

## STUDIES OF ROCK BLOCKS DISPLACEMENTS ON THE UPPER EDGE OF THE “SZCZELINIEC WIELKI” MASSIF

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(Received July 2005, accepted August 2005)

### ABSTRACT

The studies of rock block mass movements on the “Szczeliniec Wielki” were started in 1972, when local geodetic network was established, in front of a shelter-house. Analogous observations are performed in the “Piekielko” fissure. These measurements are irregularly made, the last were realised in September 2004. Apart from the local geodetic network, three crack gauges (TM-71) were established in the survey area. The first in 1974 in front of shelter-house, the second in 1979 in the “Piekielko” and in 1998 near the “Stare Schody”. The results of repeated geodetic measurements and TM-71 observations series show mass movements of rock block in the survey area. The interpretations of these results indicate tectonic instability of the “Szczeliniec Wielki” Massif and paleoseismic character of observed changes in the upper part of the “Szczeliniec Wielki” Mt.

**KEYWORDS:** rock blocks displacements, geodetic measurements, relative measurements

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### 1. INTRODUCTION

The layered geological structure and unfavourable hydrogeological conditions foster instability of the “Szczeliniec Wielki” Massif. The mechanism behind mass movements occurring there rests on squeezing plastic material (marl) from under the hard rock blocks (cretaceous sandstone) with simultaneous inclining and sliding of these blocks. The phenomenon is accompanied by strong wind and water erosion (Pulinowa, 1989). The geodetic measurements of rock block movements carried from 1972 onwards serve, apart from, cognitive value also, assessing the threat to the safety of intensive tourist activity on this object. To determine these displacements a three segment control and measurement system has been established (Cacoń, 1980), consisting of a spatial network covering the entire object, local control and measurement networks set up in the most endangered places and three crack gauges of which two are located in the upper edge of the Massif and the third one in the “Stare Schody” area at the foot of the Massif's upper stage (Fig. 1). In the study results of measurements realised in local control and measurement networks and the latest determinations of relative displacements registered with crack gauges are presented. The results of measurements obtained in spatial network, not being the subject of this article, have been given among

others in (Cacoń, Košťák 1987; Cacoń et al., 1994; Cacoń et al., 2003).

### 2. RESEARCH OBSERVATIONS IN LOCAL CONTROL AND MEASUREMENT NETWORKS

The measurements in 1972 were started with local angular-linear and elevation net being established in the most threatened area by the tourist shelter-house. The net, shown in Fig. 2, is made up of 4 observation stations and 14 controlled points. Angular, linear and levelling measurements are performed in this control and measurement network. During the first period of studies observations have been realised twice a year and to this moment altogether 13 have been made (1972, 1973A, 1973B, 1974A, 1974B, 1975A, 1975B, 1976A, 1976B, 1985, 1987, 1993 and 2004).

Significant horizontal and vertical displacements of the controlled points determined for the whole research period (1972-2004) have been shown in Fig. 3.

Analysing the results presented in Fig. 3 it can be found that in the given period of time significant horizontal displacements of most of the studied points and lowering of all the controlled points has happened in the investigated object. The direction of determined horizontal displacements might point to sliding rather than deviating of the rock block on which the tourist shelter house has been built.

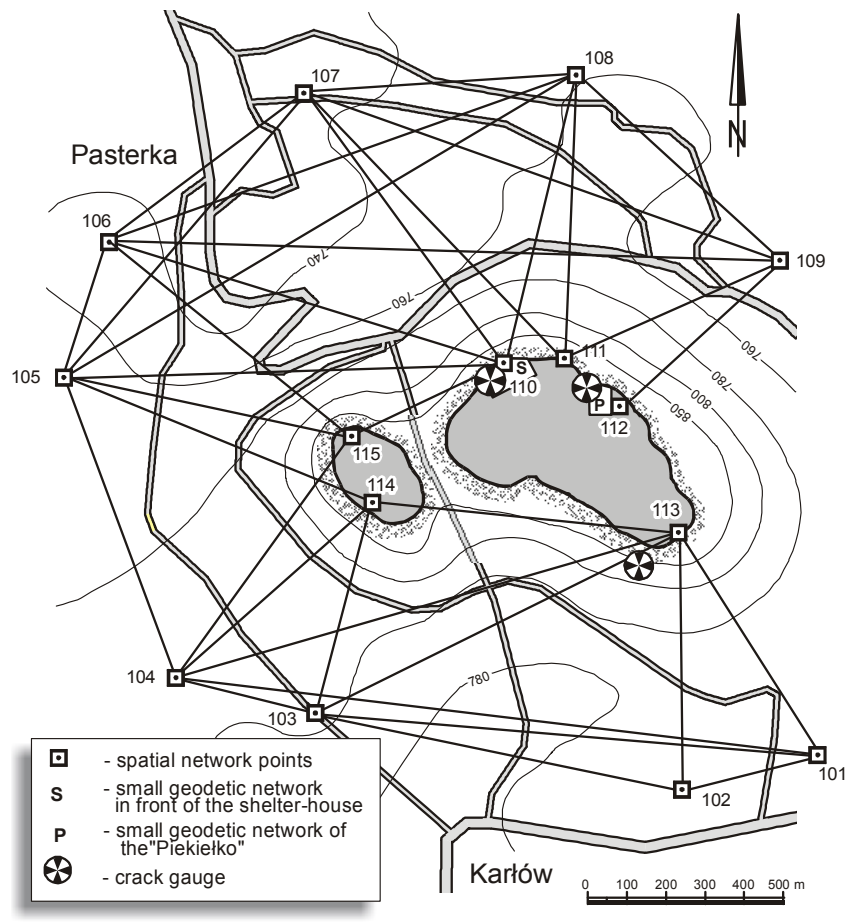


Fig. 1 Scheme of the “Szczeliniec” measurement network

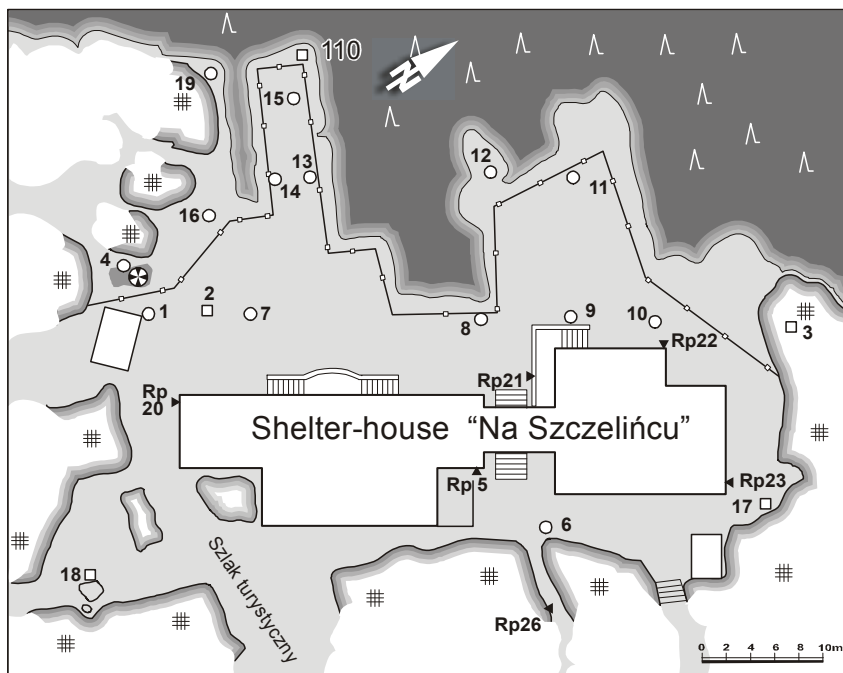
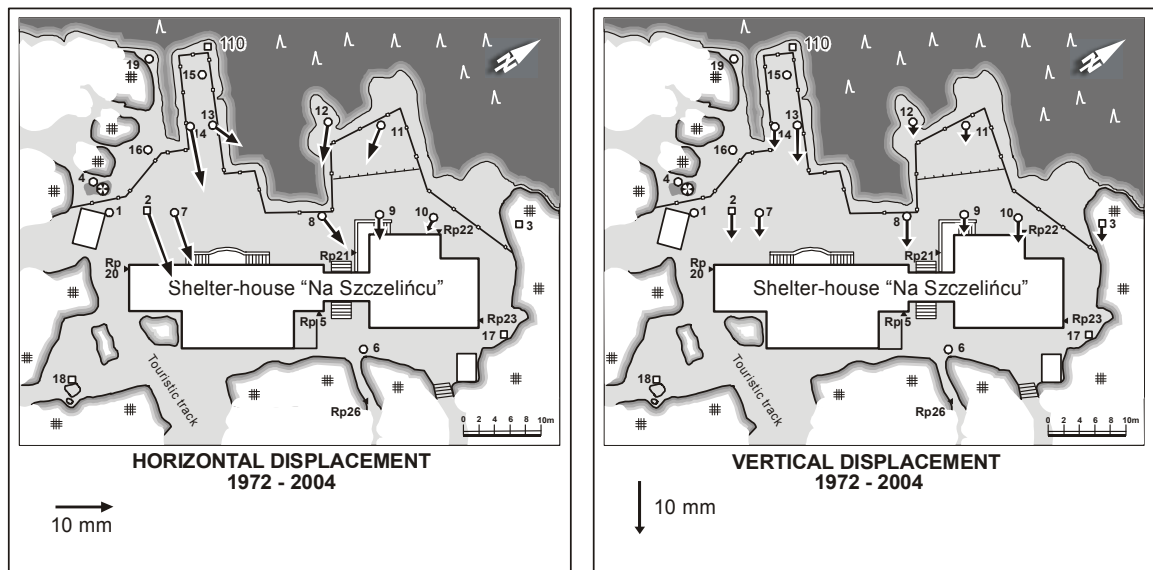
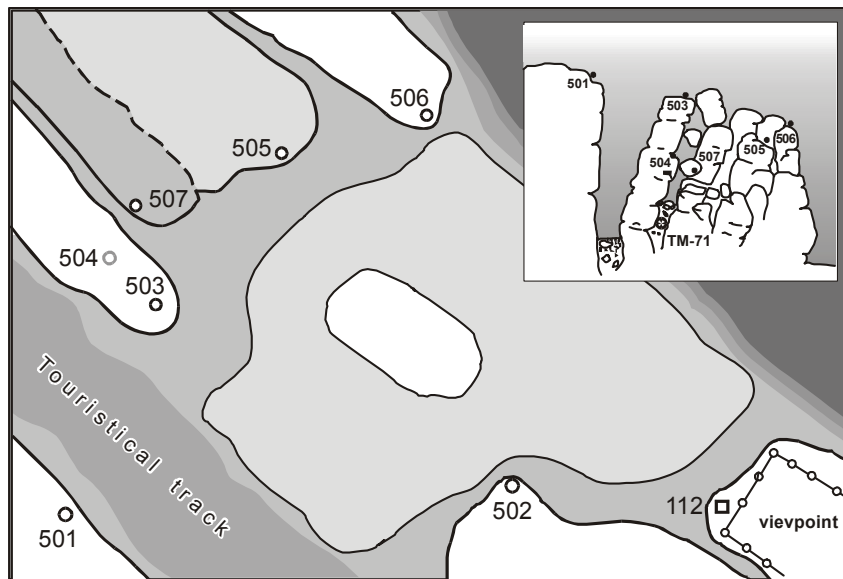


Fig. 2 Scheme of the research net by the “Na Szczelincu” shelter-house



**Fig. 3** Horizontal and vertical displacements of the “Schronisko” network points in the 1972 to 2004 period



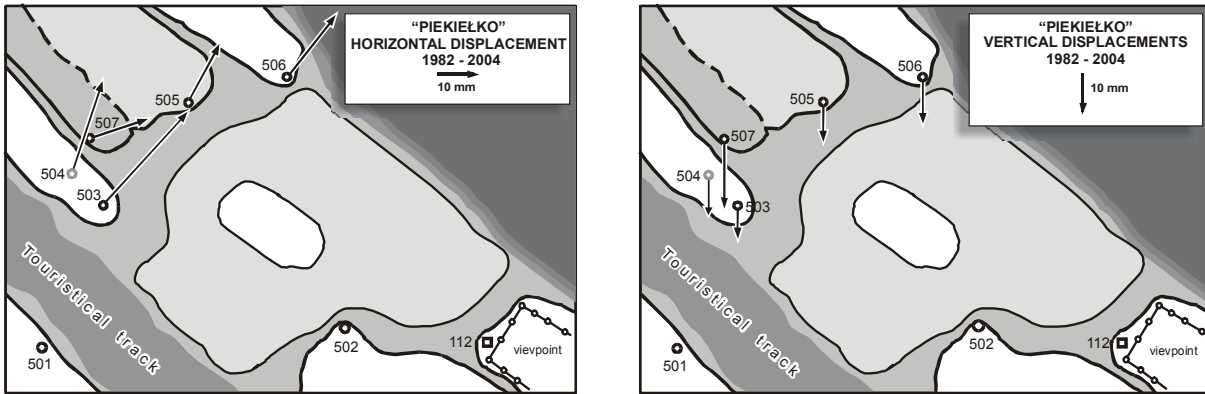
**Fig. 4** Scheme of the “Piekielko” measurement network

Since the 1982 the rock blocks displacement studies have been extended on measurements in a large edge like fissure – the “Piekielko”, which is one of the major sightseeing attractions on a tourist trail (Fig. 4). Another control and measurement net consisting of 7 controlled points and based on the point no 112 of the spatial network has been established there. As in the case of the network set up in front of the shelter-house angular, linear and precise levelling measurements are realised there. Altogether 11 measurement cycles have been performed in the

following years: 1982, 1983, 1985, 1987, 1988, 1989, 1990, 1991, 1992, 1993 and 2004.

The displacements of rocky sandstone blocks registered during the entire study period (1982-2004) have been shown in Fig. 5.

Analysing the results presented in Fig. 5 it can be established that in the studied period significant horizontal displacements and significant lowering of all the controlled points has happened in the investigated object.

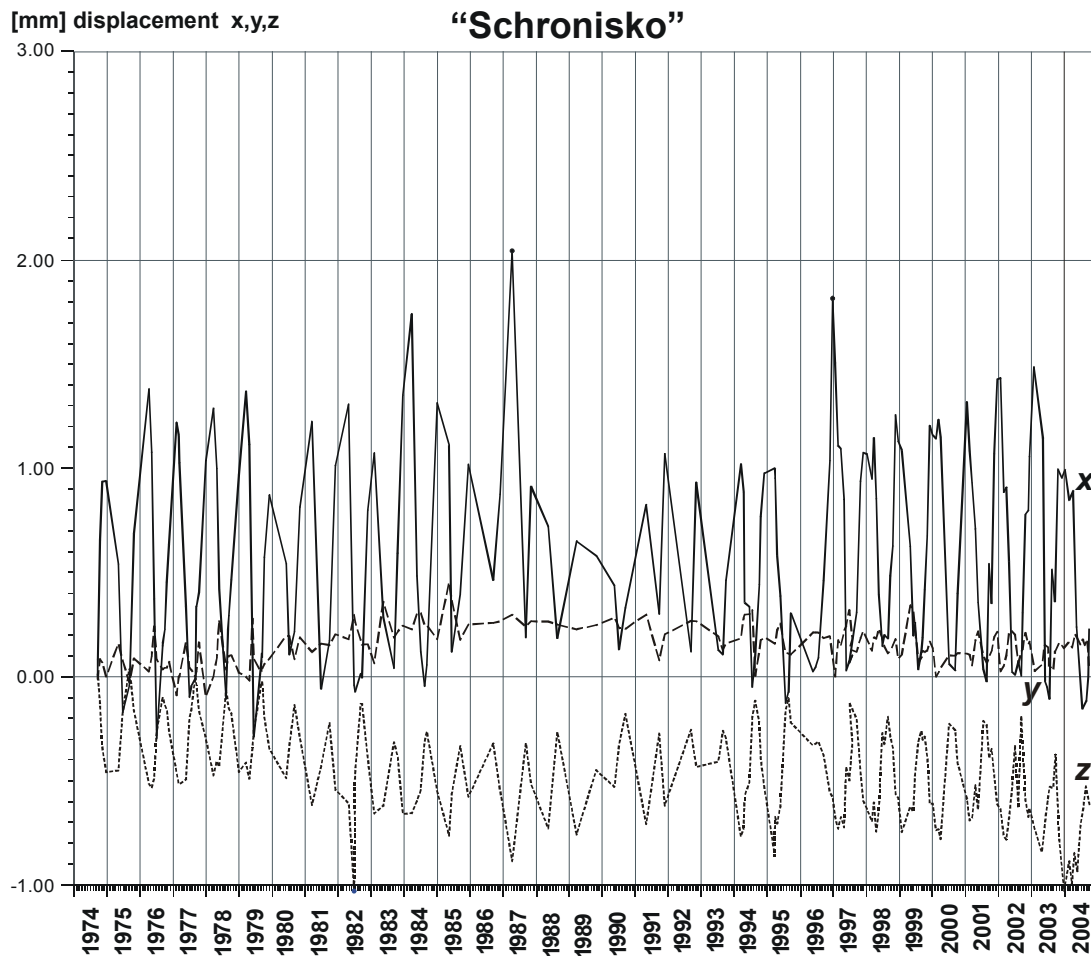


**Fig. 5** Horizontal and vertical displacements of the controlled points in the “Piekielko” network from 1982 to 2004

### 3. OBSERVATIONS OF RELATIVE DISPLACEMENTS WITH THE TM 71 CRACK GAUGES

To determine precisely relative displacements of rock blocks geodetic measurements have been augmented with relative observations realised with TM 71 crack gauges. As has been already mentioned the first crack gauge was installed on the object in

1974 in the tourist shelter-house area, the next one in 1979 in the “Piekielko” and the third in 1989 near the “Stare Schody” (Fig. 1). The readings from these instruments are taken periodically. The observation results are in accordance with the guidelines described in the paper (Košťák, 2001). The graphical representation of relative displacements of rock blocks has been shown in Figs. 6 to 8.



**Fig. 6** Results of observations from the “Schronisko” TM 71 crack gauge

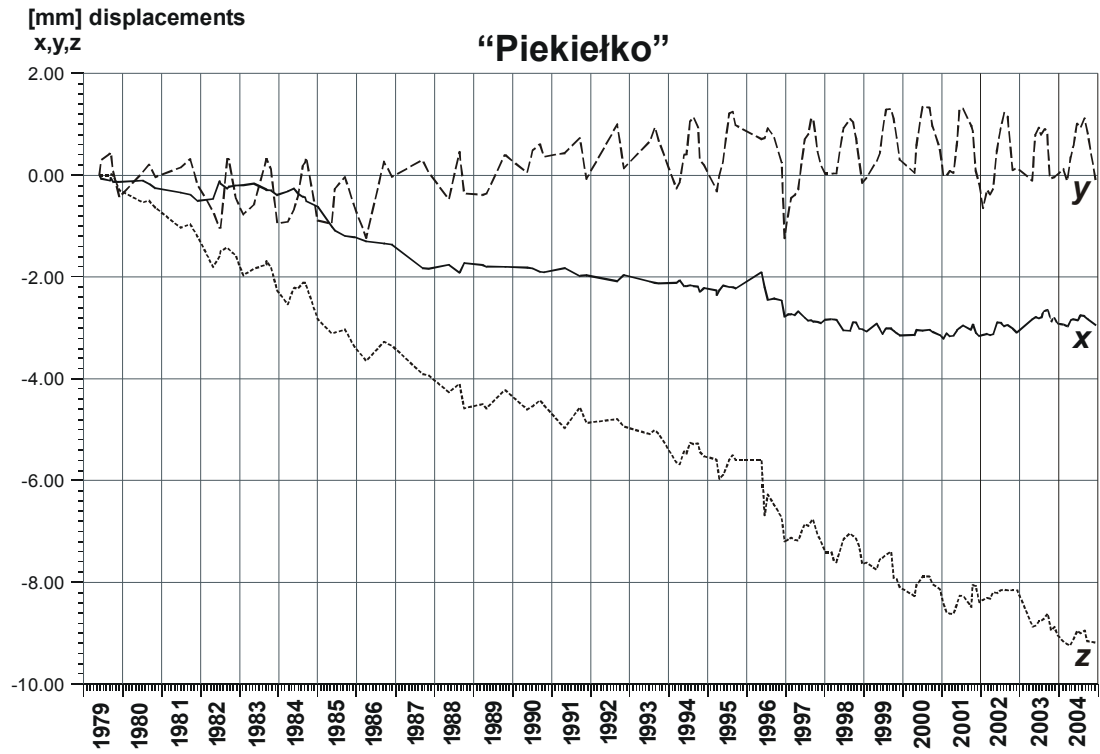


Fig. 7 Results of observations from the “Piekiełko” TM 71 crack gauge

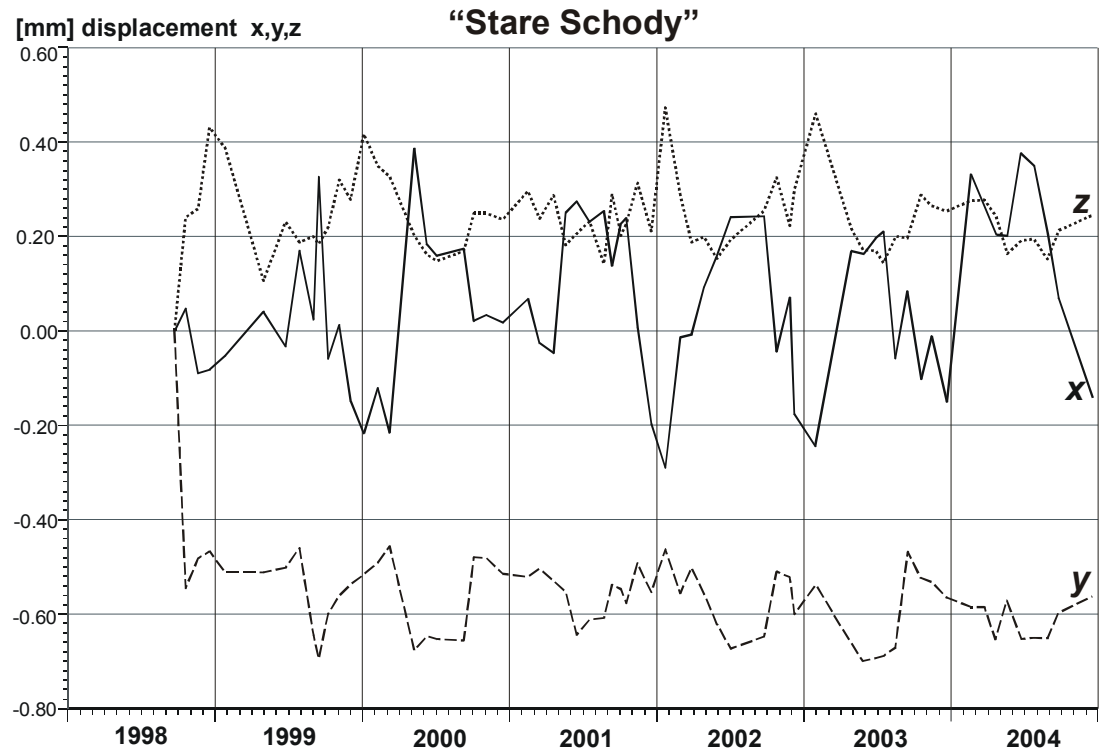


Fig. 8 Results of observations from the “Stare Schody” TM 71 crack gauge

Relative displacements registered with crack gauges indicate mainly periodically repeating changes, in yearly cycles. Only the crack gauge installed in the "Piekiełko" records progressive vertical and horizontal (extension) movements. These changes confirm displacements of the points no 504 and 507 which have been determined geodetically.

#### 4. CONCLUSIONS

The geodetic studies of rock blocks displacements of the "Szczeliniec" object have been realised for 32 years now. During this time various measurement techniques have been employed and the ones used presently allow determining displacements of controlled points with ever increasing accuracy. This accuracy improves with increasing density of the measurement "constructions" used. Considering the sandstone blocks mobility in the edge zone of the "Szczeliniec Wielki" Massif which is determined particularly in the "Piekiełko" fissure area, the continuation of such studies is necessary.

#### ACKNOWLEDGEMENTS

Research was supported by COST project No. 625, "3D MONITORING OF ACTIVE TECTONIC STRUCTURES".

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