection of weak harmonic oscillations included in those series as well as and their mean amplitudes regardless to type of noise which characterizes them.

INVESTIGATION OF THE VERTICAL CRUSTAL MOVEMENTS ALONG THE EUROPEAN COAST USING SATELLITE ALTIMETRY, TIDE GAUGE DATA, GNSS STATIONS AND RADAR INTERFEROMETRY

Kamil Kowalczyk, Katarzyna Pająk, Beata Wieczorek, Bartosz Naumowicz

Faculty of Geodesy, Geospatial and Civil Engineering,
University of Warmia and Mazury in Olsztyn, Oczapowskiego St. 2, Olsztyn, Poland,
kamil.kowalczyk@uwm.edu.pl, katarzyna.pajak@uwm.edu.pl,
beata.wieczorek@uwm.edu.pl

ABSTRACT

Keywords: vertical crustal movements, satellite altimetry, tide gauge, radar interferometry

Movements of the earth's crust can be determined using different data sets. The data sets are characterized by various levels of accuracy, noise, and time and spatial resolution. The goal of the paper is to determine the vertical crustal movements and its accuracy using the data from satellite altimetry (SA) and tide gauges (TG), permanent GNSS stations and radar interferometry (SAR), and the correlation between these data sets. The vertical movements were determined along the European coast, where a large number of measuring devices is located. Also, vertical movements of the earth's crust in that area are analyzed by many researchers. This allows on an additional evaluation of the obtained results.

Based on the data sets, the time series of various lengths were created. All the time series were decomposed, and the jumps, outliers and seasonality were defined and removed. A trend was determined using a linear regression and a Fourier spectral analysis. TG data were smoothed using a moving average with a 19 years window. Vertical movements were determined from a combination of SA and the TG data. The obtained results were compared with the ones calculated based on GNSS and SAR observations. The data sets correlation analysis and evaluation of trend determination errors were performed.

HIGH-RATE GNSS FOR MINING ACTIVITY: THE 2019 JANUARY 29TH MINING TREMOR IN LEGNICA–GŁOGÓW COPPER DISTRICT, POLAND

Iwona Kudłacik[1], Jan Kapłon[1], Grzegorz Lizurek[2]

[1] *Institute of Geodesy and Geoinformatics, Wrocław University of Environmental and Life Sciences, C.K. Norwida 25, Wroclaw, Poland, iwona.kudlacik@upwr.edu.pl, jan.kaplon@upwr.edu.pl*

[2] *Institute of Geophysics Polish Academy of Sciences, Księcia Janusza 64, Warszawa, Poland, lizurek@igf.edu.pl*

ABSTRACT

Keywords: high-rate GNSS, GNSS-seismology, mining tremor

High-rate GNSS observations are applied in earthquake analysis and structural health monitoring. Most of the studies concern natural earthquake analysis with HR-GNSS, and if they relate to induced shocks, it is only in the area of long-term displacement and standard sampling frequencies up to 1 Hz. With high-rate permanent GNSS stations located on mining areas, there is a possibility to collect the information about long-term displacements as well as dynamic deformations of these stations.

The Republic of Poland is localized in aseismic area, where natural earthquakes are very rare. On the other hand, areas covered by active underground mining exploitation are threatened with induced seismicity. Since the launch of the high-rate GNSS networks in Poland, the most prominent mining event has been recorded in Legnica–Głogów Copper District on January 29th 2019 (12:53:44 UTC) of magnitude 3.7. The epicentral distance of three high-rate GNSS stations that are closely located to the seismographs was up to three kilometres.

In this study, the analysis of GNSS-derived waveforms of the first registered mining tremor with reference to seismological data is presented. The GNSS position time series were obtained from phase measurements in the kinematic mode with two approaches – the Precise Point Positioning and relative differential positioning using RTKlib and GAMIT software. Next, the GNSS-derived and seismological solutions agreement was analysed. Moreover, as GNSS-stations dedicated to dynamic displacements monitoring are not always co-located with seismological instruments, we decided to test mining tremor detection performance with GNSS-displacement only, using statistical evaluation.

ESTIMATES OF EARTH'S CRUST DEFORMATIONS USING GRACE: COMPARISON OF SPHERICAL HARMONICS AND MASCON SOLUTION FOR CENTRAL EUROPE

Artur Leńczuk, Anna Kłos, Janusz Bogusz

Military University of Technology, Faculty of Civil Engineering and Geodesy, 2 Sylwestra Kaliskiego Str., 00-908 Warsaw, Poland, artur.lenczuk@wat.edu.pl

ABSTRACT

Keywords: GRACE, mascon solution, spherical harmonics, Earth's crust deformation

Nowadays, due to the global coverage, satellite observations of different types are applied more and more often in scientific research. Observations from Gravity Recovery and Climate Experiment (GRACE) mission are employed to analyze changes in various fields, among others, geology, glaciology and hydrology should be mentioned. In this research, we compare available solutions of GRACE data in terms of Earth's crust deformations induced by hydrology changes. Analysis is carried out for Central Europe, using different data types and filtering methods. We use two monthly mascon solutions, i.e. RL05 and RL06, available from Center for Space Research (CSR) in Texas, and RL06 data available from Jet Propulsion Laboratory (JPL) in California. We also employ spherical harmonic coefficients available from CSR to d/o 96. To smooth the stripes present in gravity fields derived from spherical harmonic coefficients, we use anisotropic DDK3 filter and isotropic Gaussian filtering with various filter radius. Then, for both types of GRACE data, Earth's crust deformations in vertical direction are computed. To compare GRACE solutions, we focus on root-mean-square (RMS) values as well as linear trends, amplitudes of seasonal signals with their accuracy, computed using least-squares estimation (LSE). RMS values calculated for deformation fields are similar for solutions obtained from spherical harmonics, whereas they are slightly larger for mascon solution. We show that mascon solution represents local deformation in Central Europe better than spherical harmonic coefficients do.

DETERMINATION OF COMMON SIGNALS IN THE HYDROLOGICAL MODEL AND GRACE OBSERVATIONS FOR EUROPE

Grzegorz Leszczuk, Anna Kłos, Artur Leńczuk, Janusz Bogusz

Military University of Technology, Faculty of Civil Engineering and Geodesy,
2 Sylwestra Kaliskiego Str., 00-908 Warsaw, Poland,
grzegorz.leszczuk@student.wat.edu.pl, anna.klos@wat.edu.pl

ABSTRACT

Keywords: Principal Component Analysis, spherical harmonics, mascons, GRACE, hydrological models

Satellite gravity missions, as GRACE (Gravity Recovery and Climate Experiment) have proven their usefulness to derive time-variable Earth's gravity field. Monthly gravity anomalies delivered by GRACE are routinely converted to elastic Earth's deformations arising from hydrological loading. For Europe, total impact of hydrology seasonal loading or unloading of Earth's crust reaches the amplitudes of no more than 12 mm in vertical direction. This total loading can be further divided into smaller sets of signals, explaining parts of total variance of original data. In the following presentation, we applied the Principal Component Analysis (PCA) for GRACE data; we used both spherical harmonics filtered with DDK3 filter and mascon solution in 0.25x0.25° grid, all converted to vertical deformations of the Earth's crust. The first Principal Component (PC) explains 89% of the total variance of GRACE solutions, while the following components explain no more than 5% of total variance.1stPC reflects a common hydrological signal for the Eastern and Central Europe. Further, common hydrological signals are observed for Northern Europe (2nd PC), Eastern part of Europe (3rd PC) and Northern and Southern Europe (4th PC). Results obtained for GRACE are compared to common signals estimated for hydrological LSDM (Land Surface Discharge Model) model by IERS (International Earth Rotation and Reference Systems Service) Associated Product Centre Deutsches Geo Forschungs Zentrum (GFZ) in Potsdam is employed.

EMISSION OF ELECTROMAGNETIC FIELD OF ROCKS UNDER STRESS AS A PRECURSOR OF THE EMERGING THREAT OF ROCK MASS COLLAPS

Krzysztof Maniak[1], Remigiusz Mydlikowski[2], Stanisław Wójtowicz[3]

[1] *National Institute of Telecommunications, Wroclaw, Poland, k.maniak@itl.waw.pl*

[2] *Wroclaw University of Science and Technology, Wroclaw, Poland, remigiusz.mydlikowski@pwr.edu.pl*

[3] *Schneider Electric Energy Poland, Świebodzice, Poland*

ABSTRACT

Keywords: electromagnetic field, coal mining, rock destruction, subsurface geophysics

The paper describes the phenomenon of electromagnetic field (EM) emitted by rocks subjected to mechanical stress. This phenomenon occurs in mines, earthquakes and landslides during their active movements. The phenomenon of electromagnetic field emissions during high mechanical stresses is indicated as providing information about the stability of the rock mass. Monitoring of EM emissions can be helpful in predicting the occurrence of geological collapse. The development of a monitoring system may limit the damage to the mine infrastructure and the human environment.

The article presents a constructed measuring station, where rock samples were tested and subjected to axial crushing. During the increasing crushing force leading to the destruction of the rock sample, the emission of electromagnetic field components was measured. The paper presents the results of research on samples of hard coal and grey dolomite, presenting the obtained time waveforms and frequency spectrum of the emitted EM field components. Further possibilities of use of EM emission tests by rocks were determined. The development and adaptation of a system for measuring EM emissions in a mine environment or on an active landslide can be helpful in assessing the risk of rock destruction, rock bumps or landslide movement. Such a system may, for example, allow for early warning of future rock mass collapse.

COMPARISON OF GNSS-DERIVED IONOSPHERIC MAPS FOR DIFFERENET SOLAR ACTIVITY LEVELS

Beata Milanowska, Anna Krypiak-Gregorczyk, Pawel Wielgosz

University of Warmia and Mazury in Olsztyn, Poland, milanowska.beata@gmail.com

ABSTRACT

Keywords: GNSS, GIM, ionosphere, TEC

The ionosphere is considered as one of the main error sources in GNSS precise positioning. This is because free electrons affect propagation of the electromagnetic satellite signals. On the other hand, since the ionosphere is a dispersive medium, analysis of the ionospheric signal delays at two or three signal frequencies allow for calculating total electron content (TEC). Hence, in late nineties of XX century, the International GNSS Service (IGS) started to routinely provide Global Ionosphere Maps (GIMs) of TEC, which are used for supporting precise positioning, but also for studying the Earth's ionosphere and space weather. These GIMs are provided by different ionospheric associated analysis centers (IAAC) and are based on different modelling techniques, and consequently present different accuracy levels. Therefore, their consistency and quality have to be evaluated.

In this contribution, we investigate consistency of seven IAAC GIMS during high and low solar activity periods. In addition, we also evaluate UQRG high-resolution GIMs provided by Universitat Politècnica de Catalunya (UPC). For the analysis, we use own approach, which is based on comparison of GIM-derived slant TEC with carrier phase geometry-free combination of GNSS signals. In the presented study, we use two years of GNSS data collected by 18 globally distributed test stations. Then we calculated the overall TEC RMS based on post-fit residuals for each test station and each analyzed GIM. In addition, we evaluated the GIM accuracy with respect to geomagnetic latitudinal sectors. The results show that among IAAC, the Center for Orbit Determination (CODE) maps present the lowest RMS. However, the overall highest accuracy was obtained for UQRG GIMs.

VERTICAL REFERENCE SYSTEMS IN SLOVAKIA AND THEIR RECIPROCAL DIFFERENCES

Marcel Mojzeš[1], Martin Kalafut[2]

[1] *Slovak University of Technology in Bratislava, Faculty of Civil Engineering, Department of Theoretical Geodesy, Radlinského 11, 811 07, Bratislava, Slovakia, marcel.mojzes@stuba.sk*

[2] *AGIS Slovakia, spol. s r. o., Prievozská 14/A, 821 09 Bratislava, Slovakia, martin.kalafut@agis.sk*

ABSTRACT

Keywords: vertical reference systems, transformation, geoid, quasigeoid

Numerical expression of vertical differences among vertical reference systems used in Slovakia and neighboring countries requires common practice based on the need of exchange of geodetical data within different international projects, where different international institutions take part in. The presented article describes definitions and realizations of three vertical reference systems: Adriatic (zero leveling point in Trieste, Italy), Baltic after adjustment – Bpv (zero leveling point in Kronstadt, Russia) and European (zero leveling point in Amsterdam, The Netherlands), transformation relations among them and numerical computation of vertical differences among them.

DETERMINATION OF EFFECTIVE YOUNG´S MODULUS BY GEODETIC MEASUREMENTS

Marcel Mojzeš[1], Pavol Kollar[1], Michal Mikolaj[1], Marek Woźniak[2], Branislav Habel[1], Marek Macak[1]

1 Slovak University of Technology in Bratislava, Radlinskeho 11, 810 05 Bratislava marcel.mojzes@stuba.sk, michal.mikolaj@stuba.sk, branislav.habel@stuba.sk, marek.macak@stuba.sk

2 Warsaw University of Technology, Warsaw, Pl. Politechniki 1, 00-661 Warsaw, Poland, marek.wozniak@pw.edu.pl

ABSTRACT

Keywords: precise geodetic measurements, effective Young´s modulus determination

The process of the deformations can be modelled using a purely elastic model based on Green´s function. These values are then compared with measured values, which can be used to study of the sub-soil structural properties. The modelling of the ground deformation process and its measurements enables the detection of patterns that are very important for practical activities. The next part of the paper will be focused on modelling of the Earth´s surface deformation in vertical direction determined by precise levelling in the locality Gabčíkovo hydroelectric power plant and in horizontal direction determined by distance measurements in the locality of the upper reservoir of the power station Zarnowiec.

EVALUATION OF QUANTITY AND SPATIAL DISTRIBUTION OF NATURAL PERMANENT SCATTERERS EXTRACTED FROM SENTINEL-1 IN URBAN AND NON-URBAN AREAS BY APPLYING DIFFERENT PROCESSING PARAMETERS

Magdalena Mleczko, Natalia Ostrowska, Marek Mróz

Institute of Geodesy, University of Warmia and Mazury in Olsztyn, 10-089 Olsztyn, ul. Oczapowskiego 1, magdalena.mleczko@uwm.edu.pl, natalia.ostrowska@uwm.edu.pl, marek.mróz@uwm.edu.pl

ABSTRACT

Keywords: PSInSAR, natural permanent scatterers, Sentinel-1, copper mining

The Permanent Scatterers Interferometry (PSInSAR, PSI) is a widely used remote sensing technique for ground and infrastructure displacement measuring and monitoring with centimeter or millimeter accuracy based on radar instruments (SAR) flying on satellite platforms. The PSI technology is sufficiently mature to stimulate several countries or institutions to develop ground motion services based among other on Copernicus (Sentinel-1) data. However PSI technique differs from usual displacement measurement methods by providing the information on objects movements in the satellite line-of-sight (LOS) geometry. Furthermore PSI technique is based on sets of scatterers (physical objects) demonstrating strong and permanent backscattering of radar signal. Multiple natural Permanent Scatterers (PS) "candidates" can be found and identified in urban areas (buildings, bridges, towers, …). The difficulties in PS identification arise on agricultural and vegetated areas.

The paper presents the methodology and the results of PSI technique application for ground movements investigations on Lower Silesia region caused by copper mining activity in the vicinity of towns Lubin and Polkowice. The 30 Sentinel-1 scenes from ascending orbit (73) acquired at VV polarization during the period from 21 July 2018 till 11 January 2019 have been exploited. Different coherence thresholds and dispersion of amplitude (muSigma) levels have been tested using SARPROZ and SARscape packages to determine reliable sets of PS points for further investigations of slow terrain surface movement. The results of PS candidates searching using the same SAR dataset showed that some parts of urban areas revealed dissimilar quantity and spatial distribution of points depending on the software and processing parameters used. Finally two sets of PS points in vertical displacement geometry were compared using: individual stable reference point, "virtual" reference point and the polynomial trend surfaces.

TOWARDS PRECISE GNSS POSITIONING WITH LOW POWER CONSUMPTION SMARTPHONES: QUALITY ANALYSIS OF OBSERVATIONS AND ASSESSMENT OF POSITIONING

Jacek Paziewski, Marta Ostapkiewicz, Rafał Sieradzki, Radosław Baryła

University of Warmia and Mazury in Olsztyn, jacek.paziewski@uwm.edu.pl

ABSTRACT

Keywords: Smartphone positioning, smartphone GNSS observations, Observation quality assessment

Application of smartphone measurements to high-precision techniques such as RTK or PPP is limited not only by high measurement noise and multipath effect but also by the presence of observation anomalies such as duty cycling and gradual accumulation of phase errors. Comprehensive analysis of signal quality, including carrier-to-noise density ratio, measurement noise and anomalies present in observables with the focus on the impact of duty-cycling provide better understanding of many phenomena and can lead to precise GNSS positioning with low power consumption smartphones. The analysis confirmed the abnormal properties of smartphone measurements related to the divergence between code and phase data and poor quality of the latter. To address these limitations long-range code-based relative positioning was tested. The results show that it is feasible to use a sparse countrywide GNSS network as reference stations for code-based relative positioning. We have also noticed a discernible benefit from the C/N0-dependent weighting scheme, which is superior to the satellite elevation one.

IST SICHER DAS NICHTS SICHER IST. SURPRISE ON THE JAKUSZYCE CLEARING

Krzysztof Pilecki[1], Krzysztof Mąkolski[2]

[1] *Geo Swing, ul. Powstańców Śląskich 80/20, 53-333 Wrocław*

[2] *Usługi Geodezyjne i Kartograficzne, ul. Postolińska 9, 51-126 Wrocław, krzysztof.makolski1@gmail.com*

ABSTRACT

Keywords: tectonic fault, deformation monitoring

The new Documentation of Foundation Soil has been prepared for the construction of "Lower Silesian Sport Center of Cross-country Skiing and Biathlon in Jakuszyce". The documentation is based on the set of geophysical studies including seismic refraction and speed core drilling to the granite roof. Accordingly, an unknown fault in the SW-NE direction has been found. The freshly discovered fault has not been presented on the Detailed Geological Map of Sudety – section Jakuszyce (1:25 000, 1993), which described only the faults in NW–SE direction.

The Mielnica river flows by this tectonic fault. The perpendicular cross-section of the new tectonic fault at a range of 25 m shows that the roof and waste of granite layer have over 19 m deepen. The part of the planned hotel building is located on the hanging wall of fault, whereas the railway tracks are located on the footwall of the fault. The direction of the tectonic fault plane regarding the planned hotel location constitutes a major construction issue. The fault plane lies in parallel to the main axis of the building as well as the railway tracks, which are situated next to the hotel from the S-direction. The main issue, which may bother the architects of the hotel is not the kinematic movement of the fault, but its dynamics. Considering the fact, that there are no existing geodetic measurements in Jakuszyce clearing, the need for setting up a geodetic monitoring network is justified.

The preliminary surveying project assumes the establishment of the control geodetic network for the precise determination of coordinates of the base points and control points. Precise total stations will be used for the control measurements whereas the elevation changes will be measured using precise electronic leveling instruments. The measurements using satellite techniques are taken into consideration in future works. The periodic measurements aim at addressing:

- assessment of the position changes of the control points located in two dislocation sites,
- evaluation of the geometric condition of the railway track,
- determination of vertical and horizontal coordinates of the control points located on each under-construction buildings and particular infrastructure objects.

The measurements are expected to be delivered as soon as possible and should be carried out during the construction and operation of the object.

GRAVIMETRIC MODELLING OF EASTERN EDGE OF UPPER NYSA KLODZKA GRABEN

Sławomir Porzucek[1], Olgierd Jamroz[2], Monika Łój[3]

[1] *AGH University of Science and Technology, Department of Geophysics, A. Mickiewicza Ave. 30, 30-059 Kraków, Poland, porzucek @agh.edu.pl*

[2] *Wrocław University of Environmental and Life Sciences, Institute of Geodesy and Geoinformatics, Grunwaldzka 53, 50-357 Wroclaw, Poland, olgierd.jamroz@upwr.edu.pl*

[3] *AGH University of Science and Technology, Department of Geophysics, A. Mickiewicza Ave. 30, 30-059 Kraków, Poland, mloj@agh.edu.pl*

ABSTRACT

Keywords: gravimetry, gravimetric modelling, Wilkanow fault, Upper Nysa Klodzka Graben

Gravimetry research was done in NE part of the Upper Nysa Klodzka Graben, East Sudety Mts., SW Poland. This study was carried out to better recognition of geological structure in the vicinity of the Wilkanow fault. Detailed gravimetry survey was done in two profiles crossing the fault in the area of Idzikow and Wilkanow. All measurements were made using quartz gravimeter Autograv Scintrex CG-5.

The results of gravimetric research along both profiles confirmed that the Wilkanow fault is not visible in the distribution of Bouguer anomalies. It is possible only when the average density of rocks on either side of the fault is almost the same, what was confirmed by gravimetric modelling. Gravimetric models in both profiles are similar to geological cross-sections presented by geologists. This work was supported by Polish Ministry of Science and Higher Education, Project NN 526223335 „Geodetic monitoring of the Waliszow–Morawa tectonic zone recent activity".

POSSIBLE GEOLOGICAL EXPLANATION OF ANOMALOUS SITE VELOCITIES IN THE MORAVIAN REGION

Lubomil Pospíšil, Otakar Švábenský

Institute of geodesy, FCE, Brno University of Technology, pospisil.l@fce.vutbr.cz, svabensky.o@fce.vutbr.cz

ABSTRACT

Keywords: geology, geodynamics, GNSS, horizontal velocities

The unification of GNSS geodynamic networks in Moravia has revealed some geodynamic active areas / sites whose geological origin is not yet fully understood. In this paper, we present examples of possible interpretation of the observed horizontal movements at four anomalous sites extending into different GNSS networks. These are the localities with the greatest proven movement tendencies in Culmian complex area – HORK and STRE (East Sudeten points), contact of Bohemian Unit with Brunian and Moldanubian Units – BUDI – HELI (Morava points), contact of Brunian Unit with Carpathian flysch zone – VRSA vs. NAHO / TUBO (Morava points) and contact of Saxonthuringian Unit with Moravosilesicum – VYHL – BOBO (Sněžník points). Detected horizontal movement sizes range here up to 2mm/year.

Determining the geological context of these movements in relation to the situated GNSS points is also a question of long-term monitoring proper evaluation. The interpretation approach is based on a comprehensive analysis of all available geoinformation. Finally, possible tectonic interpretation models of individual localities are presented.

SCIENTIFIC USE OF EPOS-PL INFRASTRUCTURE

Witold Rohm, Jan Kapłon, Maya Ilieva, Iwona Kudłacik, Damian Tondaś, Kamila Pawłuszek, Tomasz Hadaś, Kamil Kaźmierski, Krzysztof Sośnica, Radosław Zajdel, Grzegorz Jóźków, Przemysław Tymków, Mateusz Karpina, Andrzej Borkowski

Wroclaw University of Environmental and Life Sciences,
Institute of Geodesy and Geoinformatics, ul. Grunwaldzka 53, 50-357 Wrocław,
witold.rohm@upwr.edu.pl

ABSTRACT

Keywords: research infrastructure, Earth Sciences, European Plate Observing System

The integrated observation system of geodynamic processes is under construction in the framework of EPOS-PL project. EPOS-PL is a multidisciplinary infrastructural project and built Research Infrastructure is aimed to better understand geophysical processes linked to anthropogenic activity in extractive industry. It consists of at least three measurement polygons related to different stage of mining life cycle located in Upper Silesian Coal Basin (Poland). Data and products obtained in EPOS-PL may be used in any specialized research within Solid Earth.

The geodetic observations collected using EPOS-PL RI are: SAR images for ascending and descending orbits of Sentinel-1 satellites, high-frequency GNSS observations, levelling, LiDAR point clouds. These observations were processed to obtain: deformation maps and point deformations, seismograms, and position time-series.

The paper presents the two case studies that shows application of the RI to investigate anthropogenic hazards related with mining industry: 1) study that shows the land deformation analysis of extraction in the Bytom-III mining area located in the northern part of USCB, 2) passing of induced seismic event recorded by GNSS, seismometers and other geodetic instrumentation.

AN APPROPRIATE LITHOSPHERIC PLATE VELOCITY MODEL FOR THE CENTRAL EUROPEAN AREA

Vladimír Schenk[1,2], Zdeňka Schenková[1], Bernard Kontny[2], Jan Kapłon[2]

[1] *Institute of Rock Structure and Mechanics, Czech Academy of Sciences, V Holešovičkách 41, 182 09 Praha 8, Czech Republic, schenk@irsm.cas.cz, schenkova@irsm.cas.cz*

[2] *Institute of Geodesy and Geoinformatics, Wroclaw University of Environmental and Life Sciences, Grunwaldzka 53, 50-357 Wroclaw, Poland, bernard.kontny@upwr.edu.pl, jan.kaplon@upwr.edu.pl*

ABSTRACT

Keywords: relative geodynamic velocity, lithospheric plate velocity model, the Bohemian Massif, central Europe

Recent dynamics of the Bohemian Massif, one of the Variscan cratonic bodies in central Europe, were revealed on the basis of position data obtained from 15 years of monitoring GNSS/GPS signals at 129 stations. The calculated site velocity movements were referred to the WTZR observatory data taken as fiducial ones to obtain relative intra-massif velocity motions. Afterward commonly used lithospheric velocity models were applied to all detected site velocities and attained velocity movement patterns were matched up to earlier obtained relative intra-massif velocity motions to find which of them plausibly fit with it. The comparisons of individual velocity model applications allowed the appropriate velocity movement model for geodynamics of central Europe to be found. In conclusion, a discussion of model reliability for regional geodynamic motion analyses and/or continental geological interpretations is given.

COMPARISON OF VARIOUS TERRESTRIAL LASER SCANNERS APPLIED FOR DOCUMENTING STRUCTURAL DISCONTINUITIES IN RUDNA COPPER MINE, POLAND

Dominik Sokalski[1,2]

[1] *KGHM Polska Miedź S.A., 48 Marii Skłodowskiej-Curie, 59-301 Lubin, Poland, Dominik.Sokalski@kghm.com*

[2] *Wroclaw University, Institute of Geological Sciences, 9 Maksa Borna, 50-204 Wroclaw, Poland*

ABSTRACT

Keywords: terrestrial laser scanner, induced fractures, mining pillars, geohazard

In Rudna copper mines the main hazard to an operational safety are rockbursts caused by discharge of elastic energy accumulated in the rock mass, cut by mine workings. Proper maintenance of the pillars is one of the ways to counteract rock bursting. However, exploitation induces damage to pillars, which is manifested in various ways depending on the size of pillars, lithology and mechanical parameters of rocks.

Author completed tests of six different laser scanner in mine workings. Those tests indicate that terrestrial laser scanner might be useful tool for documenting structural discontinuities in mining excavations. Scanning of pillars' corners was performed in order to document induced fractures damaging mining pillars. Preliminary processing of data from point clouds was carried out in software dedicated to each device.

Results show that scanners chosen for tests give comparable quality of point cloud data. However, analytical capabilities of dedicated software are much more diverse. It appears that in choosing of a comprehensive solution for recording and analyzing pillars' failure specific features of individual software play bigger role than specification of respective scanning devices.

TECTONIC STRUCTURES RELATED TO PAULINÓW SYNCLINE IN RUDNA COPPER MINE, POLAND DOCUMENTED WITH TERRESTRIAL LASER SCANNER

Dominik Sokalski[1,2], Jurand Wojewoda[2], Damian Kasza[3], Jarosław Wajs[3]

[1] *KGHM Polska Miedź S.A., 48 Marii Skłodowskiej-Curie, 59-301 Lubin, Poland, Dominik.Sokalski@kghm.com*

[2] *Wroclaw University, Institute of Geological Sciences, 9 Maksa Borna, 50-204 Wroclaw, Poland, jurand.wojewoda@uwr.edu.pl*

[3] *Wroclaw University of Science and Technology, Department of Geodesy and Geoinformatics, 27 Wybrzeże Wyspiańskiego, 50-370 Wroclaw, Poland, damian.kasza@pwr.edu.pl, jaroslaw.wajs@pwr.edu.pl*

ABSTRACT

Keywords: Paulinów Syncline Fault Zone, fractures, terrestrial laser scanner, KGHM

The Paulinów Syncline is one the most significant fault zones observed in KGHM's Rudna Copper Mine. In the examined area it occurs as a half-graben, whereas in other districts of mine it shows off more as a synclinal or flexural structure. It has strike of WSW–ENE to W–E and is documented on the distance of more than 9 km. The syncline is accompanied by numerous faults (Paulinów Syncline Fault Zone), running obliquely (SW–NE), perpendicular or parallel to the general strike of the structure.

Authors examined mine workings in the close vicinity of Paulinów Syncline with terrestrial laser scanner to document failure of pillars. The mine workings in the studied area are built of sandstone in the bottom, overlying copper shale of low thickness and dolomite in the top. Within the dolomite just below the roof authors identified concave-up fractures system forming 'trough-like' structures. It is observed in pillars on opposite walls of the stope. Similar structures are noticed on different walls of the pillar, as well as on adjacent pillars. The axes of these 'trough-like' structures are oriented roughly perpendicular to the axis of Paulinów Syncline. The copper shale underlying the dolomite has a bipartite structure resulted from lithological changes within it. Its upper part is duplex-like structure, whereas lower part forms a shear zone for the entire overlying complex.

Authors propose a model showing development of trough-like structures in relation to the Paulinów Syncline. They suggest that rheological reaction of elastic medium (dolomite plate) is caused by shearing resulted in fracturing along predisposed helicoidal surfaces.

ANALYSIS OF VERTICAL DISPLACEMENTS OF THE GEO-INFO-HYDRO BUILDING BASED ON THE OBSERVATION FROM THE STRUCTURAL MONITORING SYSTEM

Wojciech Sowa, Adrian Kaczmarek, Krzysztof Mąkolski

Institute of Geodesy and Geoinformatics, Wroclaw University of Environmental and Life Sciences, Grunwaldzka 53, 50-357 Wroclaw, wojciech.sowa@upwr.edu.pl

ABSTRACT

Keywords: time series, geodetic monitoring, GeoMoS, precise leveling

The analysis of vertical and horizontal displacements is extremely important at the stage of construction and exploitation of buildings and engineering objects. In the era of measuring techniques development, there are many measuring techniques at our disposal, including automated structural monitoring systems. One of such systems is Leica GeoMoS, which was installed in the Geo-Info-Hydro building of the Wrocław University of Environmental and Life Sciences. The system consists of, among others, a network of inclinometers and controlled benchmarks.

The research focuses on the analysis of vertical displacements determined from inclinometers and from precise leveling. In addition, the planes calculated basing on the inclinometers data and benchmarks coordinates will be used to analyze displacements. The location of the planes relative to each other will be determined as well. This allow to determine whether the potential displacements are the same on the two extreme floors of the building.

DATA ANALYSIS OF THE SURVEYING MONITORING SYSTEM OPERATING IN OPEN-CAST MINE CONDITIONS – FIRST RESULTS

Wojciech Sowa[1], Adrian Kaczmarek[1], Tomasz Waliński[2], Michał Czerwonka[2], Andrzej Borkowski[1]

[1] *Institute of Geodesy and Geoinformatics, Wroclaw University of Environmental & Life Sciences, Grunwaldzka 53, 50-357 Wroclaw e-mail: wojciech.sowa@upwr.edu.pl*

[2] *PGE GiEK S.A. Oddział Kopalnia Węgla Brunatnego Turów*

ABSTRACT

Keywords: time series, geodetic monitoring, Leica GeoMoS

Surveying monitoring systems, including structural monitoring systems, are solutions that permit continuous observation of engineering objects. They are increasingly used in newly constructed objects, but also in existing facilities, where control measurements have been carried out using classical methods. Thanks to permanent measurements it is possible to detect the displacement of controlled points after a very short time from their occurrence. In situations where potential displacements may threaten human life or the success of investment, these solutions prove irreplaceable.

The authors present their own methods of developing data collected by the Leica GeoMoS structural monitoring system installed at the KWB Turów open-cast mine. Aspects important for the usefulness of the system have been taken into account so that the method allows for the most reliable definition of significant displacements of controlled points. The accuracy of stands coordinates, on which total stations are located was also considered (stations due to the size of the monitored area are located in places that may also be exposed to displacement).

For the analysis, all available measurement data over a period of 5-months was used, which allowed for the development of an algorithm for determining the significant displacement value of controlled points, taking into account seasonal changes and the accuracy of the instruments used for the measurements.

THE NOWADAYS STRESS FIELD PARAMETERS CALCULATED BASED ON FAULT SLIPS DATA RECORDED BY 3-D EXTENSOMETERS WITHIN THE DĚDIČNÁ ŠTOLA GALLERY IN RYCHLEBSKÉ HORY MTS.

Jakub Stemberk[1,2], Miroslav Coubal[1,3], Josef Stemberk[1], Petra Štěpančíková[1]

[1] *Institute of Rock Structure and Mechanics, The Czech Academy of Sciences, V Holešovičkách 94/41, 180 00 Prague 8, Czech Republic, jakub.stemberk@irsm.cas.cz*

[2] *Faculty of Science, Charles University, Albertov 6, 128 00 Prague 2, Czech Republic*

[3] *Institute of Geology, The Czech Academy of Sciences, Rozvojová 269, 160 00 Prague 6, Czech Republic*

ABSTRACT

Keywords: Active tectonics 3-D fault slip monitoring Transient fault slip acceleration Switching stress/strain states

The contribution presents the results of 3-D movements of faults monitored by TM-71 extensometers occurring in the Dědičná štola Gallery in the Rychlebské hory Mts. during the period between 2014 and 2017. The gallery is situated on the main mountain ridge 4 km southwest from Sudetic Marginal Fault. The detected fault slip is nonlinear in time and is affected by short transient periods of acceleration. One dominant and a series of minor transient fault slip accelerations were recognized during study period. The recorded accelerations were analyzed using standard paleostress analyses. The results show switching of two compressional stress/strain states alternated by one extensional state. The WNW–ESE to NW–SE compression corresponds to the stress field of the Western European stress domain and the NNE–SSW corresponds to the stress field of the NW part of the Carpathian stress domain. The extensional state, oriented NW–SE, is probably corresponding to gravitational spreading due to the Rychlebské hory Mts. uplift. The orientations of theoretical fault planes with maximal shear stress for each stress/strain state were calculated and were compared with known faults and morpholineaments identified in surrounding area. The results show that the faults striking 320°–350° and 20°–40° could be potentially re-activated by present-day stress field. Faults of these strikes are also morphologically dominant.

RECENT MOVEMENTS OF SALT DOME IN INOWROCŁAW IN THE LIGHT OF GEODETIC SURVEYS

Zbigniew Szczerbowski, Rafał Gawałkiewicz

Department of Mining Areas Protection, Geoinformatics and Mining Surveying, Faculty of Mining Surveying and Environmental Engineering, AGH University of Science and Technology, Al. A. Mickiewicza 30, 30-059 Kraków, Poland, e-mail: szczerbo@agh.edu.pl

ABSTRACT

Keywords: surveying, salt diapir, halotectonics, vertical displacements

Results of geodetic measurements (GNSS,levelling) applied in observation of salt diapir activity are discussed. It includes the most recent results of leveling measurements carried out by the authors. On the basis of them there was a model of ground surface movements, which by and large reflects recent tectonic activity of the salt structure of Inowrocław. Determined performance of vertical displacements of benchmarks of the research network for the last quarter-century shows its significant mobility. The results were discussed in the context of the state of art of its tectonic mobility, geological structure as in the context of present theories of formation of salt structures in Permian salt province of North European Plain. Applied geodetic methods for observation of deformation caused by geological processes (salt diapir uplift) confirmed rates of the process evaluated by geological methods.

GEODETIC DERIVED STRAIN VERSUS ELECTRONIC EXTENSOMETER MEASUREMENTS IN UNMINED ROCK MASS ON THE EXAMPLE OF THE BOCHNIA SALT MINE

Zbigniew Szczerbowski[1], Zbigniew Niedbalski[2]

[1] *Department of Mining Areas Protection, Geoinformatics and Mining Surveying, Faculty of Mining Surveying and Environmental Engineering, AGH University of Science and Technology, Al. A. Mickiewicza 30, 30-059 Kraków, Poland, e-mail: szczerbo@agh.edu.pl*

[2] *Department of Geomechanics, Civil Engineering and Geotechnics, Faculty of Mining and Geoengineering, AGH University of Science and Technology, Al. A. Mickiewicza 30, 30-059 Kraków, Poland*

ABSTRACT

Keywords: underground measurements, surveying, rock salt displacements, convergence

Underground measurements of rock mass deformations around historic The Saint Kinga Chapel in the Bochnia Salt Mine with an application of electromagnetic probe provided new value to analysis of the process. Measurements of benchmarks' displacements involved in the mine's network with the use of classical geodetic instruments enable to determine only geometric changes of contours of post mining caves and passages (convergence), however with very high precision. On the base of classical surveys it is impossible to evaluate of propagation of deformations within rock mass interior. The measurements by electromagnetic probe provided kinematic data of plastic deformation process ongoing in the salt rock mass surrounding the working. So, within the presented work deal with comparison of geodetic data devoted to convergence measurements of the cave and linear strain determined by electronic measurements within rock mass by electro-magnetic probe. Evaluated strain model shows existing tectonic stress of the Carpathians which formed the salt deposit in Bochnia in the past.

THE USE OF THE UNB_TOPODENS MODEL FOR LOCAL MODELLING OF CHOSEN GRAVITY FIELD PARAMETERS AT THE WESTERN CARPATHIANS AREA

Marek Trojanowicz[1], Lubomil Pospíšil[2,3], Olgierd Jamroz[1]

[1] *Wroclaw University of Environmental and Life Sciences, Grunwaldzka 53, 50-357 Wroclaw, Poland, marek.trojanowicz@upwr.edu.pl, olgierd.jamroz@upwr.edu.pl*

[2] *Brno University of Technology, Veveří 95, 602 00 Brno, Czech Republic*

[3] *VŠB – Technical University Ostrava, 17. listopadu 2172/15, 708 00 Ostrava – Poruba, Czech Republic*

ABSTRACT

Keywords: Bouguer gravity anomaly; Local disturbing potential model; Differences between geoid undulations and height anomalies

The latest global topographical density model UNB_TopoDens (Sheng et all., 2019) was used in the study to determine selected characteristics of the gravity field and to build a local model of disturbing potential. The study was conducted for the area of the Western Carpathians covering the Polish–Slovak border. Bouguer anomalies and differences between geoid undulations and height anomalies were determined for the area. These values were determined for the topographic masses density from the UNB_TopoDens model as well as for constant densities of these masses (2200, 2500 and 2670 kg/m^3). The result shows differences due to various densities accepted for the reduction. For example differences between the version using densities from the UNB_TopoDens model and theversion with constant density equal 2670 kg/m^3 are between -3.4 mGal and 37.5 mGal for Bouguer anomalies, and between -1.4 cm and 0.8 cm for differences between geoid undulation and height anomalies. The maximum values concerned the highest parts of the mountains, and accounted for almost 50% of the value of Bouguer anomalies and 10% of the value of differences between the geoid and quasigeoidheights. Additionaly, the UNB_TopoDens model was used as the initial density modelfor the construction of a localdisturbing potential model using the GGI method. The comparison of this approach with the previously used constant initial density did not show significant changes in the accuracy of the GGI solution forthe disturbing potential valueas well as the gravity value.

REFERENCES

Sheng M.B., Shaw C., Vaníček P., Kingdon R.W., Santos M., Foroughi I. (2019), Formulation and validation of a global laterally varying topographical density model, Tectonophysics, Vol. 762, pp 45–60.

PERIOD AND Q-FACTOR OF FREE CORE NUTATION, BASED ON DIFFERENT GEOPHYSICAL EXCITATIONS AND VLBI SOLUTIONS

Jan Vondrák, Cyril Ron

Astronomical Institute CAS, Boční II, 141 00 Prague, Czech Republic, vondrak@ig.cas.cz, cyril.ron@asu.cas.cz

ABSTRACT

Keywords: Earth rotation, free core nutation

Seven different VLBI solutions of celestial pole offsets (CPO) are used to determine period and *Q*-factor of Free Core Nutation (FCN). Brzeziński's broad-band Liouville equations are numerically integrated to account for atmospheric and oceanic excitations from different sources. Possible effect of geomagnetic jerks is also considered, which improves the uncertainty of the results in all cases. Best-fitting values of FCN parameters are found by least-squares fit to observed CPO, corrected for the difference between the FCN parameters used in IAU 2000 model of nutation and newly estimated ones; MHB transfer function is used to compute these corrections. The obtained results are compared and discussed.

ASSESSMENT OF POSTPROCESSED AND REAL-TIME GLOBAL IONOSPHERIC MAPS IN LONG-RANGE RTK POSITIONING: CNES RT GIM AND UQRG GIM CASE STUDY

Pawel Wielgosz[1], Manuel Hernández-Pajares[2], Dariusz Tomaszewski[1], Jacek Rapinski[1], Anna Krypiak-Gregorczyk[1]

[1] *University of Warmia and Mazury in Olsztyn, Poland, pawel.wielgosz@uwm.edu.pl*

[2] *UPC-IonSAT, Barcelona, Spain, manuel.hernandez@upc.edu*

ABSTRACT

Keywords: GNSS, RTK, GIM, ionosphere

Thanks to the availability of Global Navigation Satellite Systems (GNSS) and the synergic developments of ionospheric modeling and precise GNSS carrier-phase based navigation during the last two decades, it is possible to consistently and precisely determine the ionospheric electron content distribution. In particular, new developments have been presented in real-time ionosphere modeling. In this presentation, we evaluate ionospheric effects in the instantaneous long-range RTK positioning in both real-time and postprocessing modes. Namely, we evaluate the application of ionospheric corrections derived from CNES real-time RTCM streams and from global ionospheric maps (IONEX).

Numerical experiments are based and kinematic dual-frequency GPS data. For the analysis, we applied ionosphere and troposphere weighted relative positioning model. Our initial results demonstrate that, when applying the ionospheric corrections, it is possible to correctly solve for carrier phase ambiguities over baselines of 60-90 km using just a single epoch of the observational data.

THE INTRASUDETIC BASINS AND SYNCLINORIUM IN THE EXTENSIONAL MODEL OF THE SUDETES EVOLUTION – ENVIRONMENTAL AND PALEOGEOGRAPHIC SCHEMES

Jurand Wojewoda

Wrocław University, ul. Cybulskiego 32, Pl. Maksa Borna 9, 50-204 Wrocław, jurand.wojewoda@uwr.edu.pl

ABSTRACT

Keywords: Bohemian Massif, Sudetes, Intrasudetic Basin, sedimentation, extensional evolution, palaeogeography, palaeoenvironment

The evolution of the NE-periphery of the Bohemian Massif (**BM**), that is historically referred to as the **Sudetes**, had been recorded in sediments within areas conventionallyreferred to as **basins**. Sedimentary formations (**Fm**) in the Sudetes represent facies and records paleogeography of areas which extended considerably beyond the present structuralunits (**Fig. 1**). Despite the fact that these units sometimes form limited fragments of former areas of deposition, *i.e.* **sedimentary basins**, it is not entirely correct to refer to them asbasins. It is important to distinguish between these two terms. In the case where facies variabilityand thickness of sediments are clearly related to the boundaries of a structural unit, which in the past probably formed the boundaries of the depositional area, it is justifiable touse the term sedimentary basin. If this is not the case or it is impossible to verify, it is moreappropriate to use the term **basinal structural unit**.

There are several basinal structural units in the Central Sudetes, within which the current highest structural members consist of sedimentary or metasedimentary rocks. The main one is **Intrasudetic Synclinorium –** major regional structural unit consisting of relics of former sedimentary basins, but mostly of the **Intrasudetic Basin** (**ISB**). The last one had been synchronously formed with other associated basinal units of lower order, as the **Świebodzice Basin** (**SB**), the **Bardo Basin** (**BB**), the **Trutnov** (**TB**), **Nachod** (**NB**) and **Kudowa** (**KB**) basins, as well as the **Orlica Piedmont Basin** (**OPD**) and the **Nysa Kłodzka Basin** (**NKB**).

It is assumed that the most important aspects of the contemporary geological structure of the Sudetes (*i.e.* **SudeticOrogen**) resulted fromcontinuous extension, and exceptionallytroughouttwo periods of particularly important tectonictransformation – (1)subdivision of the **Pre-Sudetes** into sudeticbasins and massifs**(~350–347 Ma, Tournaisian–Visean)**), (2) which next were strengthened by the syntectonicgranite intrusions during (**~347– 315Ma**, **Visean–Westphalian**). In relation to the above, the sedimentary records comprise twopossible palaeographic periods which can be reconstructed: **pre-Sudetic** (pre-orogenic andsynorogenic) (**Fig. 2A&B**) and **Sudetic** (post-orogenic) (**Fig. 2C, D, E &F**). The products of the pre-orogenic basin buildfor example the lower part of the **Kaczawa Unit** (**Cambrian–Silurian**). The synorogenicdeposition represent sediments of the upperpart of the Kaczawa Unit, also **Bardo** (**BBi**), **Świebodzice** (**SBi**) **initial basins**, andoldest sediments of the Intrasu-

detic Synclinorium (the **initial Intrasudetic Basin**) (**ISBi**). The post-orogenic basins and successions include the **Intrasudetic Basin** (**ISB**), **Karkonosze Piedmont Basins**, i.e. **Vrchlabi** and **Trutnov** (**VB, TB**), **Nachod Basin** (NB), **Orlica Basin** (OB) and the **Nysa Kłodzka Basin** (**NKB**) ones.

The current position of the sudetic structural units i.g. sudetic basins and massifs in relation to the major structural units of the pre-Variscan basement (southern and eastern part of the **Karkonosze–Izera Massif**, **Orlica–Śnieżnik Massif**, **Góry Sowie Massif**, as well as the facies variability and palaeogeographic reconstructionsindicate the possibility of **permanent extensional development of the Sudetic region, which started in the Tournaisian and is still continued** (Don, Wojewoda 2005; Wojewoda 2007, 2009 a, b & c; Cacoń et al., 2009). At the same time they put a question mark on the local meaning of the orogenic phases already mentioned above, which are result of the so-called tangential pressure forces.At the same time they also question the previous understanding of the mechanics of the Sudetic Orogeny.

The model of extensional evolution of the Sudetes does not exclude periods of basin inversion in its literal meaning, *i.e.* a relative inversion of the basin areas and the areas of sedimentsupply. **The idea of kinematic inversion on the most important fault planes in the Sudetes is unclear and poorly documented**. The extensional model of the evolution of the Sudetic region clearly indicates the high importance of two main fault systems which havebehaved uniformly since the end of the Devonian. These are the **Intrasudetic Tension Zone** (**ISTZ**) and the **Intrasudetic Shear Zone** (**ISZ**) (**Fig. 2 F**) *cf.* Wojewoda 2007, 2008). **The rhomboidal subbasins VB,TB and NTB are clearly related to the permanently clockwise strike-slip regime within the SSSZ. The ISB is a polygenicand multistage basin which started and developed within the ISTZ**. The basinal units SB and BB are related in their paleogeography and facies to the areas of the **Fore-Sudetic Homocline** and **East Sudetic Basin** (**ESB**) respectively, and they used to represent the marginal (proximal)zones of those basins.

The **Poříčí–Hronov Fault Zone** (***P–HFZ***) represents one of the fault systems inside the ISZ and it is closely related to the extensional evolution of the ISB since the late Devonian toearly Triassic and of the IntrasudeticSynclinorium since the late Cretaceous till now. The ***P–HFZ***constitutes the northern marginal fault system for the rhomboidal pull-apart basins related to the ISZ (VB, TB, NB and NKB) which form together basin successions – *i.e.* **South Sudetic Basin Succession** (**SBS**). **Local reverse faults that occur on the boundaries between TB, NB and ISB can be explained by local transpression induced by irregularities of the *P–HFZ* plane in relation to the main direction of the regional dextral sense of shearing** (*cf.* Wojewoda 2007, 2009 a, b & c).

LITERATURE:

Cacoń, **S**., **Wojewoda**, **J**., **Kapłon**, **J**., **2009**. Acta Geodynamica et Geomaterialia, 6(3): 230–239.
Don, **J**., **Wojewoda**, **J**., 2005. Przegląd Geologiczny, 53 (3): 212–221.
Wojewoda, **J**., **2007**. Acta Geodynamica et Geomaterialia, 4, 4 (148), 1–11.
Wojewoda, **J**., **2009a**. Acta Geodynamica et Geomaterialia, 6 (3): 273–290.
Wojewoda, **J**., **2009b**. 7th Meeting of the CEETG, 13–16.05.2009, Pecs, Hungary. Abstracts, p. 60.

Wojewoda, **J**., **2009c**. 10th Czech–Polish Workshop on Recent Geodynamics of the Sudetes and Adjacent Areas, 5–7.11.2009., SzklarskaPoręba, Poland.

Wojewoda, **J**., [et al.], **2011**. Geology of the Góry Stołowe National Park – selected issues). In: Chodak, T., Kabała, C., Kaszubkiewicz, J., Migoń, P., Wojewoda, J., [eds.] – Geoekologiczne Warunki Środowiska Przyrodniczego Parku Narodowego Gór Stołowych. WIND, Wrocław, pp. 53–96.

Wojewoda, **J**., **2011b**. SEDIMENT 2011: Archives of the Earth Sydtem, Abstracts, pp. 101–103. June 23–26, Leipzig, Germany.

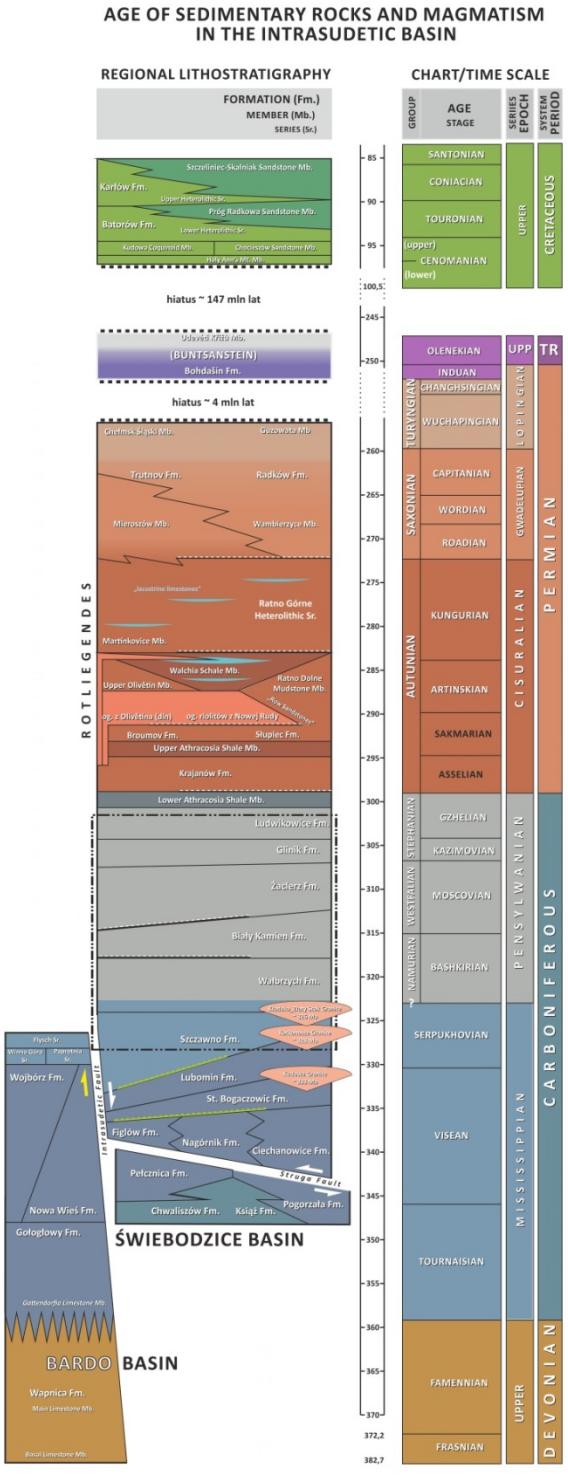

Fig. 1. Lithostratigraphy and age of the Central Sudetean sedimentary and igneous rocks in reference to the International Chronostratigraphic Chart (v 2019/05)

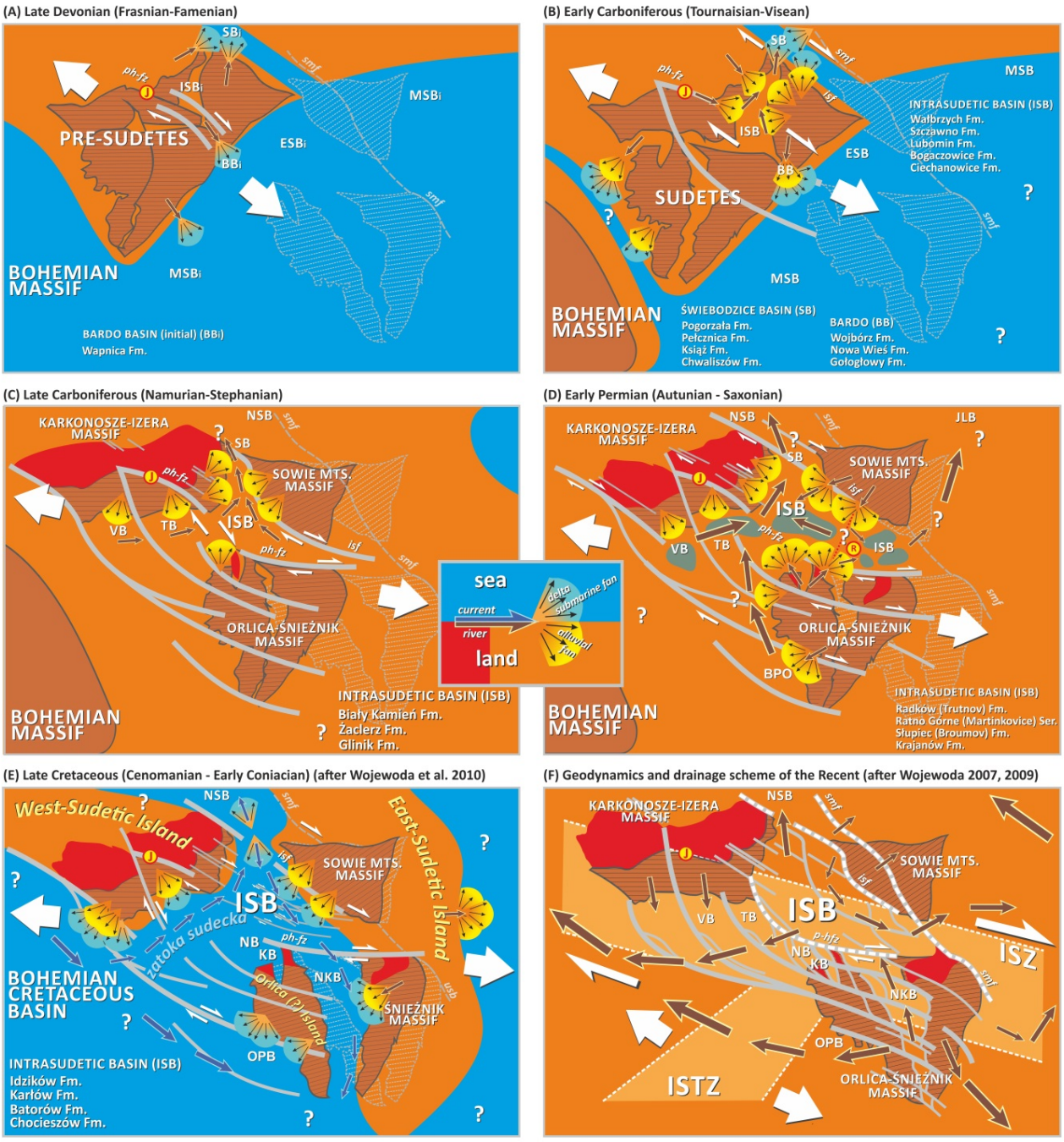

Fig. 2. Extensional evolution of Sudetes as recorded from sedimentary and structural data (wg Wojewoda 2011b, zmienione)

GEOLOGICAL LINES, GEOLOGICAL SURFACES, SCALE ISSUES IN GEOLOGY, STRUCTURAL ENTROPY, FRACTAL NATURE OF GEOLOGICAL STRUCTURES...

Jurand Wojewoda

Wrocław University, ul. Cybulskiego 32, Pl. Maksa Borna 9, 50-204 Wrocław, jurand.wojewoda@uwr.edu.pl

ABSTRACT

Keywords: geological surfaces, structural geology, kinematics, transformation, minimal surfaces, fractal analysis

Are there material geological straight lines? On a small, local scale, probably yes. It cannot be denied that the edges of the crystals, traces of gas or animal escaping from the sediment, growing stalactite on the cave ceiling, or covered with sediment or fossilized root of the plant, very often creates a **geological material linear structure**. In general, such structures are excellent indicators of the former vertical (paleovertical), and even up-down direction (Wojewoda 1992). **However, the answer for the geological space on a supra-local, global scale is – definitely not!** For a simple reason – straightness, as such, is not a natural feature for geological space (Wojewoda 2018).

Surfaces in geology have a various character. They can set the boundaries of real, material geological objects (**material surfaces**), they can set the boundaries of matter with different attributes, e.g. the state or type of matter (**geometric surfaces**), they can finally be a mapping or spatial model of a selected feature of a geological object or combination traits, usually of a contractual nature, often even arbitrary (**abstract surfaces**).

The flat surface is a **minimal surface**, *i.e.* one that has an average curvature of zero at each point (all its points are saddle points). The minimal surfaces also are **helicoids**, the so-called **Scherk surface**, as well as the **sphere**. Only the first three surfaces are **ruled surfaces**, *i.e.* surfaces where a straight line (forming) contained in that surface passes through each point. Almost all natural geological surfaces are minimal, sometimes on a small scale or fragmentarily – are flat and very often ruled.

Are there flat geological surfaces? It can be proved that **flat material geological surfaces do not occur on a large scale**. And this is mainly due to planetary and astronomical planetary processes in which gravity plays a dominant role on the one hand, and solar system dynamics on the other. Also thermodynamic processes in the interior of the Earth closely refer to (result from?) the spherical structure of our planet. This does not exclude the possibility of the formation of flat geological surfaces on a small scale, which can arise wherever in the formation of matter and geological space processes are independent of the above prevail. The only example of a process that by definition creates flat surfaces is crystallization and associated crystal surfaces. They can also be tectonic processes and their effects – flat surfaces of damage in a small and medium scale (e.g., fractures, joints, faults), sedimentation

processes and their products – flat sedimentation surfaces (e.g. layering, erosional surfaces), or mixed, for example metamorphic processes and associated shear and recrystallization surfaces (e.g. foliation). However, if the surfaces are not flat, then various displacements can occur along them, but on a much smaller scale. In each case, the **movement of points takes place along curvilinear (circular, elliptical) trajectories, and the displacements of solids are always accompanied by the transformation of translational to rotational movement** (Fig. 1) (Wojewoda 2018).

Entropy increases and this principle also applies to geology. The past and present development of the geological space (Earth) is unidirectional and consists in increasing the number of geological objects and **increasing the complexity of the geological structure**. This thesis is obvious in the **spherical geometry** and has global application under real conditions, though with some assumptions.

Particularly important in geology are the so-called **surfaces of discontinuities**. Especially the **surfaces of damage** of all kinds and on **different scales**. These dominate in the geological space, setting the most important **boundaries between homogeneous geological objects** and thus co-create with the latter the so-called **geological structure**. Damage surfaces are not necessarily related to movement, i.e. relative movement of geological objects. Thus, as such, they cannot be regarded as the sole and unambiguous movement / displacement indicator. **It also results from the fractal nature of the damage surface considered at various scales** (Fig. 2) (Wojewoda 2017).

LITERATURE:

Wojewoda, **J**., **1992**. Wyznaczanie stropu i spągu w skałach osadowych. Instrukcje i metody badań geologicznych. W: Mierzejewski, M.P., (red.) – Badania elementów tektoniki na potrzeby kartografii wiertniczej i powierzchniowej. Państwowy Instytut Geologiczny, 51: 13–35. Warszawa.

Wojewoda, **J**., **2017**. Powierzchnie geologiczne – zagadnienie skali w geologii. Abstrakty, 85 Zjazd PTG, 18–21.09.2017, Koszalin.

Wojewoda, **J**., **2018**. Powierzchnie w geologii, powierzchnie geologiczne… Studium Generale, t. XXI, pp. 64–83.

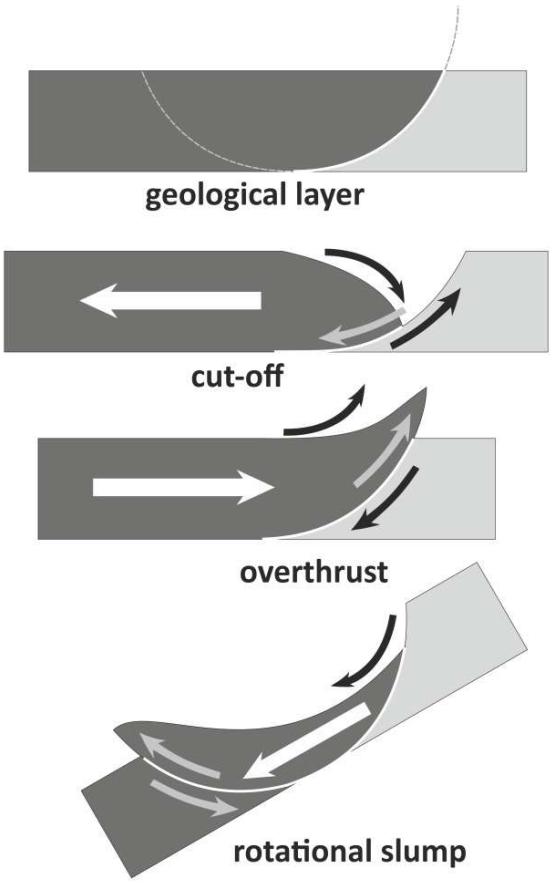

Fig. 1. Schematic models of various transformation possibilities translational motion into rotation

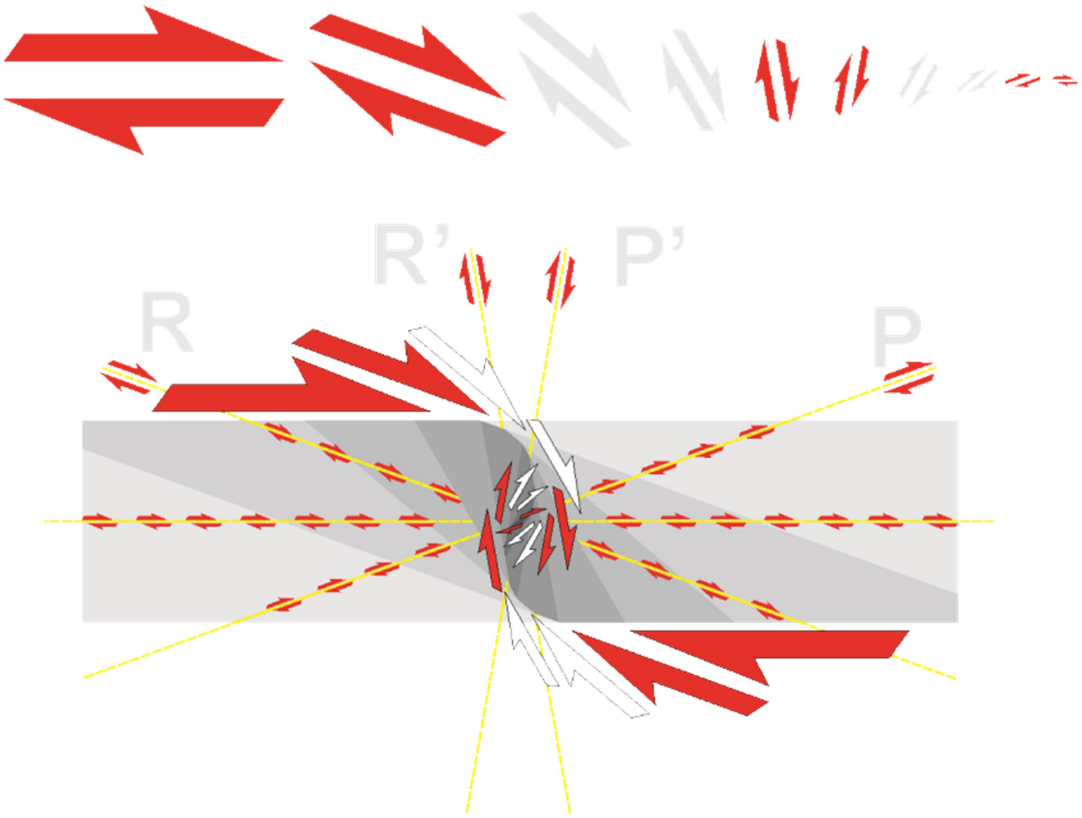

Fig. 2. Illustration of the fractal nature of the surface of damage under simple shear conditions (Riedel diagram)

SUB-DAILY EARTH ROTATION PARAMETERS FROM GPS, GLONASS, AND GALILEO

Radosław Zajdel, Krzysztof Sośnica, Grzegorz Bury, Kamil Kaźmierski, Dariusz Strugarek

Wroclaw University of Environmental and Life Sciences, C.K. Norwida 25, 50-375 Wroclaw, radoslaw.zajdel@upwr.edu.pl

ABSTRACT

Keywords: GNSS, sub-daily ERPs, ocean tides, polar motion

The sub-daily Earth Rotation Parameters (ERPs) can be estimated from the space-geodetic techniques, especially GNSS. However, the residual signals between GPS-derived estimates and the conventional IERS model show differences, especially close to the diurnal and semidiurnal frequencies. A major part of these differences may originate from the overlapping periods of the diurnal and semidiurnal tidal terms and the GPS revolution period, which equals half of the sidereal day. Since 2019, the European GNSS called Galileo may be considered as fully operational with 24 healthy satellites in space. Galileo satellites have a different revolution period than GPS, and moreover, two additional Galileo satellites are orbiting on an eccentric orbit which helps to decorrelate tidal constituents from orbit parameters.

This contribution shows the Galileo-based ERPs from 2-year (2017–2018) global processing. The estimates were compared to the results delivered in GPS-only, GLONASS-only, and combined multi-GNSS solutions. Moreover, we evaluate the consistency between the GNSS-based estimates of the sub-daily PM with three independent models, i.e., International Earth Rotation and Reference Systems Service (IERS) 2010 Conventions, Desai-Sibois model, and Gipson model. The sub-daily PM estimates, which are delivered from system-specific solutions, are inherently affected by the artificial non-tidal signals, which arise from the combination of the Earth revolution period and the satellite revolution period. We found strong spurious signals in GLONASS-based and Galileo-based results with amplitudes up to 30 μas. Nonetheless, even the incomplete constellation of 14–18 Galileo satellites can provide sub-daily ERPs with better quality than GLONASS.

Programme of the 20th Czech–Polish Workshop
ON RECENT GEODYNAMICS OF CENTRAL EUROPE
AND
THE 2nd SYMPOSIUM OF THE COMMITTEE ON GEODESY
OF THE POLISH ACADEMY OF SCIENCES
Jakuszyce, 24–26 October 2019

Thursday, October 24, 2019

12:00 – 14:00 Registration

12:00 – 14:00 Lunch

14:00 – 14:10 Opening Session
Chairman: Stefan Cacoń, Bernard Kontny, Vladimír Schenk

14:10 – 15:25 Session I
Chairman: Jan Kryński, Jan Vondrak

14:10 – 14:40 Invited speaker

Holger Steffen, Rebekka Steffen, Christian Brandes, Lev Tarasov
GLACIAL ISOSTATIC ADJUSTMENT IN EUROPE - OBSERVATIONS, MODELLING AND ITS EFFECTS SOUTH OF THE BALTIC SEA

Lubomil Pospíšil, Otakar Švábenský
POSSIBLE GEOLOGICAL EXPLANATION OF ANOMALOUS SITE VELOCITIES IN THE MORAVIAN REGION

Filip Hartvich
RECENT GEODYNAMIC BEHAVIOUR OF MOLDANUBICUM FAULTS

Paweł Aleksandrowski, Joanna Figuła, Marek Sada, Łukasz Sito, Marek Wojdyła
SUDETIC BOUNDARY FAULT'S DEEP STRUCTURE AS REVEALED BY MAGNETOTELLURIC SOUNDING

15:25 – 15:40 Coffee break

15:40 – 16:55 Session II
Chairman: Andrzej Borkowski, Otakar Švábenský

Vladimír Schenk, Zdeňka Schenková, Bernard Kontny, Jan Kapłon
AN APPROPRIATE LITHOSPHERIC PLATE VELOCITY MODEL FOR THE CENTRAL EUROPEAN AREA

Sławomir Porzucek, Olgierd Jamroz, Monika Łój
GRAVIMETRIC MODELLING OF EASTERN EDGE OF UPPER NYSA KLODZKA GRABEN

Walyeldeen Godah, Małgorzata Szelachowska, Jagat Dwipendra Ray, Jan Kryński

COMPARISON OF VERTICAL DISPLACEMENTS OBTAINED USING GRACE DATA AND GNSS DATA OVER POLAND

Krzysztof Maniak, Remigiusz Mydlikowski, Stanisław Wójtowicz

EMISSION OF ELECTROMAGNETIC FIELD OF ROCKS UNDER STRESS AS A PRECURSOR OF THE EMERGING THREAT OF ROCK MASS COLLAPS

Radosław Zajdel, Krzysztof Sośnica, Grzegorz Bury, Kamil Kaźmierski, Dariusz Strugarek

SUB-DAILY EARTH ROTATION PARAMETERS FROM GPS, GLONASS, AND GALILEO

16:55 – 17:10 Coffee break

17:10 – 18:25 Session III
Chairman: Paweł Aleksandrowski, Vladimír Schenk

Jurand Wojewoda

GEOLOGICAL LINES, GEOLOGICAL SURFACES, SCALE ISSUES IN GEOLOGY, STRUCTURAL ENTROPY, FRACTAL NATURE OF GEOLOGICAL STRUCTURES

Jurand Wojewoda

THE INTRASUDETIC BASINS AND SYNCLINORIUM IN THE EXTENSIONAL MODEL OF THE SUDETES EVOLUTION – ENVIRONMENTAL AND PALEOGEOGRAPHIC SCHEMES

Ihor Bubniak, Kornyliy Tretyak

VIRTUAL GEOLOGICALOUTCROPS – NEW APPROACHES IN SEDIMENTOLOGY, STRUCTURAL GEOLOGY, TECTONOPHYSICS

Kamila Karkowska, Monika Wilde-Piórko

HOW CAN GRAVIMETERS IMPROVE THE DETERMINATION OF THE EARTH'S MANTLE STRUCTURE?

Jan Jelenek

MONITORING OF HIGHWAY STABILITY USING SENTINEL-1 DATA AND INTERFEROMETRIC TECHNIQUES – A CASE STUDY OF A DOBKOVIČKY LANDSLIDE AREA, CZECH REPUBLIC

19:30 – 23:00 Dinner

Friday, October 25, 2019

7:00 – 8:00	**Breakfast**
Field session	
8:00 – 15:00	Guided tour: Bozkov dolomite caves, mining museum Harrachov, Mumlavský waterfall
15:00 – 16:00	**Lunch**
16:00 – 17:30	**Session IV** **Chairman: Lubomil Pospíšil, Pawel Wielgosz**

Jan Vondrák, Cyril Ron

PERIOD AND Q-FACTOR OF FREE CORE NUTATION, BASED ON DIFFERENT GEOPHYSICAL EXCITATIONS AND VLBI SOLUTIONS

Wiesław Kosek, Anna Kłos, Janusz Bogusz

DETECTION OF HARMONIC SIGNALS IN GNSS POSITION TIME SERIES USING FREQUENCY-DEPENDENT AUTOCOVARIANCE

Artur Leńczuk, Anna Kłos, Janusz Bogusz

ESTIMATES OF EARTH'S CRUST DEFORMATIONS USING GRACE: COMPARISON OF SPHERICAL HARMONICS AND MASCON SOLUTION FOR CENTRAL EUROPE

Grzegorz Leszczuk, Anna Kłos, Artur Leńczuk, Janusz Bogusz

DETERMINATION OF COMMON SIGNALS IN THE HYDROLOGICAL MODEL AND GRACE OBSERVATIONS FOR EUROPE

Janusz Bogusz, Anna Kłos, Jürgen Kusche

TOWARDS ESTIMATES OF PRESENT-DAY VERTICAL DEFORMATIONS USING GPS AND GRACE OBSERVATIONS

Anna Kłos, Janusz Bogusz

CAN WE BLINDLY TRUST GPS ESTIMATES? A COMPARISON TO ENVIRONMENTAL LOADINGS

17:45 – 19:15	**Session V** **Chairman: Janusz Bogusz, Zdeňka Schenková**

Witold Rohm, Jan Kapłon, Maya Ilieva, Iwona Kudłacik, Damian Tondaś, Kamila Pawłuszek, Tomasz Hadaś, Kamil Kaźmierski, Krzysztof Sośnica, Radosław Zajdel, Grzegorz Jóźków, Przemysław Tymków, Mateusz Karpina, Andrzej Borkowski

SCIENTIFIC USE OF EPOS-PL INFRASTRUCTURE

Marcel Mojzes, Pavol Kollar, Michal Mikolaj, Marek Woźniak, Branislav Habel, Marek Macak

DETERMINATION OF EFFECTIVE YOUNG´S MODULUS BY GEODETIC MEASUREMENTS

Zbigniew Szczerbowski, Rafał Gawałkiewicz

RECENT MOVEMENTS OF SALT DOME IN INOWROCŁAW IN THE LIGHT OF GEODETIC SURVEYS

Zbigniew Szczerbowski, Zbigniew Niedbalski

GEODETIC DERIVED STRAIN VERSUS ELECTRONIC EXTENSOMETER MEASUREMENTS IN UNMINED ROCK MASS ON THE EXAMPLE OF THE BOCHNIA SALT MINE

Jakub Stemberk, Miroslav Coubal, Josef Stemberk, Petra Štěpančíková

THE NOWADAYS STRESS FIELD PARAMETERS CALCULATED BASED ON FAULT SLIPS DATA RECORDED BY 3-D EXTENSOMETERS WITHIN THE DĚDIČNÁ ŠTOLA GALLERY IN RYCHLEBSKÉ HORY MTS.

Iwona Kudłacik, Jan Kapłon, Grzegorz Lizurek

HIGH-RATE GNSS FOR MINING ACTIVITY: THE 2019 JANUARY 29TH MINING TREMOR IN LEGNICA-GŁOGÓW COPPER DISTRICT, POLAND

19:15 – 19:30 Poster Discussion

20:00 – 23:00 Gala dinner

Saturday, October 26, 2019

8:00 – 9:00 Breakfast

9:00 – 10:15 Session VI
Chairman: Filip Hartvich, Zbigniew Szczerbowski

Marcel Mojzeš, Martin Kalafut

VERTICAL REFERENCE SYSTEMS IN SLOVAKIA AND THEIR RECIPROCAL DIFFERENCES

Dominik Sokalski

COMPARISON OF VARIOUS TERRESTRIAL LASER SCANNERS APPLIED FOR DOCUMENTING STRUCTURAL DISCONTINUITIES IN RUDNA COPPER MINE, POLAND

Dominik Sokalski, Jurand Wojewoda, Damian Kasza, Jarosław Wajs

TECTONIC STRUCTURES RELATED TO PAULINÓW SYNCLINE IN RUDNA COPPER MINE, POLAND DOCUMENTED WITH TERRESTRIAL LASER SCANNER

Bartłomiej Ćmielewski

THE UAS LANDSLIDE SURVEY AND DEFORMATION ANALYSIS IN COMPARISON TO THE HISTORICAL DATA ON EXAMPLE SIEDLĘCIN LANDSLIDE

Wojciech Sowa, Adrian Kaczmarek, Tomasz Waliński, Michał Czerwonka, Andrzej Borkowski

DATA ANALYSIS OF THE SURVEYING MONITORING SYSTEM OPERATING IN OPEN-CAST MINE CONDITIONS – FIRST RESULTS

10:15 – 10:30 Coffee break

10:30 – 11:30 Session VII
Chairman: Stefan Cacoń, Marcel Mojzeš

Pawel Wielgosz, Manuel Hernández-Pajares, Dariusz Tomaszewski, Jacek Rapiński, Anna Krypiak-Gregorczyk

ASSESSMENT OF POSTPROCESSED AND REAL-TIME GLOBAL IONOSPHERIC MAPS IN LONG-RANGE RTK POSITIONING: CNES RT GIM AND UQRG GIM CASE STUDY.

Beata Milanowska, Anna Krypiak-Gregorczyk, Pawel Wielgosz

COMPARISON OF GNSS-DERIVED IONOSPHERIC MAPS FOR DIFFERENET SOLAR ACTIVITY LEVELS

Magdalena Mleczko, Natalia Ostrowska, Marek Mróz

EVALUATION OF QUANTITY AND SPATIAL DISTRIBUTION OF NATURAL PERMANENT SCATTERERS EXTRACTED FROM SENTINEL-1 IN URBAN AND NON-URBAN AREAS BY APPLYING DIFFERENT PROCESSING PARAMETERS

Jacek Paziewski, Marta Ostapkiewicz, Rafał Sieradzki, Radosław Baryła

TOWARDS PRECISE GNSS POSITIONING WITH LOW POWER CONSUMPTION SMARTPHONES: QUALITY ANALYSIS OF OBSERVATIONS AND ASSESSMENT OF POSITIONING

11:30 – 12:00 Final Discussion and Closing Ceremony
Chairman: Janusz Bogusz, Olgierd Jamroz, Bernard Kontny, Vladimír Schenk

12:00 – 13:00 Lunch

Poster Session

Posters can be viewed during coffee breaks.
Poster authors will be available at the posters on Friday from 19:15 to 19:30

Jurand Wojewoda

THE INTRASUDETIC BASINS AND SYNCLINORIUM IN THE EXTENSIONAL MODEL OF THE SUDETES EVOLUTION – ENVIRONMENTAL AND PALEOGEOGRAPHIC SCHEMES

Marek Trojanowicz, Lubomil Pospíšil, Olgierd Jamroz

THE USE OF THE UNB_TOPODENS MODEL FOR LOCAL MODELLING OF CHOSEN GRAVITY FIELD PARAMETERS AT THE WESTERN CARPATHIANS AREA

Joanna Janicka, Dariusz Tomaszewski, Jacek Rapiński, Renata Pelc-Mieczkowska

PREDICTION OF GEOCENTRIC CORRECTIONS DURING COMMUNICATION LINK OUTAGE

Kamil Kowalczyk, Katarzyna Pająk, Beata Wieczorek, Bartosz Naumowicz

INVESTIGATION OF THE VERTICAL CRUSTAL MOVEMENTS ALONG THE EUROPEAN COAST USING SATELLITE ALTIMETRY, TIDE GAUGE DATA, GNSS STATIONS AND RADAR INTERFEROMETRY

Stefan Cacoń, Wojciech Milczarek, Marek Zygmunt

VERTICAL MOVEMENTS OF THE LAND ON THE ODER ISLANDS IN THE AREA OF SZCZECIN, NW POLAND

Wojciech Sowa, Adrian Kaczmarek, Krzysztof Mąkolski

ANALYSIS OF VERTICAL DISPLACEMENTS OF THE GEO-INFO-HYDRO BUILDING BASED ON THE OBSERVATION FROM THE STRUCTURAL MONITORING SYSTEM

Piotr Gołuch, Kazimierz Ćmielewski, Janusz Kuchmister, Bartłomiej Ćmielewski, Izabela Wilczyńska

STATION TO TESTING OF VERTICAL DIGITAL INCLINOMETER SISGEO

Krzysztof Pilecki, Krzysztof Mąkolski

IST SICHER DAS NICHTS SICHER IST. SURPRISE ON THE JAKUSZYCE CLEARING

Grzegorz Bury, Radosław Zajdel, Krzysztof Sośnica

PROCESSING OF SATELLITE LASER RANGING TO GNSS SATELLITES