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RESEARCH OF GEODYNAMIC ACTIVITY IN THE VICINITY OF OBŘÍ HRAD, ŠUMAVA MTS.

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ABSTRACT
Following article deals with the research of recent and historical activity of geodynamic processes in vicinity of a famous archaeological site at Obří Hrad in Šumava Mts. The geomorphological mapping, structural measurements and dilatometric monitoring were the chief investigation methods. Though the research is not completed yet, certain clues suggest persistent activity of geodynamic processes in the studied area.

KEYWORDS: Geomorphological mapping, exodynamics, dilatometric measurement, landslides, Obří Hrad, Šumava Mts.

INTRODUCTION

The studied area is situated in the southeastern Bohemia in the Šumava Mts., where it spreads along the Losenice River in the vicinity of Kašperské Hory Town. As a core area of interest is perceived the prominent, outstretched spur of Valy Hill called Obří Hrad, where remains of the Celtic fortification are located (Fig. 1). Whole area of interest is protected within the Šumava National Park, some parts even as the first, most protected zone (Obří Hrad, Šafářův vrch).

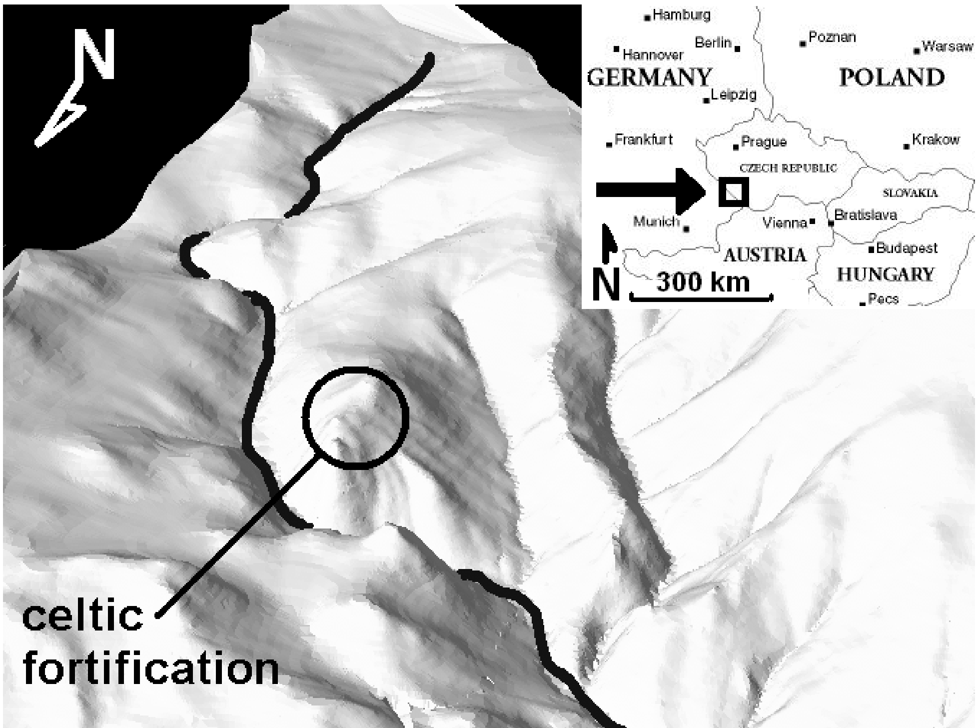

Fig. 1 Position of studied area within the Czech Republic, and Losenice R. catchment (digital elevation model, vertical exaggeration 1,5x)

Obří Hrad is primarily an important archaeological monument. It is, however, an attractive site for geodynamic research as well (Zvelebil 1999). Steep spur with the fortifications bears the traces of both ancient and recent slope movements. Large slope deformation has developed in the slopes of Valy Hill due to significant fracturing of the rock massif, which is rather unique in the Šumava Mts. (Záruba, Mencl 1987). Depth of the massif disturbance was proven by geophysical research, carried out by Beneš et al. (2002).

Most prominent shape is a rock outcrop called "Brána" (the Gate). It is built in the Celtic fortifications and forms its northernmost point. Within the Celtic citadel there are a number of disturbed and broken outcrops. At some of them, their original position and directions of fall can be reconstructed. It shows that many of them fell rather curiously against the slope orientation. Preliminary reconstruction suggests a dynamic triggering impulse (Zvelebil, Slabina 2002), coming from the southeast. Due to the presence of the archaeological structures, this locality is rather unique for estimating of the timing and intensity of the geodynamical events.

GEOLOGICAL CONDITIONS

Geologically, the studied area is a part of the south-bohemian Moldanubicum unit, a crystalline complex of metamorphic and igneous rocks, predominantly of Paleozoic age. Here in particular, it is the Monotonous unit of Moldanubicum that forms the bedrock (Kodym ml. et al. 1961).

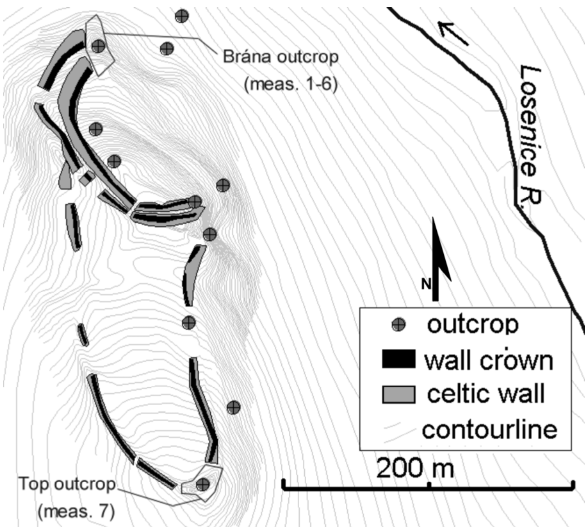

Fig. 2 Archaeological site of Obří Hrad with position of the dilatometric measurements

Metamorphic gneisses of various types are the most common bedrock type in the area of interest, most widespread being sillimanit-biotitic paragneiss and biotitic orthogneiss (Müller, ed., 1999). Their common characteristic is a significant foliation, which strongly influences mechanical behaviour of the rocks.

ARCHAEOLOGICAL SITE

The archaeological site of Obří Hrad, the highest situated Celtic site in Czech republic (940-981 m.a.s.l.), is well known to local people since the medieval times, as is documented by many histories and legends, bound with the site. Even its name Obří Hrad (Giants´ Castle) has originated from one of the legends.

The modern archaeological research started with the 20th century, since when several generations of archaeologists worked on the site, including Šimek, Streitová, more recently Horpeniak, Waldhauser and Slabina.

The fortified Celtic citadel reaches approximately 370 m in length and about 80 meters in width. It consists of a forecastle, encircled by outer wall, and of a citadel, semi-encircled by two belts of walls (Fig. 2). The walls are up to 2-7 m high and, according to archaeological research, in the outer wall the stones were aligned to form a smooth surface (Slabina et al. 1990). As a material, the builders used local gneiss stones. Rather curious is the unclosed ring of fortification, which suggests discussion about the cause of the missing walls.

MORPHOMETRIC PROPERTIES

The area in question is spread on the outer slopes, encircling the levelled surfaces of the Šumava Plains, where the higher parts of Šumava descend towards Pošumaví Hills (Fig. 3). Consequently, the slopes are considerably steep even in a very generalized overview. The steepness is locally even enforced by the deep incision of the Losenice River, which quickly loses altitude after leaving the spring area upon the Šumava Plains, so that by the spur of Valy Hill under Obří Hrad the slope inclination in the narrow, deep valley exceeds 50° (Fig. 4).

The longitudinal profile of the Losenice River (Hartvich 1999) shows two principal steepest segments of the profile: On the queer, significant half-arc approximately 2 km above Popelná and just under the Obří Hrad site, where the Losenice River turns towards west (Fig. 5). Possible cause of the anomaly may be either tectonic fault, litho logical inhomogenity, backwards erosion or other (Hartvich 1999).

After the recent field research and monitoring, the author is inclined to explain the anomaly by the fact that the river is cutting through the accumulations of the slides, which occurred on the NE slopes of the Valy hill. As the accumulations cause noticeable irregularity in quite a coarse longitudinal profile, it is

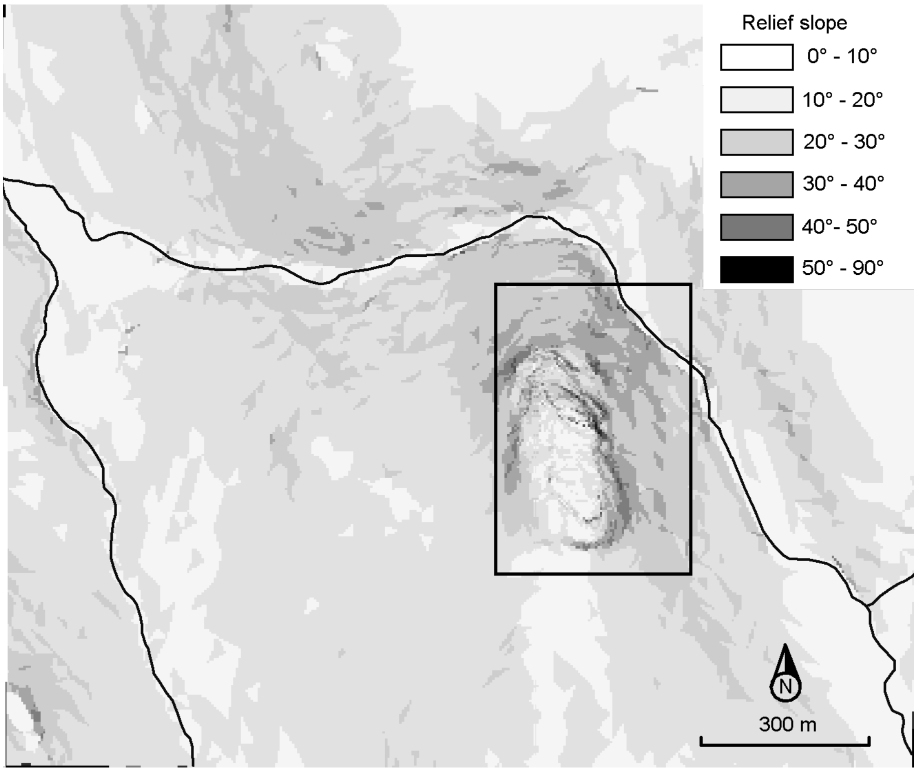

Fig. 3 Slope inclination in the vicinity of Obří Hrad based on DEM. The rectangle indicates the archaelogical site and its steep northeastern slope

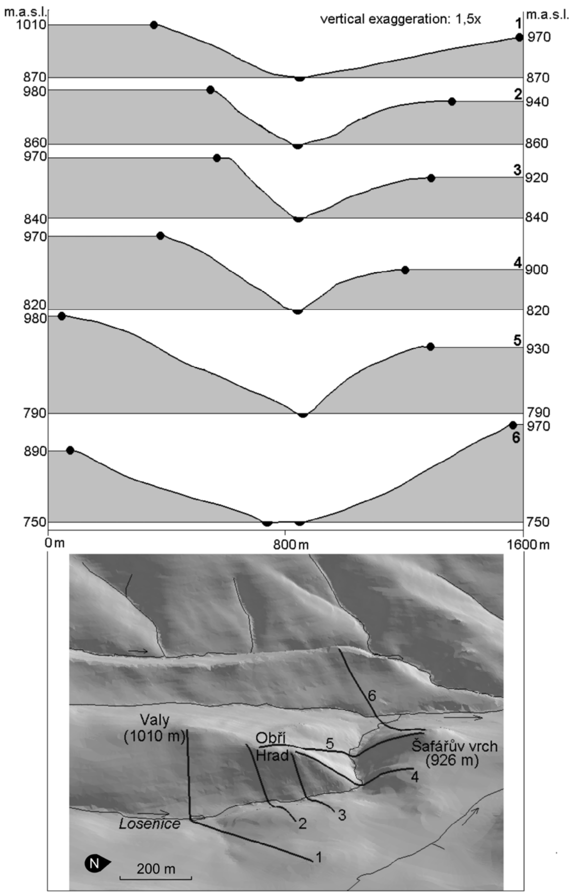

Fig. 4 Transversal profiles through Losenice R. valley

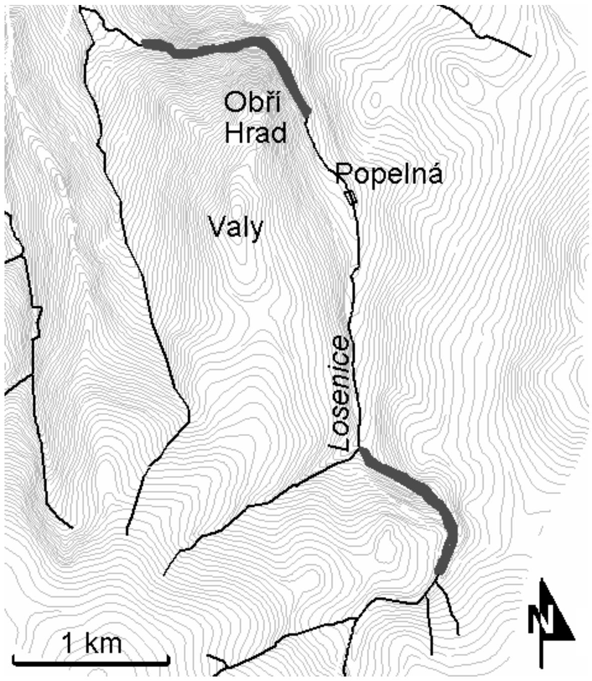

Fig. 5 Steepest segments in the longitudinal profile of the Losenice R.(thick line)

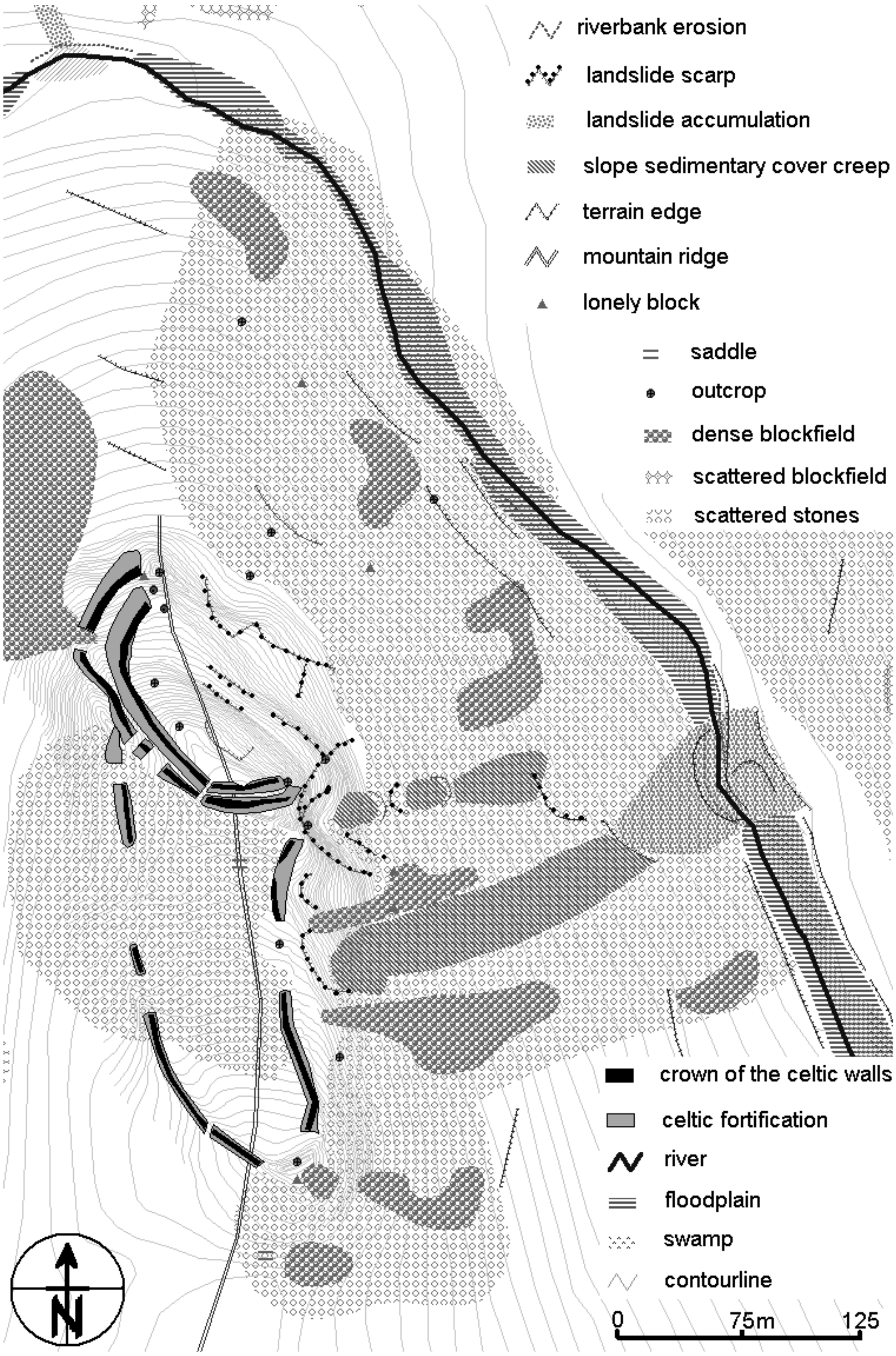

Fig. 6 Selected geomorphological elements on eastern slopes of Valy Hill

to be believed that the activity of the mass movements has not ceased yet, particularly when we take into account the massive erosive power of the 2002 flood on the Losenice River. This statement is supported by observations of archaeologists, who have been working in the area for many years and who claim certain observable changes of the rock structures since the 1980s (Slabina 2003).

GEOMORPHOLOGICAL MAPPING IN THE VICINITY OF OBŘÍ HRAD

The initiate campaign of GPS - assisted geomorphological mapping in the scales 1: 5000 and 1: 10 000 was carried out since autumn 2003 till summer 2004. During the mapping, the locality of Obří Hrad and its vicinity was examined for the traces of geodynamical activity both in the past and in present. Special geomorphological map (Fig. 6) shows selected shapes and forms.

Among the most significant geodynamical processes, documented during the mapping, was the occurrence of landslides. There are several important conditions that predispose the development of mass movements upon the flanks of the Valy Hill: steepness of the slope, undercutting by the Losenice River, tectonic predisposition of the scarps and structural parameters, namely foliation orientation and dip in the gneiss layers.

The most interesting is the existence of landsliding on the eastern slope of Valy Hill, just under the Celtic structures. From a reconstruction map (Fig. 2) we can see that almost a half-circle of the walls in the eastern side of the citadel (inner castle) is missing. The citadel in this area is limited by a series of scarps and extremely steep slope (up to 65°). Even though there are no fresh slope accumulations directly under the missing part of the fortifications, the presence of several levels of clear scarps in the upper part of the slope may indicate if not recent, then at least not very old activity. The accumulations would be already cleared away by the activity of the Losenice River (probably mostly during flood periods), which is rather strong in a narrow, steep valley.

STRUCTURAL PARAMETERS

During the geomorphological mapping, a measurement of structural properties, particularly fissure orientation and foliation strike and dip, was carried out on several outcrops in the vicinity of Obří Hrad site. In total, 745 fissure orientations were recorded on the outcrop of the Gate, on the outcrop at the top of the site and on smaller outcrops, spread in the surroundings.

Two prevailing systems of fissure directions were discovered (Fig. 7). Most significant is the fissure system of complementary directions NNE – SSW and ESE - WNW, which also shapes outer form of the Brána outcrop (Fig. 7).

The second system consists of NNW – SSE and WSW – ENE fissures. This system is not visible on the shape of the outcrops; the fissures of this direction are, nevertheless, present on all outcrops. This orientation is very similar to valley directions in the neighbourhood of Obří Hrad. It is to be presumed that this system might be probably predisposing the general terrain structure. Definitive conclusion must, however, wait for finishing and analysis of the fissure measurements on outcrops in wider surroundings.

Foliation order showed on all the outcrops similar characteristics. The foliation surface strike varies between 120° - 160°, keeping thus the foliation sloped approximately towards northeast. This fact has a strong influence on the slope development. The dip is notably lower in the top outcrop, where it reaches only around 20°, while in the very neighbourhood of the Gate the dip raises up to 30-35°. It is to be presumed on evidence of relief properties that further down slope it may rise even higher (40-45°), though for the instability of outcrops (and therefore

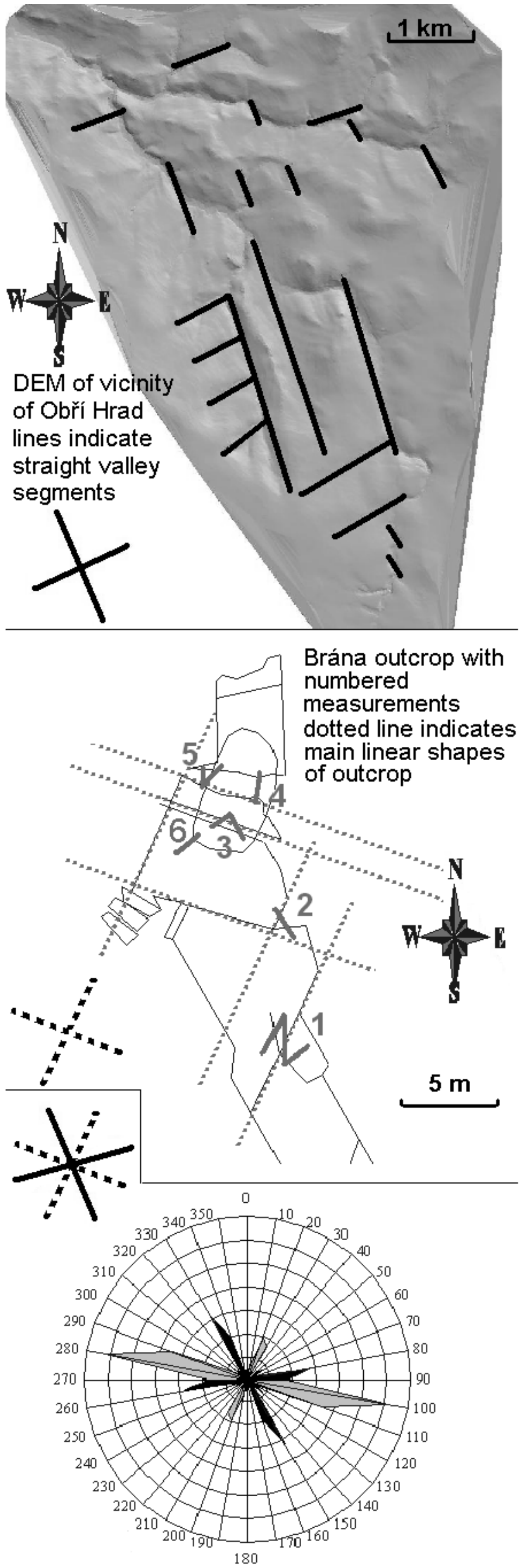

Fig. 7 Structural parameters in vicinity of Obří Hrad:
Top – linear valley segments
Center – scheme of Brána outcrop
Bottom – Cloos rose diagram of the strike of measured fissures (262 measurements)

impossibility to measure the foliation parameters) it is difficult to prove.

MONITORING

The recent geodynamic activity on the locality of Obří Hrad is being monitored by a system of dilatometric measurements, installed in August 2003 on the outcrop of the Gate and the top outcrop within the area of archaeological site. As a measuring device, portable dilatometer type Holle is being used. The reading of it is very easy to perform and its precision reaches 0,1 mm. There are in total 12 measurements in 7 groups, devised so that it is possible to observe relative movements of particular blocks (Fig. 7, center).

The readings are realized approximately once a month and a relative change of two fixed points is then calculated, taking into account also the temperature, which affects the values by thermal extension of the dilatometric bar. Temperature is a very important factor in monitoring, for a thermal extension of the rock mass strongly affects the dilatation of the fissures. A typical cycle on a dilatometric site, where the only cause of differences is the rock thermal extension (i.e. there are no tectonic, gravity or other influences), follows the course of the temperatures in a sinus-like curve, where the highest values (widest cracks) are found in the winter and early spring, when the rock mass shrinks, and the lowest in the summer due to extension of rock in the warm period.

Due to a short measurement period, which has only now exceeded one year, it is yet premature to derive definite conclusions concerning the relative movements of particular blocks. It is possible, however, to observe certain trends in the general behaviour during the yearly cycle.

As an example, we can take the measurements from the outcrop on the top of the crest (Fig. 9), which forms the southernmost and highest part of the fortifications (Fig. 2). We can see the different behaviour of the 7A and 7B measurements in regard to temperature (Fig. 8). For the measurement 7A, any activity can be traced only during the warm period of the year, basically when the temperature exceeds 10°C. 7B, on the other hand, was the most active during the coldest winter period. It will be very interesting to observe the behaviour of these two measurements during next winter, to check if there is any regularity in the activity periods and – if so – to try and explain the cause of this behaviour.

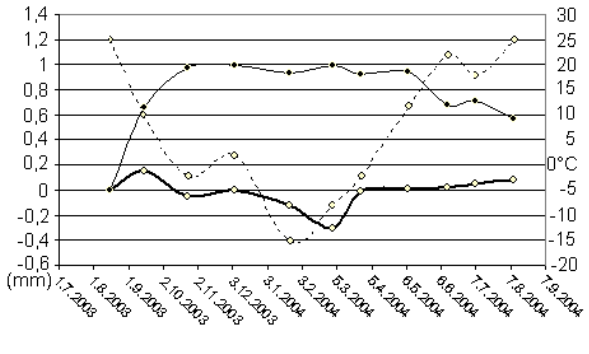

Fig. 8 Dilatometric measurements 7A (thin line), 7B (thick line) and temperature course (dotted line)

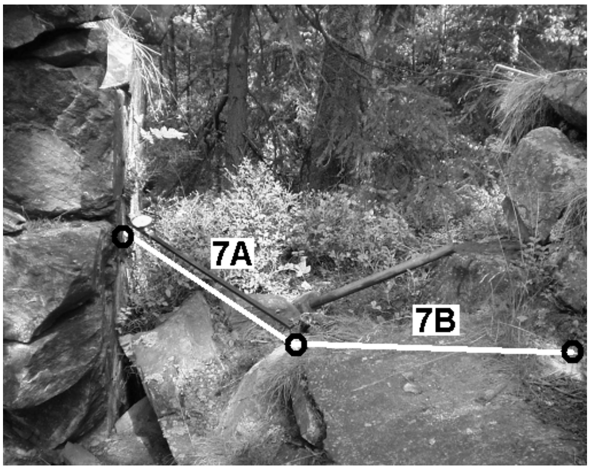

Fig. 9 Situation of dilatometric measurements 7A and 7B

CONCLUSION

From the mapping experience, facts and data discussed above, we can conclude that the geodynamic activity is still active in the area of interest. We found out that the sliding under Obří Hrad is influenced both by morphology of the relief and tectonic structures.

Continuation of the measuring together with further geomorphological mapping of the surrounding area, data analyses and GIS data mining may lead to formulation of the hypotheses on the historical and possible future development of the relief on the site.

Even though, as was stated above, the monitoring period is too short to make exact prognoses and conclusions, the development on some measurements is already highly interesting and curious. It is to be hoped that the measurements will continue to yield such valuable data. We also consider the installation of the extensometric measurements, another quantitative tool for assessing the present day activity of the geodynamic processes.

ACKNOWLEDGEMENTS

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