

THE RESEARCH OF VERTICAL DISPLACEMENTS OF THE ROCK MASS INSIDE AND IN ENVIRONMENT OF THE BEARS' CAVE IN KLETNO

The Bears' Cave in Kletno is the most beautiful cave in Poland. Students of Geodesy and Cartography at the Agricultural University of Wroclaw take level survey of the Cave during their training camps of the Scientific Circle of Geodesists for over twenty years. The study is used to scientific research of the Sudetes, as well as to estimate the degree of security of tourist routes in the Cave. The measurements are taken with precise level equipment and additionally, readouts are rectified by laboratory tests. The Cave area is characterised by complex geologic structure. Two tectonic faults are situated in close of the surroundings Caves. Results of the studies show instability of geologic-tectonic structures on analyzed area.

Медвежья пещера в Клетно является самой живописной пещерой в Польше. Студенты-геодезисты и картографы Вроцлавского сельскохозяйственного университета уже более 20 лет проводят нивелирование пещеры во время учебных практик. Исследование проходит в рамках изучения Судетов, а также для оценки степени безопасности туристических маршрутов внутри пещеры. Замеры проводятся с использованием высокоточных нивелиров, а полученные результаты уточняются лабораторными испытаниями. Пещера характеризуется сложным геологическим строением. В окрестностях пещеры расположены два тектонических разлома. Результаты исследования подтверждают нестабильность геологических и тектонических структур на изучаемой территории.

Introduction

Bears' Cave (Jaskinia Niedzwiedzia) in Kletno has been in scientific care of Agricultural University in Wroclaw for 21 years. Geodetic measurements are performed in a cyclic way, every year in July and are designed for obtaining reliable information about geologic activity of massif in Cave locality.

The survey enables description of deformation of the massif that has complex geologic structure, in the lens of crystalline limestone at the contact point of Snieznik gneiss and mica slate in the area of numerous tectonic faults (Fig.1). It makes possible to estimate the degree of security of tourists visiting the cave, especially taking into account the fact that more and more tourist visit this place every year.

Characteristic of the cave

Bears' Cave is situated on the slope of Stroma Gora (Steep Mountain), in the valley of Klesnica stream near Kletno in Snieznik Klodzki Massif, which is the part of Eastern Sudetes, in southwest part of Poland.

The Cave started coming into existence about one billion years ago. It was explored in 1966 and made available for tourists in 1983. It's the biggest cave in the Sudetes. It has three levels that are connected with chimneys. The total length of tunnels amounts 2,5 km (1,5 miles) and vertical range between the highest and the lowest point amounts up to 60 m (65 yards). It's the most wonderful cave in Poland with impressive number of beautiful stalactites, stalagmites and very rare helictites,

dripstones resembling tree-roots hanging down from the roof. 90 % of bones found inside, belonged to cave bears (*Ursus speleaus*), hence the Cave name. Temperature in the cave remains at 5-6°C and the relative humidity almost 100 %.

The precise levelling network and the measurements

The measurements are performed inside the cave, as well as, at the surface of the terrain. First benchmarks were established in 1984 and their localization was correlated with the geologic-tectonic structure, the structure of the

massif fissures and the situation at the surface on the terrain and in the cave. 23 control points inside and 24 outside the cave formed a network of the precise levelling (Fig.1, 2).

The measurements in cycles I and II showed instability of the entrance pavilion; visible scratches on the walls and cracks on the floor of the pavilion confirmed it. To measure the subsidence of the pavilion additional network of benchmarks there were established: eight points inside and five outside the pavilion (*Cacoń, Mąkowski, 1989; Geodetic..., 1985-2005*). The network has been modernized many times and now levelling network has 70 points.

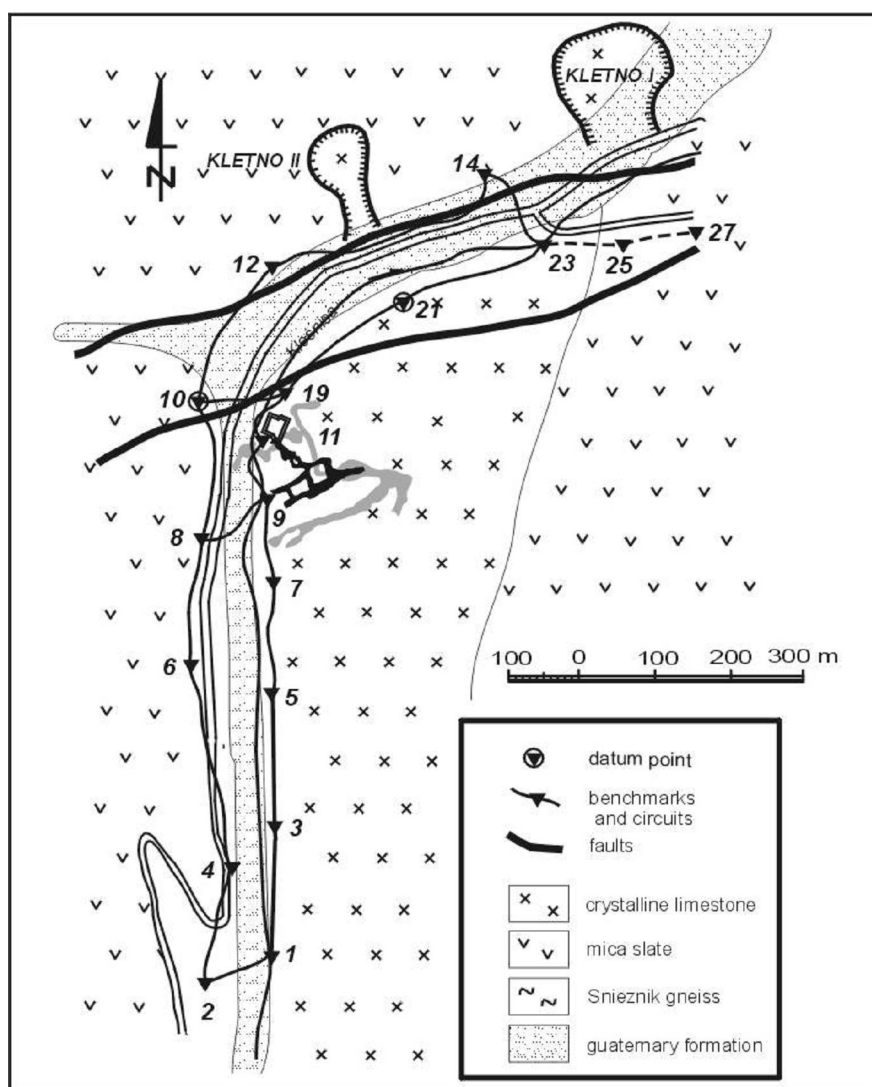


Fig.1. Localization of levelling circuits benchmarks, established in Cave surrounding (Geodetic..., 1985-2005)

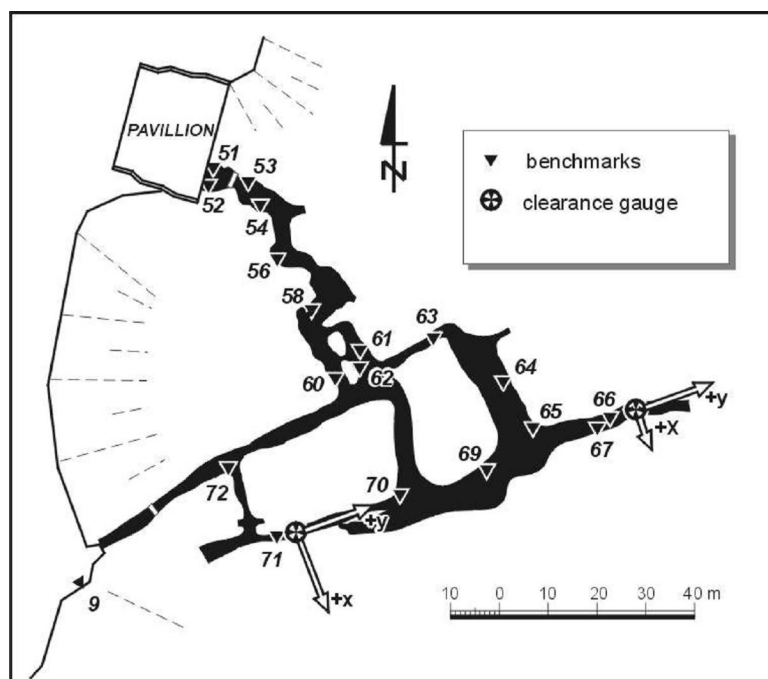


Fig.2. Localization of benchmarks inside the Cave (Geodetic..., 1985-2005)

The measurements are performed with Ni 005 and Ni 007 precision levellers Carl Zeiss Jena and with the use of precision levelling staff sets and wedges. Each levelling section is measured twice in the main and return direction, with the change of the height of aim axis at the post. The calculations are evened according to C-Geo programme basing on permanent points 10 and 21 selected with the use of analyses (Geodetic..., 1985-2005).

To increase accuracy of research, measuring staffs were compared by means of comparison with model staff. In laboratory tests stu-

dents took readings on model rod and on staffs used in measurements. Differences between the readings were drawn on graphs in relation to the value of readings and quadratic functions were fitted into. Hence we have the quadratic equations for every examined staff (Fig.3). The staffs' readings that we obtain during the measurements, in the next step are corrected according to these functions (Piotrowicz, 2005).

Despite numerous net modernizations, there have been no changes in the net form since 1997. By the reason exactly 1997-2005 period is analyzed in this research.

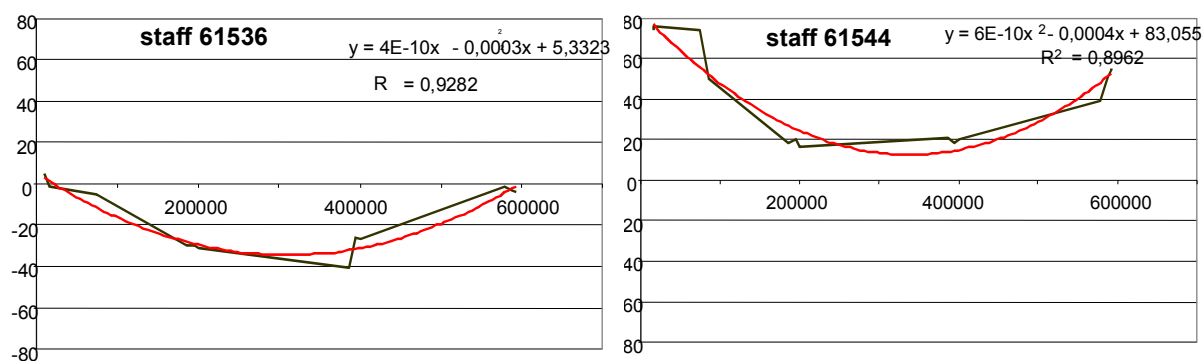


Fig.3. Graphs of invar bands' deviation from standard with fitted trend (Piotrowicz, 2005)

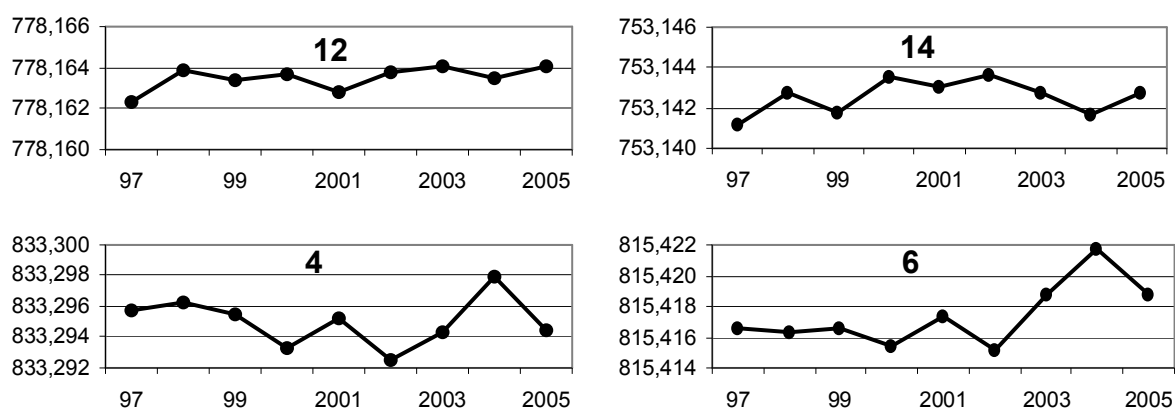


Fig.4. Vertical movements of benchmarks situated in the cave surroundings

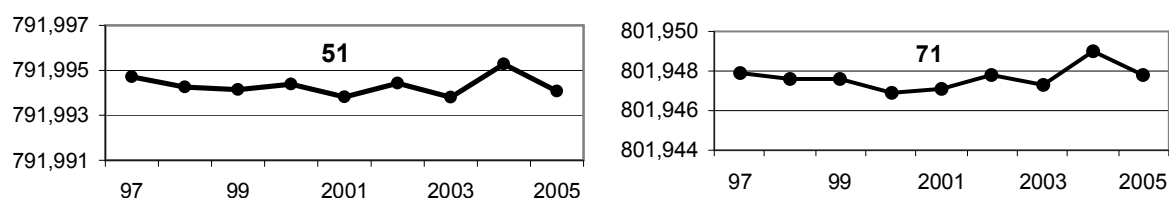


Fig.5. Vertical movements of benchmarks situated inside the cave

Results of the research

Benchmarks heights changes, determined in analyzed period, correspond with geologic-tectonic structure of the area. Displacements of benchmarks 12, 14 that are situated in mica slate in front of the lower fault, take similar course; so benchmarks 2, 4, 6 that are situated in mica slate too but above the faults line, and 1, 5, 7 established in crystalline limestone (Fig.4). Relative benchmarks heights changes inside the cave are not considerable, either (Fig.5).

The existence of groups with similar displacements courses indicates the changes between datum points that form a quasi-permanent configuration. Without connection in an external, permanent precise levelling network we analyse relative displacements only.

Conclusion

Similarity regarding the changes of points in the same geologic structure and, simultaneously, differences for points situated in various structures, suggest relative instability of geologic-tectonic structures on the research area. This conclusion is confirmed by another re-

searches (Cacoń, Kaczalek, Mąkolski, 1989; Cacoń, Košťak, Mąkolski, 1996).

The results obtained prove that investigation involving the measurements conducted in the Bears' Cave is necessary and should be continued.

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