IPL Project Annual Report Form 2015

1 January 2015 to 31 December 2015

1. Project Title: Landslides monitoring at selected historic sites in Slovakia

1. Main Project Fields

2. Safeguarding of historic sites endangered by landslides, monitoring, estimation of temperature as the potential co-trigger for creep movements

3. Name of Project leader

Assoc. Prof. Dr. Jan Vlcko, PhD

Affiliation: (office and position) and Contact: (postal address and email)

Comenius University in Bratislava, Faculty of Natural Sciences, Dept. of Engineering Geology,

84215 Bratislava, Slovakia: vlcko@fns.uniba.sk

Core members of the Project: Names/Affiliations: (4 individuals maximum)

Assoc.Prof. Vladimir Greif, PhD,
Assoc.Prof. Dr. Martin Bednarik, PhD

4. Objectives: Long-term temperature monitoring within the rock mass, comparison of the measured and computed heat flow within surficial part of the rock mass, improvement of the testing procedure related of the thermal expansion of different rock types, estimation the thermal expansion (volume changes) of the rocks due to daily and seasonal temperature fluctuations. Modeling of relationship between rock slope failure kinematics and the temperature influence in comparison to recorded rate of displacement.

5. Study Area: (2 lines maximum)

Eastern Slovakia – Hornadska kotlina Basin filled with flysh-like sediments, Central and Western Slovakia – Mesozoic rocks in nappe position, Pravcicka brana Arch in Czech Republic, Central Slovakia rock cut dwellings in volcanic tuffs, granitoide massif forming the subgrade of Bratislava Castle.

6. Project Duration (1 line maximum)

2010-2015

7. **Report**

Progress in the project: Within the project several historic sites in Slovakia are monitored. Spis Castle under Patrimony of UNESCO, following National monument as Bratislava and Devin Castle (new site since December 20145) and rock cut dwellings in Brhlovce.

- Monitoring carried out by the mechanical-optical crack gauge type TM-71 and portable mechanical crack gauge type SOMET, automatic crack gauge GEOCON and Rissfox mini – readings are every week on mechanical gauges, 4 times a day by automatic gauge and Rissfox mini with hourly readings and automatic data transfer once a weak.

- Estimation (laboratory and in situ) of environmental temperature oscillation on the rate of displacement of the travertine rock.

The main goal of the Project is to illustrate some causal phenomena acting in sub-surface depth of the rock mass from the viewpoint of permanently acting temperature, or more precisely temperature oscillations. Authors perform long-time research concerning in situ temperature monitoring at three sites in the travertine rock mass forming the subgrade of the Spiš Castle as well as in tuff dwellings in Brhlovce. The research has shown that diurnal temperature changes influence mainly superficial parts of rock mass (to the depth of 1.5 m), deeper parts of rock mass are influenced by temperature change with longer time period, e.g. annual time period. Simultaneously, relation between moisture or saturation of the rock mass and temperature change with the depth within rock mass has been the topic of the study. From these relations it was found out, that the precipitation rate higher than 1.5 $mm.day^{-1}$ increased the depth of diurnal temperature changes by 0.3 m as compared to the period without precipitation.

- Deformations dynamics of Pravcicka Brana Rock Arch (Czech Republic) in response to seasonal temperature oscillation. The aim of the study is to find out the relationship between spatial temperature distribution and rate of displacement as the response to temperature oscillations and estimate the kinematic behavior (deformations dynamics) of the rock arch using computer modeling to simulate if there exists any potential hazard to sandstone body rock arch to collapse.

- The study of the moisture distribution in rock mass influencing the potential rock collapse of rock-cut dwellings in Brhlovce. To estimate the moisture influence on rock deterioration and the potential roof collapse of rock cut dwellings we adopted the moisture sensor which consists of a small cylinder having the diameter and length of 20 mm in which a sensing element 2 mm in diameter is embedded that delivers the heat in step-wise regime and simultaneously measures temperature. During monitoring we have identified diffusion of moisture associated with cycle day/night and cycle wetting/drying caused by precipitation, no rock fall was at the monitored monument recorded.

1) Planned future activities or Statement of completion of the Project (15 lines maximum)

Since 2009 we expand our activities to measure moisture within rock mass in order to have the knowledge on the rock mass behavior under changing climatic conditions and their influence on UNESCO site Spis Castle, Pravcicka brana rock arch (CZ) and rock-cut dwellings in Brhlovce,

where stability problems occurred. Several publications over local and international journal and conferences with the acknowledgement to ICL were within this project published

Proposed activities for 2016:

1. Modeling of thermal flow in superficial parts of the castle rocks at Devin Castle National Monument

2. The study of relation between weathering-creep deformation and thermal cycles in the rock mass

3. Moisture study and its influence on stability of rocky walls

b) Beneficiaries of Project for Science, Education and/or Society (15 lines maximum)

Selected lectures for post-graduate students at private international university ACADEMIA ISTROPOLITANA NOVA focused at the influence of geohazards on cultural heritage, seminars for MSc and PhD students at Faculty of Natural Sciences, Comenius University

c) Results: (15 line maximum, e.g. publications)

The project is aimed at the study of rock slope stability at sites which are of high societal value, the benefits we gained within research period in International Program on Landslides where published in several publications including CC journals.

The most cited papers within last five years elaborated within the IPL project:

Vlčko, Ján - Greif, Vladimír - Gróf, Vladimír - Jezný, Michal - Petro, Ľubomír - Brček, Martin : Rock displacement and thermal expansion study at historic heritage sites in Slovakia. In: Environmental Geology. - Vol. 58, No. 8, Sp. Iss. (2009), s. 1727-1740

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[o1] 2011 - Bakun-Mazor, D. - Hatzor, Y.H. - Glaser, S.D. - Santamarina, J.C. . - 45th US Rock Mechanics / Geomechanics Symposium . - [s.l.] : American Rock Mechanics Association, 2011 ; Nestr. [7 s.] ; SCOPUS
[o1] 2012 - Baba, H. O. - Peth, S. . - Soil and Tillage Research, Vol. 125, 2012 ; s. 38-43 ; SCOPUS
[o1] 2013 - Do Amaral Vargas Jr., E. - Velloso, R.Q. - Chávez, L.E. - Gusmão, L. - Do Amaral, C.P. . - Rock Mechanics and Rock Engineering, Vol. 46, No. 1, 2013 ; s. 123-134 ; SCOPUS
[o1] 2013 - Bakun-Mazor, D. - Hatzor, Y.H. - Glaser, S.D. - Carlos Santamarina, J. . - International Journal of Rock Mechanics and Mining Sciences, Vol. 61, 2013 ; s. 196-211 ; SCOPUS
[o1] 2014 - Martino, S. - Mazzanti, P. . - Natural Hazards and Earth System Sciences, Vol. 14, No. 4, 2014 ; s. 831-848 ; SCOPUS
[o1] 2014 - Vařilová, Z. - Zvelebil, J. - Hubatka, F. - Beneš, V. - Frolka, J. . - Acta Universitatis Carolinae, Geographica, Vol. 49, No. 1, 2014 ; s. 49-59 ; SCOPUS

Greif, Vladimír - Vlčko, Ján : Monitoring of post-failure landslide deformation by the PS-InSAR technique at Lubietova in Central Slovakia. In: Environmental Earth Sciences. - Vol.

66, No. 6 (2012), s. 1585-1595

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[o1] 2013 - Bianchini, S. - Cigna, F. - Casagli, N. . - Landslide Science and Practice, Vol. 1: Landslide Inventory and Susceptibility and Hazard Zoning . - Berlin : Springer, 2013 ; S. 119-125 ; SCOPUS
[o1] 2014 - García-Davalillo, J.C. - Herrera, G. - Notti, D. - Strozzi, T. - Álvarez-Fernández, I. . - Landslides, Vol. 11, No. 2, 2014 ; s. 225-246 ; SCOPUS
[o1] 2014 - Liang, X. - Zhao, X. - Xiang, J. - Chen, X. - Tang, H. . - Tumu Jianzhu yu Huanjing Gongcheng/Journal of Civil, Architectural and Environmental Engineering, Vol. 36, No. 1, 2014 ; s. 92-100 ; SCOPUS
[o1] 2014 - Wang, K.-L. - Lin, J.-T. - Lin, M.-L. - Lin, C.-W. - Chen, H. - Chen, T.-C. - Tseng, C.-M. . - Disaster Advances, Vol. 7, No. 3, 2014 ; s. 1-6 ; SCI ; SCOPUS
[o1] 2013 - Prokešová, R. - Medveďová, A. - Snopková, Z. . - Landslide Science and Practice, Vol. 2: Early Warning, Instrumentation and Monitoring . - Berlin : Springer, 2013 ; s. 331-337 ; SCOPUS
[o1] 2014 - Abdikan, S. - Arikan, M. - Sanli, F.B. - Cakir, Z. . - Environmental Earth Sciences, Vol. 71, No. 9, 2014 ; s. 4081-4089 ; SCI ; SCOPUS
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[o1] 2014 - Lu, P. - Bai, S. - Casagli, N. . - Remote Sensing, Vol. 6, No. 8, 2014 ; s. 6817-6843 ; SCI ; SCOPUS
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[o1] 2015 - Sun, Q. - Zhang, L. - Ding, X.L. - Hu, J. - Li, Z.W. - Zhu, J.J. . - Remote Sensing of Environment, Vol. 156, January, 2015 ; s. 45-57 ; SCI ; SCOPUS
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[o1] 2015 - Huang, Y. - Yu, M. - Xu, Q. - Sawada, K. - Moriguchi, S. - Yashima, A. - Liu, C. - Xue, L. . - Environmental Earth Sciences, Vol. 73, No. 11, 2015 ; s. 7661-7668 ; SCI ; SCOPUS

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[o1] 2015 - Zheng, J. - Kulatilake, P.H.S.W. - Deng, J. . - Engineering Geology, Vol. 188, April, 2015 ; s. 110-125 ; SCI ; SCOPUS
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