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FINAL REPORT - 2010

„In the scope of project "Comprehensive monitoring of natural environment in National Park Czech Suisse"

I. Introduction

This is the final report about monitoring in localities “Lugano” and “Norway_2” in the scope of project “Comprehensive monitoring of natural environment in National Park Czech Suisse”, financed by FM EHP/Norway.

II. Methods for evaluation od data gained by an automatic measuring system

The values of measured deformations mostly depend on voluminous changes of sandstones, which occur in dependence on daily and seasonal temperature changes. In this paper and in literature, these changes have been referred to “a standard activity of rocky massive, becuase it is measurable also on stabile slopes. only smaller part of measured motions is irreversible, also generated by the slope movement or by erosion of the massive, respectively. The basement of the interpretation also is, to distinguish reversible standard portions of deformation from irreversible ones.

III. Results of measurements

III. A. Locality “Lugano”

It is a deeply disturbed zone in the massive of 20 meters hight, which is a part of the main rock slope beneath the Kamenice river over hotels Lugano and Oasa in the village Hřensko. This massive is created by a system of plate-like blocks, which are extruded into their hight and width, and, which stepwise lean out into the valley like a fan. The lower part of the wall has been reinstated in the year 2002 because of its breakdown, but, only in a necessary scope: the immediately unstable lowest rock scale has been supported by a reinforced concrete pilar.

The accidental unstability has been derived from time series, gained by handy dilatometric measurements. Then, the control of reinstating efficiency has been done by continuing dilatometric measurements by hand. But, even after this time, the monitoring still captured some long-time irreversible creep deformations, also in tenths and hundredths of mm per year. These deformations have been documented in the upper and middle part of the massive, where the most potentialy dangerous is the block Nr. 32 in the upper edge, the system of rock scales No. 742 and the heavily damaged rock pilar No. 739.

Thus, it was decided to install automatic measurement on 6 key locations in the year 2008. These locations are on sides of the block No. 32 on the upper edge (L_1 and 2), in the upper massive´s third 742 (L_4 and 5) and, massive 739 (L_3).

The potentialy unstable rock scale westerly from these massives (L_6) has been newly added, because there is a risk of fall onto nearby hotel Oasa and a living house situated westerly from the hotel. Detailed situation of the measuring points on each location can be seen on photos, which are a part of graphic presentation (Images 1 to 16).

Locality L1 - Eastern side of the block No. 32

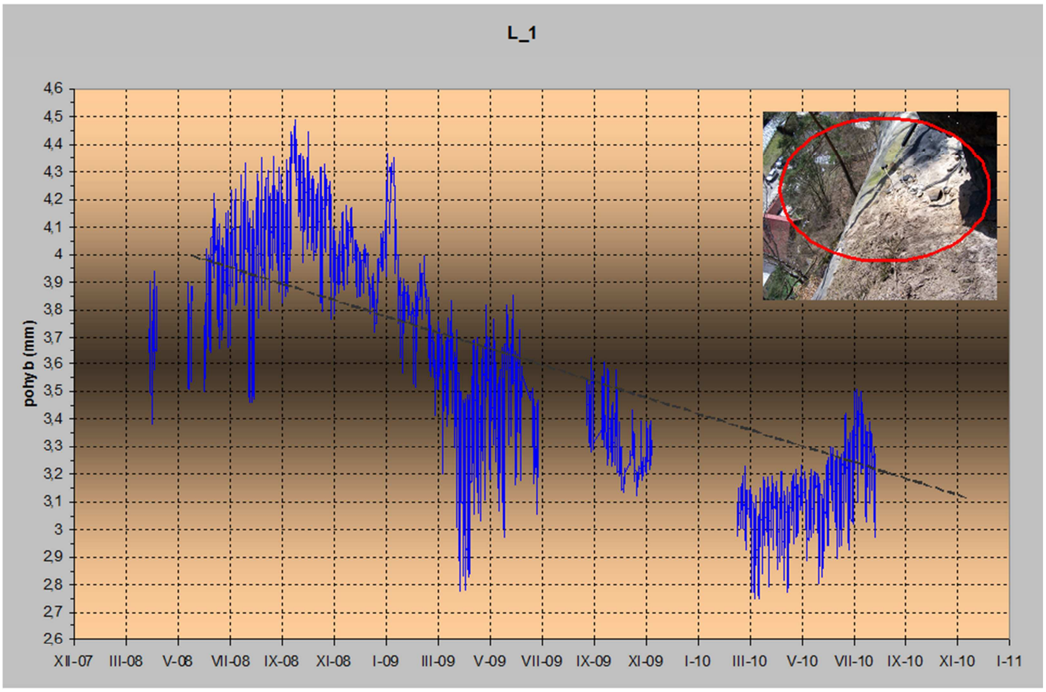

Image 1: Deformation series on the eastern side of the object, measuring point No. 32, partially modified data.

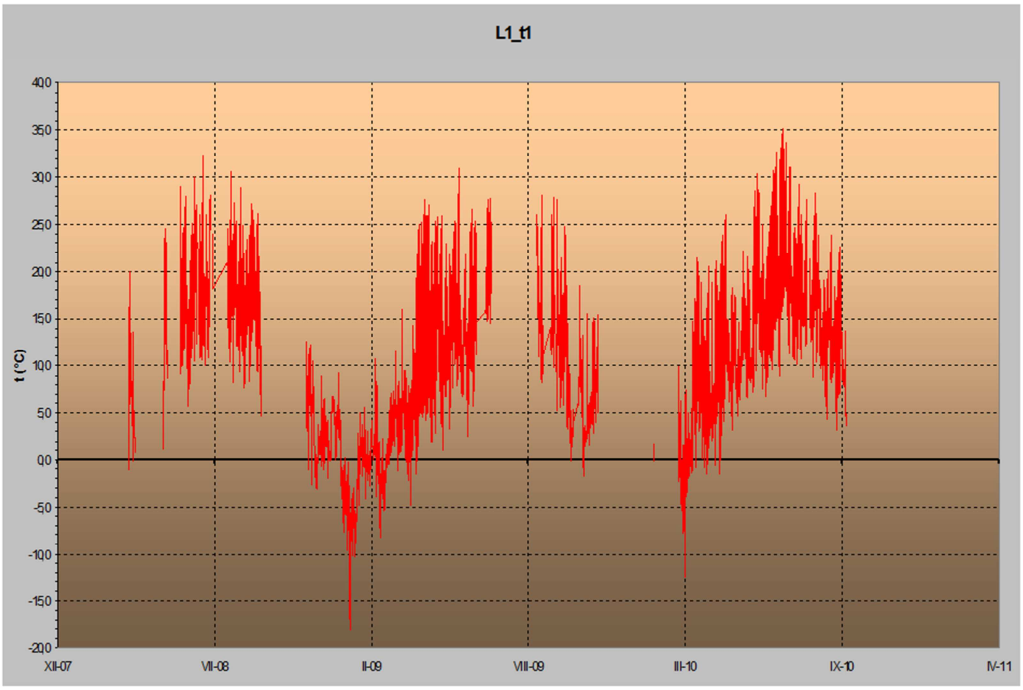

Image 2: Temperature series on the eastern side of the object, measuring point No. 32, partially modified

data.

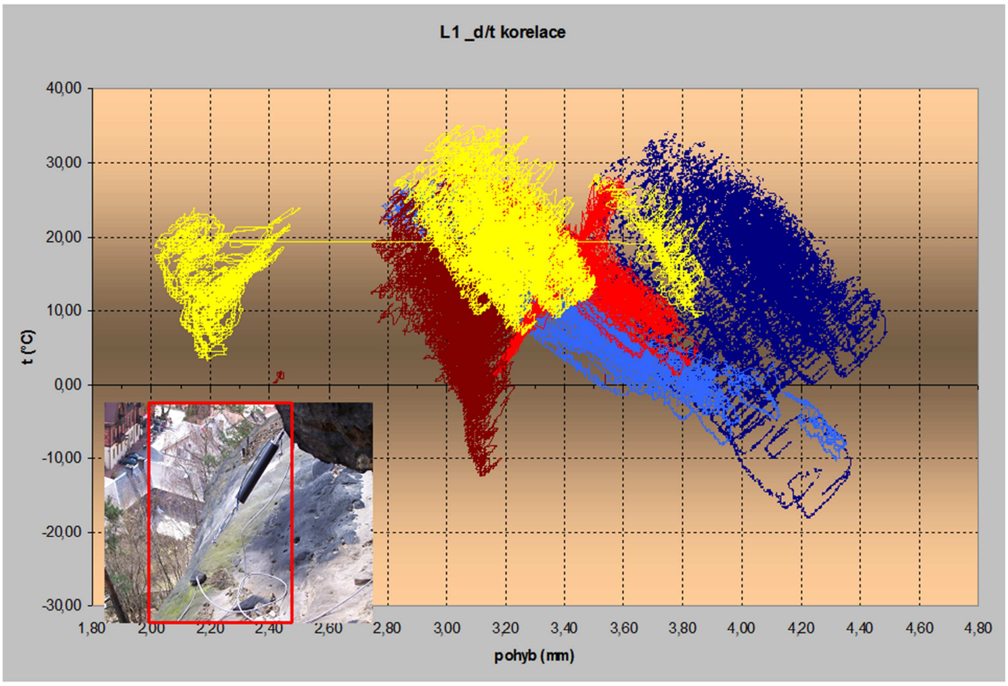

Image 3: Correlogram of temperatures and deformations on the eastern side of the object, measuring point No. 32.

Locality L2 - Western side of the block No. 32

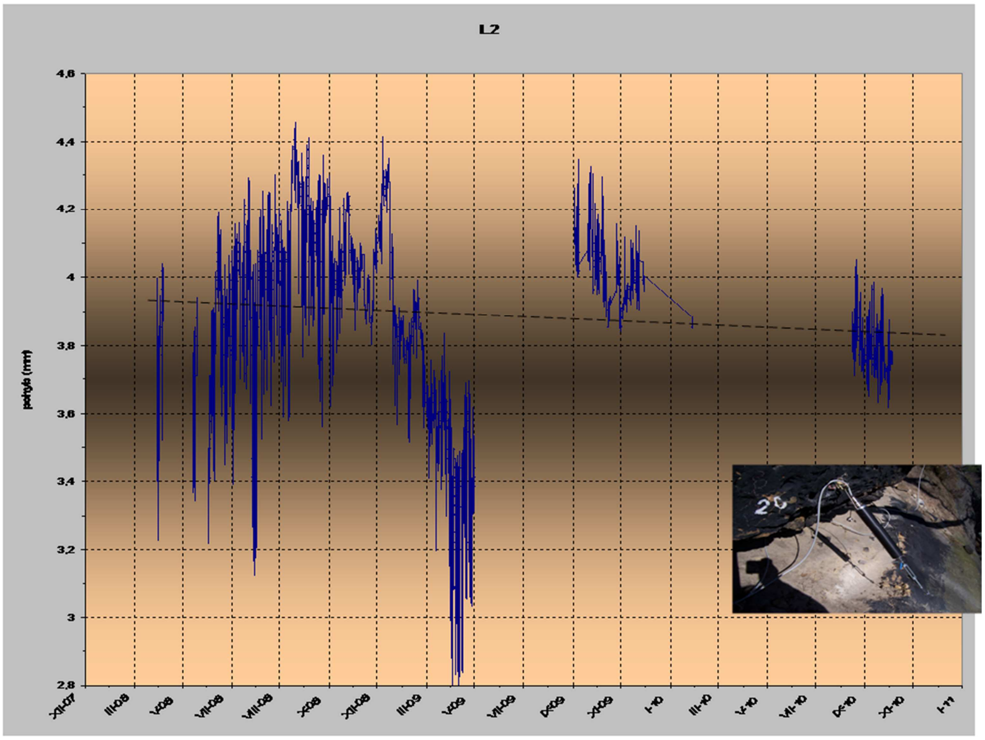

Image 4: Deformation series on the western side of the object, measuring point No. 32, locality L2, partially compensated data.

Based on the second approximation of the state on the locality No. 32, we came to the conclusion, that probably theree is also an irreversible deformation of 0,2 - 0,3 mm / 30 months.

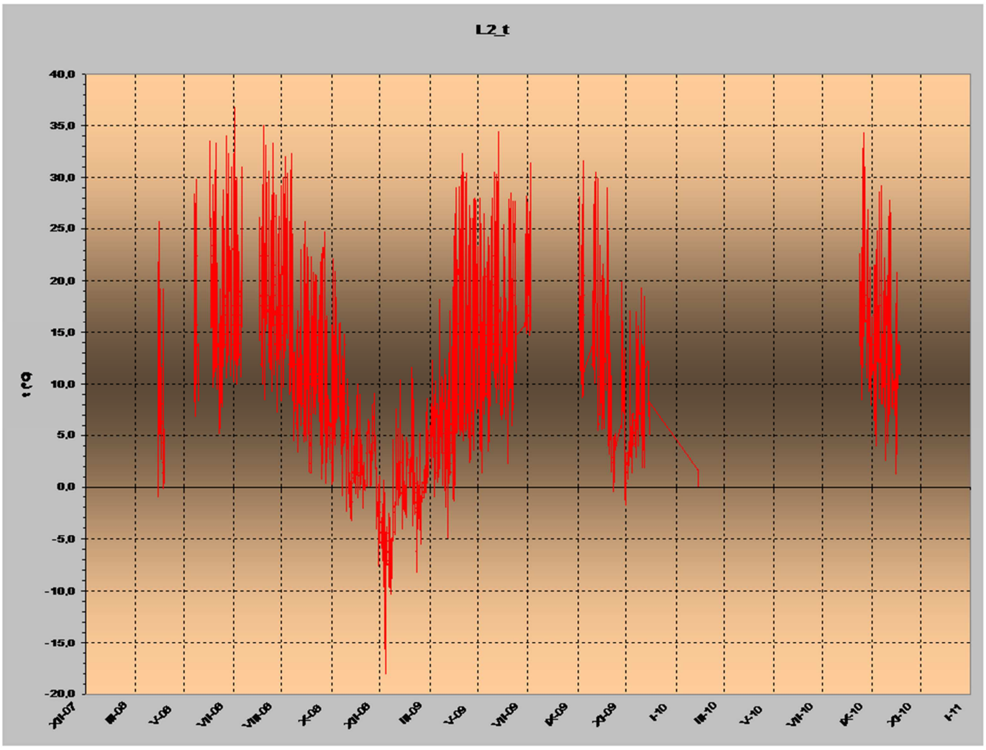

Image 5: Temperature series on the western side of the object, measuring point No. 32, locality L2, partially compensated data.

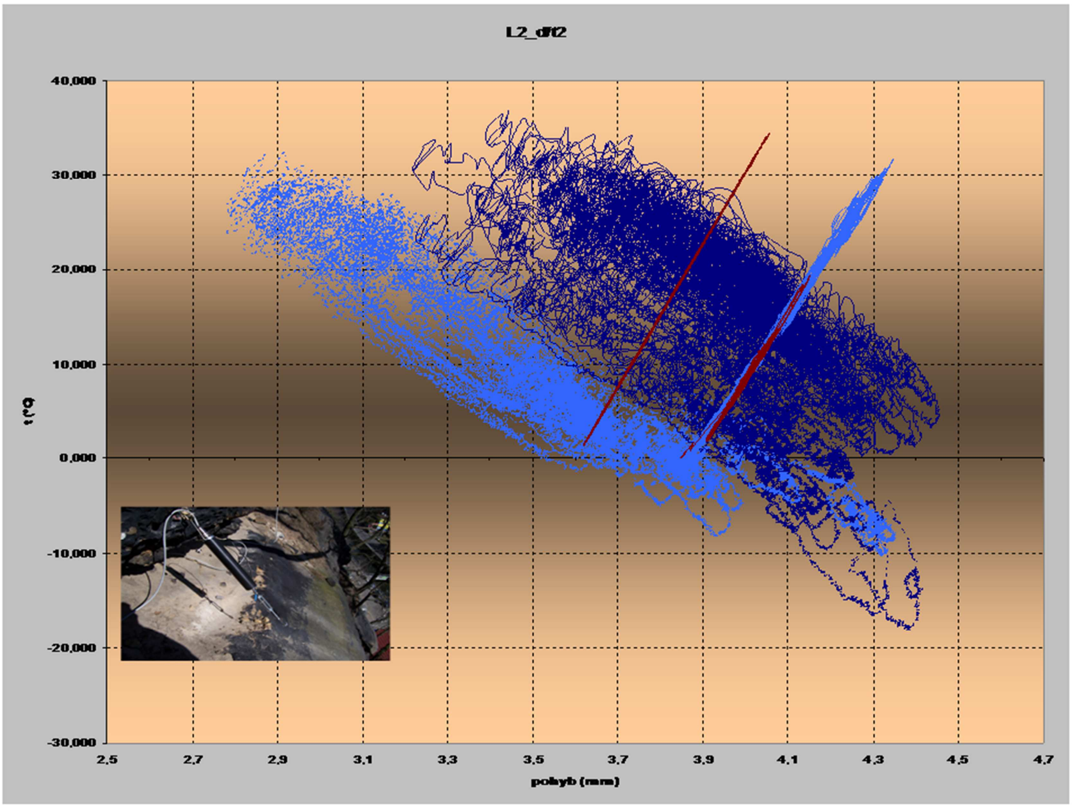

Image 6: Correlogram of temperatures and deformations on the western side of the object, measuring point No. 32, locality L2, rough data.

Locality L3 - Western side of the block No. 739

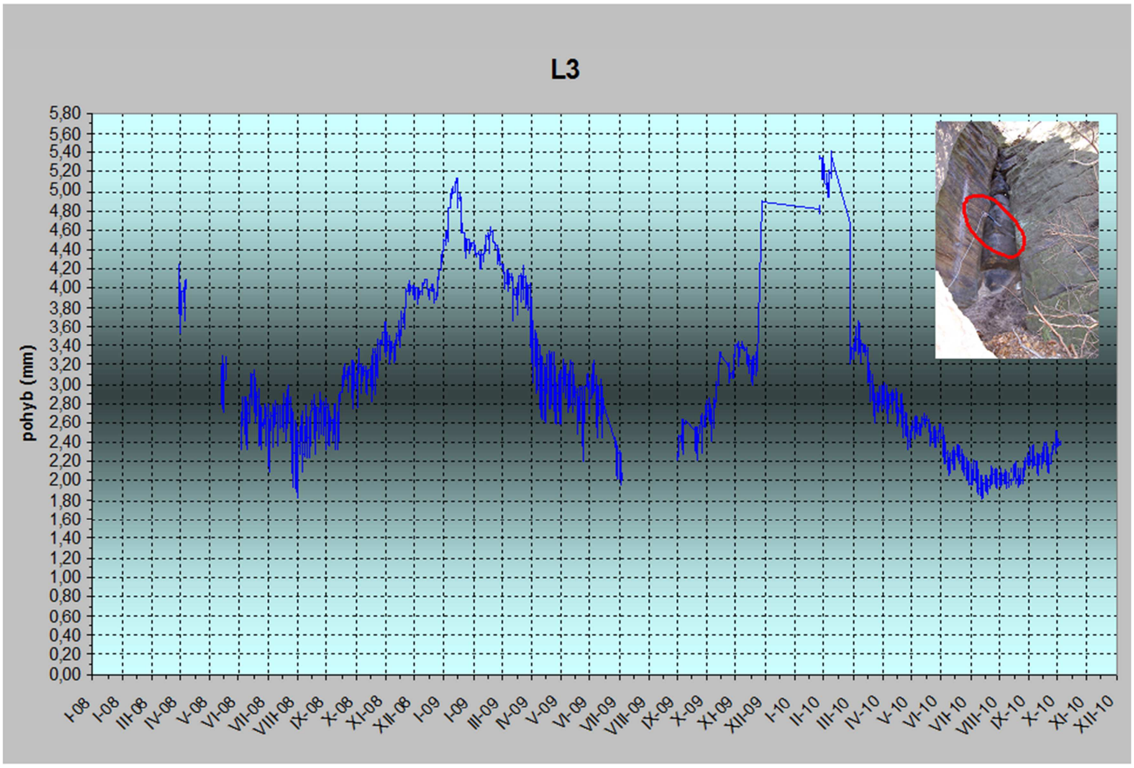

Image 7: Deformation series on the western side of the object, measuring point No. 739.

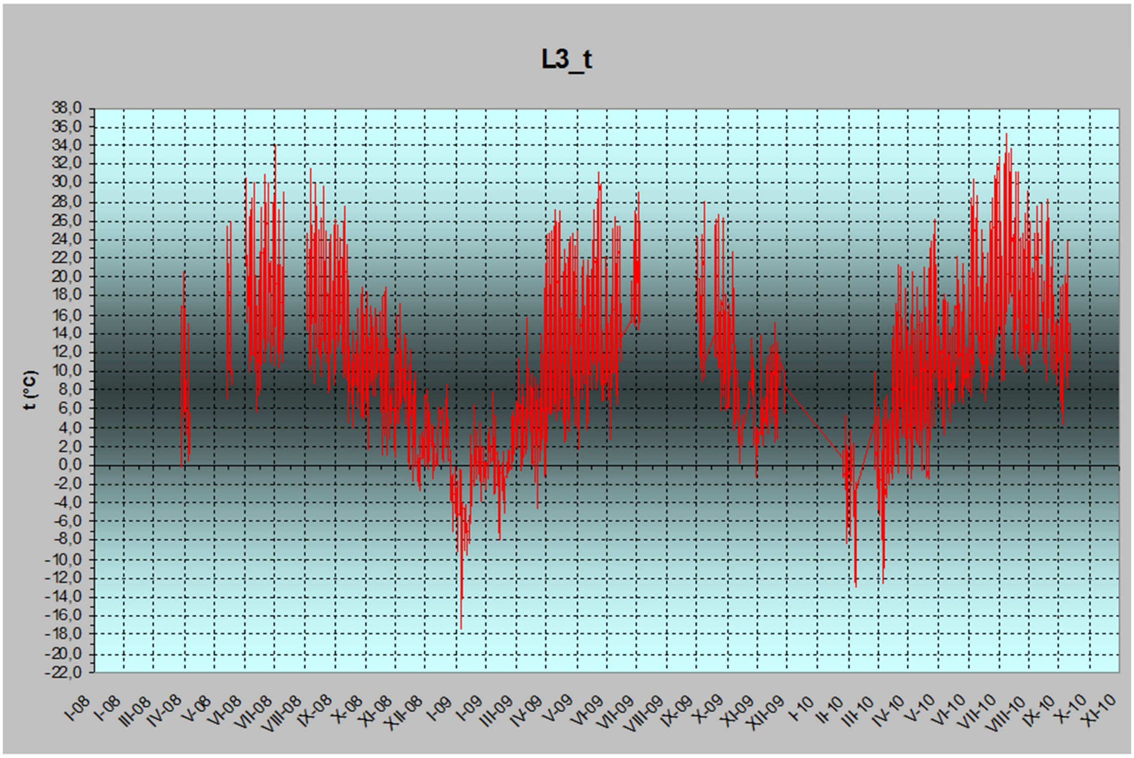

Image 8: Temperature series on the eastern side of the object, measuring point No. 739.

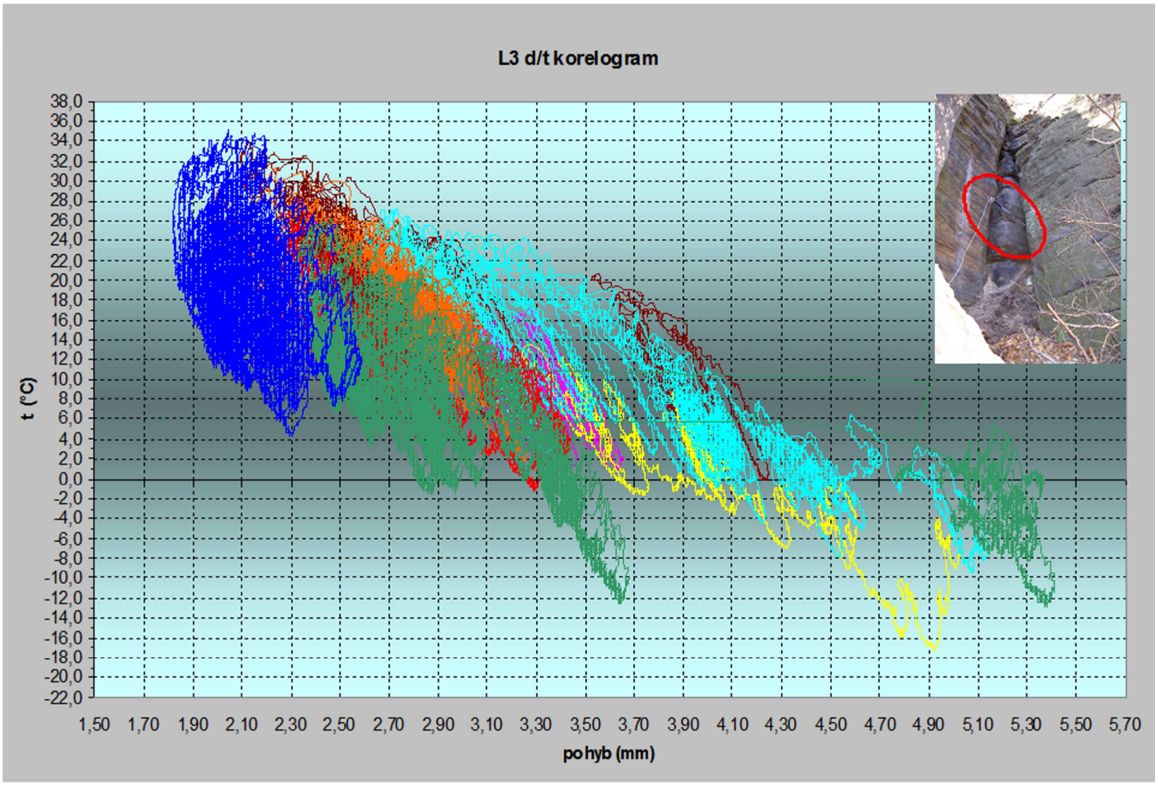

Image 9: Correlogram of temperatures and deformations on the western side of the object, measuring point No. 739.

Locality L4 and L5 - A central part of the wall, measuring point No. 742

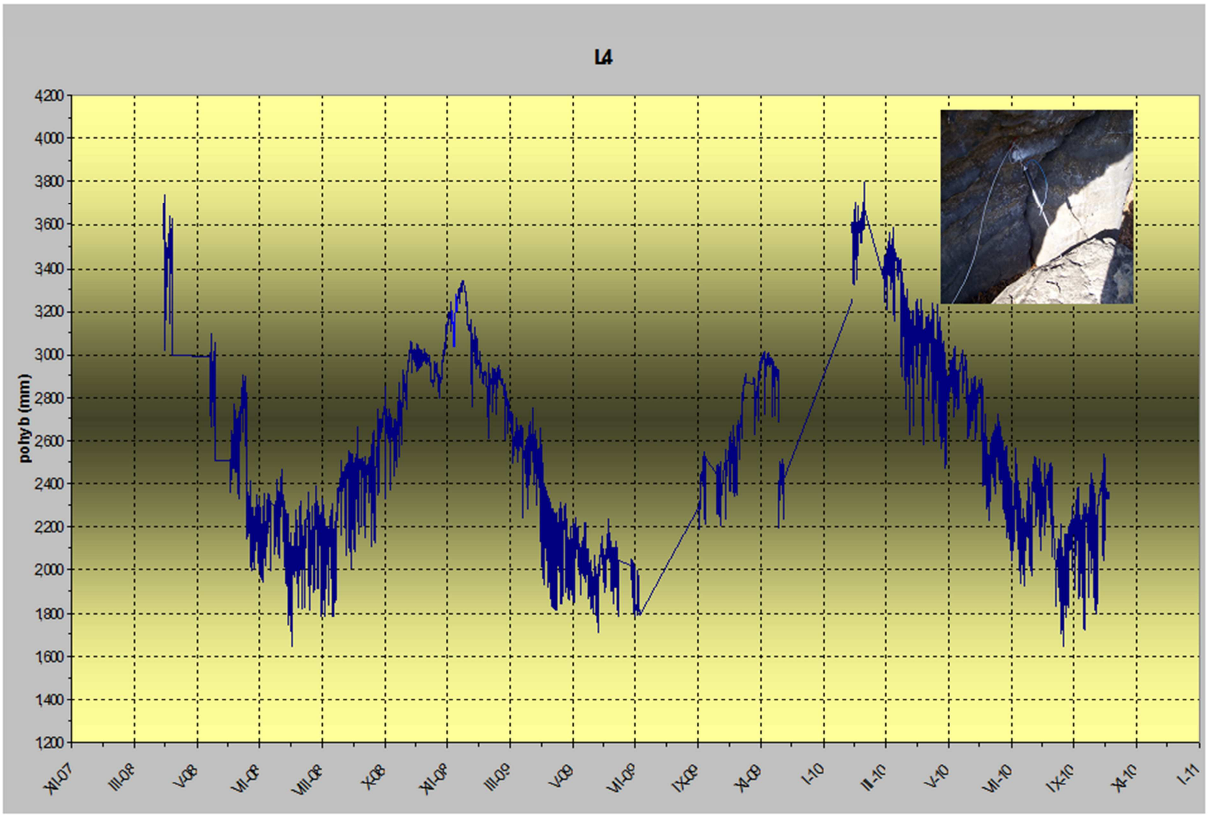

Image 10: Deformation series on the eastern side of the middle rock scale, measuring point No. 742.

Evaluating the graphic record of changes of measured distance (Img. 10) and also correlogram of these changes in relation to temperatures during measurement, we came to the conclusion, that we cannot exclude a deformation, ie. that the measured distance grows up about 0,1 mm / 30 months.

It was not possible to evaluate records from the locality L5 because too frequent failures of the measurement device.

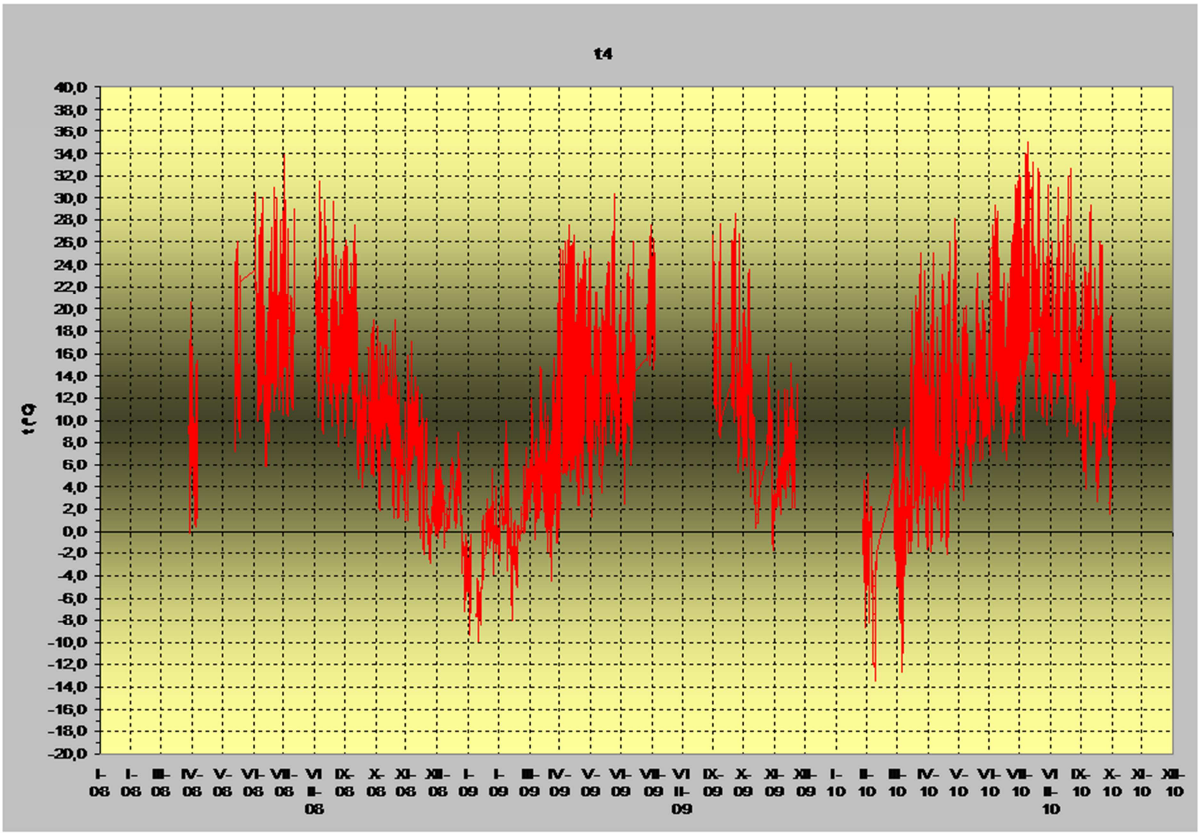

Image 11: Temperature series on the eastern side of the object, measuring point No. 742.

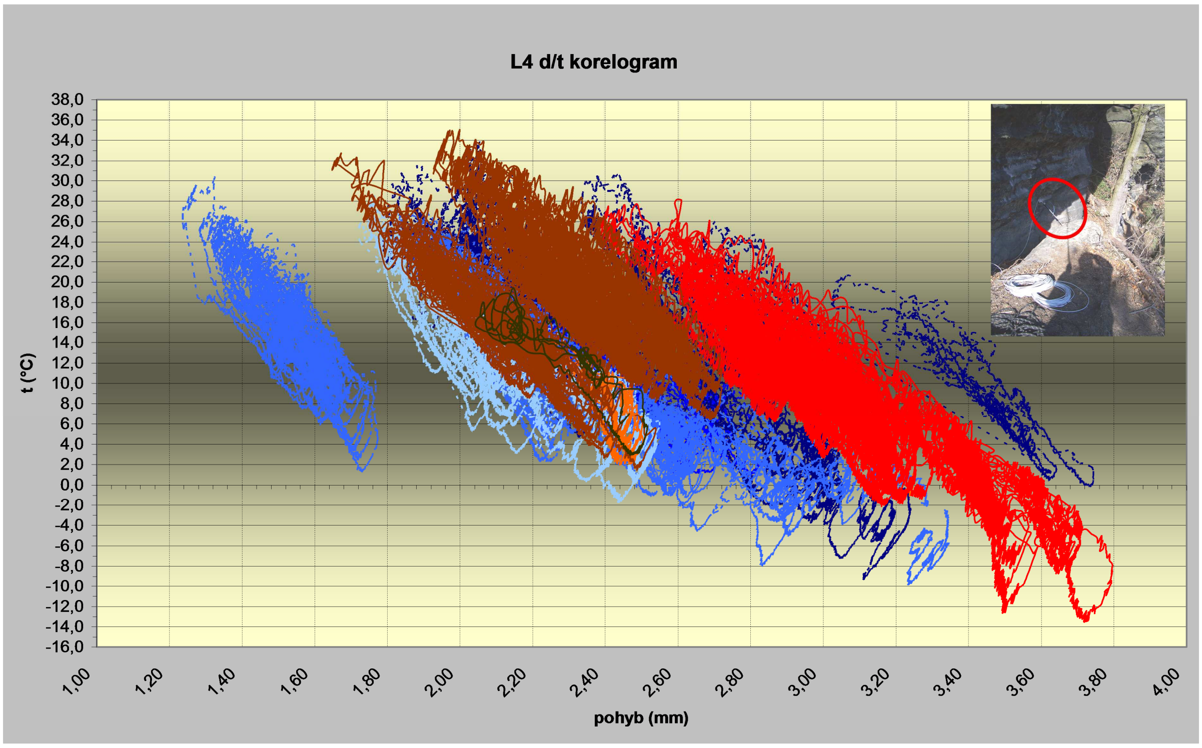

Image 12: Correlogram of temperatures and deformations at the foot of the eastern side of the object, measuring point No. 742.

L6 - rock scale westerly from the object, measuring point No. 742

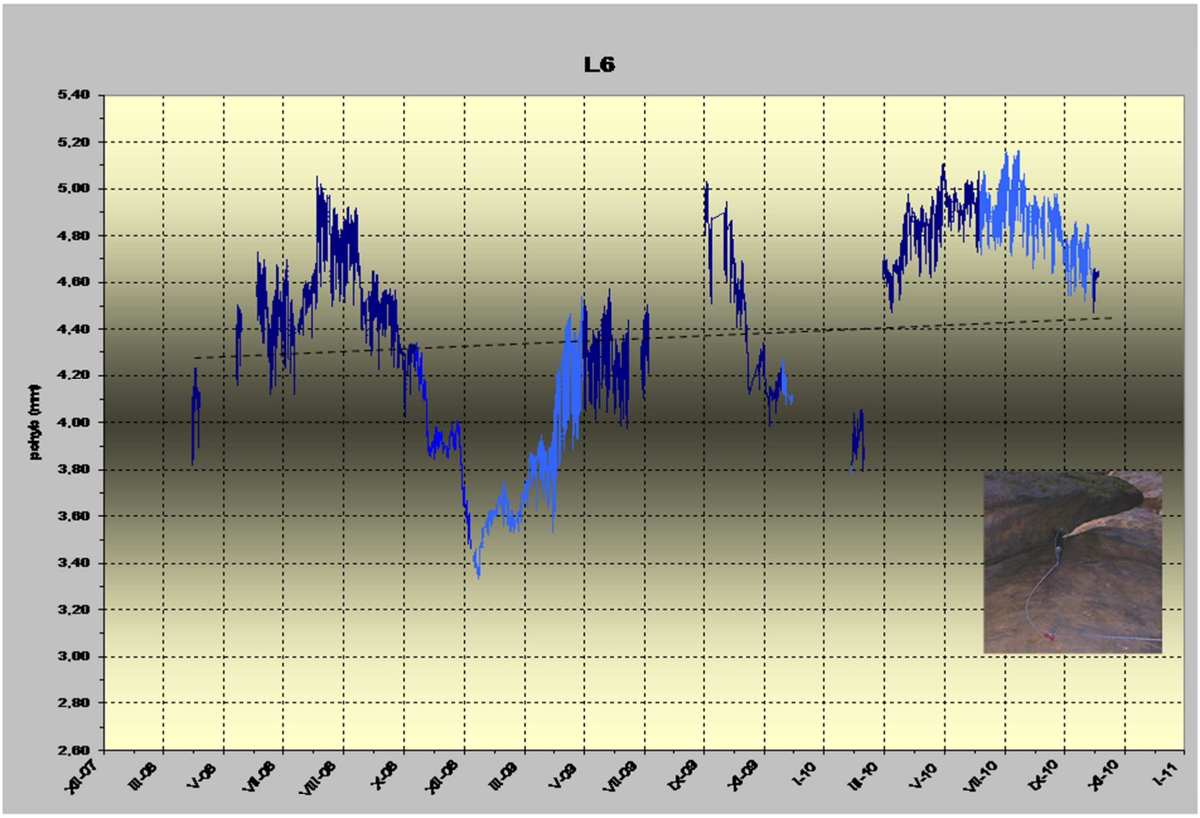

Image 13: Deformation series on the eastern side of the western rock scale in the lower part of the wall.

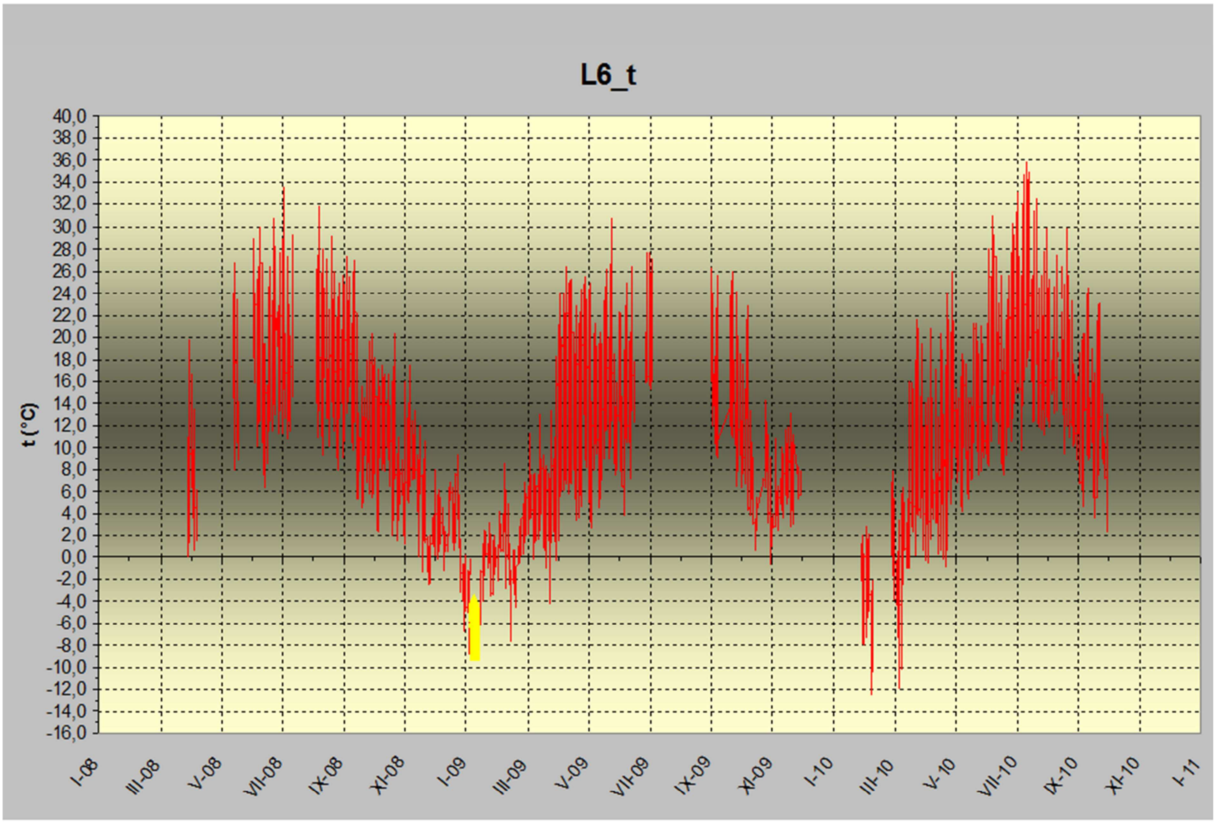

Image 14: Temperature series on the eastern side of the western rock scale in the lower part of the wall.

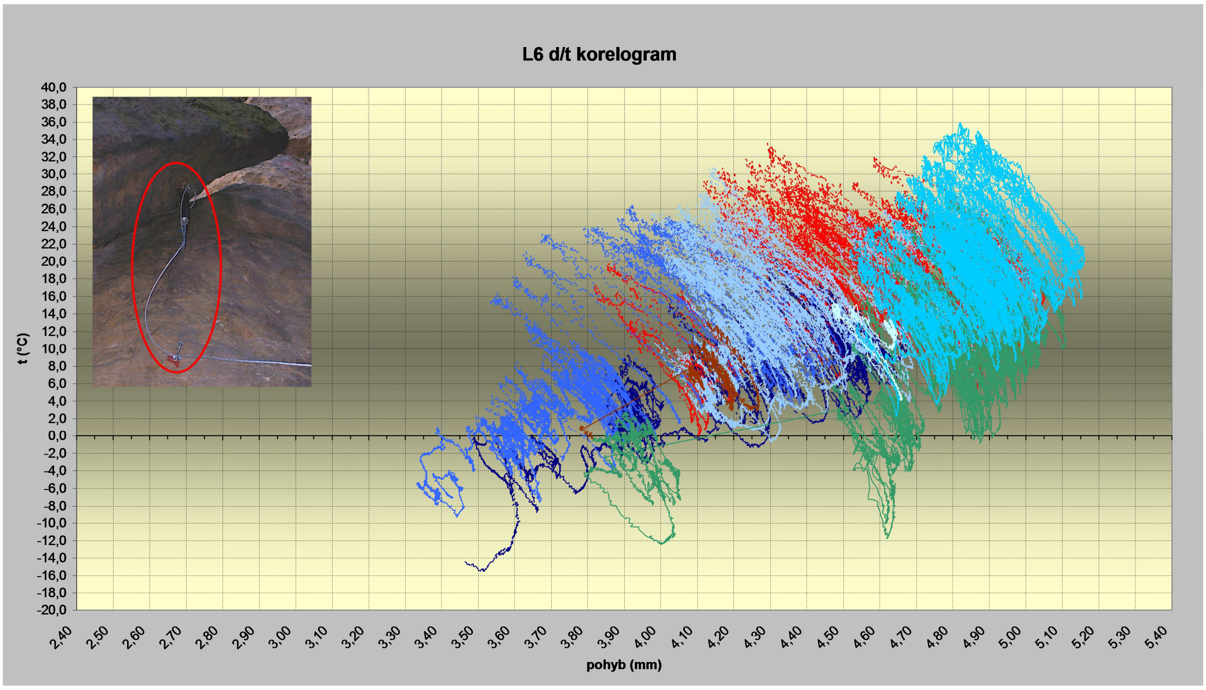

Image 15: Correlogram of temperatures and deformations on the eastern side of the western rock scale in the lower part of the wall.

IV. Conclusion

On the locality Lugano, we register a irreversible motion in two partial subareas.

x) Tild-down or shifting of the block No. 32, which is immediately on the upper edge of the rock wall, directly over objects in the village. The velocity of this irreversible motion is about 0,2 - 0,4 mm / 30 months in the eastern side, about 0,2 - 0,3 mm / 30 months in the western side (locality L1) and, 0,17 mm / year (locality L2) on the western corner.

The dynamics of the measuring series does not indicate, that some beginning of exponential acceleration is comming onto final phase of rock fall of this block. But, we hereby draw the attention to the fact, that the starting-up of this phase can be very fast and, its duration can be relatively short (days, but not more than weeks), due to the large volume and geometry of the block´s placement. Already nowaday, the incrementation of volume in the area of irreversible deformation is very high.

xx) Between the foot of the highest center rock scale of the object (measuring point No. 742) and the upper part of the scale in the middle hight level, there is an increasing of the measured distance about 0,1 mm / 30 months. The measured movement dynamics does not indicate yet, that there is any soon preparation of final rockfall phase, also any immediately risk.

On the next measuring point of the locality Lugano incl. point L6 on the eastern side of the rock scale westerly from the deeply crushed wall (point No. 742), there is no proof of any irreversible deformation. The point L5 is the exception, because it was not possible to evaluate any data due to permament failure of the device.

Evaluation and recomendation The accidental reinstating made in the lower part of the massive in year 2002 has removed only the immediate danger. But, very slow irreversible motions in the upper and center part of massive still exist. They don´t seem to be in the final phase, when the fall-down prepares but, it is necessary to continue with monitoring of the massive. Based on the character of the movements, measurement by handy instruments will be reliable enough.

On this locality, there is also some irreversible tild-down and / or sliding of a large detritus block (No. 32), which stays immediately on the odge of the main wall. Based on relatively big irreversible deformations and geometry and position of the block, we suppose there is a higher risk of its fall-down than in the previous case. That´s why recomend to foresee a reinstating of this block. Until this, it must be monitored by usual handy measuring. Before we set-up dangerous limits (f.e. deformation close to the tilt-dowm limit), we recomend do make detailed survey of geometry and stability of this block.

V. Locality N2

It is a deeply damaged rock pilar with total hight of 14 meters, situated in the slope near right bank of Kamenice river in the village Hřensko. Its lower half has been created by a system of scale plates, which have been loaded by blocks beneath them. There is a very much inclined separating (sliding ?) discontinuity, which separes plates from blocks. In the past, there already was a rockfall in the immediate northern neigbourhoud of the pilar.

The bottom part of the locality - measuring points N2_1 and 2

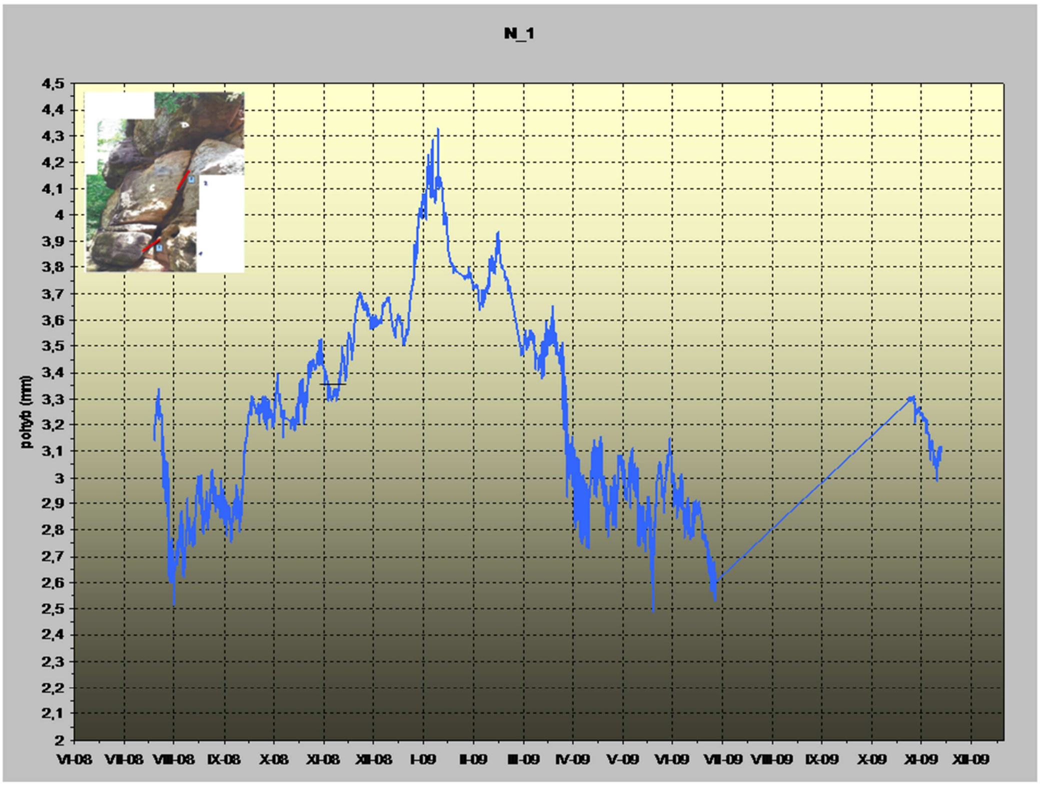

Image 16 Locality N2_2: Series of deformation on the rock scale B in the bottom part of western side of the pilar N2.

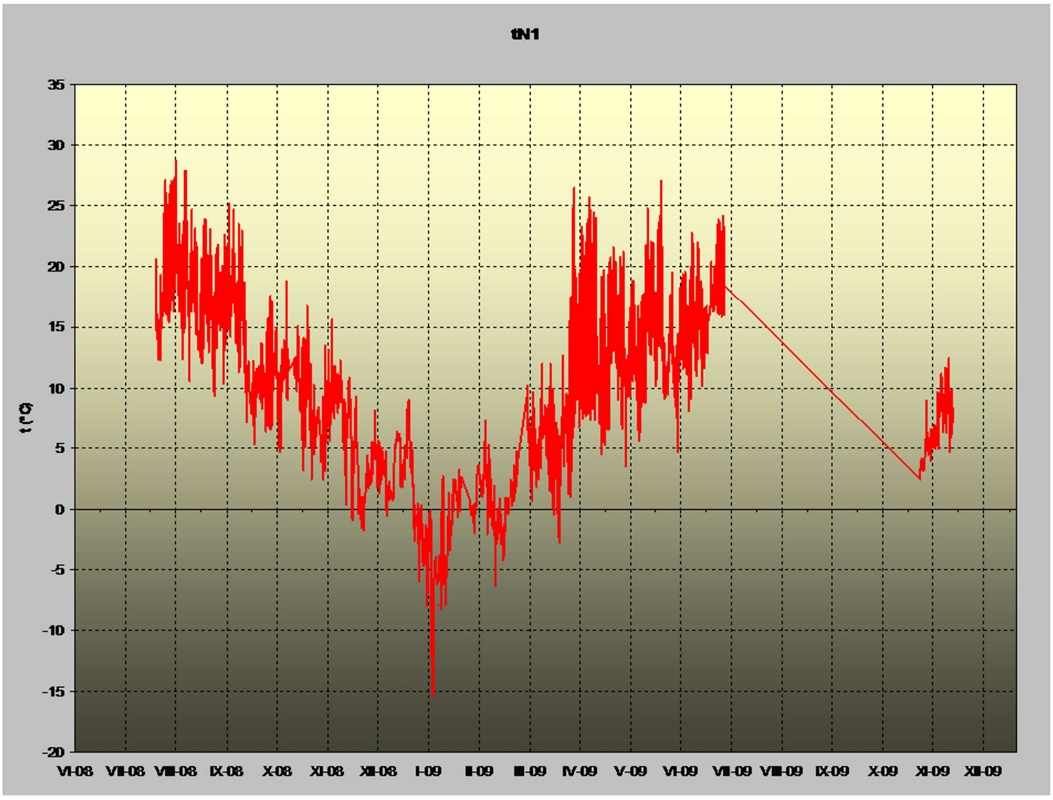

Image 17 Locality N2_2: Series of temperatures on the rock scale B in the bottom part of western side of the pilar N2.

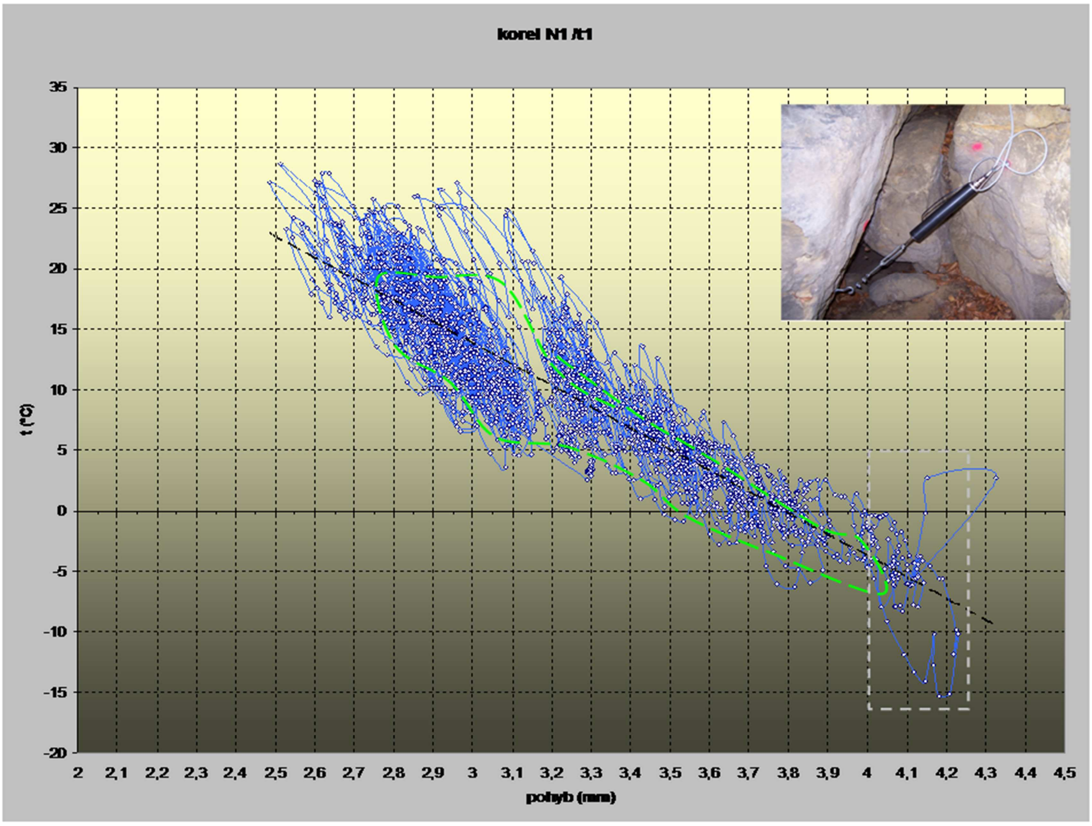

Image 18 Locality N2_1: Correlogram of temperatures and deformations on the rock scale B in the bottom part of western side of the pilar N2.

<u>Locality N2_2:</u> The eventual movement of the scale B int the valley could be captured on the locality N2_2, which measures diagonally down.

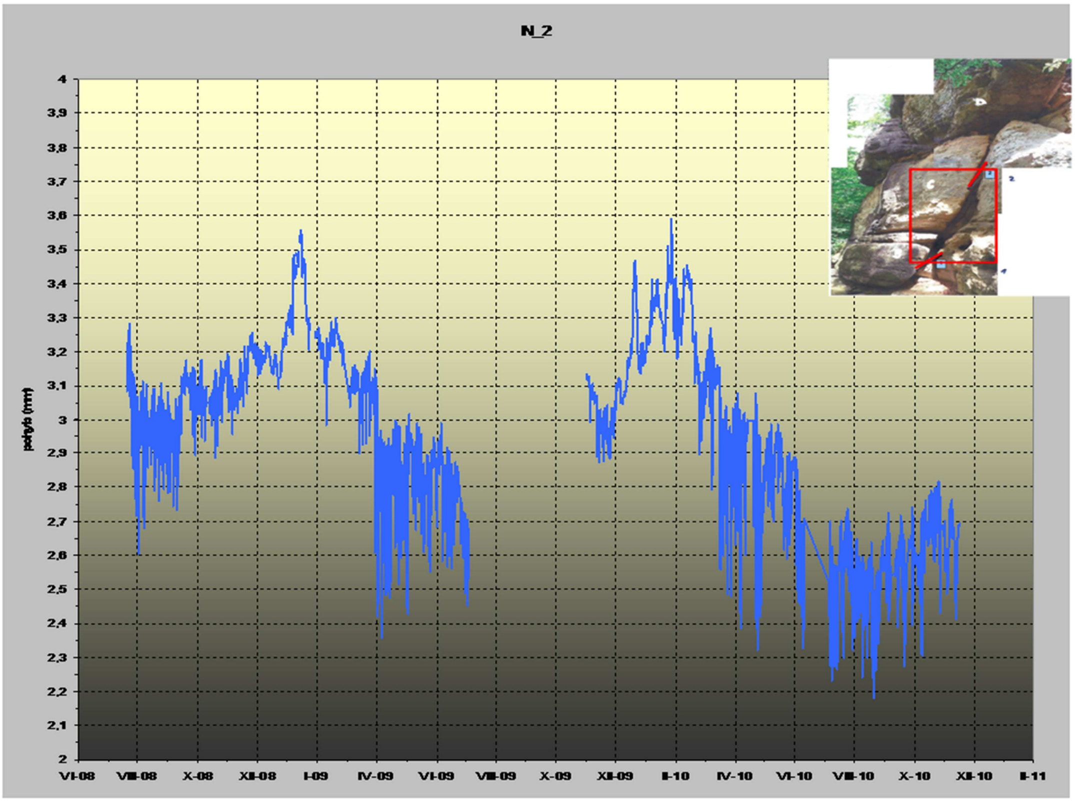

Image 19 Locality N2_2: Series of deformation on the rock scale B in the bottom part of western side of the pilar N2.

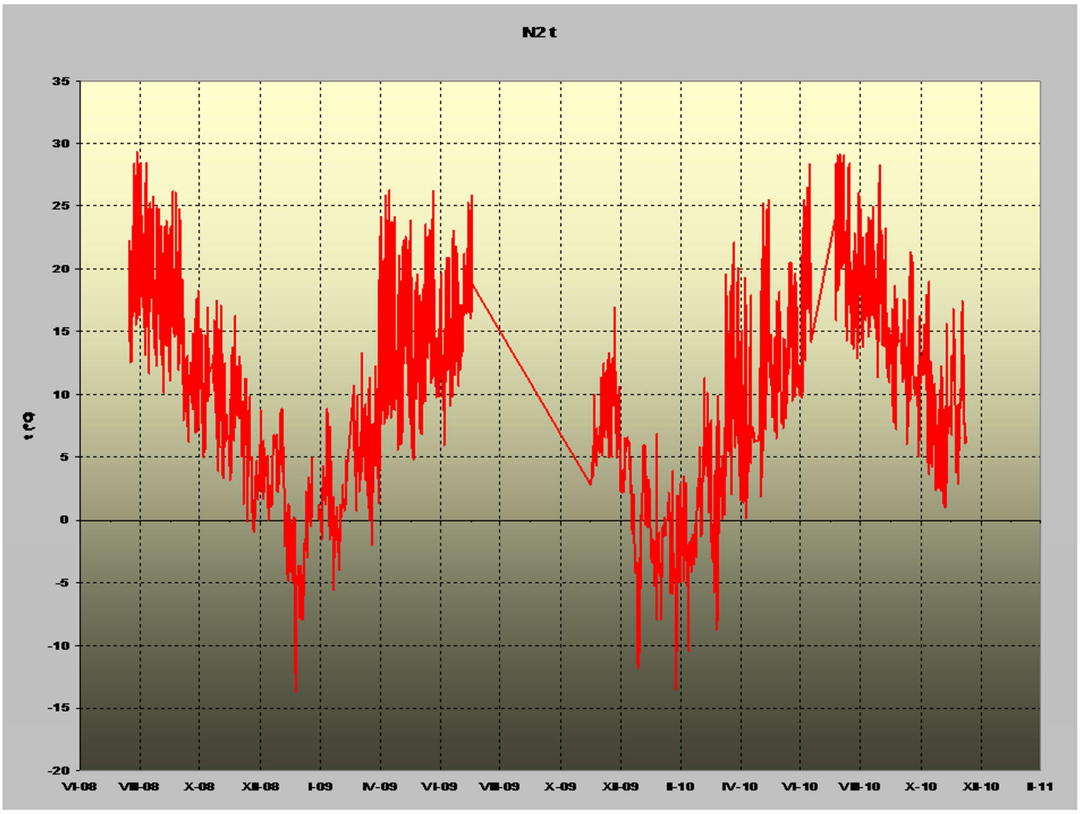

Image 20 Locality N2_2: Series of temperatures on the rock scale B in the bottom part of western side of the pilar N2.

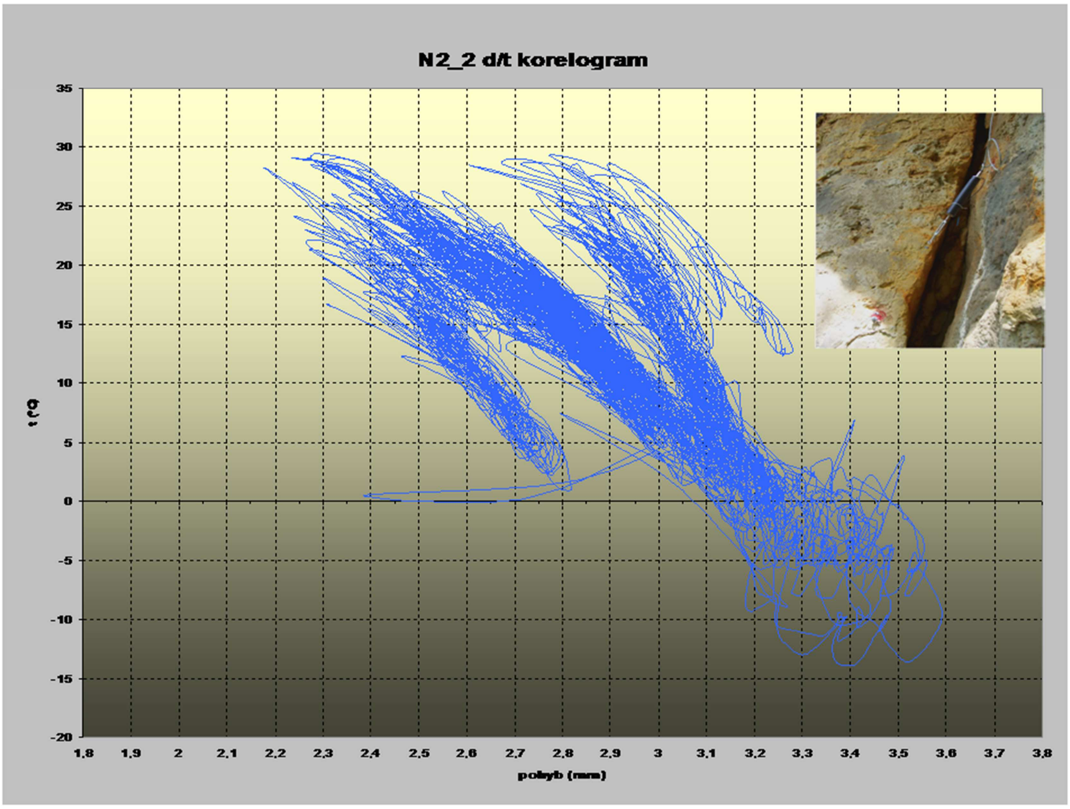

Image 21 Locality N2_2: Correlogram of temperatures and deformations on the rock scale B in the bottom part of western side of the pilar N2.

Middle of the object´s hight - locality N2_3 and N2_4

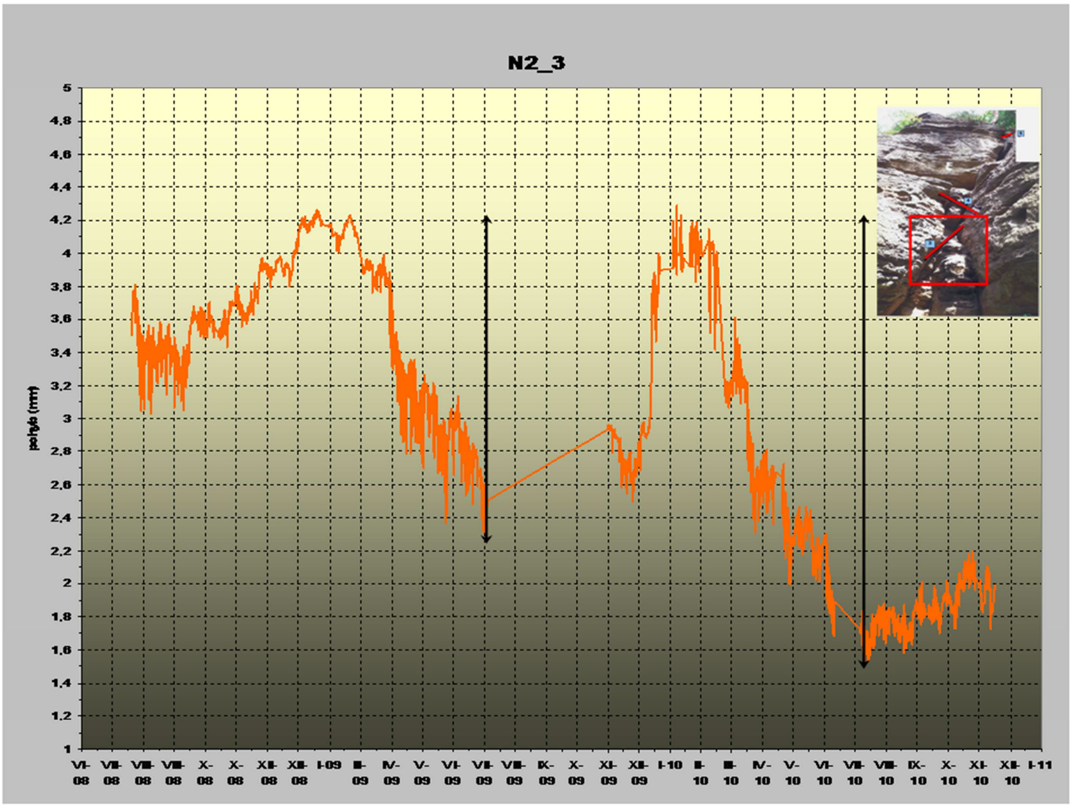

Image 22 Locality N2_3: Series of the skewed part of deformations on the rock scale D in the center part of western side of the pilar N2.

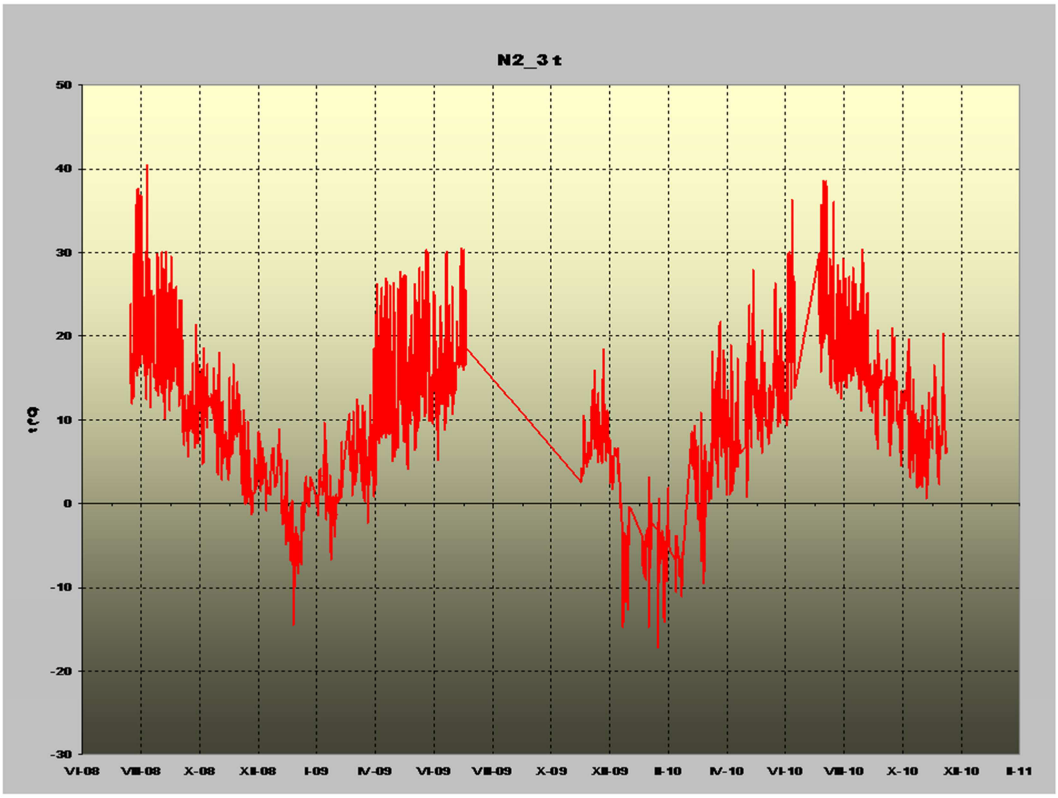

Image 23 Locality N2_3: Temperature series in the point, where the skewed part of deformations on the rock scale D in the center part of western side of the pilar N2 has been measured.

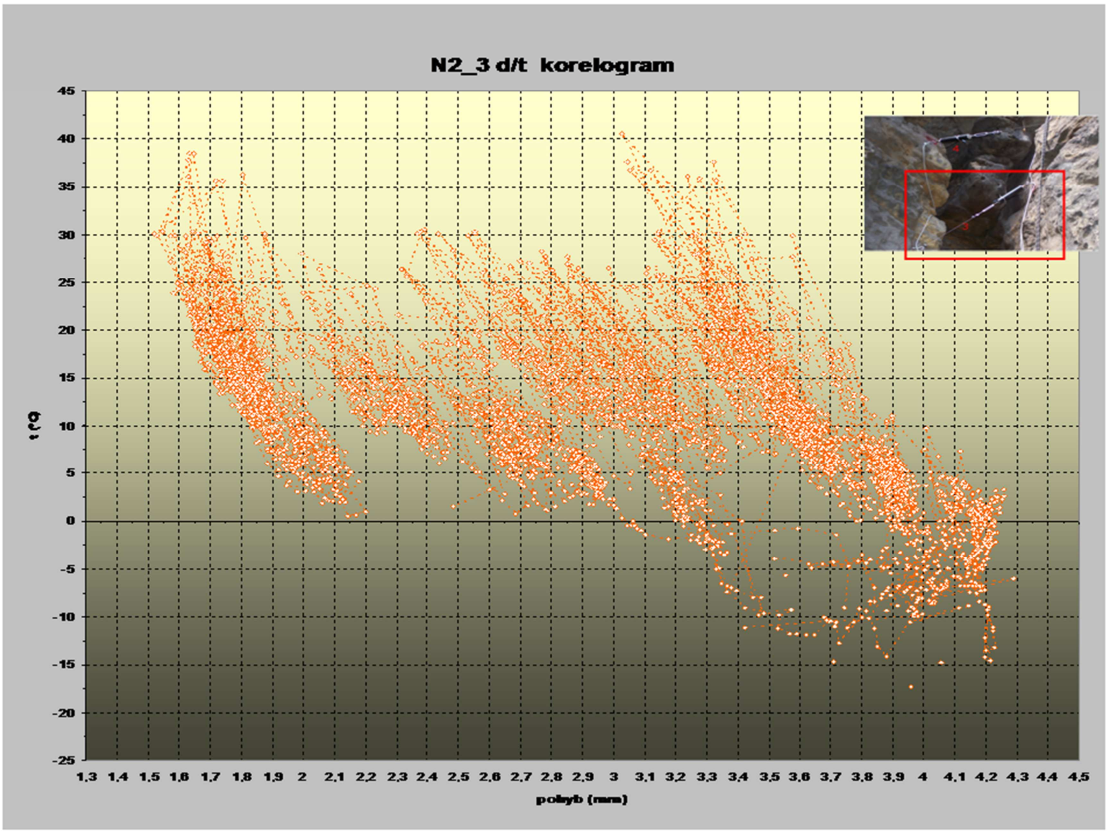

Image 24 Locality N2_3: Correlation between temperatures and deformations at the point, where the skewed

part of deformations on the rock scale D in the center part of western side of the pilar N2 has been measured.

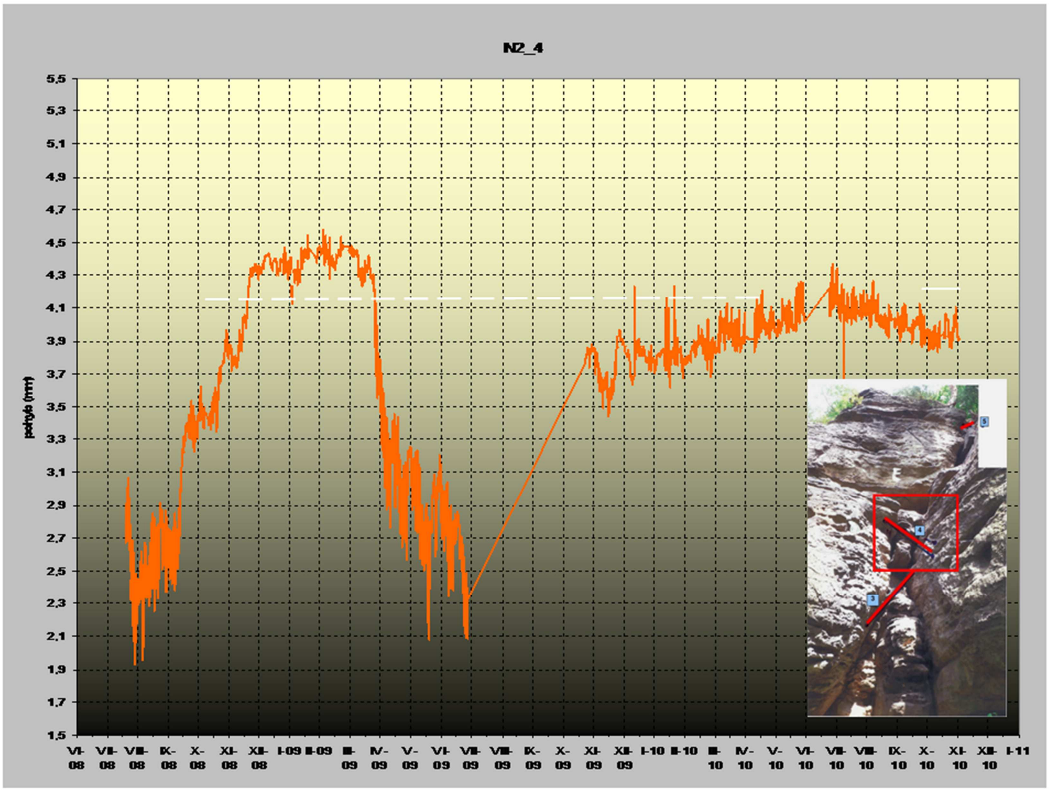

Image 25 Locality N2_4: Series of the horizontal part of deformations on the rock scale D in the center part of western side of the pilar N2.

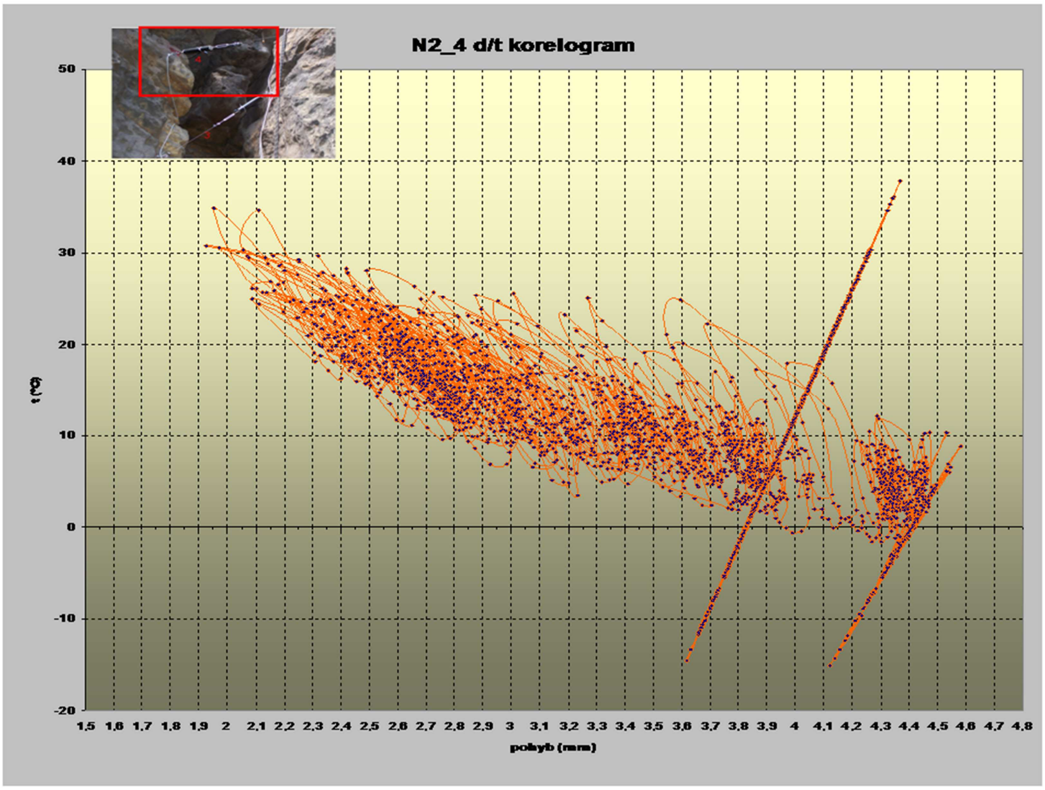

Image 26 Locality N2_4: Correlation between temperatures and deformations at the point, where the horizontal part of deformations on the rock scale D in the center part of western side of the pilar N2 has been measured.

Upper part of the object - N2_5 and N2_6.

Locality N2_5 captures a movement of the highest block D down on the slip plane into the valley, which creates ist back wall.

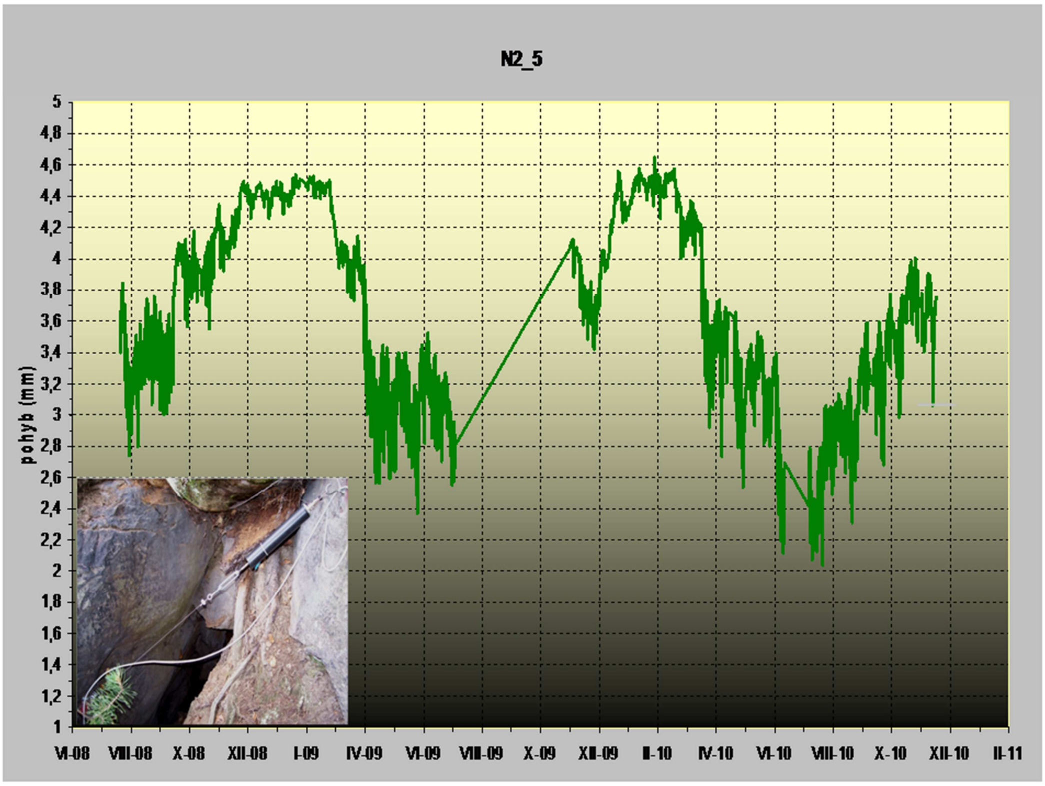

Image 27 Locality N2_5: Series of the skewed part of deformations of the block E in the upper part of western side of the pilar N2.

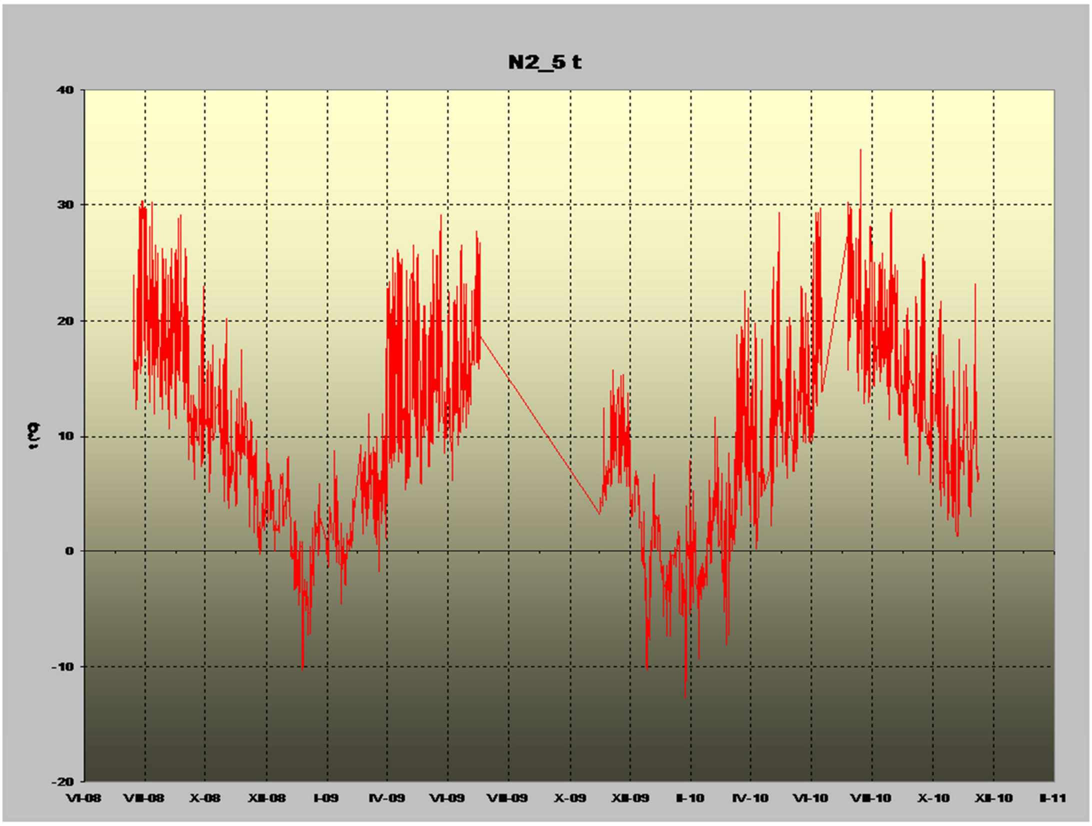

Image 28 Locality N2_5: Temperature series at the point, where the skewed part of deformations on the block E in the upper part of western side of the pilar N2 has been measured.

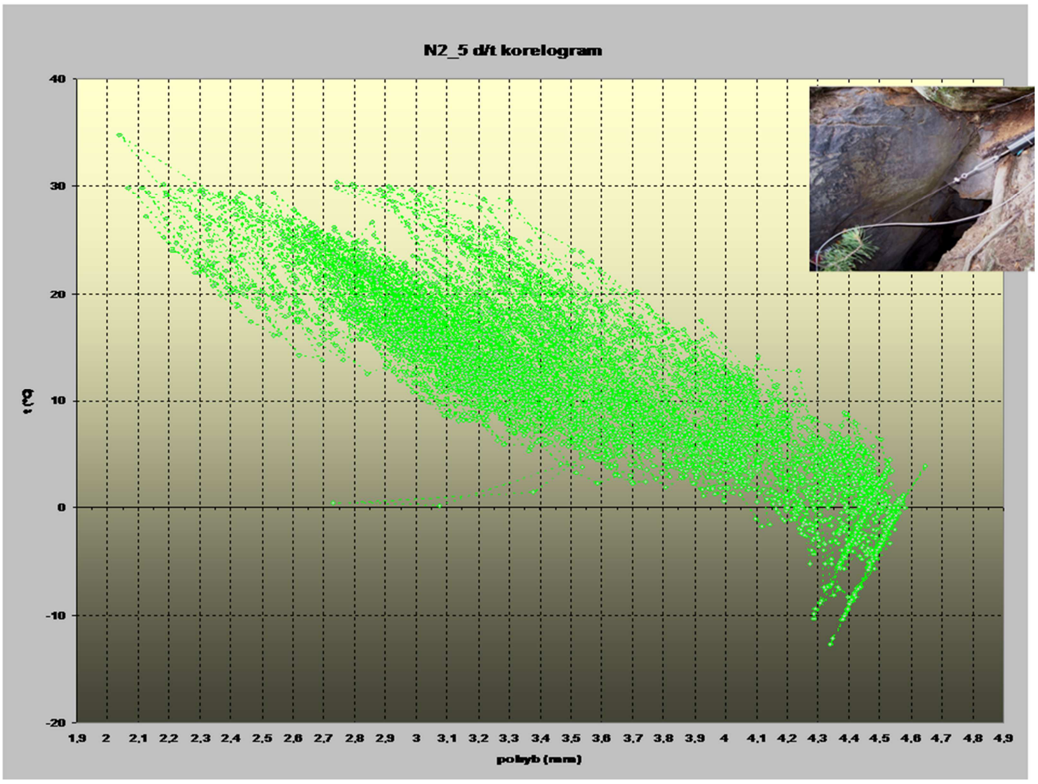

Image 29 Locality N2_5: Correlation between temperatures and deformations at the point, where the skewed part of deformations on the block E in the upper part of western side of the pilar N2 has been measured.

The locality N2_6 could capture an eventual tilt-down of the block D in the sub-horizontal plane towards the valley.

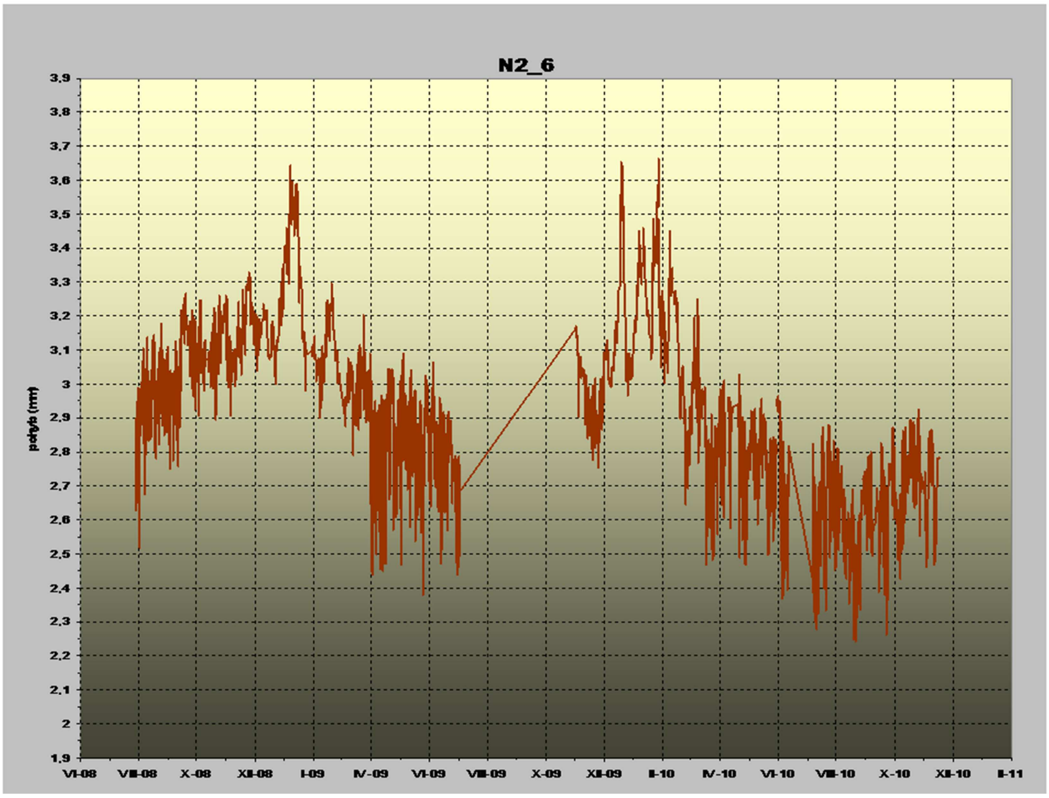

Image 30 Locality N2_6: Series of deformations in the upper part of western side of the pilar N2.

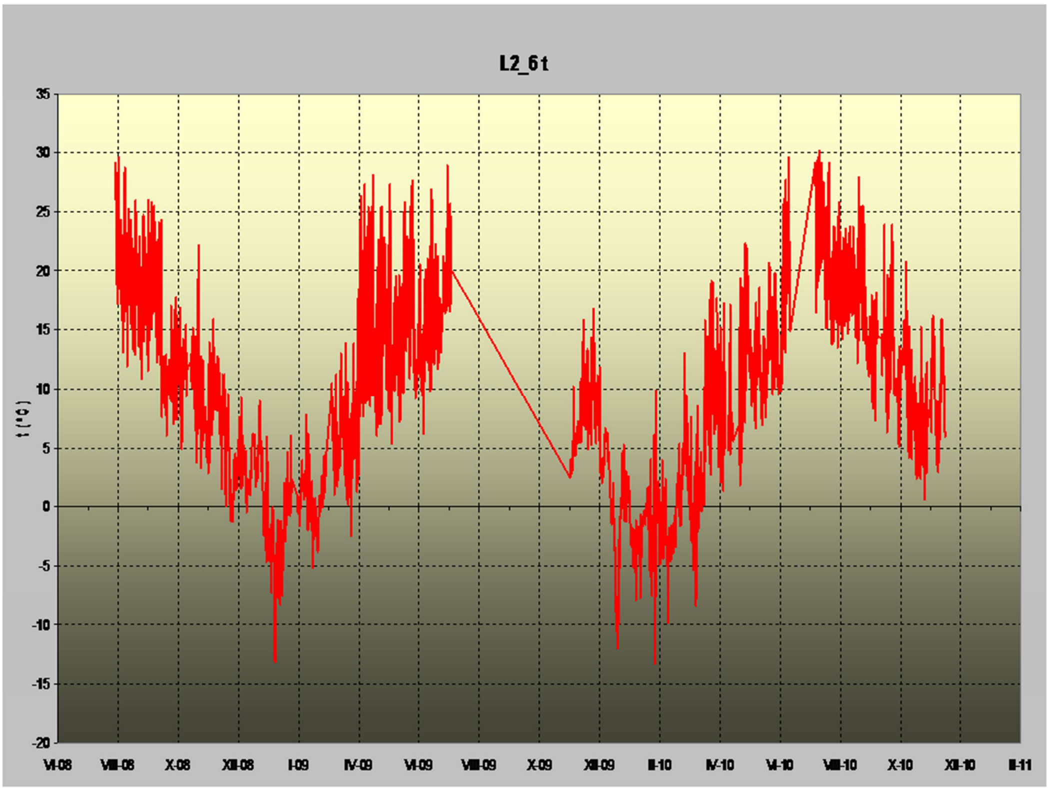

Image 31 Locality N2_6: Temperature series at the point, where the skewed part of deformations on the block E in the upper part of western side of the pilar N2 has been measured.

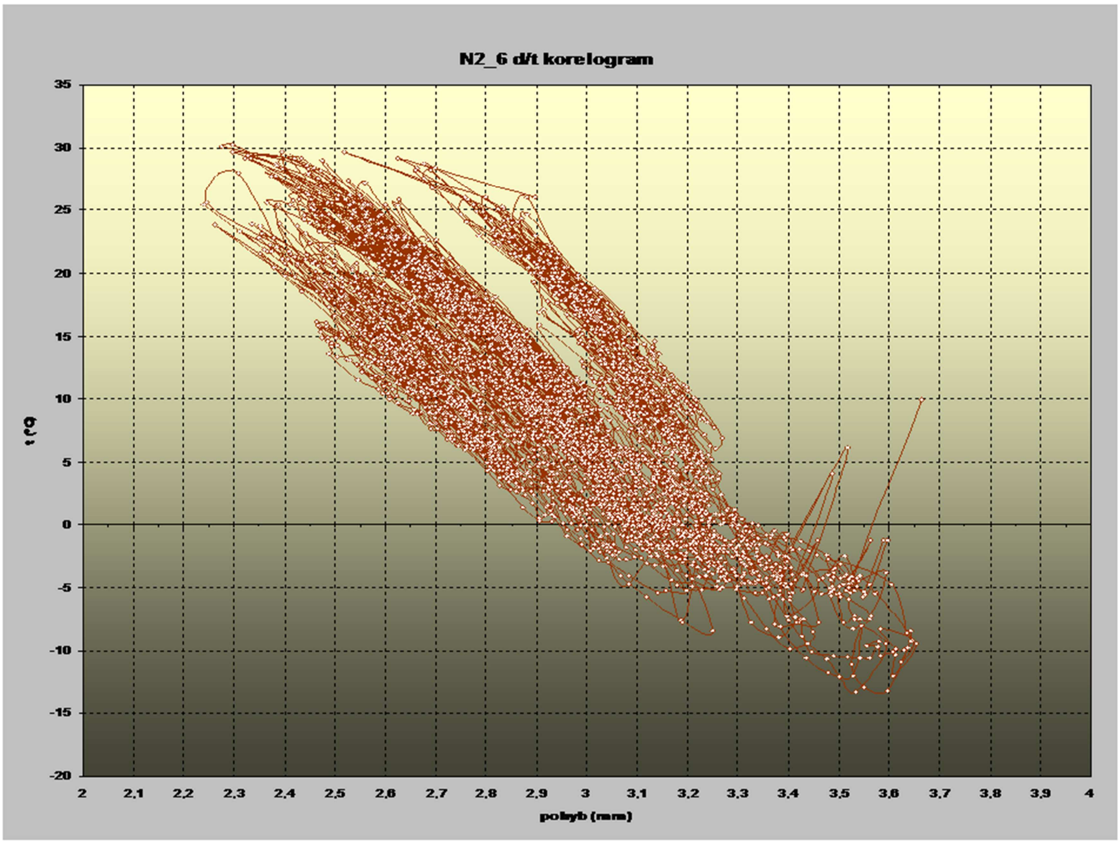

Image 32 Locality N2_6: Correlation between temperatures and deformations in the upper part of western side of the pilar N2.

Conclusions:

B. At the locality N2, the measurement results seem to show, there are none irreversible motions in the bottom, center and upper part of of the sliding zone. The same could be said also for the topmost block C with the locality N2_6. In the year 2009, there was an apparent irreversible movement, due to only partial cleaning of data. After the correction has been made, there is a quiet without any indication of slope movement.

Evaluation and recomendation On this locality, there probably are not any active deformations caused by slope movements. Thus, it is not necessary to continue here with the automatic monitoring. Nevertheless, based on some uncertainity given by frequent failures of the measurement, we recomend to verify our conclusions by systematic handy monitoring over 3 year period. The measuring points must be installed as close as possible and have the possibel close geometry like we have today.

VI. Common conclusion for both localities

The automatic measurement has been frequently interrupted and corrected. Due to this, evaluated time series were not continuous and, it was necessary to join them and to shift them onto the “standard zero”. This is why our conclusions are not clearly evidential but, they are only probably.

At both localities, it was necessary to assure security. Due to this fact, it is necesary to continue with control monitoring on both localities. But, it is not necessary to use automatic units with transfer of gained data, because there is a very high request on maintenance and data transfer. It will be enough to use a handy dilatometric monitoring as usually done at most localities in the National Park.

High frequencies and periodic intervals in reading of automaticaly measured values have made it possible to use correlogram of changes between measured distances and temperatures as an alternative method. This method has proven to be very useful namely for discovering of errors, including bad setting of the common zero level for different time series and also errors caused by bad function of the electronic convertor or slipage in mechanisms of sensors.

Literature:

Zvelebil, J. Paluš, M. Novotná, D. (2006): Nonlinear Science issues in the dynamics of unstable rock slopes: New tools for rock fall risk assessment and early warning. In: Cello, G. Malamud, B. (eds): Fractal Analysis for Natural Hazards. Geological Society Special Publication No. 261, Chap. 6, 79 - 93. The Geological Society Publishing House, London.

Zvelebil, J. Vařilová, Z. Paluš, M. (2008): New challenges for mathematics in Safety Monitoring of Rock slopes. Textbook “Geotechnical days 2008” ČKAIT, ČAIG, Ústí n/L.

Vařilová, Z. Zvelebil, J. Paluš, M. (2010): Complex system approach to interpretation of monitoring time series: two case histories from NW Bohemia. Landslides,7,1, http://www.springerlink.com/content/110832/