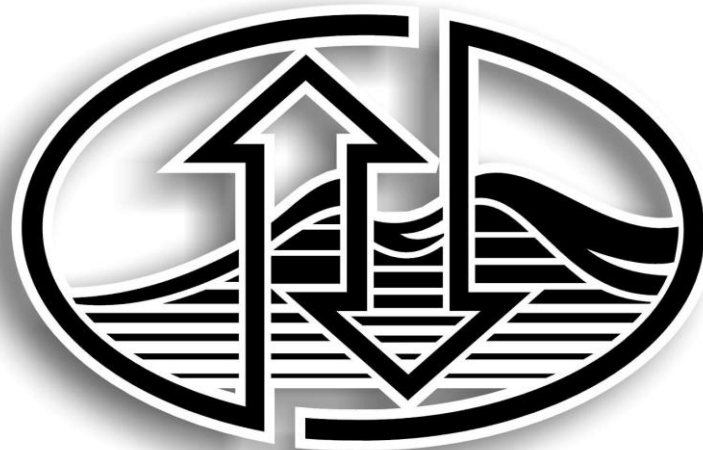**IGiG** Institute of Geodesy and Geoinformatics, Wrocław University of Environmental and Life Sciences

Institute of Rock Structure and Mechanics, Academy of Sciences of the Czech Republic

PAN Section of the Geodynamics, Committee of Geodesy, Polish Academy of Sciences

13th CZECH–POLISH WORKSHOP

ON RECENT GEODYNAMICS OF THE SUDETY MTS. AND ADJACENT AREAS

ABSTRACTS

Wrocław–Pawłowice, Poland
November 22-24, 2012

Organizing Committee
of the

13th Czech–Polish Workshop

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ABSTRACTS
Contents (in alphabetical order)

THE SPATIAL GEOLOGICAL AND MINING MODEL OF THE FORMER WALBRZYCH COAL BASIN. DEVELOPMENT AND APPLICATIONS

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ABSTRACT

In the paper spatial geological and mining model of the part of the former Walbrzych Coal Basin is presented. The methodology of developing spatial model of geology with division into local geological formations and tectonic faults has been characterized. The geological part of the model has been constructed basing on selected geological profiles and digital terrain model using the potential function. The mining part of the model has been taken from the geoinformation system of the former mines developed by (Blachowski, 2008) basing on old mining maps showing underground workings in the past 200 years.

Applications of the combined model have been demonstrated on the examples of numerical analyses of old mining activities on the ground surface and examples of analyses of former mining operations in the spatial and temporal domain used to aid studies of mining and post-mining ground deformations in the Walbrzych area.

LITHOSPHERIC DEFORMATIONS MODELLING FROM CONTINENTAL TO LOCAL SCALE USING SATELLITE DATA

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ABSTRACT

The increasing number of both permanent stations performing observations to navigation satellites, and the amount of data collected by them can significantly increase the reliability of estimation of geodynamical parameters. Coordinates determined using satellite systems are referred to a geocentric reference frame, so they naturally serve as an ideal base for geodynamic studies not only in local or regional scales, but even in the global scale. From the point of view of geodynamics, the analyses of coordinate time series enabled us to identify not only plate or intraplate movements but also their derivatives by means of deformation parameters. The presentation contains data collected during research on the geodynamical module, an interpretative part of ASG+ project. It presents determination of intraplate velocities and deformation parameters represented by the strain ellipse starting at the continental scale (Europe), through regional (Poland) to a local scale (Sudeten). The study used observations made by permanent sites from EPN and ASG-EUPOS networks. Bernese program was used to determine the coordinates, CATREF – their changes in time expressed in ETRF2000 reference frame and GRID_STRAIN – the basic parameters of deformation. The presentation also includes extensive analysis with regard to interpretation of existing data.

SUITABILITY ASSESSMENT OF AIRBORNE LASER SCANNING DATA FOR LANDSLIDE STUDY

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ABSTRACT

Airborne laser scanning (ALS) is an effective data acquisition method describing the topographic terrain surface that still finds new areas of application. In recent years, this technology is increasingly being used in landslide studies. ALS data can be applied to identify (manual or automatic) landslide areas and to describe its morphometry. Multitemporal laser scanning is used to detect the landslide activity and to determine the volume of material displaced.

ALS is presented as an almost perfect data collection technique in various publications related to landslides study. However, the problem of the accuracy and reliability of the ALS data obtained is not considered, while this method has limitations as the other.

The problem of assessing the suitability of ALS data for landslide studies is addressed in this paper. Analyses were carried out on the study area of about 40 km^2 located at the south-eastern edge of Roznow Lake. The area was scanned using Riegl LiteMapping laser scanning system. Scanning was performed at the beginning of April, and then, in July 2010, with the same scanning parameters. ALS accuracy was estimated using direct field measurements with GNSS technology. Comparison of the results showed a significant decrease in the accuracy of scanning performed in the period of intense vegetation. Also density of terrain points decreased significantly. Scanning performed in July was partially not useful to determine the amount of displaced landslide material. Furthermore, the occurrence of systematic errors in ALS data set was found. Detailed results of the analysis are given in the paper.

RECENT TECTONIC ACTIVITY OF THE WESTERN SUDETES IN POLAND AND CZECH REPUBLIC

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ABSTRACT

The Sudety Mts. area and in this their western part is differentiated in terms of geomorphology, geology and tectonics. In the past, the Sudety Mts. have been subjected to intensive tectonic movements. Their greatest intensification occurred in the Tertiary. Tectonic movements have also repeated in the Quaternary. Recent geodynamic studies carried out with various methods confirm that these movements have not yet ended. This is confirmed, most of all, by earthquakes registered in the Sudety Mts. and adjacent areas.

During the past 20 years a number of epoch, precise, satellite GPS and gravimetric measurements have been done in local and regional networks in the Sudety Mts. both in Poland and in Czech Republic. Results of these measurements show mobility of the main tectonic zones and in this the Sudetes Marginal Fault that separates the Sudety Mts. Massif from the Fore-Sudetic Block in Poland.

In this paper the results of analysis of precise leveling measurements in 1st and 2nd class national networks in the Western Sudetes in Poland and Czech Republic have been presented. These measurements have been done in the 40/50'ties and 70/80'ties of the 20th Century and on the turn of the 20th and 21st Centuries. The main focus has been given to relative changes of benchmark heights located on both sides of identified faults with reference to stable benchmarks along an analysed leveling line. Significant velocities of vertical movements of geological structures on the opposite sides of faults are within the -0.2 – -0.8 mm/year range (subsidence) and +0.2 mm/year (elevation) in the Polish part of the Sudety Mts. In the Czech Republic area these values are -0.2 mm/year and +0.4 mm/year respectively.

FAST AND PRECISE POSITIONING USING MAFA METHOD AND NEW GPS AND GALILEO SIGNALS

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ABSTRACT

The paper presents the foundations of MAFA method, as well as its application to the processing of new GPS and Galileo signals. Numerical tests have been carried out on the basis of data obtained from a hardware GNSS signal simulator. First, linear combinations have been formed using these new GNSS signals. These linear combinations make up a data set for a cascade adjustment algorithm employing MAFA method. Feasibility of a single-epoch precise positioning has been tested. The obtained test results and analysis show that MAFA method may be successfully used with new GPS and Galileo signals, even in the single-epoch mode.

EFFECT OF ADDITIONAL DISTANCE MEASUREMENTS ON SATELLITE POSITIONING QUALITY

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ABSTRACT

When performing measurements for displacements monitoring, reliable positions of chosen points together with proper accuracy analysis, is of crucial significance. In most systems, equal accuracy of all 3 coordinates is highly recommended. The GNSS system, under standard observation conditions, often fulfills these requirements. However, in situations of limited sky visibility, it may happen that positioning based on only GNSS satellites is not sufficient and a kind of augmentation is needed, especially for height component determination. Additional pseudolite-like distances measured to known on-ground points may help in solving such problems.

The paper starts with a general introduction on a pseudolite being created by the authors. In research part of the paper, analyses of an effect of including additional distance observations into double-differenced relative satellite positioning functional model, are discussed. Scenarios with one or more simulated pseudolites were considered. Resulting coordinates as well as their accuracy analysis were investigated, in comparison to satellite-only positions.

USE OF LOW-COST MEMS TECHNOLOGY IN EARLY WARNING SYSTEM AGAINST LANDSLIDE THREATS

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ABSTRACT

The paper presents the concept of using low-cost MEMS technology (called Micro-Electro-Mechanical Systems), to determine the initial masses movements.

Accelerometers used to detect two types of acceleration: dynamic and static. In a study of masses movements the attention focuses mainly on the static acceleration, accelerometers which was used was the branches of "low-g", which have high resolution for small accelerations of the order 1 to 2 g. The use of such systems will take advantage of Earth's gravity, and precisely the components in each axis, the designation of displacement and indirectly can show the initial mass movements.

This work describes a laboratory test procedure designed sensors. The purpose of testing was to determine the parameters of the measurement sensors: repeatability, resolution and accuracy in use. Then in the paper is presented the concept of integrated motion measurement system and the results of laboratory tests on a test frame elements, which will simulate the movements of masses of earth.

DEFORMATION RESEARCH OF GROUND OBJECTS USING A TERRESTRIAL LASER SCANNER

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ABSTRACT

To determine the deformation of the surface objects, not monolithic, it requires a dense network of establishment controlled points, which increases investment costs and do not fully reflect the changes occurring in nature. This is due to the nature of the measurement point by the geodetic methods which are not always in optimal distribution on object.

The article will be described a method using terrestrial laser scanning as a tool to study deformation of slopes. Results obtained from terrestrial laser scanning can greatly assist in the process of determination and deformation analysis of slopes.

Test measurements were made by terrestrial laser scanner from Leica HDS ScanStation II. The study was conducted on test landslide Bardo–Janowiec and two example of landslide, after stabilization, on the rail route Wrocław–Malczyce E-30/CE-30 located in Lower Silesia.

ANALYSIS OF THE DYNAMICS OF WATER EROSION PROCESSES USING TERRESTRIAL LASER SCANNING

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ABSTRACT

The paper presents the preliminary results of the analysis of the water erosion processes of soil occurring in forestry mountain catchment area in the West Sudety Mountains (Przedgórze Izerskie). The research was carried out within the area of skid trails (operational trails), which were used to the end of 2010 in obtaining wood and its mechanical transport to the place of storage. As a consequence of forestry work that was carried out it was changing the natural structure of ground on the wooded slopes, which, combined with the favorable hydro-meteorological conditions contributed to the intensification of the water erosion processes of soil.

For the implementation of the research project of the analysis of water erosion processes in the forestry catchment area innovative was used terrestrial laser scanning. Using terrestrial laser scanning has enabled the analysis of the dynamics of erosion processes both in time, as well as in spatial terms. The result of the analyses that was carried out is identification areas of denudation and accumulation of erosion material, and also determine the intensity of the erosion processes and their quantitative analysis.

Carried out a research project using the terrestrial laser scanning shows that human impact on forest ecosystems, artificial delimitation traffic routes and work carried out affect the natural balance hydrological and soil conditions and may contribute to a significant intensification of the erosion processes. Submit the results of the analysis consider the problem of dynamics and intensity of erosion processes in mountain areas, and show the effectiveness of the methodology of research.

EVALUATION OF RECENT GOCE GLOBAL GEOPOTENTIAL MODELS OVER THE AREA OF POLAND

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ABSTRACT

The dedicated satellite gravity missions have provided homogeneous and uniformly accurate information on the long and medium wavelengths of the Earth's gravity field. Since the lunch of the Gravity Field and Steady-State Ocean Circulation Explorer (GOCE) satellite gravimetry mission by the European Space Agency (ESA) in 2009, several global geopotential models (GGMs) have been published.

This study evaluates over the area of Poland the recent GOCE-based GGMs. The evaluation has been performed with the use of the EGM2008 and 184 high-precision GPS/levelling control traverse stations. One GOCE-only based GGMs, four GOCE/GRACE satellite-only GGMs and one GOCE/GRACE GGM combined with terrestrial gravity data have been selected for the evaluation. The results of inter-comparison of the models as well as their accuracy assessment were discussed.

THE POSSIBILITY OF USING CLOSE-RANGE MONO-PHOTOGRAMMETRY IN MEASURING RELATIVE DISPLACEMENTS OF ROCK BLOCKS

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ABSTRACT

The paper presents a method for measuring the relative displacements of rock blocks on the basis of recorded images of measurement prototype plates. The developed measurement targets, after deposition on the measurement object (for example examined blocks of rock) act as control points, which represent the behavior of the object over time. Two types of targets ware constructed: passive (appropriately chosen figure) and active (respectively arranged fiber aims). The paper presents preliminary results of work in the laboratory test using a calibrated semi-metric camera (Canon D5 Mark II – SLR camera with a CMOS 21 million pixels sensor), two targets passive, geodetic engineering tripod, micrometric simulator of shifts and total station Leica TC1800.

During the experimental work one of the targets was set on a tripod, and the other placed on the total station telescope set on the observational pole. In the performance of a series of images the first target was fixed, while the other was moved and rotated. The shift was made with a micrometer table in two mutually perpendicular directions XY in the level, and by simulated rotation of the horizontal wheel and vertical wheel of the total station (rotation of the instrument by the adjusting screws). Using the principles of close-range mono-photogrammetry from automatic measurement of the recorded images of both signal targets, the values of shifts and rotations were compared with the references.

CALCULATION OF GLONASS SATELLITE POSITION BASED ON ANALYTICAL THEORY OF MOTION

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ABSTRACT

The presented algorithms computation of orbital elements and positions of GLONASS satellites are based on the generalized problem of two fixed centers. The analytical algorithm embraces the disturbing acceleration due to the oblatness J2. Other main disturbing accelerations – due to the moon and the sun attraction – are also computed analytically, where geocentric position of the moon and the sun are obtained by evaluating known analytical expressions for their motion. The given numerical examples shown that the presented method is more efficient and can improve the accuracy of satellite coordinates calculation for GLONASS.

PRECISE GRAVIMETRIC PROFILING IN THE REGION OF WILKANÓW TECTONIC FAULT, LOWER SILESIA, SW POLAND

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ABSTRACT

The study analysis included NE part of the Upper Nysa Kłodzka Graben on the east and adjacent to the north the Śnieżnik Massif. Since the end of the Cretaceous, this area was largely tectonically rebuilt. Both the tectonic fault and the adjacent areas has been uplifted. This process was, however, very strongly differentiated. Eastern frames of the graben have been uplifted of 1000–1200 m (Wilkanów fault), while the northern frame of about 700–800 m (Krosnowice fault). The diverse tectonic movements also have been marked within the graben vicinity. They are much better recognized in its western part. Nysa Kłodzka river in several places creates breakthrough episodes associated with raising a young tectonic blocks. Tectonic movements taking place in the NE part of the graben are recently postulated. Aim of this study is to determine the geodynamic activity occurring on the border of two tectonic blocks.

The morphotectonic analyzes confirm relatively young tectonic movements that occur not only along the northern and eastern border of the Upper Nysa Kłodzka Graben, but inside it as well. The development of relief was connected with uplifting of the Śnieżnik Massif. It was differently proceeded on the north and east part of the massif. Particularly complex movements occurred along the Wilkanów fault. Wilkanów fault surface passes within Cretaceous rocks, and not on the lithological and stratigraphic boundary, as it is marked on the geological maps. Uplifting movements occurring on the Krosnowice fault, causing flexural uplift of the Late Cretaceous sediments.

Analysis of benchmark movements in precise leveling network shows subsidence occurring in the western part of the Śnieżnik Massif. The gravimetric profiling partially explains this apparent contradiction. Under gneisses building the Massif are located geological formations of lower density, which are responsible for subsidence measured currently by geodetic methods. The analyzes carried out were supported by the results of gravimetric geophysical profiling in two designed intersections (Fig. 1).
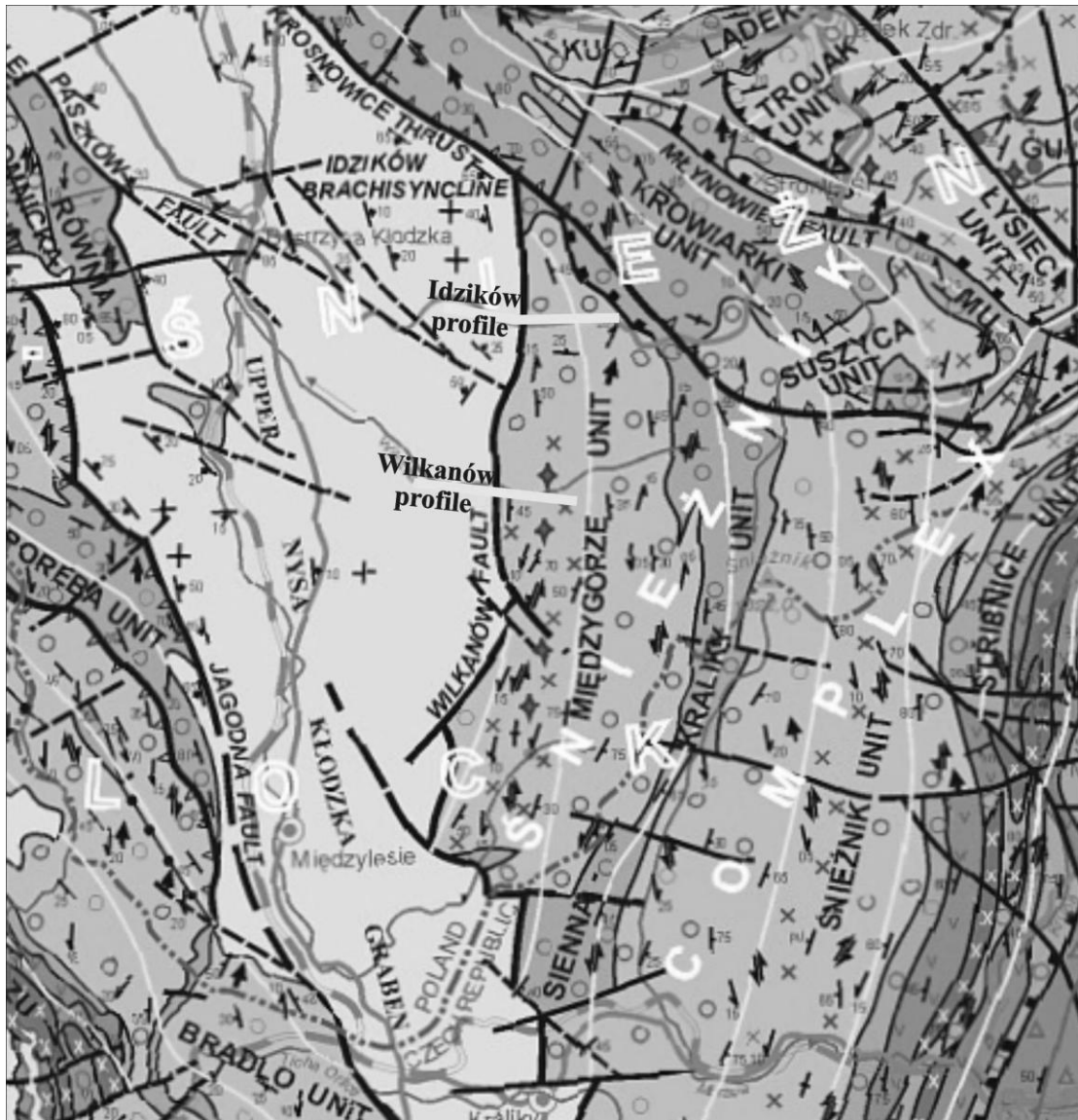
*Fig. 1. Gravimetric profiles against the Tectonic Map of Sudety Mts.
and Fore-Sudetic Block (by Cymerman, 2010)*

The Wilkanów profile was measured in the vicinity of Wilkanów and Międzygórze, while the Idzików profile was located on the north, in the Idzików village. Both cross sections are passing through Wilkanów fault separating the Upper Nysa Kłodzka Graben and Międzygórze unit. Distributions of Bouguer's anomaly along both profiles has been obtained on the base of measurement data. These data were used to refine the geological structure of the fault zone, fault location, direction and the size of the dump.

THE ORIGIN OF A MOSAIC-LIKE RECENT STATE OF STRESS IN THE WIELKOPOLSKA AND LOWER SILESIA AS INFERRED FROM IN-SITU STRESS MEASUREMENTS AND NUMERICAL MODELING

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ABSTRACT

Stress measurements in the Wielkopolska and Lower Silesia regions are rather scarce and of moderate and low quality. The results suggest diversity of maximum horizontal stress (SHmax) directions in a broad range from WNW–ESE clockwise to NNE–SSW and stress regimes either strike-slip or normal fault. By means of numerical finite element modeling (FEM) we have examined if this puzzling stress pattern is possible to explain based on the recent geodynamic scenario for the European part of lithospheric plate. We have built 2D elastic plain stress model of Central Europe consisting of tectono-mechanical units with variable material properties separated with frictional contact elements. Introducing several fault zones allowed to obtain more detailed local variations in stress pattern. In result of stress simulations we have defined three first-order stress generating factors governing stress field in the Wielkopolska and Lower Silesia regions: (1) counterclockwise rotation of the Adria microplate that exerts compression to the Dinarides, transfer farther across the Pannonian basin and the Carpathians to the Polish Lowlands; (2) the Adria advance northwards exerting compression to the Alps which propagates across the Bohemian Massif to the Lower Silesia; and (3) Atlantic ridge push exerted to the NW passive margin of Europe and transmitted SE-wards to western Poland.

The effectiveness of stresses propagation and its redistribution within the plate depend on the complex structure and heterogeneous rheology of the north European lithosphere. Based on modeling results we are able to predict a role that the main faults may play in stress field differentiation in the study regions. (1) The eastern segments of the Marginal Sudetic Fault and the Mid-Odra Fault Zone seems to be recently active normal faults. The SHmax turns parallel to the strike of these faults. Both, the stress regime and direction are similar to this inferred from the focal mechanism solution for the Marginal Sudetic Fault. (2) For the western segments of the Marginal Sudetic Fault and the Mid-Odra Fault Zone we have predicted a tendency to dextral strike-slip motion. The SHmax is directed towards N–S, forcing dextral slip on both faults. (3) The Kraków–Szczecin fault zone seems also to move in a dextral strike-slip manner. Recent reactivation of this fault is proven by the Jarocin earthquke from 6 January 2012. However, extensional (or transtensional) focal mechanism solution for this event does not match exactly the modeled strike-slip scenario. This

discrepancy can be explained by assuming a pull apart splitting in seismically active fault segment. In the model, the SHmax direction in the Wielkopolska region is close to NW–SE, which is similar to that determined for deep boreholes beneath the Zechstein salt layer. Stress measurements from above the evaporites indicate essentially different SHmax direction, which can be explained by discrete sliding of the Mesozoic complex down-dip the ductile salt homocline.

The results of stress modeling and measurements indicate that all faults active in neotectonic period still play an important role in stress redistribution in this region. They cause a mosaic-like stress pattern in the Lower Silesia and Wielkopolska regions, in addition complicated by stress decoupling at a weak Zechstein salt layer. Some aspects of this stress variations can be explained by implementation of numerical FEM simulation.

USING GPS MULTIPATH FOR SOIL MOISTURE AND SNOW DEPTH SENSING – FIRST EXPERIENCE WITH DATA FROM PERMANENT STATIONS IN SLOVAKIA

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ABSTRACT

Multipath in GPS observations is generally considered as a disturbing effect systematically influencing static and kinematic positioning. The broadcasted satellite microwave signal directly reaching the GPS antenna is interfered with the satellite signal reflected from the terrain around the antenna. Motion of the satellite in the sky and features of the reflection surface affect the multipath characteristics. Recently several studies have shown that the analysis of multipath at permanently observing GPS sites allows to infer the properties of the environment of the antenna, namely the variability of depth of the reflecting surface and consecutively to deduce the variations of soil moisture or the changes of snow cover. Two types of GPS data are efficient for such analysis of multipath – signal-to-noise ratio and geometry-free linear combination of carrier phases since the centimeter accuracy is expected. We examined both approaches on several permanent GPS stations in Slovakia, situated in various environments. The applied analysis methods and the experience with both kinds of input data will be presented.

DISTURBING EFFECTS OF WATER TUBES TILTMETERS MEASUREMENTS.
HARMONIC OSCILLATIONS OF WATER LEVEL WITH SEVERAL HUNDRED NANOMETERS AMPLITUDES
AND 10-3 HZ FREQUENCIES AND THEIR CORRELATION WITH AIR PRESSURE FUNCTION

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ABSTRACT

Presented effects of water level harmonic oscillations are visible only by gauge situated nearest to entrance to the underground. Other free gauges of water-tubes tiltmeters are significantly more distant from entrance to the underground and situated at the ends of the corridors. Lack of any similar signals in registrations from other gauges (asymmetry of signals from opposite ends of tubes) indicates that harmonic oscillations of water level are not associated with any Earth solid body phenomenon.

The long water-tube tiltmeters are extremely sensitive on horizontal component of air pressure gradient. The water-tube tiltmeters can register inverse barometric effects caused by air pressure effect 10-7 [Hp]. Horizontal pressure gradient causes in tiltmeter additional variations of water level (inverse barometric effect) registered as well as tidal signals. The results of observations indicate that harmonic disturbances of water level are correlated with extremes or inflections points of pressure function. These are the moments while pressure achieves state of quasi equilibrium. During several days long monotonic variations of air pressure harmonic oscillations are not visible. This time in underground corridors there arise stable gradient of pressure along the water-tubes of tiltmeters. Stable gradient causes systematic deflection of water level without any oscillations.

Observed harmonic oscillations of water level amount of 1/10 of tidal signal amplitude that is 300 to 500 nanometers and corresponds to $3 \times 10\text{-}5$ [Hp] of air pressure variations. The frequencies of harmonic oscillations are of order 10-3 Hz and cannot be explained directly by any resonance effect of air from inside of the underground. Resonance frequencies of air column in the underground are of order of Hz.

The observed micro oscillations of air pressure are produced probably outside of the laboratory in space of dimension of thousand kilometers. The open question is what is the origin of water level micro oscillations.

ANALYSIS OF VIRTUAL REFERENCE STATIONS APPLICABILITY FOR DISPLACEMENT MONITORING

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ABSTRACT

Purpose of the study was to analyze the possibilities of application of synthetic GPS observations, created with the Virtual Reference Station (VRS) technique, to displacement monitoring. Stability of a reference system provided by VRS stations as well as accuracy of positioning using VRS stations were investigated. The static and kinematic determinations were analyzed. The VRS data were obtained from the POZGEO-D service of the ASG-EUPOS network. The test computations were performed using the GNSS Solutions (v. 3.10.13, Ashtech, 2010) as well as authors' own GPS software. Discussion of results is preceded by general description of VRS method and algorithms.

NEAR REAL-TIME REGIONAL TROPOSPHERE MODEL FROM GNSS DATA

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ABSTRACT

One of the open problem in GNSS (Global Navigation Satellite Systems) positioning is the tropospheric delay modelling, both for autonomous and relative positioning. Tropospheric delay empirical models are functions of meteorological parameters (temperature, pressure and humidity). They determine zenith tropospheric delay (ZTD), which is then mapped into slant tropospheric delay (STD) using respective mapping functions. 90% of refractivity is caused by the neutral hydrostatic atmosphere, while the remaining 10% depends on water vapour 3D distribution and therefore is hard to calculate. Application of standard atmosphere parameters or global models, such as GPT (Boehm et al. 2007) or UNB3 (Leandro et al. 2006), may not be sufficient enough, especially when positioning in non-standard weather conditions.

Institute of Geodesy and Geoinformatics of Wrocław University of Environmental and Life Sciences (IGG WUELS) developed regional troposphere model for the territory of Poland, which is estimated in near-real time regime using GNSS data from Polish Ground Based Augmentation System (GBAS) named ASG-EUPOS established by Polish Head Office of Geodesy and Cartography (GUGiK) in 2008.

This paper describes the methodology of permanent NRT-ZTD estimation, called IGGHZG model and its application into E-GVAP II project. Second part of presentation describes the quality assessment of PPP coordiantes estimated in near-real time with the use of IGGHZG model.

GEOSUD/SUDETEN NETWORK GPS DATA REPROCESSING AND NEW SITE VELOCITY ESTIMATIONS

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ABSTRACT

Geodynamic network of the Sudety Mts. (GEOSUD) was established in 1996 in Poland. Simultaneously on the Czech side the geodynamic network EAST SUDETEN was built in 1997 and in 2001 it was extended for sites towards west (the WEST SUDETEN network). Annual GPS campaign measurements were performed on all networks for two days. Satellite observations gathered by the Institute of Geodesy and Geoinformatics (IGG), Wrocław, and by the Institute of Rock Structure and Mechanics (IRSM), Prague, were processed several times using the Bernese GPS Software, versions of 4.0, 4.2 and 5.0. Different time intervals of observations were used with different models for Earth's rotation, satellite ephemeris, pole motions, ocean loadings and antennas calibration parameters. This presentation delivers the uniform reprocessing strategy of all sessions realized in 1997-2012 period based on Bernese GPS Software v. 5.0 supported by IGS Final ephemeris and Earth's rotation parameters, absolute antenna phase center models and L5/L3 ambiguity resolution strategy. Two different data reprocessings had been made. The first processing was fitted into datum using minimum coordinate constraining of weekly solutions of the EPN network in the reference frame valid for the date of individual measurements. The second one fitted into IGS05 reference frame based on the EPN reprocessed weekly solutions (REPRO1). Both solutions put together all campaign measurements and newly calculated velocity vectors for sites of GEOSUD, EAST and WEST SUDETEN networks are presented and compared.

GLOBAL AND REGIONAL SEASONAL VARIATIONS OF THE GEOID DETECTED BY GRACE

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ABSTRACT

Since 2002, the US–German GRACE (Gravity Recovery and Climate Experiment) mission has been providing a precise survey of Earth's time-variable gravity field, with unprecedented temporal and spatial sampling. GRACE time-variable gravity fields provide a means of measuring temporal and spatial variations of mass redistribution within the Earth system. The GRACE mission starts a new era in studying a series of geophysical problems ranging from deep Earth structure to tracking mass redistribution on and near the surface of the Earth. Time variability of the gravity field depicted here is based on transformation of „monthly gravity field models" to geoid. We show the changes caused by the global water cycle and land hydrology.

EVALUATION OF LEVELING DATA FOR THEIR USE IN KINEMATIC VERTICAL CRUSTAL MOVEMENTS MODEL IN POLISH AREA

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ABSTRACT

To develop the kinematic elevation frame a movement model of earth's crust is required. Currently, even though the system ASG-EUPOS, it seems that most reasonable approach is to use the model developed from the leveling data. In Poland on the base of leveling data, three maps of vertical crustal movements were developed (Wyrzykowski 1971, Wyrzykowski 1985a, Kowalczyk2006 a) and were an attempt to develop a model using data from the station ASG (Kontny, Bogusz 2012). Also two maps of vertical crustal movements were created (Wyrzykowski 1990, Kowalczyk, Rapiński 2011). In the above mentioned elaborations, the vertical crustal movements were calculated from two subsequent first order leveling campaigns. To include more data, results of all four leveling campaigns in Poland were accumulated and digitalized. One, unified database was developed on the basis of collected and unified data set of unadjusted observations (Kowalczyk, Bednarczyk, 2009; Kowalczyk, Bednarczyk, Kowalczyk, 2011). First trials of common use of three first order leveling campaigns were performed in 2008 (Kowalczyk 2008). Though the available leveling data was not complete. The goal of this paper is to evaluate the usefulness of the data from the last three campaigns of precise leveling for the development of vertical movement kinematic model in Poland.

VALIDATION OF INTERPOLATION TECHNIQUES FOR IONOSPHERIC REGIONAL TOTAL ELECTRON CONTENT MAPPING

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ABSTRACT

The overall aim of this study was to assess the performance of several interpolation techniques for ionospheric Total Electron Content (TEC) mapping. Interpolation techniques based on data-fitting two-dimensional local and general polynomials, fitting local surfaces or simple distance-dependent interpolation were used and tested. For the ionospheric modeling, dual-frequency GPS data from Polish GBAS system (ASG-EUPOS) were used, and the Total Electron Content was derived from phase-smoothed pseudoranges. The resulting vertical TEC values were calculated at the ionosphere pierce points (IPP). Then, a regular grid of vertical TEC values with spatial resolution of 0.25 degrees in both latitude and longitude was generated using several interpolation techniques. This grid was used order to create regional TEC maps with 5-minute temporal resolution and also to create ionospheric delay corrections for GPS positioning.

The quality of the ionospheric maps was tested twofold. First, by comparison to the high-quality CODE global ionosphere maps (GIM), which are generated from about 150 GPS sites of the IGS. This model is provided with 2.5×5.0 degrees spatial, and 2-hour temporal resolutions. Second, by creating double-differenced ionospheric delay corrections and them to high-accuracy reference values derived from the reference network data processing. In addition, the correction impact on the positioning results obtained in fast-static positioning mode. For the positioning tests two perpendicular baselines directed N–S and W–E and reaching up to 100 km were selected. All the interpolation methods were analyzed with a special emphasis on the varying ionospheric conditions. For the testing, quiet ionosphere day of 20 Mach 2012 and active ionosphere day of 9 March 2012 were selected. The results show that regional models better represents the changing ionosphere comparing to a global one, and that fitting local functions has an edge over a general ones.

THE APPLICATION OF OPTOELECTRONIC TECHNIQUE FOR TRANSFER THE HEIGHT FROM BENCHMARKS, WHICH ARE PARTLY BUILT, IN NETWORKS FOR RESEARCH OF THE ROCK MASS DEFORMATION

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ABSTRACT

This paper presents new methods to transfer height, during measurements from benchmarks on which the leveling rod cannot be set. Reference points and check points, on geodetic networks to observe deformation of different object types, was stabilized as wall marks or ground height marks. Processes in the field of the technical infrastructure and inanimate objects mean that some marks are damaged or become unavailable for classic leveling measurements.

The first of the proposed methods is based on mono-photogrammetry, using the Direct Linear Transformation (DLT) method. The experimental measuring set, enabling the implementation of the height transfer proposed, includes: camera (CCD / CMOS), a typical leveling rod with box level and the designed signaling device. The signal device is mounted on the benchmark, and in close proximity, the leveling rod is set vertically on the positioning wedge. A single photo of signal and leveling rod was made, and next the image was transformed by the DLT method. The height difference between the benchmark and level rod footer was determined on this basis.

The second proposed method for transferring the height, designed by the authors uses a leveled laser beam emitted from the benchmark to the scale of the leveling rod. Photos taken by digital camera of the leveling rod scale with the laser spot image are digitally processed. Image processing allows you to specify the value of reading references on the scale. The experimental works make it possible to estimate the accuracy of the laser measurement and its range.

Laboratory experiments presented in this paper have shown the feasibility of references measurement of height with submillimetre accuracy. The presented measurement sets are characterized by small size and simple operation.

MONITORING OF GALLERY FOR DUAL USE IN TERMS OF PASKOV MINE

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ABSTRACT

High anchoring is the support system which supports long mine workings or large-scale mining and atypical works, when the steel arch support elements are embedded in solid layers in the overburden above the supported work. The purpose is to enhance the stability of the supporting reinforcement mine to suit the load resulting from the additives lead wall faces or another expected additional loadings and mine remained stable for the required period of his life. Whether high anchoring is functional, it is a subject of monitoring of gallery No. 063 5348 located in Paskov Mine, whose partial results are published in this paper.

THE INFLUENCE OF CHOSEN ENVIRONMENTAL CONDITIONS ON VERTICAL ANGLES MEASUREMENTS RESULTS USED TO DETERMINING THE DEFORMATIONS OF GROUND OBJECTS

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ABSTRACT

Deformation studies of field objects, depending mainly on the size of the object and required accuracy of changes, may be implemented by using different measurements methods. In case of small, difficult to reach objects the best method for determining displacements is trigonometric leveling. Accuracy and therefore the credibility of the height difference depends primarily on accurate determining of vertical angles. Observations of these angles are under the influence of many conditions describing environment of measurements, including weather and terrain conditions. To determine the effect of multiple, often dependent confounders, which affect on correctness of results, measurements are made at different times of year, different parts of day and different field conditions. To obtain a large amount of data it is possible to use data from a structural monitoring systems. Total stations used to research, implementing continuous measurements of distances, horizontal and vertical angles gives data, which make possible to examine dependence between measured vertical angles and defined confounders. It allow to designate observation corrections, by using statistical methods such as regression method.

GEOHAZARDS IN THE BUILT ENVIRONMENT – PS INTERFEROMETRY AS AN OBSERVATION TOOL. CASE STUDY: GDANSK AREA

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ABSTRACT

A geohazards term can be defined as any kind of human activities or natural phenomena that cause ground displacement and simultaneously has potential to cause harm. Geohazards are classified as earthquakes, landslides, groundwater abstraction and recharge, drilling work, underground construction etc. In order to estimate geohazard scale the terrain displacement should be determined. One of the most advanced method used to measure ground movements is Persistent Scatterer Interferometry (PSI). The basic principles of this methods was developed by Ferretti from Politechnico di Milano to overcome some drawbacks of standard DInSAR. PSI enables to find very small movements (mm) and to infer the deformation velocity and its variation over the time. In the PSI technique, two basic concepts are applied. The first idea concerns the use of many interferograms as possible to compensate atmospheric delay and temporal correlation. The second idea says that the analysis should be based on the pixel whose signal is stable over time. Stable man-made reflectors that might have independent displacements respect to the surrounding areas. The paper presents results of PSI method and focuses on the use of ERS-1/2 images acquired over the Gdansk town (Poland). The authors have chosen this area of interest due to seismic events in the Gulf of Gdansk in 1996–1997 and due to long term ground subsidence of Gdansk Old Town.

APPLICATION OF INTEGRATED MEASUREMENT TECHNOLOGY: GNSS, TOTAL STATION AND GEOID MODEL, TO BUILD THREE-DIMENSIONAL MODELS OF ROCK BLOCKS

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ABSTRACT

The article proposes an algorithm for the spatial adjustment of total station data, relative to known GNSS points and using the known components of the vertical deflection taken from the EGM2008 geoid model. Refraction influence is also considered. Experimental measurements (made in a quarry in Tlumaczow) show that using components of the vertical deflection provides geocentric coordinates of control points (measured by the total station) with an accuracy of about 1 cm, which is comparable to the measurement accuracy of GNSS receiver.

This method can be useful to obtain precise metric 3D models of terrestrial objects (e.g. rock blocks) in the WGS84 geocentric coordinate system, as well as to determine geocentric coordinates of control points used in constructing the photogrammetric three-dimensional model of rocks. Presented method can also be used to determine geocentric coordinates of tie points used to connect point clouds obtained from different positions of the terrestrial laser scanner.

APPLICATION OF SBAS PSEUDORANGE AND CARRIER PHASE SIGNALS IN PRECISE GNSS POSITIONING

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ABSTRACT

The main task of the SBAS systems such as EGNOS and WAAS is to provide integrity information together with the differential correction data in order to enhance the performance of positioning navigation services. What is more, these systems transmit also carrier phase and pseudorange observations, which can be applied in precise positioning together with observations from global satellite positioning systems.

This research evaluates the potential benefits of the combined processing of one of the global navigation satellite system (Galileo, GPS) together with the additional observations from SBAS systems. The tests were based both on simulated and real data. The first experiment presents results of precise Galileo+EGNOS positioning. Due to the insufficient number of Galileo satellites, the simulated data from the hardware GNSS signal simulator were used. Second experiment relies on the processing of real GPS+EGNOS/WAAS signals.

The results show that in specific conditions it is possible to obtain improvement in the accuracy and reliability of precise positioning when including observations from SBAS systems.

SIGNIFICANCE OF HIGH RESOLUTION DEM DATA FOR SAR INTERFEROMETRY IN LANDSLIDE ENVIRONMENT

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ABSTRACT

The presented research work is focused on the performance of time series SAR interferometry (InSAR) analysis for monitoring surface movement in mountain areas. The overall goal was to provide the improvements to SAR interferometry towards its robustness end efficiency in mountain environment, especially affected by landslides.

Interferometric SAR is an effective remote sensing technique for surface movement monitoring, and it has been recognized as the only technique that could provide area monitoring capability by now. The recent development in SAR interferometry called time series SAR interferometry technique, using phase information of the stable scatterers on the multi-temporal SAR acquisitions over the same area, have resulted in the successful derivation of land subsidence history in urban and some rural areas, however, rugged mountain area such as landslides and mass movements on the slopes are often difficult to monitor with InSAR technique due to layover, foreshortening and shadow. In addition, rugged topography causes a big challenge in compensate residual topographic phase.

In order to minimize the rugged topography contribution to interferometric phase the high resolution, detailed DEMs derived from Airborne Laser Data (ALS) have been tested against worldwide Shuttle Radar Topography Mission (SRTM) data commonly used in InSAR studies. 19 ERS-1/2 SAR scenes covering the area near Roznów lake in Southern Poland have been processed with StaMPS implementation of PSI technique.

The application of high resolution DEM data allow to detect higher number of persistent scatterers and therefore increase spatial density of obtained dataset. Detailed results of the analysis are given in the paper.

KINEMATIC MODEL OF MOVEMENT TENDENCIES
AT THE MORAVIA REGION

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ABSTRACT

Moravia territory has been the subject of geokinematic investigation within scope of several realized research projects and repeated GPS campaigns since 1992. The monitoring had been concentrated on all the Moravia region as well as on particular areas of interest concerning the eventual possible geodynamic changes (Králický Sněžník Massif, Diendorf–Čebín Tectonic Zone and others)

At present time all the territory is covered by several tenths of permanent and epoch GNSS stations. Long observation time series at permanent stations alone are not sufficient for delivering the regional velocity field of sufficient density. On the other hand, epoch stations are more densely spread but periods of repeated observations are less frequent and often the data processing is not homogeneous.

In the paper the preliminary kinematic model is briefly described which gives for the first time the general view of movement tendencies at the region of Moravia. On base of long-term monitoring it shows that the Southern Moravia region is more active then it was supposed.

M-SPLIT TRANSFORMATION FOR THE ANALYSIS OF THE STABILITY OF REFERENCE POINTS IN DEFORMATION MONITORING

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ABSTRACT

The analysis of the stability of reference points is related to the monitoring of building deformations and displacements surveys. The reference points should be placed in a locations ensuring stability of their relative positions. Unfortunately, despite much care in choosing the localization of the reference points, there are cases of reference points being displaced. So each time before making the measurement of control points it is necessary to check the stability of the reference system and to identify the reference points with outliers.

The authors propose to use the new method of M-split transformation to identify the stable reference points and the reference points with outliers. This method also allows to perform calculations and compare the results of several measurement campaigns simultaneously. The M-split transformation was tested on the example of Legnicko–Głogowski Copper District.

SLR TECHNIQUE USED TO DESCRIPTION OF THE EARTH ELASTICITY

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ABSTRACT

We present estimated values for the global elastic parameters (h_2, l_2) derived from the analysis of Satellite Laser Ranging (SLR) data. We analyse SLR data for LAGEOS 1 and LAGEOS 2 and for two low satellites, STARLETTE and STELLA, collected over a period of two and half years, from January 3 2005 to 1 July 2007, from 18 globally distributed ground stations. We carry out a sequential analysis for the all satellites, and study the stability of the estimates as a function of the length of the data set used. The adjusted final values (h_2, l_2) for all satellites are compared. A major discrepancy between the two solutions was only found for the Shida number l_2. Computations were performed using GEODYN II NASA/GSFC software.

TO RECENT GEODYNAMICS OF THE SUDETEN AREA

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ABSTRACT

Site velocities calculated from permanent GNSS and campaign GPS data monitored on sites of the Geodynamic network of the Academy of Sciences (GEONAS) and on four regional geodynamic networks (EAST and WEST SUDETEN, HIGHLANDS, WEST BOHEMIA) in 1997-2012 period were analyzed. In the first step the analyses concentrate to all available data to evaluate recent dynamic processes ongoing in the whole Bohemian Massif. After subtraction of values corresponding to motion of the Eurasian lithospheric plate, actual motion of the Bohemian Massif in this plate was determined. Regional and local changes of this motion were observed and discussed from a view of geological structures of the Massif and their influences on fundamental blocks of the Sudeten unit. Knowledge of an interactive motion hierarchy allows to detect credible balance conditions among blocks. Simultaneously, a recent neotectonic hierarchy and a type of faulting in the Sudeten unit has to be assessed.

HORIZONTAL STRAIN FIELD OF THE BOHEMIAN MASSIF

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ABSTRACT

Permanent GNSS and campaign GPS data monitored on several geodynamic networks located in the territory of the Bohemian Massif, Central Europe, allowed site movements to be determined. To constrain the first image of regional strain field for this territory a regional analysis of observed movements were carried out and then a 2D numerical modeling based on the theory of continuum mechanics under an assumption of homogeneity of the area were performed. Attention was paid to influences of regional geological discontinuities of the Massif to evaluate their mechanical decoupling along major fault zones in respect to the regional and local displacement and stress fields. Fundamental source of a mobility of the zone depends on existing northward movements of structural blocks of the Alpine orogenic system. Horizontal strain field of the Bohemian Massif displays significant E–W extensions in the eastern and western parts of the Massif and mild N–S compressions in its central part. The analyses of the strain field pattern will be discussed from the viewpoint of data processing and knowledge of geological structures.

MORPHOSTRUCTURAL ANALYSIS OF THE HŘIBOVSKÁ HORNATINA MTS. AND THE ADJACENT AREA

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ABSTRACT

Morphostructure analysis has been carried out in the Hřibovská hornatina (HH) Mts., a part of the Rychlebské hory Mts. Northeastern mountain front of the HH Mts. is controlled by the NW–SE striking Sudetic Marginal Fault, which is one of the most pronounced morphotectonic structure in central Europe with the length of 130 km. The analysis was focused on stream network parameters (based on DEM data) and detailed geomorphological mapping of spatial distribution of selected landforms which could potentially indicate recent tectonic activity in the studied area.

As a result, supposed courses of faults marked in morphology were suggested based on linear arrangement of selected landforms and morpholineaments. Fault activity assessment was considered based on changes in erosion intensity indicated in longitudinal profiles and valley cross-sections. Based on the values of Stream-Length (SL) index the areas suggesting recent tectonic activity were delimited: parallel faults (direction 80°) near Bílá Voda municipality, faults (direction 90°) between Vojtovický potok and Mlýnský potok Brook, arched faults (direction 0°) near Horní Hoštice village and the zone of Sudetic Marginal Fault (direction 140°–150°) between Bílá Voda and Horní Hoštice municipalities and between Horní Fořt and Bergov municipalities. It is possible to suggest Quaternary tectonic activity of the faults of Variscan direction (80°–100°) near Travná village inferred from the deepened gorges and terraced slopes. More detailed results of the analysis will be presented.

Recently, the research in the region has been focused on the adjacent area, on the valley of Biala Kłodzka River, which has consipicuously asymmetrical river basin probably due to Quaternary tectonic activity.

OPTIMAL DATA PROCESSING STRATEGY IN PRECISE GPS LEVELING NETWORKS

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ABSTRACT

GPS technique has become a major tool in contemporary surveying and geodesy. This concerns mostly measurements of horizontal point coordinates, where centimeter-level accuracies are usually required and easily achievable. For the height component, however, these requirements are higher and millimeter-level accuracy is necessary. On the other hand, the intrinsic precision of GPS-derived heights is clearly lower comparing to the horizontal components. This is due to unfavorable satellite geometry, adverse effects of the troposphere or GPS antenna phase center offset and variations. In order overcome these effects one has to carefully model all the error sources and rigorously process the GPS data.

This study presents analysis of the optimal GPS data processing strategy suitable for precise leveling. This was done through the extensive testing and selection of the most appropriate observational session duration, GPS signal linear combination, ambiguity resolution strategy, network geometry, troposphere modeling, antenna phase center calibration and geoid model. The analyzed processing strategies were tested on two leveling polygons, each ~70 km long. These polygons were additionally surveyed using classic, geometric precise leveling, which results served as a reference for the GPS leveling. The obtained results show that the precise GPS leveling with the selected optimal processing strategy may serve as fast and cost-effective replacement of classic geometric leveling.

PROBLEM OF INFLUENCE OF FIDUCIAL SITES' CONFIGURATION ON THE RELIABILITY OF THE NATIONAL REFERENCE FRAME REALIZATION

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ABSTRACT

The ASG-EUPOS (Active Geodetic Network European Position Determination System) is Polish multifunctional system of precise positioning consisting of more than 120 permanent GNSS (Global Navigation Satellite System) sites. Besides being a reference for differential surveying it plays a role of ETRS89 realization (EPN densification on the territory of Poland). Cumulative solution based on long-span observation constitutes a precise geodetic frame for geodetic and geodynamic measurements and has a great influence on position determination, so its accuracy and reliability is of crucial importance. As it was proved, the reliability of the reference frame increases with the growing number of stable fiducial stations and their geographical extent. The authors made several tests of fiducials' configuration (EPN sites belonging to the class A) impact on the final solution of ASG-EUPOS, which indicates different aligning of ASG-EUPOS to EPN. This presentation deals with the determination of ASG-EUPOS reference solution (coordinates and velocities of all sites), which were made according to EUREF Guidelines. The CATREF software was used to cumulate weekly SINEX files being GNNS solutions' results obtained with the Bernese software. Several approaches to the fiducial sites configuration has been tested in order to obtain the best aligning of Polish national frame to the EPN.

TOWARD TO DATA INTEGRATION AND ANALYSIS IN DETECTION OF TERRAIN SURFACE DEFORMATION ON THE EXAMPLE INOWROCŁAW SALT DOME

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ABSTRACT

Long-term geodetic observations of the terrain surface displacements show local trends in uplifts and subsidence as effects of mining and geological processes related to the salt structure of Inowrocław. Surveys have been carried out on a number of control points of the geodetic network, thus, observations provide detailed data, but limited to a short area. The application of InSAR data extending a spatial range of displacements depicted by levelling can provide a regional context of the process. The presented combination of levelling and InSAR (PSI) data in modelling of displacements can be a good option on the condition that the peculiarities of the methods are analyzed and considered.

EFFECTS OF FAULTS ON THE DISTRIBUTION OF STRESS IN OPEN PIT MINES

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ABSTRACT

Redistribution of stress and deformations in the rock mass surrounding large open pit mines may be significantly affected by the presence of geological faults in the area. By comparing deterministic model of rock mass deformation with the results of monitoring surveys the presence and location of the faults can be identified. This must be considered at the stage of designing monitoring surveys as shown on an example of a gold open pit mine in Nevada, USA.

DYNAMICAL AND REDUCED-DYNAMICAL ORBIT MODELS FOR DORIS SATELLITES AND THEIR IMPACT ON THE PRECISE POSITIONING

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ABSTRACT

The reduced-dynamical modeling is currently used by the routine solutions of GOP analysis center, which achieves similar accuracy as the other centers utilizing a precise non-conservative force modeling. The GOP works with a modified version of the Bernese GPS Software that has not included the non-conservative modeling, replaced by empirical and pseudo-stochastic orbit modeling. This limitation is now overcome by the new scientific modification of the software, which opens the unique possibility to compare both approaches by using the same software platform. The precise dynamical LEO orbit modeling includes the attitude models and the nominal satellite macro-models, with modeling of non-conservative acceleration, i.e., Sun radiation pressure, Earth radiation pressure and atmospheric drag. Both approaches are used at analysis centers providing DORIS solutions. The focus of the studies is the analysis of the comparison between these two different approaches for LEO satellite orbit estimation. The quality of the orbit in not represented only by the self orbit comparison, but also by the accuracy of the ground stations coordinates, derived from the free-network solutions. Since DORIS is one of the Spatial Geodesy techniques used for ITRF definition, the accuracy of the estimated station coordinates is a very important factor, evaluated by all the DORIS analyses centers.

LOCAL QUASIGEOID MODELLING USING GRAVITY DATA INVERSION TECHNIQUE – QUANTITATIVE ANALYSIS OF THE INPUT DATA

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ABSTRACT

The paper presents analysis relating to the method of local quasigeoid modelling based on the geophysical technique of gravity data inversion, using non-reduced surface gravity data and GNSS/levelling height anomalies. One of the main problems occurring in the application of the method is to determine the quantitative parameters of the input data. As the input data should be considered in addition to the aforementioned gravity data and GNSS/levelling height anomalies, the digital terrain model and the Moho depth model, defining the area of inversion. In the paper there were examined the impact of changes in size of the area of inversion, changes in size of the area covered by gravity data and density of gravity data, on the estimated quasigeoid model.

G-NUT SOFTWARE LIBRARY – STATE OF DEVELOPMENTS AND FIRST RESULTS

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ABSTRACT

Global Navigation Satellite System (GNSS) software library called G-Nut has been developed at the Geodetic Observatory Pecny (GOP) since 2011. At least the part of the library is expected to be provided as an open source, although it has not been released yet. The main purpose of the project is to create programming packages suitable for various applications such as station coordinates monitoring, zenith tropospheric delay estimation, satellite clock estimation and others. The library is written in C++ programming language following object-oriented concept. Basis class structure implementing inputs/outputs and product/data containers supports both real-time and post-processing modes. Incorporations of all global navigation satellite systems as well as new signals are also properly handled. The configuration is governed through XML format. The estimation model currently supports the least square adjustment, Kalman and square root covariance filtering methods based on processing undifferenced data and fixed precise orbit and clock products. The estimated state vector then includes receiver coordinates and clocks, troposphere zenith path delays and carrier phase ambiguities. Currently, only the ambiguity float solution is possible, but in near future the fixing of integer ambiguities will be supported too. The first applications based on G-Nut library will be shown with examples for off-line/online kinematic precise point positioning and ultra-fast troposphere estimation.

DETERMINATION OF QUASIGEOID IN LOCAL NETWORK USING MODERN ASTROGEODETIC TECHNOLOGIES

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ABSTRACT

This study shows the very first usage of Mobile Automated Astronomical System No. 1 in a local network with an area of approximately 50 km sq. The network has been built-up especially for experimental purposes to compare the local quasigeoid determined by three different methods, namely GNSS-levelling, gravimetry and using the newly presented MAAS-1 for the astronomical method. The network consists of 34 core points where the astronomic and geodetic coordinates have been measured. Subsequently the measured data has been processed to obtain vertical deflections and to determine the quasigeoid heights by astronomical levelling. Afterwards, the quasigeoid has been independently determined also using gravimetric measurements and by the method of GNSS-levelling. The resulting astronomical quasigeoid as well as the results of the comparison are being presented. The overall agreement of independently determined quasigeoids is on the level of 3 mm. After an overall accuracy evaluation of resulting quasigeoid model authors discuss the benefits of astronomical measurements using MAAS-1.

NEW SOLUTION OF ATMOSPHERIC AND OCEANIC EXCITATION OF NUTATION

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ABSTRACT

We use the most recent data of atmospheric and oceanic excitations to derive their impact on the quasi-periodic motion of the Earth spin axis in space – nutation. To compute the celestial pole offsets due to these geophysical excitations, we use a non-rigid Earth model and the corresponding transfer function to account for the realistic Earth's response. The results are compared with the celestial pole offsets observed by Very Long-baseline Interferometry.

APPLICABILITY ASSESSMENT OF IGGHZG AND IGGHZM NRT TROPOSPHERE MODELS TO FAST-STATIC GNSS POSITIONING

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ABSTRACT

The tropospheric refraction is considered as one of the most important error sources in precise GNSS applications. It is usually parameterized as tropospheric Zenith Total Delay (ZTD) and cannot be eliminated by using dual frequency signals, because the troposphere is not dispersive. In fast-static positioning, when short data spans are available, accurate ZTD is very difficult to model. Therefore, fast-static positioning requires external tropospheric information in order to improve its accuracy. This can be achieved by a network of reference GNSS stations, where ZTD can be obtained in near real-time (NRT) in the adjustment of GNSS data or directly from the ground meteorological data, and provided as an external supporting product. Therefore, in this work, we focus on the application of two ZTD modeling techniques to fast-static GNSS positioning: (1) IGGHZG (Institute of Geodesy and Geoinformatics one Hour ZTD GNSS) and (2) IGGHZM (Institute of Geodesy and Geoinformatics one Hour ZTD Meteo). Both models are derived in near real-time.

The IGGHZG model is based on GNSS data from Polish GBAS system (ASG-EUPOS) and IGS/EPN and IERS products. The IGGHZM model is based on meteorological data collected in real-time from ASG-EUPOS, METAR and SYNOP systems. In order to assess the accuracy of these two ZTD modeling techniques, four test baselines of several tens of kilometers were processed in fast-static mode using the GINPOS software developed at UWM in Olsztyn. A total of 144 sessions, each 5-minute long, were processed independently and the obtained coordinate residuals were analyzed. A special attention was paid to the height component accuracy. Five different approaches to the troposphere modeling were applied and tested in fast-static positioning: (1) using the official ZTD provided by the ASG-EUPOS system (also for the rover) – this was considered as a reference solution, (2) using the official ZTD provided by the ASG-EUPOS system, fixed for the reference stations and interpolated to the rover receiver, (3) using the IGGHZG model, (4) using the IGGHZM model, (5) using UNB3m troposphere model.

VERIFICATION OF LONG TERM STABILITY, ROBUSTNESS AND ACCURACY OF WEATHER OBSERVATIONS IN POLAND AND ADJACENT AREAS

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ABSTRACT

Modern GNSS CORS networks provide ionosphere and troposphere correction applied in precise positioning, in DD (Double Differenced) and PPP (Precise Point Positioning) mode. Currently the greatest challenge in real time estimation of point coordinates are unknown troposphere conditions, especially water vapour distribution. Integrated observations from number of different sensors and models will enhance understanding of troposphere processes.

Precise resolution of meteorological parameters (atmospheric pressure, temperature and relative humidity) is of a key importance for the future of water vapour modeling. Well known distribution of pressure and temperature are significant for Integrated Water Vapour (IWV) calculations and Slant Wet Delay (SWD), basic GNSS troposphere water vapour observations.

In this study ground based meteorological observation data are collected from five different networks: Euref Permanent Network (EPN), ASG-EUPOS stations, synoptic meteorological stations (SYNOP), airport meteorological stations (METAR) and civil network of meteorological stations (CWOP).

Moreover, collected data set is supported by Numerical Weather Prediction model outputs from COAMPS (Coupled Ocean/Atmosphere Mesoscale Prediction System). The outputs covers 4D field of temperature, pressure and mixing ration over Poland, delivered in $145 \times 169 \times 30$ node points every hour.

Main issues with such data set are its inhomogeneity, unknown accuracy and instability. This causes a necessity of spatial and temporal interpolation of parameters and subsequently finding appropriate methods of verification.

The paper presents feasibility studies, which were performed to create methodology of different data sources integration, that will result in introducing more accurate tropospheric parameters model as well as assessment of stability, robustness and accuracy of available stations.

JOINTS IN CRETACEOUS SANDSTONES OF THE GÓRY STOŁOWE MOUNTAINS: TECTONIC AND NON-TECTONIC

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ABSTRACT

In upper Cretaceous sandstones over the area of the Góry Stołowe Mts., at least 4 systems of fractures occur, which significantly influenced modern outcrop pattern of lithological formations, their hydrogeologic properties and landscape evolution of this mountain massif (Wojewoda et al., 2011).

Synsedimentary fractures originated as results of seismic shocks (**extensional fractures**) or sediment deformation above active tectonic zones (**shear zones**). Both genetic types relate to deformation in soft sediments. The latter is evidenced by fracture infill, which consists of wall-rock and/or over- and underlying deposits (cf. Wojewoda 1987, 2011; Wojewoda & Burliga 2003).
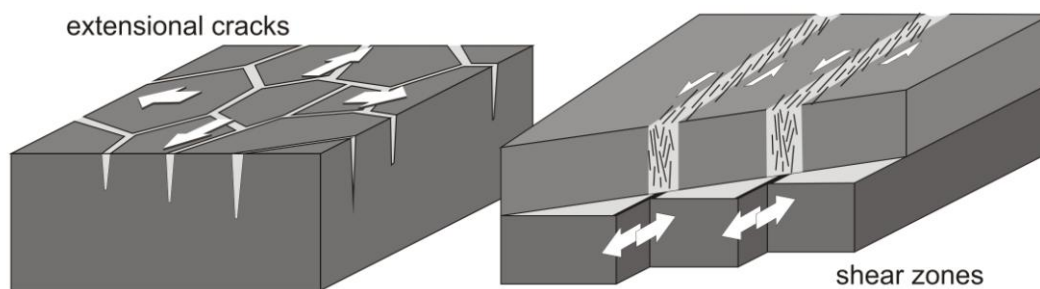
Joints depict penetrative, orthogonal system of variably spaced fractures which dissect sandstone lithosomes into smaller or bigger blocks. This joint system determined the lithostratigraphic term introduced for sandstones occurring in the Góry Stołowe Mts., which are referred as Jointed Sandstones Fm.. Various explanations have been proposed for the origin of the joint system, among others diagenetic processes, seismicity and epeirogenesis. The latter is consider as the most probable mechanism in geological settings analogous to the Góry Stołowe Mts. massif (cf. Jerzykiewicz 1967, 1968; Wojewoda et al, 2011).
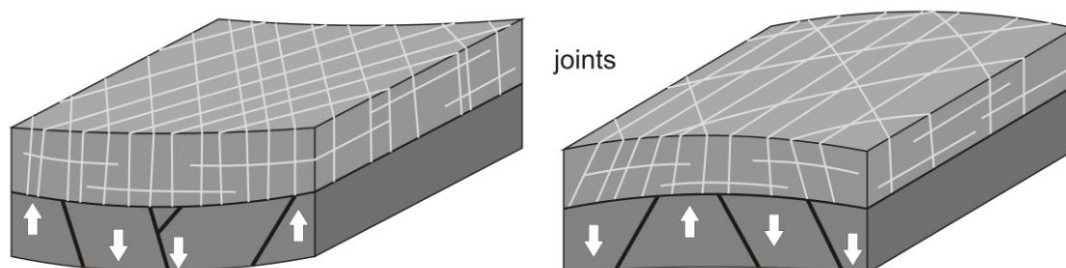
Fault induced fractures developed in response to tectonic movements either over the area of the entire massif or locally. This type of fractures is spatially related to the regional system of faults or folds. In the area of the Góry Stołowe Mts., the fault induced fractures distinctly are linked with the displacement along the a Czerwona Woda Creek Fault Zone (eastern prolongation of a regional-scale fault zone – the Poříčí–Hronov Fault Zone), which is implied by similar fracture pattern both in the Cretaceous sandstones and their basement (Cacoń et al., 2009).
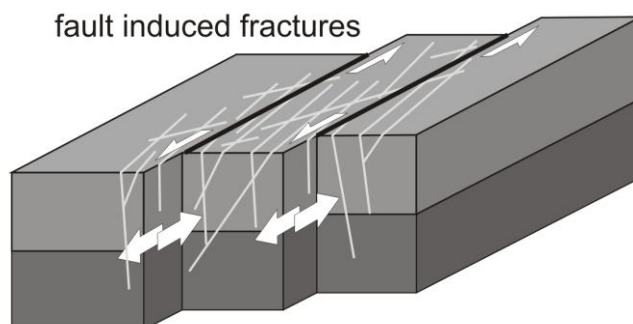
Epigenetic fractures are coming into existence locally, as a result of the decay of rock forms becoming apparent or coming into existence on denudation surface of the massif of the Góry Stołowe Mts. (cf. Ollier 1978; Jerzykiewicz 1967, 1968). Their spatial orientation is almost entirely determined by the shape of individual rock forms, and the time of their origin is enigmatic.
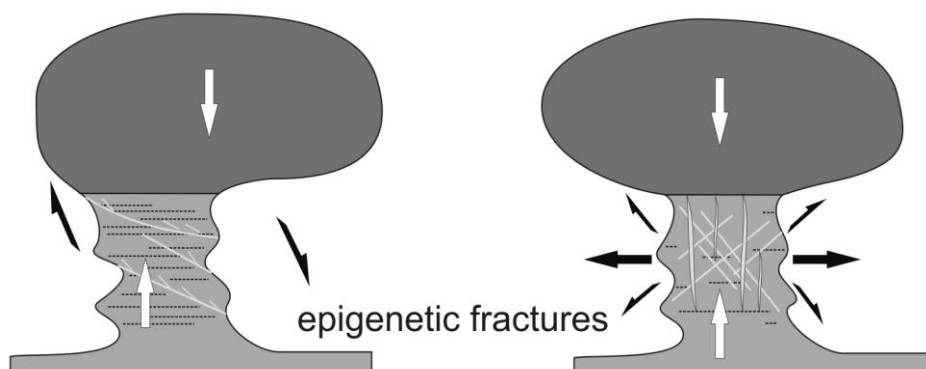
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RESULTS OF GPS PERMANENT MEASUREMENTS FROM GEODYNAMIC LABORATORY IN KSIĄŻ. PRELIMINARY COMPARISON BETWEEN TILTMETERS AND GPS DATA

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ABSTRACT

The following paper contains continuation of works presented in the contribution 'Permanent GPS station in Książ Geodynamic Laboratory for supporting investigation of neo-tectonic movements in Książ massif'. On GPS station KSIA almost two years long continuous observations were collected. Those observations are gradually processed in order to determine station velocity and episodic displacements caused by local rocks motions, on which the Książ Geodynamic Laboratory (LGK) was established. The GPS data analysis are performed in different scales using different strategies and methods for determination station movements relative to adjacent as well to regional geological structures. Parallel elaborations are near to completion and first analysis of the observations of the tilting instruments (water-tube tiltmeters and horizontal pendulums), covering the period till the end of June 2012 were performed. This paper presents some preliminary results obtained from different observing techniques, first comparisons of them as well as preliminary conclusions.

WYCIECZKA TERENOWA

W POSZUKIWANIU STAREJ ODRY

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WPROWADZENIE

Dzisiejsza Odra na obszarze aglomeracji miejskiej Wrocławia nie ma nic wspólnego z naturalną rzeką, która przez ten obszar przepływała zanim rozpoczęło tutaj osadnictwo, a z czasem powstała zwarta osada, która przekształciła się w miasto o zwartej zabudowie. Wszystkie rekonstrukcje dawnej architektury hydrologicznej, od paleolitu po dzień dzisiejszy, z konieczności opierają się na przesłankach geomorfologicznych i znaleziskach archeologicznych. Tylko z dużym przybliżeniem można odtworzyć plany hydrologiczne Wrocławia o dłuższej historii. Dynamika procesów osadniczych, a zwłaszcza rozbudowa miasta, zmiana arterii komunikacyjnych, budowa i przebudowa urządzeń fortyfikacyjnych i wreszcie naturalne wydarzenia, jak powodzie, czy trzęsienia ziemi sprawiały, że miasto cały czas się zmieniało, a razem z miastem zmieniała się rzeka…

WSPÓŁCZESNA ODRA

Odra wypływa z Gór Odrzańskich (Oderske Hory) w Czechach, które stanowią pasmo Gór Opawskich. Przyjmuje się, że źródła rzeki występują na wysokości od ok. 630 do 680 m n.p.m., na zboczach góry Vysoká. W górnym biegu, po opuszczeniu obszaru górskiego, rzeka kieruje się ku północy i przez Bramę Morawską wypływa na Przedgórze Sudeckie. W okolicach Koźla skręca ku północnemu zachodowi i utrzymuje ten kierunek aż do ujścia Nysy Łużyckiej, skąd kieruje się ponownie ku północy, bezpośrednio do Morza Bałtyckiego.

Odra jest drugą, co do wielkości, rzeką w Polsce i po Łabie (~1165 km, zlewnia Morza Północnego) – najdłuższą rzeką wypływającą z Sudetów (~854 km). Co ciekawe, obszary obydwu rzek są porównywalne (odpowiednio: 118861 km^2 i 144055 km^2). Różni je jednak zdecydowanie wysokość obszaru źródłowego – źródła Łaby oraz trzeciej co do wielkości rzeki sudeckiej – Morawy (~352 km, zlewnia Dunaju i Morza Czarnego), znajdują się na wysokości ok. 1380 m. Odrę wyróżnia również to, że jej zlewnia obejmuje niemal cały obszar Sudetów, zatem większość wody z opadów w tym regionie spływa w dół właśnie Odrą.

Na odcinku dolnośląskim, Odra płynie szerokim, miejscami nawet na ponad 20 km, obniżeniem – Pradoliną Odry. Trzykrotnie napotyka po drodze na wyniesienia terenu. Rozcina je jednocześnie zmieniając swój bieg. W miejscach tych (przełomach) dolina jest wąska i głęboka. Kiedy dochodzi do wezbrań dolinnych okoliczne miejscowości są zagrożone powodziami. Pierwszy przełom znajduje się w okolicach

Opola, gdzie koryto Odry rozcina wypiętrzany tektonicznie blok wapiennych skał kredy i triasu. Drugie rozcięcie, w okolicach Ścinawy, rozdziela pas moreny czołowej stadiału Odry na dwa pasma – Wzgórza Trzebnickie na wschodzie i Wzgórza Dalkowskie na zachodzie (200–250 m n.p.m.). Trzecie rozcięcie, na wschód od Nowej Soli, rozdziela Wzgórza Zielonogórskie od Pojezierza Leszczyńskiego, które stanowią relikty moreny czołowej i dennej stadiału Warty (**Fig. 1**).
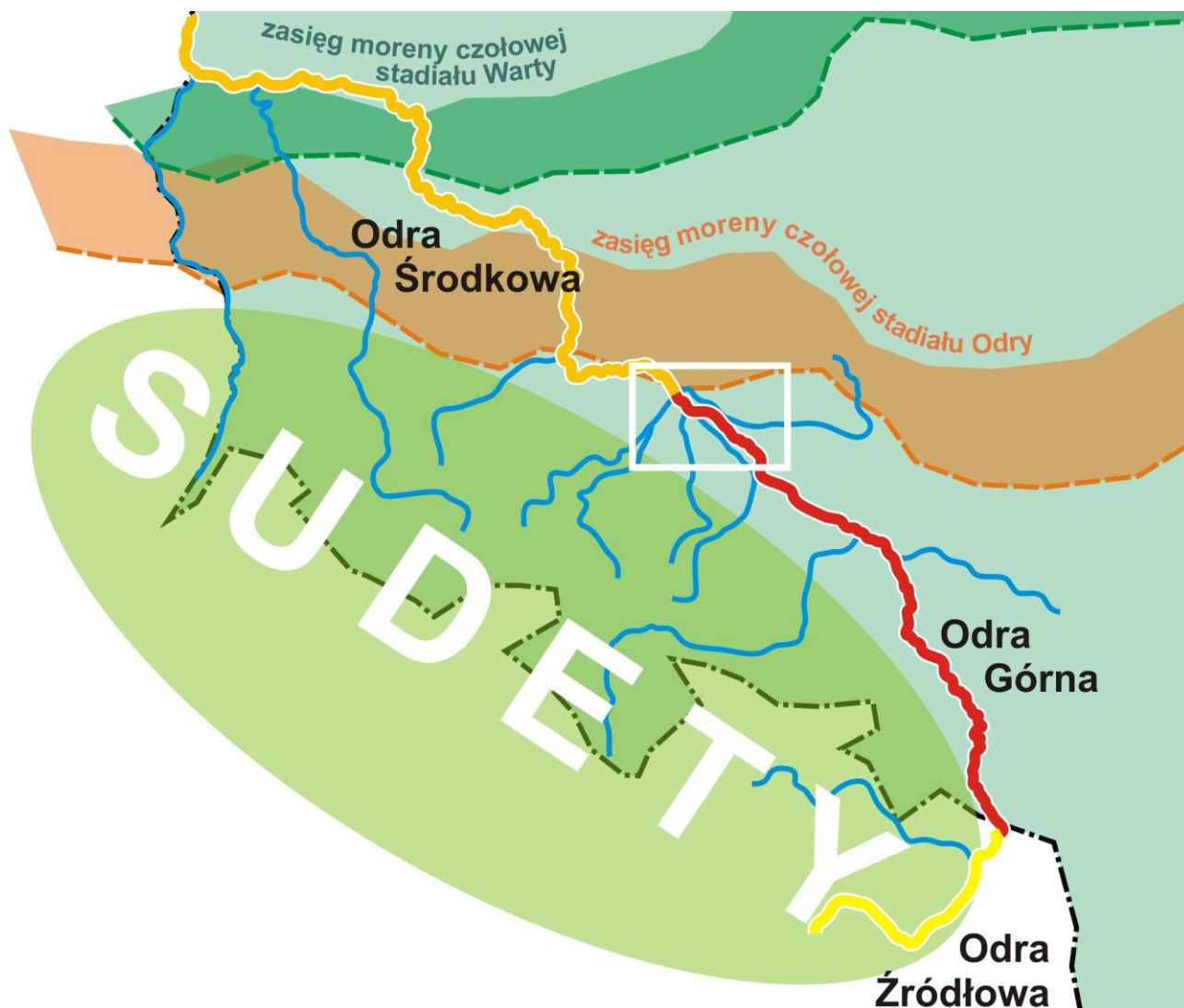

Fig. 1. Dolina Środkowej i Górnej Odry na tle najważniejszych jednostek geomorfologicznych regionu
(zaznaczone odcinki przełomowe oraz obszar omawiany w tym tekście)

PRA-ODRA, CZYLI JAK DOSZŁO DO POWSTAWAŁA DZISIEJSZEJ ODRY

PRA-Odra – tak geolodzy zajmujący się paleogeografią Sudetów nazywają rzekę, której historia jest nierozłącznie związana z powstaniem pasma górskiego Sudetów. W tym miejscu warto wyjaśnić, że „góry" w sensie geologicznym nie zawsze oznaczają to samo w znaczeniu geograficznym. I tak Sudety, lub inaczej – skały, z których Sudety są zbudowane, a które tworzą fragment struktury geologicznej dzisiejszej Europy, powstały w okresie między od ponad 500 do ok. 60 milionów lat temu, chociaż w przewadze powstały między ok. 320 a 180 milionów lat temu, czyli w trakcie
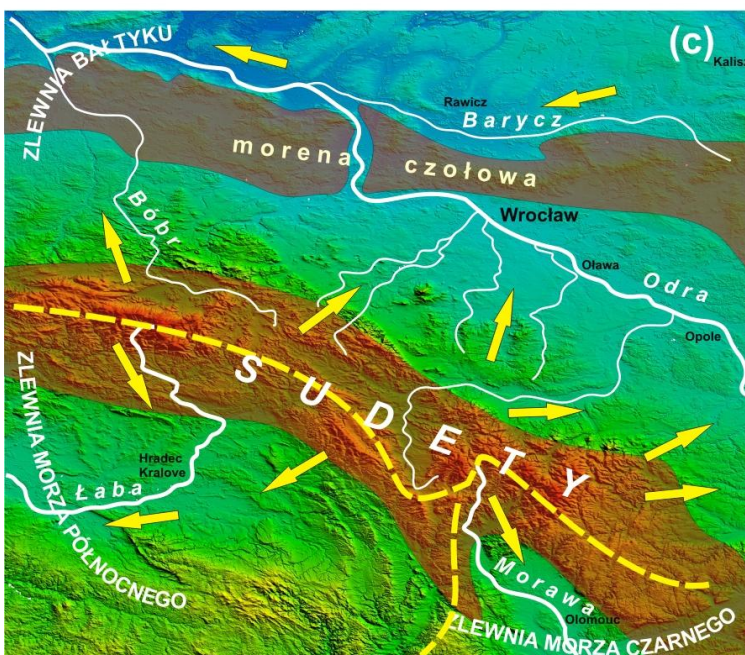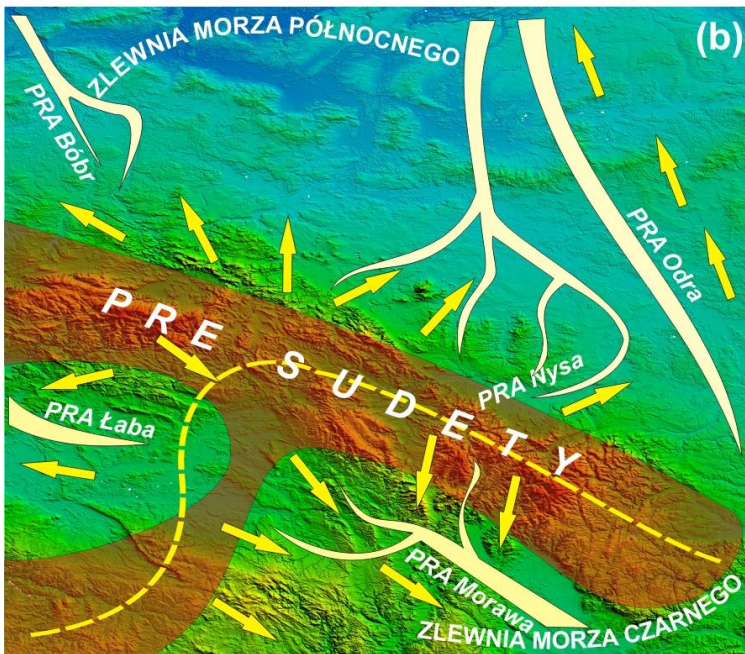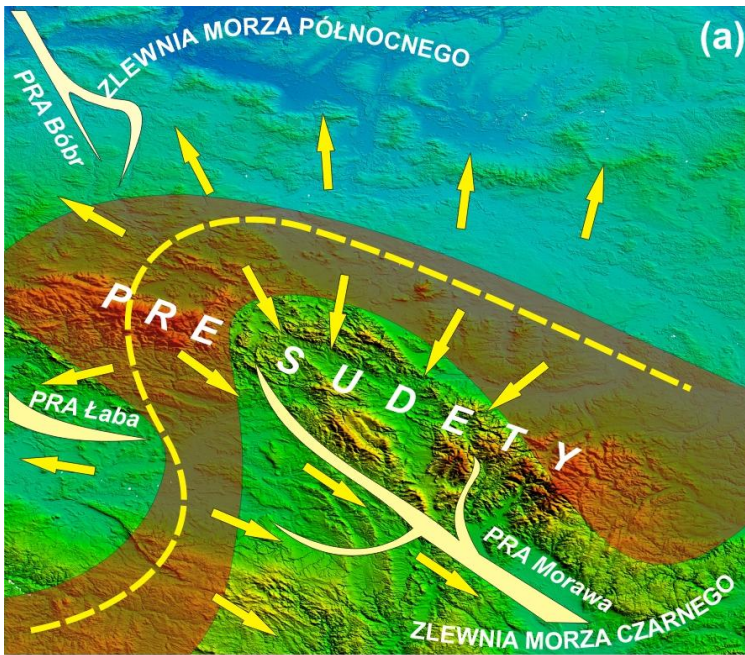
tzw. orogenezy waryscyjskiej oraz okresie, który nastąpił bezpośrednio po niej. Sudety w sensie geograficznym, to zespół pasm górskich i dolin o bardzo różnej genezie, które tworzą współczesny i bezpośrednio go poprzedzający krajobraz.

Dzisiejszy system dolin rzecznych Dolnego Śląska zaczął powstawać już ok. 20 mln lat temu, czyli znacznie wcześniej zanim na obszar ten dotarł Człowiek. Pierwsze udokumentowane ślady kulturowe udokumentowane zostały w południowej części dzisiejszego Wrocławia (stanowisko Hallera, Wiśniewski 2006) w utworach uważanych za osady przedwarciańskie (Wiśniewski i inni, 2011).

W późnym miocenie, ok. 8-5 mln lat temu, na południowym wschodzie Europy zaczęły się fałdować (i wypiętrzać) Karpaty. Przedtem, z obszaru dzisiejszej Skandynawii płynęły rzeki, z których część uchodziła do „morza przedkarpackiego" na południu dzisiejszej Polski. Obszar Sudetów w tym czasie stanowił lokalne wyniesienie, z kulminacją na obszarze dzisiejszego Przedgórza Sudeckiego, z którego pierwsze prarzeki rozpływały się promieniście we wszystkich kierunkach, w tym ku południowi i południowemu wschodowi (PRA-Morawa). Można z dużym prawdopodobieństwem przyjąć, że większość dolin rzecznych Sudetów ma założenia z tego właśnie okresu (**Fig. 2a**).

Fig. 2. Schemat rozwoju paleogeograficznego od późnego miocenu (a), poprzez preglacjał (b) po współczesność (c)

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W pliocenie, ok. 4–1 mln lat temu, obszar dzisiejszych Sudetów nadal stanowił elewację morfologiczną, z której wody (rzeki) rozpływały się zarówno ku północy, jak i na południe. tworząc rozległe równiny aluwialne dzisiejszej Fryzji na północy i delty Dunaju na południu. Pozostałością po tym okresie jest m.in. przełom Morawy przez Sudety Wschodnie i Karpaty oraz relikty osadów rzecznych na południu Sudetów (Boboszów). Jednak tuż przed dotarciem lądolodu skandynawskiego na obszar Sudetów (tzw. okres preglacjalny) doszło do radykalnej zmiany krajobrazu, tak zwanej **inwersji** – obszar dzisiejszego przedgórza sudeckiego obniżył się, natomiast wypiętrzyło się dzisiejsze pasmo Sudetów. Do dzisiaj najbardziej wyraźną granicę tych dwu jednostek geologicznych wyznacza linia – bieg sudeckiego uskoku brzeżnego. Tym samym pasmo Sudetów stało się nowym wododziałem między płynącymi ku południowi rzekami zlewni PRA-Morawy i rzekami płynącymi ku północy, które utworzyły nową zlewnię PRA-Odry. Część nowych rzek sudeckich wykorzystując dawne doliny zaczęła płynąć wręcz w przeciwnym kierunku (**Fig. 2b**).

W plejstocenie, postępujący z północy lądolód, dotarł aż do frontu wypiętrzających się Sudetów. Wody wypływające zarówno z topniejącego lądolodu, jaki i z obszaru dzisiejszych Sudetów, tworzących w tamtym czasie rozległą elewację na północnych krańcach masywu czeskiego, osadzały materiał na niemal całym obszarze Dolnego Śląska. Lądolód skandynawski w trakcie kolejnych postojów, uformował pasma moren, które po jego ustąpieniu utworzyły kolejne ciągi wzgórz morenowych.

Od okresu ostatnich zlodowaceń do współczesności (holocen), obszar Sudetów cały czas się wypiętrza tworząc wyraźny wododział dla wypływających stąd rzek. Część z nich spływa ku południowemu wschodowi (zlewnia Morawy, dalej Dunaju i Morza Czarnego), część jest dopływami Łaby, która należy do zlewni Morza Północnego. Jednak największą i najważniejszą rzeką wypływającą z Sudetów jest Odra wraz z dopływami (również wypływającymi z Sudetów) – Białą, Nysą Kłodzką, Bystrzycą, Strzegomką, Kaczawą, Bobrem, Kwisą i Nysą Łużycką (**Fig. 2c**).

Przed zlodowaceniami PRA-Odra mogła bez ograniczeń płynąć ku północy i północnemu zachodowi i rozsypywać swoje osady na dużym obszarze. W trakcie cofania się czoła lądolodu, na północ od Sudetów powstały równoleżnikowe pasma wzgórz morenowych. Tym samym PRA-Odra została „zamknięta" w nienaturalnych dla rzeki ramach, co zasadniczo wpłynęło na dalszy rozwój doliny Odry. Początkowo rzeka spływała ku zachodowi i próbowała zmieścić się między frontem Sudetów, a moreną stadiału Odry tworząc rozległą formę pradolinną – **Pradolinę Odry**. Jednak z czasem doszło do zasypania tak ograniczonego traktu osadami i przerywania (przełomy) kolejnych wałów morenowych. Współczesna Odra spływa do Bałtyku wykorzystując kolejne obniżenia między wysoczyznami morenowymi i odcinki przełomowe (**por. Fig. 1**).

Jednym z reliktów dawnego krajobrazu są dzisiejsze wyloty dolin rzek sudeckich na Przedgórze Sudeckie. Pomimo górskiego krajobrazu zachowały one charakterystyczne, meandrujące kształty typowe dla rzek nizinnych, które podkreślają dynamikę współczesnego wypiętrzania Sudetów wzdłuż powierzchni tektonicznej uskoku sudeckiego brzeżnego. Tempo wypiętrzania Sudetów jest obecnie szybsze, niż możliwości „dopasowania" się rzek do nowych warunków krajobrazowych. Kręte kształty dolin, odziedziczone po starszych okresach krajobrazowych sprawiają, że

górskie odcinki starych rzek sudeckich są znacznie dłuższe niż doliny młodych rzek, które współcześnie „rozcinają" krawędzie Sudetów. Sprawia to, że wody opadowe z dużym opóźnieniem wypływają z obszaru górskiego Sudetów, co znacznie wzmaga retencję w kotlinach śródgórskich. To właśnie kręty kształt dolin jest główną przyczyną zatopień w kotlinach i w konsekwencji katastrofalnych powodzi, o czym wielokrotnie przekonali się mieszkańcy Kotliny Kłodzkiej.

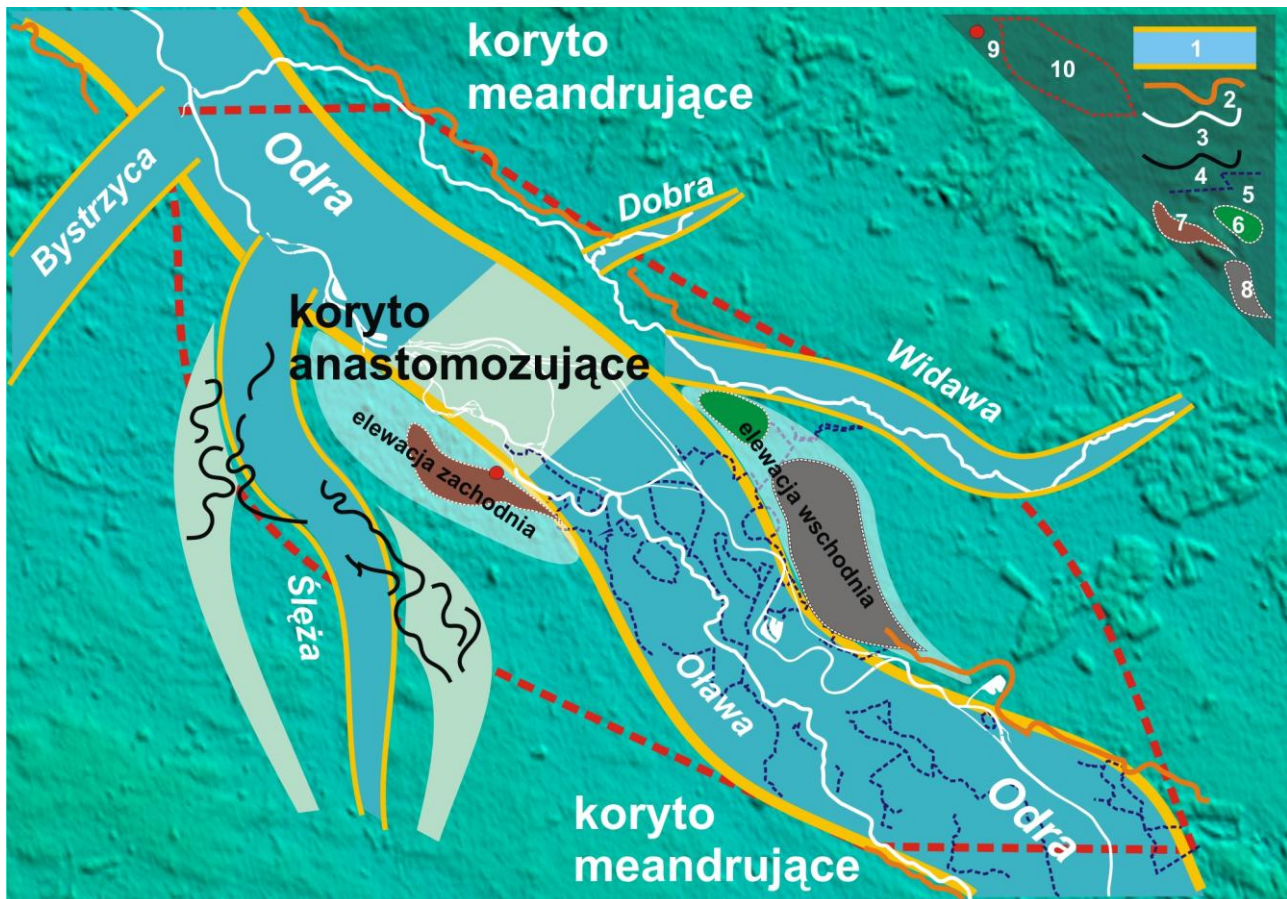## DOLINA ODRY NA ODCINKU OD OŁAWY DO BRZEGU DOLNEGO

Fig. 3. Schematyczne rozmieszczenie najważniejszych elementów dla interpretacji genezy wrocławskiego odcinka Doliny Odry.
Objaśnienia: 1 – doliny ważniejszych rzek wrocławskiego węzła wodnego, 2 – granice obszaru zalewowego współczesnej Odry, 3 – koryta aktywne rzek, 4 – koryta nieaktywne i pasy meandrowe Ślęży, 5 – wały, tamy i nasypy dolinnego systemu retencyjno-przeciwpowodziowego, 6 – płytko zalegające wychodnie przedwarciańskich iłów na elewacji wschodniej, 7 – erozyjna powierzchnia zrównania pokryta brukami korytowymi (elewacja zachodnia), 8 – stare osady roztokowe na powierzchni, z brukami korytowymi w spągu (elewacja wschodnia), 9 – stanowisko archeologiczne przy ul. Hallera (środkowy paleolit, elewacja zachodnia), 10 – szacunkowy zasięg wrocławskiej struktury rombowej

Rekonstrukcja naturalnych parametrów doliny Odry na odcinku między Oławą a Brzegiem Dolnym jest utrudniona, głównie przez wielowiekowe jej zagospodarowanie dla celów żeglugowych i funkcje retencyjne, jakie lokalnie stworzono w granicach doliny w celu zmniejszenia skutków wezbrań. Szczególne kłopoty sprawia obszar aglomeracji Wrocławia, gdzie praktycznie nie ma już żadnych pierwotnych

elementów doliny, a większość wód powierzchniowych płynie wykonanymi przez ludzi traktami o cechach kanałów (por. Rast i inni 2000, Badura 2006). Jednak opierając się na reliktach pierwotnych form dolinnych, głównie rozmieszczenia tzw. pasów meandrowych, oraz geometrii starorzeczy i form odsypowych, udało się w przybliżeniu zrekonstruować zasięg pierwotnej (czytaj: naturalnej) doliny Odry (**Fig. 3**).

Dolina Odry na omawianym odcinku ma kształt bardzo regularnego pasa o przeciętnej szerokości ok. 4,8 km, przeciętnej krętości ok. 1,06 i przeciętnym spadku ok. 0,4 m/km (1 m / ~2,4 km). Dolina ma największą szerokość w okolicach Siedlec-Jelcza (~5,6 km), a najwęższa jest w okolicach Urazu (~3,7 km). Odcinkowa analiza spadku doliny wskazuje, że odcinki zorientowane bardziej południkowo mają spadki mniejsze (1 m / 4–4,5 km), a te bardziej równoleżnikowe spadki większe (1 m / 2,1–2,5 km). Ponadto, na obszarze aglomeracji Wrocławia krzywa spadku osi doliny jest obniżona w stosunku do pozostałych obszarów o blisko 1 metr.

Na większości omawianego obszaru koryto Odry ma charakter meandrowy o krętości powyżej 1,7. Zupełny wyjątek stanowi śródmiejski odcinek doliny, mniej więcej od linii Czarnej Odry do ujścia Widawy. Na tym obszarze rzeka płynie (i płynęła) wieloma korytami tworząc liczne kępy i wyspy. Formy dolinne na tym odcinku wydają się wykazywać wielowiekową stabilność, na co wskazują liczne szkice i odwzorowania kartograficzne od XIII wieku po współczesność. Niewątpliwie taka architektura hydrologiczna sprzyjała osadnictwu, spełniając liczne wymogi komunikacyjne, obronne i gospodarcze dla lokacji miejskich (**Fig. 3**).

UWARUNKOWANIA GEODYNAMICZNE DOLINY ODRY

Opisana wyżej architektura Doliny Odry na odcinku śródmiejskim jest typowa dla rzek **anastomozujących**, czyli takich, które formują swoje doliny i koryta ponad obszarami o znaczącej subsydencji. Analizując rozmieszczenie innych form terenu, a w szczególności lokalizację i geometrię dolin głównych dopływów Odry – Oławy, Widawy i Ślęży, można wyznaczyć inne tereny na obszarze Wrocławia, które wykazują tendencję do obniżania.

Jednocześnie, na tym samym obszarze występują wyraźne **elewacje podłoża** o zachowanych, w przybliżeniu równowiekowych elementach dawnego krajobrazu. Jedna z takich elewacji występuje w południowej części Wrocławia. To na niej właśnie udokumentowane zostały ślady bytności Człowieka w środkowym paleolicie (stanowisko Hallera, Wiśniewski 2006). Elewacja w tym miejscu stanowi wyniesiony ponad 10 metrów powyżej dna dzisiejszej doliny Odry płaskowyż, o charakterze rozległej powierzchni zrównania erozyjnego (**pavement**) pokrytego brukami korytowymi dawnej rzeki (Pra-Odry?)(por. Wiśniewski i inni 2011). Drugą elewację tworzy pas wychodni utworów rzecznych o cechach osadów **rzeki roztokowej** (por. Badura 2009) również z brukami w spągu w okolicach Chrząstawy. Do tej samej elewacji należą się również występujące tuż pod powierzchnią utwory ilaste na Kowalach (ul. Ceglana), które obecnie przykryte są hałdą, ale jeszcze w latach 60-tych XX w. były eksploatowane w miejscowym wyrobisku.
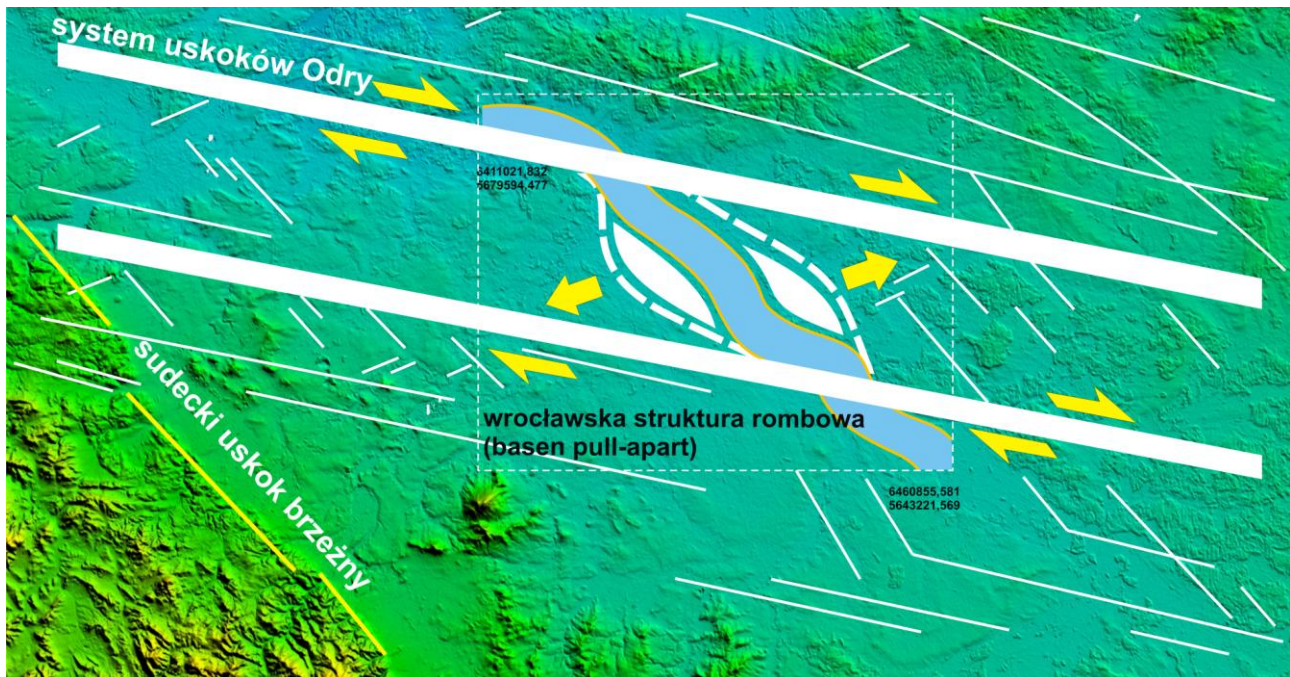
Fig. 4. Prawdopodobny schemat kinematyki i geneza wrocławskiej struktury rombowej (basen pull-apart?)

Odra, dopływy Odry oraz podłoże geologiczne aglomeracji Wrocławskiej tworzą charakterystyczną, rombową w zarysie strukturę o cechach przypominających tzw. baseny z odciągania (ang. pull-apart). Baseny takie cechują się silną subsydencją i powstają w systemie równoległych (w przybliżeniu) uskoków (stref uskokowych) o dominującej składowej przesuwczej. W przypadku „wrocławskiego basenu pull-apart wydaje się, że taką rolę odgrywają uskoki środkowej Odry – i te już rozpoznane (por. Cymerman 2004), i te jeszcze nieudokumentowane.

ODRA ŚRÓDMIEJSKA – TRASA WYCIECZKI (Fig. 5)

Obszar starego miasta to wielusetletnia historia osadnictwa i przebudowy zastanego planu hydrograficznego Odry. Do najstarszych reliktów dawnej Odry i jej kanałów należą stawy i sama ulica Bolesława Prusa (**Pkt. 1 i 2**). Tamtędy, aż do niemal polowy XVII wieku płynęła tzw. Odra Wincentego, która z czasem została zamieniona (jak wiele koryt i kanałów na terenie Wrocławia) w miejską arterię. Podobnym reliktem jest staw na terenie wrocławskiego Ogrodu Botanicznego. Jest to pozostałość po tzw. Odrze Szczytnickiej oraz kanałach, które łączyły to ramię Odry z Odrą Wincentego (**Pkt. 3**). Co ciekawe część tego dawnego koryta po połączeniu kanałem Odry stworzyło wyspę, na której wybudowane zostały najstarsze budowle Wrocławia, w tym między innymi wrocławska Katedra. Również i w tym przypadku dawny kanał zmienił się z czasem w ulicę (św. Józefa), a jego ślady są rozpoznawalne zarówno w wykopach budowlanych, jak i w obrazie płytkiej geofizyki (**Pkt. 4**). Dzisiejsze nabrzeża wyspy piaskowej i wyspy katedralnej to najstarszy relikt pierwotnego koryta Odry z początków lokacji (**Pkt. 5**). Oczywiście i w tym miejscu linia dawnego brzegu Odry została silnie zmieniona, ale z grubsza zachowała swój pierwotny przebieg. Jednym z ważniejszy obszarów w życiu dawnego i dzisiejszego Wrocławia było dawne nabrzeże handlowe, które obecnie znajduje się w sąsiedztwie nadal spełniającej swoje funkcje Hali Targowej (**Pkt. 6**). Dokumentacja histo-

ryczna pokazuje sceny z nieodległej przeszłości (pocz. XX w.) kiedy przy nabrzeżu tym cumowały liczne statki transportowe i pasażerskie, a Odra była najważniejszym traktem handlowym regionu. Idąc dalej tym nabrzeżem w kierunku wschodnim docieramy do małej zatoczki – zachowanego fragmentu zewnętrznej fosy obronnej Wrocławia, okalającej miasto od południa i południowego wschodu (**Pkt. 7**). Zdecydowana większość tego systemu wpisuje się w krajobraz dzisiejszego miasta, chociaż liczne odcinki, głównie zasilające fosę, zostały z czasem zasypane. Właśnie na takim zasypanym fragmencie dawnej fosy jest częściowo posadowione muzeum upamiętniające Powstanie Kościuszkowskie – Panorama Racławicka (**pkt. 8**).

Fig. 5. Trasa spaceru „W poszukiwaniu śladów dawnej Odry"
(objaśnienia punktów w ostatnim akapicie tekstu)

CYTOWANIA

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