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GEODYNAMIC LABORATORY SRC PAS IN KSIĄŻ – STATE OF 2013

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Abstract: The paper provides information on the history of the creation and activities of the Geodynamic Laboratory in Książ (Central Sudetes, SW Poland). A unique laboratory environment, instrumental facilities and research program were presented. Particular attention was paid to the study of geodynamic signals of non-tidal nature, relating to the local geological and tectonic situation. Tectonic research is examined in terms of both cognitive (identification of causes of the occurrence and scale of the problem), as well as utilitarian aspect designed to assess the impact of recorded effects on the earth's surface and architectural objects

Keywords: geodynamic research, Książ, water-tube tiltmeter, geodesy, Świebodzice Depression

1. INTRODUCTION

Many research centers around the world are studying geodynamic phenomena in cognitive, instrumental and utilitarian respect. Particularly noteworthy is Geodynamic Laboratory (GL) in Książ belonging to the Space Research Centre of the Polish Academy of Sciences (SRC PAS). It is the only one in Poland and one of the few in this part of Europe (Central Sudetes, SW Poland) research establishment located in the underground corridors of the II World War (Kaczorowski, 2010; ECGS, 2014). A rich and constantly supplemented modern set of instruments and measurement techniques allows seeing geodynamic phenomena, both in terms of local and global impacts.

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2. GEODYNAMIC LABORATORY IN KSIĄŻ

2.1 LOCATION AND HISTORICAL BACKGROUND

Geodynamic Laboratory in Książ uses underground tunnels located at a depth of about 50 meters below the courtyard of Książ Castle. They are the residue of a secret Nazi military facility from the end of World War II with the same name (in German: Fürstenstein) that is one of the objects of "Riese" complex. So far, in addition to Książ, six underground tunnels systems located in the Sowie Range were discovered (Dudziak, 1996; Aniszewski and Zagórski, 2006).

Workings in Książ have approximately the shape of a regular grid, with a total galleries length of approximately 950 meters. Of the 4 existing tunnels only one of them is currently used and is the entrance to the laboratory.

In the early 70s of the last century prof. Roman Teisseyre founded in underground tunnels a Geophysical Observatory belonging to the Institute of Geophysics of PAS. Initial work included seismic research, which since the mid-70s was extended to the tidal study conducted by prof. Tadeusz Chojnicki using quartz horizontal pendulums (HP).

In the early years of the XXI century in Książ was founded the Geodynamic Laboratory of the Space Research Centre of PAS. In the underground appeared new measuring instruments – water-tube tiltmeters (WT), relative and absolute gravimeters and interference extensometer (Kaczorowski, 2010).

2.2. GEOLOGY OF THE REGION

Książ Castle is located in the central part of the geological-structural unit of Świebodzice Depression (Grocholski, 1969). It is parallelogram-shaped and extends to the NW-SE (Oberc, 1978; Żelaźniewicz and Aleksandrowski, 2008). Deposits filling the Variscan mountainous sedimentary basin come from between the Upper Devonian to Lower Carboniferous (Oberc, 1972). You can distinguish among them the Książ Formation, Chwaliszów Formation, Pełcznica Formation, Pogorzała Formation, as well as volcanic and metamorphic rocks of Kaczawa complex (Teisseyre, 1951; Teisseyre and Gawroński, 1965; Porębski, 1981, Marcinowski et al., 2004).

Świebodzice Depression is characterized by a dense network of dislocation zones, which also define the boundaries of adjacent units (Fig. 1). The most important of them is a Sudetic Marginal Fault (Stepancikova et al., 2010) separating the Świebodzice sedimentary basin from pre-Sudetic fault block (Teisseyre and Sawicki, 1955; Haydukiewicz et al., 1962; Teisseyre and Gawroński, 1965; Teisseyre, 1969; Walczak-Augustyniak, 1988).

Bedrock, inside of which is located Geodynamic Laboratory, is also cut by numerous lines of discontinuities and cracks. This situation is extremely important due to the nature of the conducted tectonic phenomena research, since moving along the

faults blocks of rocks fall in direct interaction with the measuring apparatus (Kaczorowski and Wojewoda, 2011).

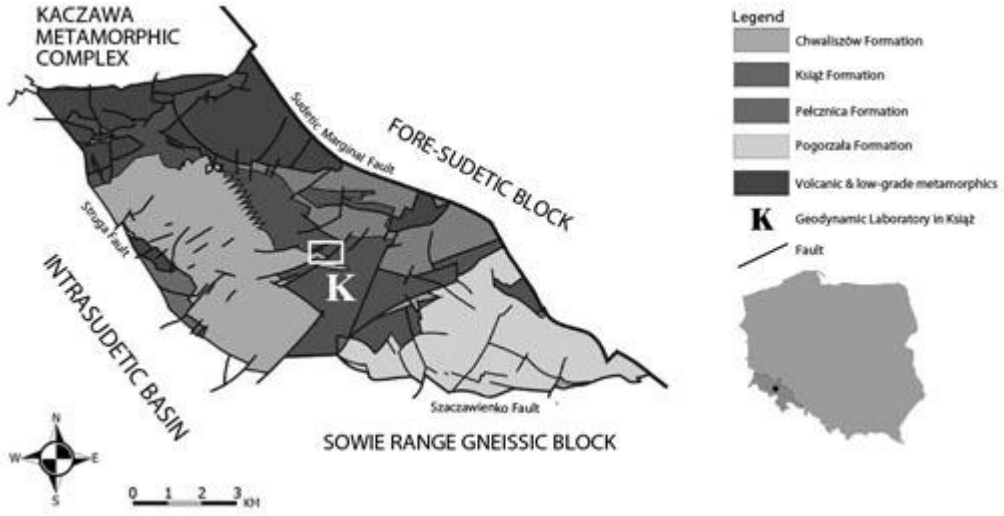

Fig. 1. Geological map of Świebodzice Depression (Kaczorowski and Wojewoda, 2011, modified)
Rys. 1. Mapa geologiczna depresji Świebodzic (Kaczorowski and Wojewoda, 2011, zmodyfikowane).

2.3. NATURAL CONDITIONS OF LABORATORY

Underground galleries system of laboratory was bored by mining methods (Aniszewski and Zagórski, 2006) hence their cross-sectional shape is characteristic of the excavations in underground mines. In some tunnels was made hard casing, the remaining fragments are unsecured.

From the point of view of the conducted research an important feature of the GL is its microclimate. In the underground there is approximately constant temperature. Annual change in the level of tenths and daily of hundredths of a Celsius degree are observed. Relative humidity varies seasonally between 85 to 95%. Continuous monitoring of temperature, humidity and pressure (air movement) is necessary because of their impact on the instruments operating there (Kaczorowski, 2010).

The water is present in the rock mass surrounding the Laboratory only by soaking through the surface. The absolute gravity measurements made in the laboratory fully confirmed the lack of water in the rock mass and changes of its level (Kaczorowski and Olszak, 2010).

3. RESEARCH TASKS

3.1. GEOPHYSICAL OBSERVATORY OF THE INSTITUTE OF GEOPHYSICS OF PAS

The underground of observatory and laboratory in Książ are used by two institutes of the Polish Academy of Sciences: Seismological Observatory (SO) of the Institute of Geophysics (IG) and Geodynamic Laboratory of the Space Research Centre.

The first instruments installed right after establishing SO were seismographs, which were intended to, among others, monitor the tremors caused by mining activities in the Legnica-Głogów Copper Region. Today, the main task of the SO is the observation of earthquakes (Eduscience, 2014).

3.2. GEODYNAMIC LABORATORY OF SRC PAS

Since the mid-70s the research activity in Książ was extended by prof. Tadeusz Chojnicki to tidal studies conducted using quartz horizontal pendulums. The work focused on continuous observation of tidal signals and their analyses. The tidal research included the determination of tidal ephemeris, study of interactions between ocean tides and the tides of earth, study of tidal signals seasonal variation and the load effect (Kaczorowski, 2010).

At the beginning of the XXI century in Książ was founded a Geodynamic Laboratory of Space Research Centre. In the underground appeared new measuring instruments – water-tube tiltmeter, relative and absolute gravimeters and interference extensometer. The development of measurement techniques has widened the research to non-tidal phenomena. These include the natural vibration of the Earth, subsonic signals, the phenomena produced by the contemporary tectonic activity. In the laboratory are monitored the tectonic effects i.e. vertical and horizontal movements and the slope of the rock mass and more recently the radon-effects related to tectonic activity in the region. A new instrument for the measurement of tectonic phenomena in the Laboratory is a TM-71 deformeter.

The development of laboratory included modernization of technical infrastructure of Laboratory (communication system and power supply) that allowed for the enrichment of instrumental facilities of laboratory with a new equipment. In the corridors of the laboratory were installed two water-tube tiltmeter pipes with lengths of 67 and 92 meters. The water-tube tiltmetrs began full measurements at the end of 2002. A new type of instruments has enabled further observations of systematic and long-term slope effects and vertical movements of the tectonic soil, the phenomena of free oscillations of the Earth, the infrasound effects (10^{-3} Hz), as well as conducting comparative studies between horizontal pendulums and water-tube tiltmeters (Kaczorowski, 1999a, 199b, 2005, 2006a, 2006b, 2010; Kaczorowski and Olszak, 2010). In 2006 was built a gravimetric pavilion equipped with columns for the relative and absolute gravity measurements (Fig. 2). In 2007 was installed a second pair of horizontal pendu-

lums, while also changed the way of observations recording from a photographic to an electronic (Kaczorowski, 2010).

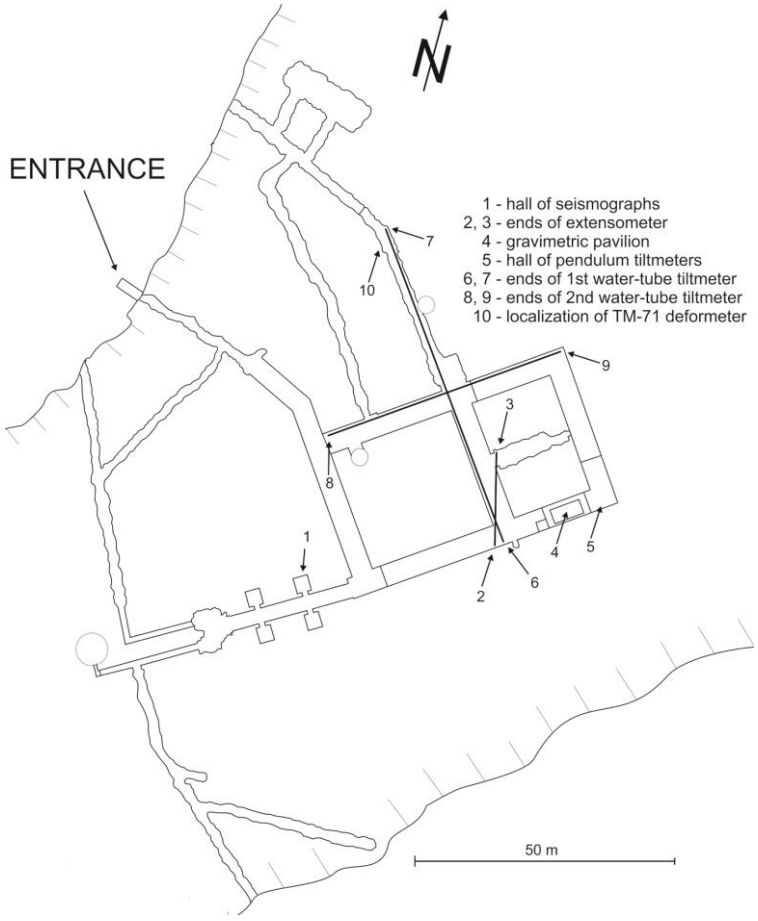

Fig. 2. Map of Książ Castle underground complex
Rys. 2. Mapa podziemnego kompleksu zamku Książ

3.3. New research directions of GL

A constantly developed set of new, innovative instruments and measurement techniques favor starting up new research directions. The current program, which was based mainly on observations of tidal signals, has been extended to the study the non-tidal signals.

Taking this theme was driven by recording non-tidal events by highly sensitive instruments – water-tube tiltmeters. These events took the form of irregular water level changes at the ends of both water-tube tiltmeters. Since launching the WT have recorded several effects of varying amplitude (exceeding 100 mas) and duration (from several to several dozen days). Conducting comparative analysis with data of horizontal pendulums confirmed the occurrence of this phenomenon (in the corresponding periods HP showed instability in equilibrium positions). Recording strong non-tidal effects by two instruments of various types, and the compensating effect observed by WT (precluding the effects of gravity), indicates a tectonic cause of an irregularly appearing phenomenon. Previous studies indicate a need to seek answers about the origin of these signals, correlation with other geodynamic phenomena, such as tectonic strike-slip movements, radon flux changes and the impact on the morphology of the terrain and on engineering facilities (Chojnicki and Blum, 1996; Kaczorowski, 2007, 2008, 2009a, 2009b; Kaczorowski and Wojewoda, 2011; Kasza, 2013).

Observations of non-tidal signals using HP and WT are held in the aspect of the ground slopes and vertical movements of rock blocks, on which the instruments are installed (Kaczorowski, 2010). These observations will be replenished by observations of the horizontal component of displacement performed on the identified areas of dislocation (Kaczorowski and Wojewoda, 2011; Kasza, 2013) using geodetic measurement techniques and deformeters. Therefore was performed a stabilization of the horizontal surveying reference points adapted to measure using Total Station in the GL underground galleries. Also a project of the measuring polygon in the area of Pełcznica river valley is already prepared. Particularly important will be the first results from the deformeter (model TM-71, made in Czech Republic) installed on the arms of fault, which surface intersects one of the WT tubes. Deformeter will provide information on the size of the horizontal movements at the time of detection of tectonic events by tiltmeters and effect compensation phase (Kasza, 2013).

An important element of the Laboratory work is interference extensometer launched in 2010. Its base of length about 30 meters allows monitoring earth's crust deformation with a relative resolution of 10-9 meter. Obtained information about changes of tension states and directions of the forces are support for WT in terms of the Earth's natural vibrations, and the long-term and systematic changes of the vertical line (Kaczorowski, 2010).

GL instruments are complemented by two permanent GPS stations installed on the IG building in Książ (2010) and on the main building of Stallions Herd in Książ (2013). GPS stations are located at a distance of approximately 300 meters on the opposite sides of the main southern fault stretching the Pełcznica river valley. The stations deployment will allow determining the movement of arms of the main fault. The resulting time-series sequences of stations own movement will be used for testing non-tidal signals of ground slopes and vertical movements observed by tiltmeters (Kaczorowski, 2010).

4. CONCLUSIONS

Location of Geodynamic Laboratory in the underground of the Książ Castle provides a unique opportunity to conduct subtle geodynamic research on local phenomena (related to the geological and tectonic structure of GL environment) and large-scale - global phenomena. Modern, constantly evolving test equipment and advanced data analysis methods allow for the development of work on the origins of recorded signals.

Conducting research on non-tidal signals determines the works associated with the extension of appliance facilities and perfection of measurement techniques. Research dimension has been expanded by the utilitarian aspect in the form of verification of the potential impact of recorded signals on the historic architecture of the Książ Castle. In the future, will be attempted to assess how the developed methodology will allow studying the tectonic effects and their impact in the areas covered by significant ground movement caused even by mining activities or related to downforce site changes caused by engineering structures such as dams.

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REFERENCES

ANISZEWSKI M. and ZAGÓRSKI P., 2006. *Podziemny świat Gór Sowich - wydanie II rozszerzone*, Wydawnictwo TECHNOL, Kraków.

CHOJNICKI T., BLUM P. A., 1996. *Analysis of ground movements at the Ksiaz observatory in 1974-1993*, Artificial Satellites, vol. 31, no. 3, pp. 123-129.

DUDZIAK M., 1996. *Tajemnica Gór Sowich – przewodnik*, Wydawnictwo JMK, Konin.

GROCHOLSKI W., 1969. *Przewodnik geologiczny po Sudetach*, Wydawnictwa Geologiczne, Warszawa.

HAYDUKIEWICZ A., OLSZEWSKI S., PORĘBSKI S. J. and TEISSEYRE A., 1982, *Arkusz Wałbrzych – Szczegółowa Mapa Geologiczna Sudetów, 1:25 000*, Państwowy Instytut Geologiczny, Warszawa.

KACZOROWSKI M., 1999a. *The long water-tube clinometer in Książ Geophysical Station. Promotion of the works*, Artificial Satellites, vol. 34, no. 3, pp. 171-191.

KACZOROWSKI M., 1999b. *The results of preliminary tilt measurements by use of the long water-tube clinometr in Książ Geophysical Station*, Artificial Satellites, vol. 34, no. 3, pp. 193-201.

KACZOROWSKI M., 2005. *Discussion on the results of analyses of yearly observations (2003) of plumb line variations from horizontal pendulums and long water-tube tiltmeters*, Acta Geodynamica et Geomaterialia, vol. 2, no. 3 (139), pp. 1-7.

KACZOROWSKI M., 2006a. *Earth free oscillations observed in plumb line variations from the 26 December 2004 Earthquake*, Acta Geodynamica et Geomaterialia, vol. 3, no. 3 (143), pp. 79-84.

KACZOROWSKI M., 2006b. *High-resolution Wide-Range Tiltmeter: Observations of Earth Free Oscillations Excited by the 26 December 2004 Sumatra – Andaman Earthquake*, Monograph: Earthquake

Source Asymmetry, Structural Media and Rotation Effects. pp. 493–520, Springer-Verlag, Berlin Heidelberg.

KACZOROWSKI M., 2007. *Preliminary results of investigations of long lasting non-tidal signals observed by horizontal pendulums and long water tube tiltmeters in Low Silesian Geodynamic Laboratory of PAS in Ksiaz*, Acta Geodynamica et Geomaterialia, vol. 4, no. 4 (148), pp. 109-119.

KACZOROWSKI M., 2008. *Non-tidal plumb line variations observed with help of the long water-tube and horizontal pendulums tiltmeters in Geodynamic Laboratory of PAS in Ksiaz*, Reports On Geodesy, No. 2 (85) pp. 79-86.

KACZOROWSKI M., 2009a. *Discussion on strong non-tidal signals registered by horizontal pendulums and water tube tiltmeters in Geodynamic Laboratory of PAS in Ksiaz*, Acta Geodynamica et Geomaterialia, vol. 6, no. 3 (155), pp. 369-381.

KACZOROWSKI M., 2009b. *Non-tidal signals of plumb line variations observed with help of the long water-tube tiltmeter, in Geodynamic Laboratory of PAS in Ksiaz*, Bulletin d'Information des Marées Terrestres (BIM) no 144, pp. 11605-11613, 16th International Symposium on Earth Tides, 1st-5th of September 2008, Jena, Germany.

KACZOROWSKI M., 2010. *Laboratorium Geodynamiczne w Książu. Instrumentarium, program badawczy, wybrane rezultaty badań (Stan z 2010 roku)*, Centrum Badań Kosmicznych Polskiej Akademii Nauk, Warszawa, raport niepublikowany.

KACZOROWSKI M. and OLSZAK T., 2010. *Pomiary absolutne siły ciężkości jako uzupełnienie programu badawczego Laboratorium Geodynamicznego w Książu*. Monografia: Jednolity system grawimetrycznego odniesienia polskich stacji permanentnych GNSS i poligonów geodynamicznych, Politechnika Warszawska, Wydział Geodezji i Kartografii, pp.101-126.

KACZOROWSKI M. and WOJEWODA J., 2011. *Neotectonic activity interpreted from a long water-tube tiltmeter record at the SRC Geodynamic Laboratory in Ksiaz, Central Sudetes, SW Poland*, Acta Geodyn. Geomater., Vol. 8, No. 3 (163), pp. 249–261.

KASZA D., 2013. *Koncepcja rozwoju sieci badawczej na potrzeby pomiarów współczesnych ruchów tektonicznych w obszarze Książańskiego Parku Krajobrazowego*, Mining Science, vol. 20, pp. 19−25.

MARCINOWSKI R., PIOTROWSKI J., PIOTROWSKA K., 2004. *Słownik jednostek litostratygraficznych Polski*, Państwowy Instytut Geologiczny.

OBERC J., 1972. *Tektonika. Sudety i obszary przylegle*, Wydawnictwo Geologiczne, Warszawa.

OBERC, J., 1978. *The Pre-Assyntian and Assyntian (Baikalian) Elements in South-Western Poland*. In: KSIĄŻKIEWICZ, M., OBERC, J. and POŻARYSKI, W. [Eds.] – *Geology of Poland*, Wydawnictwa Geologiczne, Warszawa, pp. 99–173.

PORĘBSKI A. J., 1981. *Sedymentacja utworów górnego dewonu i dolnego karbonu depresji Świebodzic (Sudety Zachodnie)*, Geol. Sudetica, vol. XVI, nr 1, pp. 102- 185.

STEPANCIKOVA P., HOK J., NYVLT D., DOHNAL J., SYKOROVA I., STEMBERK J., 2010. *Active tectonics research using trenching technique on the south-eastern section of the Sudetic Marginal Fault (NE Bohemian Massif, central Europe)*, Tectonophysics Vol. 485, pp. 269-282.

TEISSEYRE H., 1951. *Budowa geologiczna depresji Świebodzic*, Annales Societatis Geologorum Poloniae, Vol. 21, 4, PP. 380-386.

TEISSEYRE H., 1969. *Arkusz Stare Bogaczowice – Szczegółowa Mapa Geologiczna Sudetów, 1:25* 000, Państwowy Instytut Geologiczny, Warszawa.

TEISSEYRE H. and GAWROŃSKI O., 1965. *Szczegółowa mapa geologiczna Sudetów w skali 1:25000, arkusz Świebodzice*, Państwowy Instytut Geologiczny, Warszawa.

TEISSEYRE H. and SAWICKI L., 1955. *Arkusz Zagórze Śląskie – Szczegółowa Mapa Geologiczna Sudetów, 1:25 000*, Państwowy Instytut Geologiczny, Warszawa.

WALCZAK-AUGUSTYNIAK M., 1988. *Arkusz Świdnica – Szczegółowa Mapa Geologiczna Sudetów, 1:25 000*, Państwowy Instytut Geologiczny, Warszawa.

ŻELAŹNIEWICZ, A. and ALEKSANDROWSKI, P., 2008. *Regionalizacja tektoniczna Polski – Polska południowo-zachodnia*, Przegląd Geologiczny, 56, 10, pp. 904–911.

ECGS, website of European Center for Geodynamics and Seismology, http://www.ecgs.lu/wulg/, dostęp 31.03.2014.

EDUSCIENCE, website of EDUSCIENCE educational program, http://www.eduscience.pl/strony/wycieczki-książ, dostęp 31.03.2014.

UPF, website of University of French Polynesia, http://www.upf.pf/ICET/bim/bim138/memoriam.htm, dostęp 31.03.2014.