SEARCHING FOR INTERRELATION BETWEEN DEFORMATION AND STRESS DISTRIBUTION IN THE SHALLOW BASEMENT

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Abstract

Geodynamical studies of the area of the Pieniny Test-field have been engaged both geodetic and geophysical methods since 1970. The paper discusses probable relationship between deformation observed on the surface and stresses in the shallow basement.

1. Short History

The Pieniny Klippen Belt is a tectonic formation separating the outer from the inner Carpathians. The geodynamic Test-field of the PKB is situated close to the Polish/Slovak border (Czosztyn/Niedzica area).

The following studies were executed in two periods of 1970-1974 and of 1978-1980 (for results see CZARNECKA, 1988a, 1988b):

- ✓ precise levelling (repeated once-a-year)
- ✓ measurements of the inclination of the river terraces and geomorphologic studies of neo-tectonic activity of the area,
- ✓ shallow seismic refraction-sounding and electric resistance profiling.

The studies comprising the following activities were conducted by ZĄBEK (1978-1990) and by MARGAŃSKI (1993-1995):

- ✓ precise levelling measurement (repeated once-a-year) in the vertical network,
- ✓ laser distance measurement (repeated once-a-year) in the horizontal network,
- ✓ repeated measurement of the gravity variation (4 stations + 5 reference stations),
- ✓ absolute gravity measurement,
- ✓ satellite GPS positioning.

2. Summary of geodetic measurements results (1970-1995)

Diversified vertical motion of a block character going from near-Pieniny flexure in Podhale-flysh has been proved. The levelling raw data demonstrated non-regular motion on the level of units of millimetres.

Irregular horizontal displacements, demonstrating roaming character, changing both magnitude and direction from year-to-year, reaching 10 mm/year were proved. General distance shortening in the meridian direction was evident.

The gravity changes appeared generally inessential except the station Niedzica changing its gravity of 0.1 mgal during the period of 17 years.

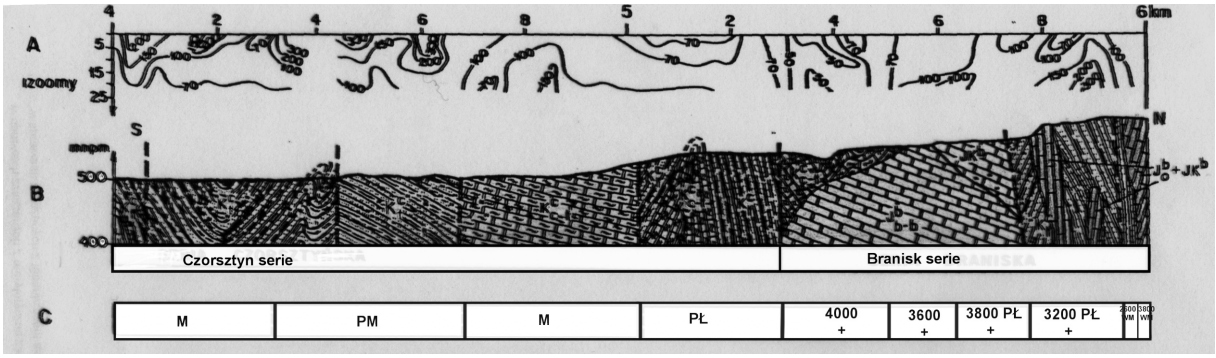
3. The new project

NEW PROJECT sponsored by the State Polish Research Committee and launched in the autumn 2000 comprises:

- ✓ repeating the auxiliary geophysical studies: shallow seismic and electric resistance profiling (the work done early spring 2001),
- ✓ re-observing the control networks (vertical and horizontal) performed two times in the early autumns of 2001 and of 2002,
- ✓ extending satellite GPS measurements for wider geodynamic context of the area (including the Tatra-Mtn.) executed in autumn of 2001 and repeated in 2002,
- ✓ repeating gravity measurements including the gravity vertical gradients.

4. Shallow seismic sounding as stress indicator

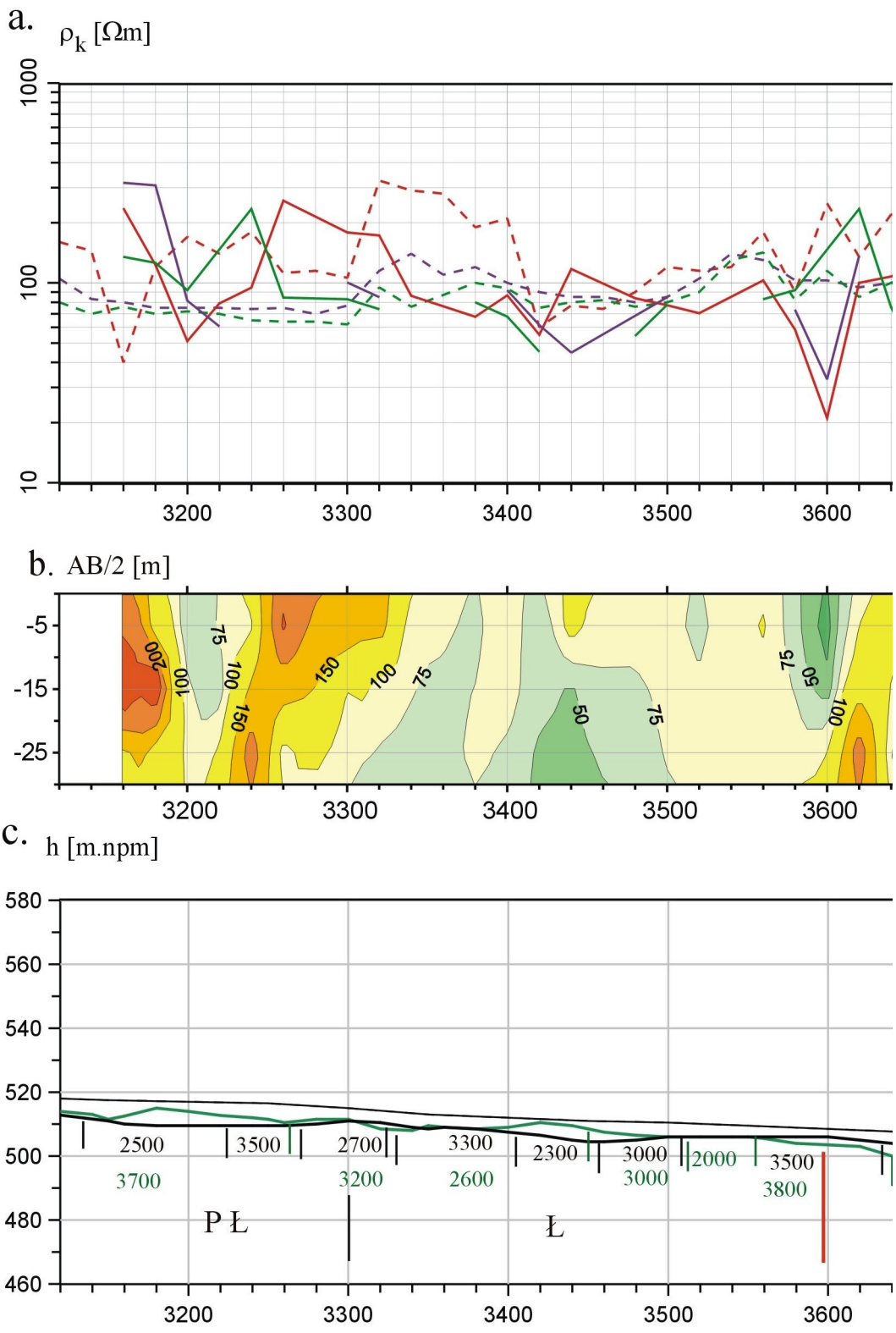
Shallow seismic sounding and electric resistance profiling have resulted in demonstrating the relationship between crustal weaknesses and vertical movements. The crustal squeezing is demonstrated on the surface as a twisting motion of particular rock-formations.



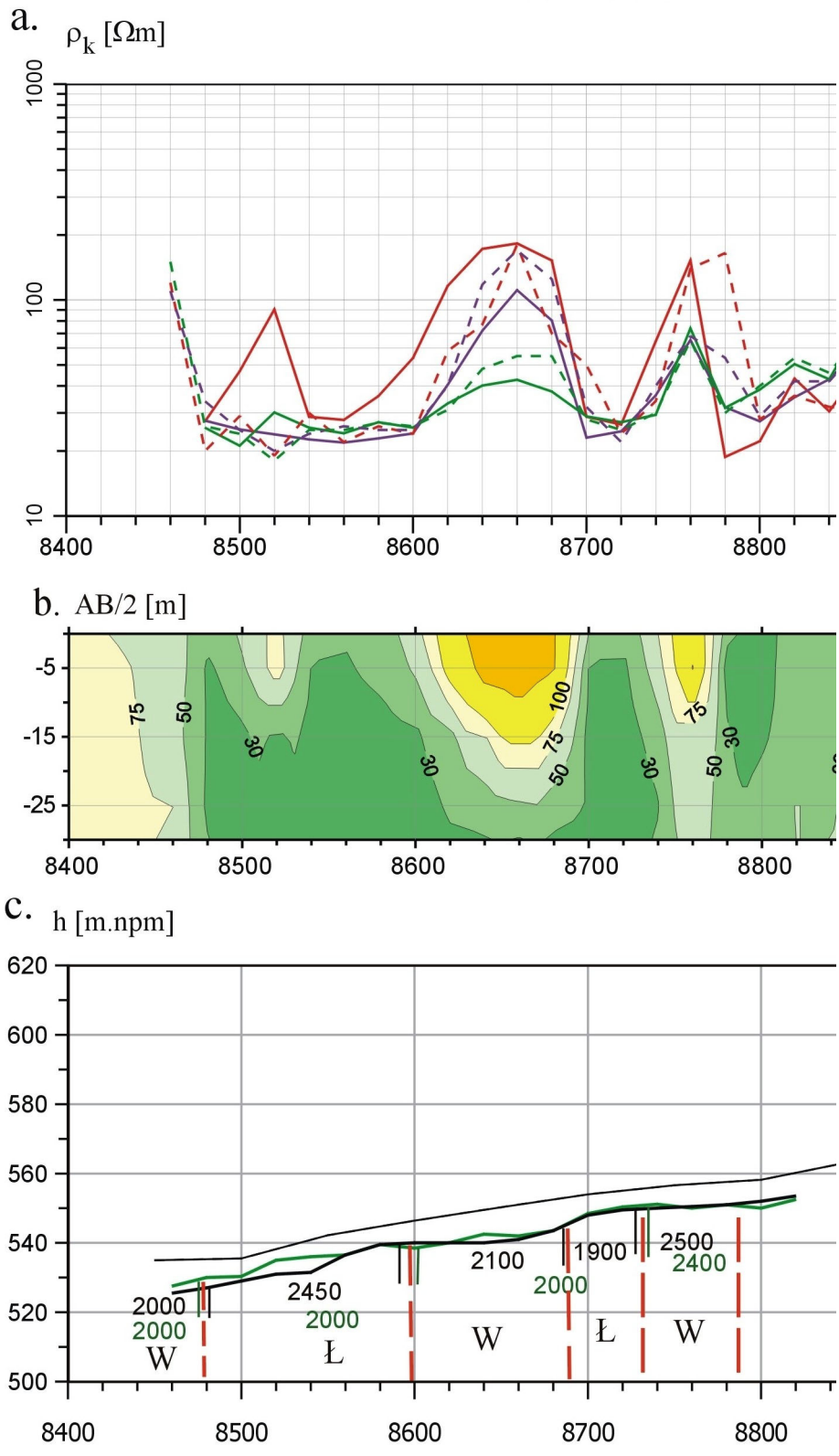
Shallow seismic as stress indicator (after CZARNECKA, 1988b)

Row 'C' demonstrates velocities of the seismic wave. In 'Branisk series' increased velocities can be observed as exceeding characteristic ones for particular rock formations. These velocities may testify the stress resulted from the horizontal movement squeezing the Pininy klippen belt by adjacent tectonic units.

The results of the electric resistance profiling (a) executed before creation of the artificial lake (dot line) and after creation of the lake (full line) are presented below for characteristic parts of the profile. Different colours are referred to the different distances separating neighbouring electrodes (read – 10 m, violet – 30 m, green – 50 m). Chart (b) displays the map of iso-ohms. The most important stress indicator is velocity of the seismic wave. The velocities are shown on the chart (c). The results of measurements performed in 1980 are shown in green, that of 2001 in black.



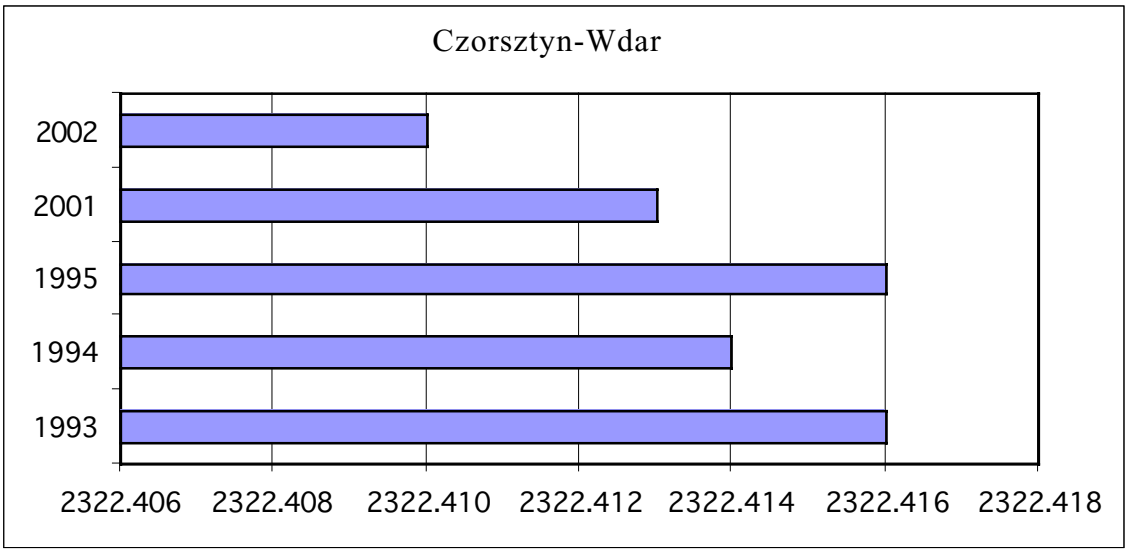
The part of the profile 3100-3600 concerns the Southern contact of the Pieniny klippen belt witn Podhale flysh. One can clearly notice reduced velocities in the epoch of 2001. The Northern part of the profile (8450 – 8800) demonstrates the opposite tendency.

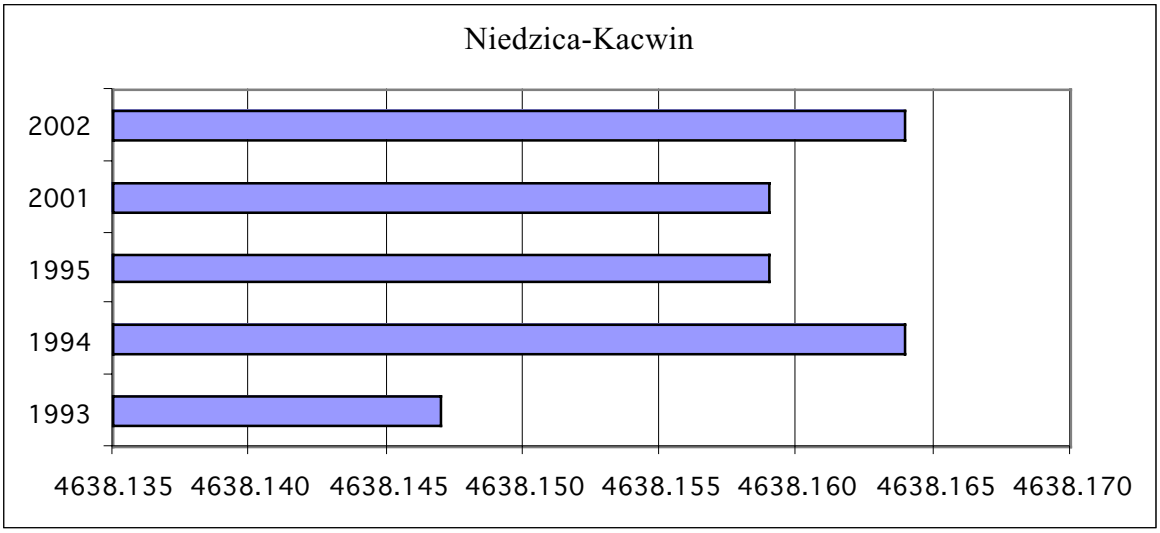


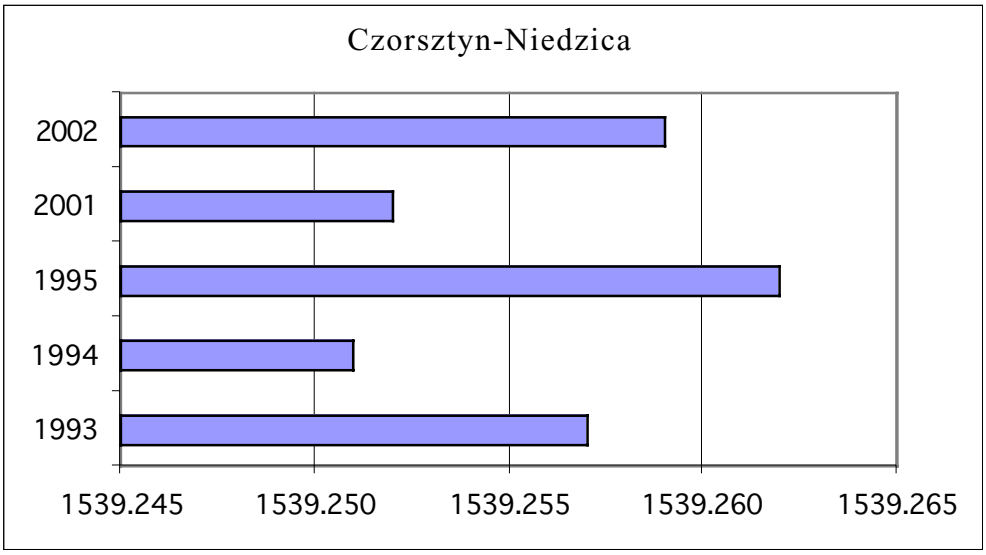
5. Horizontal and vertical movements in the period of 1993-2002

The results of horizontal and vertical displacements observed of the control points determined after filling the artificial lake are quoted below after WALO et al. (2003).

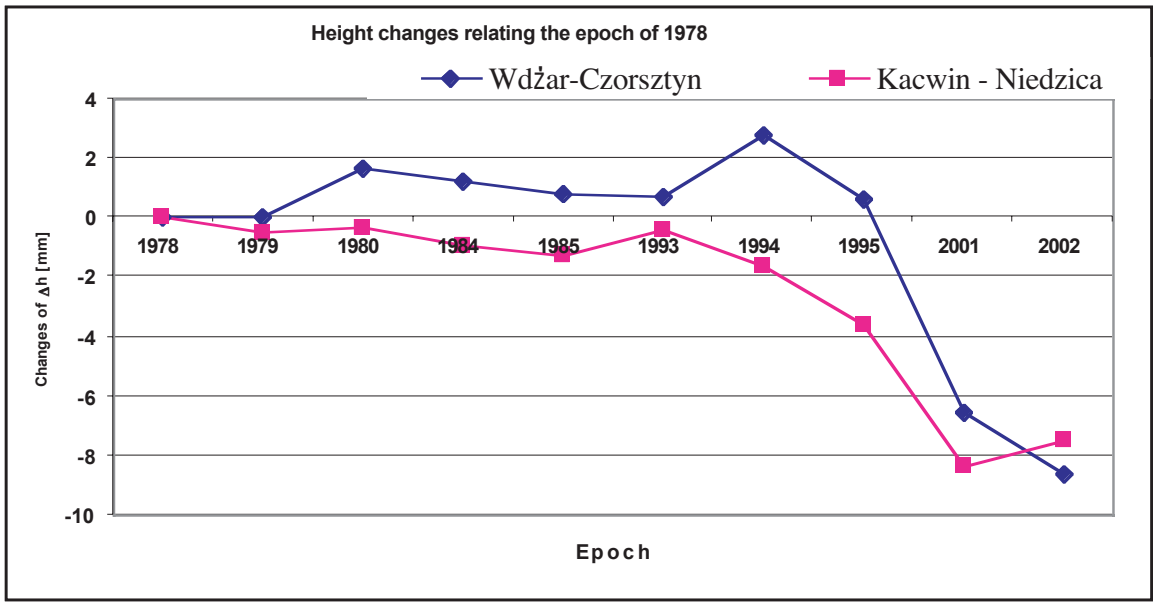
Horizontal distance changes:







Vertical changes:



6. Discussion of the results

1. Clearly reduced velocity of seismic wave in the Southern disjunctive contact-zone of the Pieniny klippen belt with Podhale-flysh (3100-3600 of the seismic profile) accompanying by the distance lengthening can be explained by an effect of stress relaxation resulting in horizontal motion (Niedzica - Kacwin). Depression of the North-wing of the fault due to the loading of the artificial lake has probably initiated such a motion.
2. Stress changes in the Northern contact-zone of the Pieniny klippen belt with Magura-nappe (8400-8800 of the seismic profile) and distance shortening (Czorsztyn - Wdťar) testify the northwards inclination of the Czorsztyn-rocks. It probably results in slight stress increase in the basement caused by Wdťar-injection stability.
3. Depression of the area of Pieniny klippem belt (Niedzica - Czorsztyn), generally coinciding with the area of artificial lake, originated probably from the loading of the area with lake-water. Stress changes are differentiated similarly as distance differences. Explanation may result from complicated tectonics of small structures.

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