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STUDY ON DEFORMATION PARAMETER IN POLAND OBTAINED FROM TECTONOPHYSICS AND GPS DATA ANALYSIS.

Mgdalena Klek[1], Jerzy B. Rogowski[1], Marek Jarosiński[2]

[1]*Institut of Geodesy and Geodetic Astronomy, Warsaw University of Technology*
[2]*Polish Geological Institute*

Abstract

The paper presents preliminary results of determination of deformation in Poland. In the Polish area there are not enough stations to determine deformation and because of that one can use stations from periodic campaign made in Central Europe. For the comparison in the paper there are presented preliminary result of determination of the stress in Poland taken from the geological data. Those values are compared with velocity vectors obtained from solution of CERGO campaigns.

1. Introduction

The deformation of the Earth surface can be computed from GPS observations. The GPS observations campaigns are conducted in two ways: permanent and periodical. To determine deformations one can use both methods.
In Polish area there are 5 permanent stations, where observations take place. These are Jozefoslaw, Borowiec, Borowa Gora, Lamkowko and Wroclaw. The points there aren't enough to determine precisely the deformation of the Polish area. Also the distribution is not very regular for the analysis to be proper (for the observations to be taken into consideration and used for analyses). Other problem is that the distances between permanent points are too big to determine deformations.
Stations periodically observed are also useful for some analysis. However those stations one can use only in case that there are two or more campaigns performed. Period between two campaigns must be one year or more.
All periodic epoch networks in Poland:

- CERGOP
- EXTENDED SAGET
- EUREF-POL
- PSG

However it has to be noticed that in PSG network only one observation campaign was executed.
Campaigns CERGOP, EXTENDED SAGET and EUREF POL had more then one observation campaigns. It should be considered also that Polish area is not situated only on one tectonic unit. The boundary of tectonic units is not identical with the country border. Because of that, it is very important to use for observations also the stations located outside the country.

As an example the figure 1 presents points of CERGOP'II project.

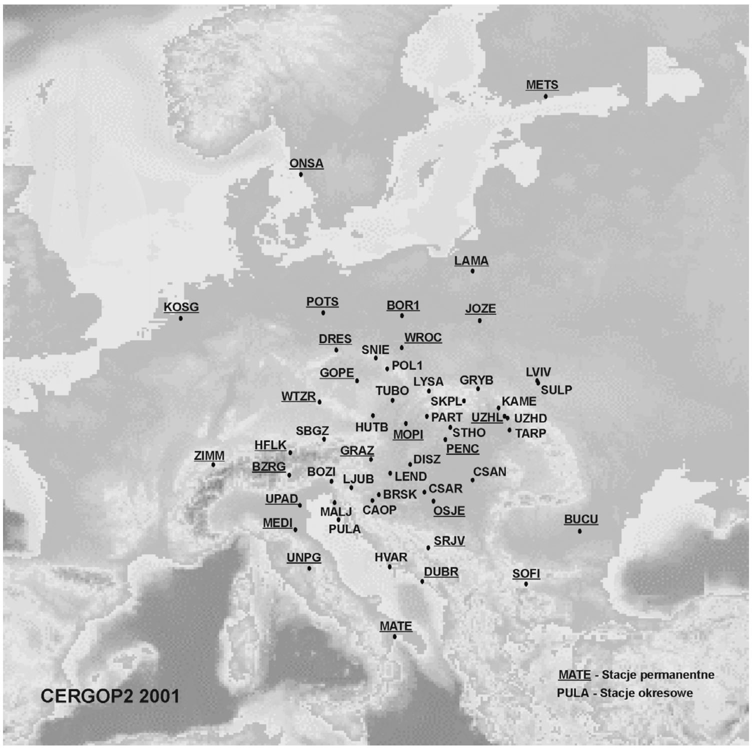

Fig 1. Stations which were observed during CERGOP II campaign.

As we can notice, points in Polish area are not distributed regularly. On the North of the country one can spot no stations at all. This situation isn't comfortable to determine deformations on the whole area of Poland. It is possible only for South part of Poland.

2. Result of data processing

Based on GPS observations one can determine the deformation. For this we have to compute coordinates of stations in two different epochs or changes of those coordinates. Using this data we can compute following parameters:

- surface dilatation
- extreme value oh the linear elongation
- distortion scales
- distortion vectors

To determine those values we can use the following formulas (Altiner, 1999):

$\overline{q} = f^{\alpha\beta} \cdot \varepsilon_{\alpha\beta}$ surface dilatation

$q_{(\eta)} = \varepsilon_{\alpha\beta} \cdot r^{\alpha}_{(\eta)} \cdot r^{\beta}_{(\eta)}$ extreme value of the linear elongation

$m = 1 + q$ distortion scales

$m^{\alpha}_{(\eta)} = m_{(\eta)} \cdot r^{\alpha}_{(\eta)}$ distortion vectors

where

$f^{\alpha\beta}$ metric tensor

$\varepsilon_{\alpha\beta}$ linear deformation tensor

$r^{\alpha}_{(\eta)}$ deformation direction

3. Application

Using formulas presented in point 2, a test has been conducted. For this test the coordinates of stations observed in CERGOP'99 and CERGOP 01 campaigns have been used. Figure 2 presents stations that have been used to compute deformation in the Poland area. At the beginning one can see how velocity vectors of this station has been computed. The outcoming values are presented in the table 1.

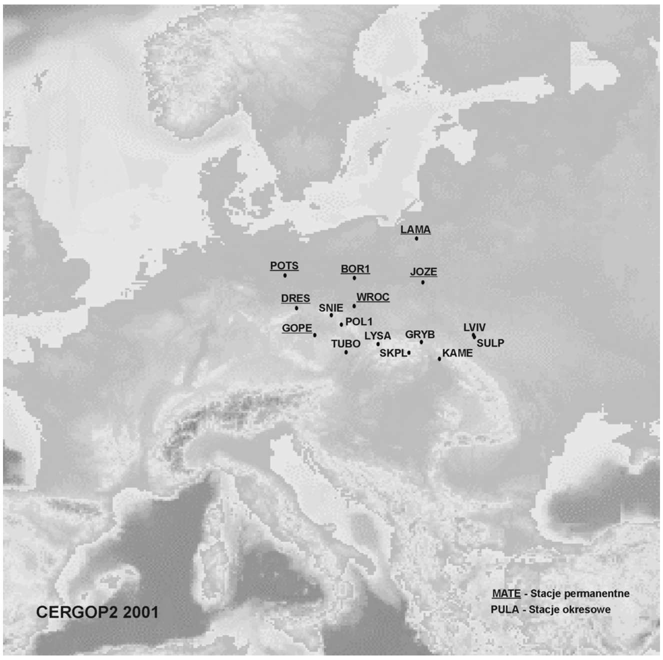

Fig. 2. Stations that has been used to compute deformation in the test

station	V_B	V_L	V_H
POTS	1,25	2,46	-0,03
BOR1	1,25	2,49	0,16
LAMA	1,11	2,13	-0,56
JOZE	1,22	2,57	0,16
DRES	1,30	2,42	0,08
SNIE	1,15	2,17	0,56
WROC	1,32	2,36	0,14
POL1	1,50	1,80	0,51
GOPE	1,23	2,64	-0,65
TUBO	1,49	2,50	0,72
LYSA	1,15	2,45	0,61
SKPL	1,14	2,58	0,66
GRYB	0,99	2,32	0,93
LVIV	1,13	2,41	-0,46
SULP	0,77	2,65	0,78
KAME	1,26	2,62	-0,24

Table 1. Velocity vectors of stations.

Then, based on those vectors, using algorithm presented by Atltiner, deformations have been computed.

Table 2 shows deformations computed in the center of the investigated area.
Table 2 Deformations in the center of the investigated area.

surface dilatation	$q = 7{,}483 \cdot 10^{-8}$
Max linear elongation	$q_1 = 1{,}011 \cdot 10^{-7}$
Min linear elongation	$q_2 = -5{,}9782 \cdot 10^{-8}$
distortion scales	$m_1 = 1{,}00000101$ $m_2 = 0{,}999999972$
distortion vectors	m_1: $4{,}765 \cdot 10^{-7}$ $1{,}568 \cdot 10^{-7}$ m_2: $2{,}503 \cdot 10^{-7}$ $-4{,}864 \cdot 10^{-8}$

4. Comparison of geological and geodetic determination of stress and motions in the lithosphere

The results of recent maximum horizontal stress (S_{Hmax}) determination for Poland allow for differentiation of two domains. The western domain comprises Bohemian massif, Fore-Sudetic monocline and Upper Silesian massif is characterised by NW-SE direction of S_{Hmax} (Fig.2). The eastern domain with the average N-S orientation of the S_{Hmax} consists of East European craton and Malopolska massif. These two domains are separated by the Teisseyre-Tornquist zone (TTZ), along which S_{Hmax} rotates both in plane and with depth.

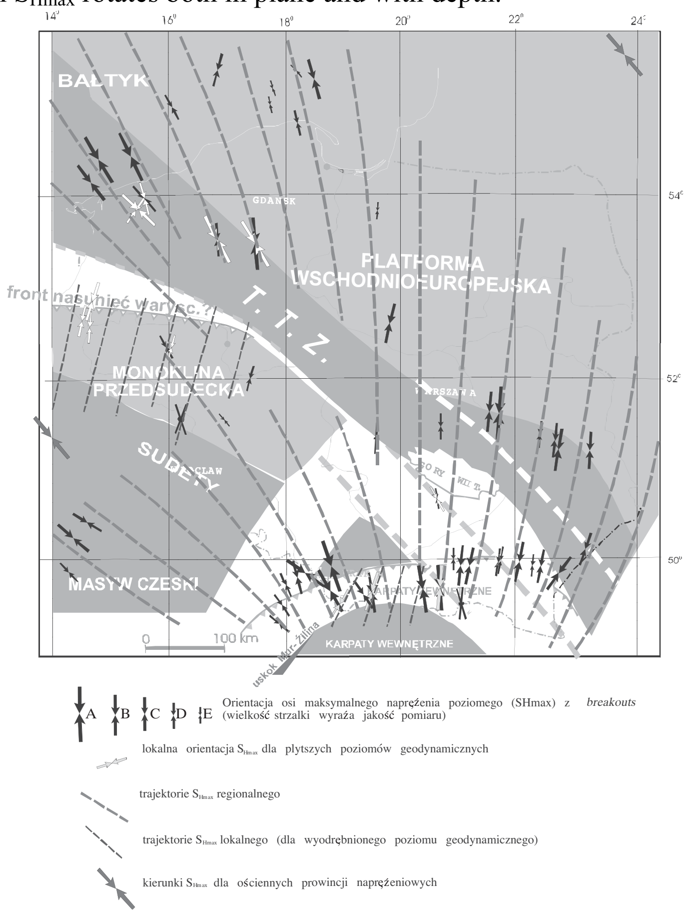

Fig. 3 S_{Hmax} directions determined by borehole breakouts analysis.

Fan-like pattern of stress in the Outer Carpathians and its partitioning among geodynamic levels suggest on-going compressive reactivation of the orogen (Jarosiński, 1998 and 1999). The push of the Carpatho-Pannonian microplate towards NNW can be accounted for tectonic pressure exerted to the accretionary wedge of the Outer Carpathians and also to the basement of Malopolska massif. Tectonic stresses from the Carpathians are transmitted within the foreland plate as fare as the Baltic Sea, where they are taken over by the stresses generated by an ocean ridge push component, oriented towards NW-SE.
Comparison of stress direction with preliminary results of intra-plate motions (IPM) shows some similarities and also regular deviations (fig. 4). In the eastern Poland S_{Hmax} directions are almost compatible with vectors of the IPM what imply the co-axial character of deformation. In the western part of Poland S_{Hmax} directions are systematically deviated against vectors of the IPM that suggests simple shear type of deformation. Treating both, the stresses and motions in the lithosphere together have potential to characterize the inhomogeneity of horizontal deformation field.

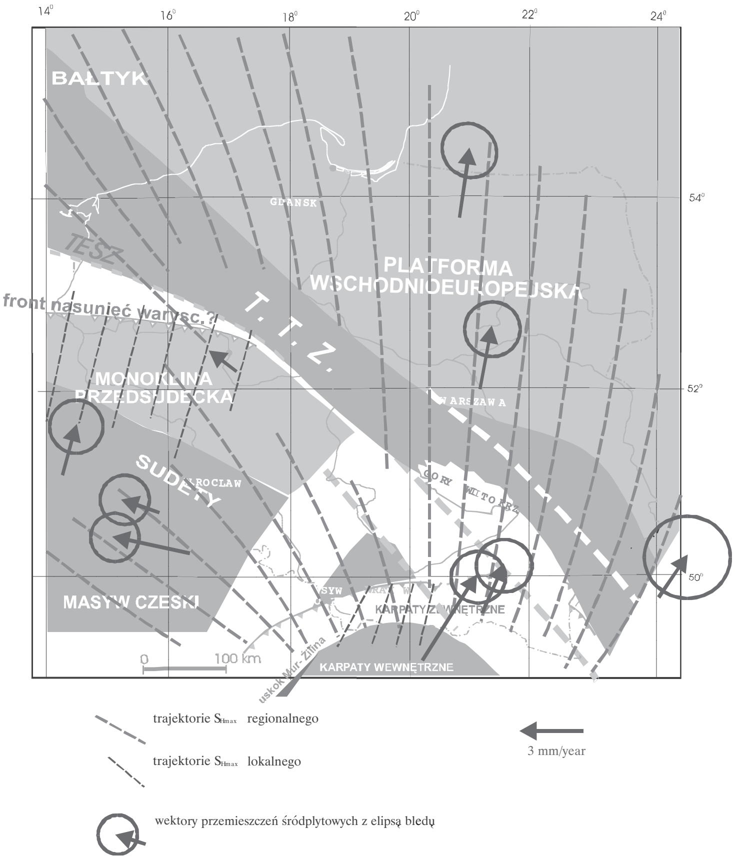

Fig.4. Vectors of the intra-plate motions at the background of maximum horizontal stress trajectories.

4. Conclusions

The distribution of the stations being investigated is very important. Distance between two points cannot be too long. But this depends on the character of the area. If the region is homogenous then this distance is much longer. In the region of tectonic differentiation the best distribution is when at least one point is on one tectonic unit. Optimal distribution of measured points in Poland present fig 5. It is a PSG network. However this network, as it has been mentioned at the beginning has been observed only ones. Because of that it is not possible to determine deformation using those points.

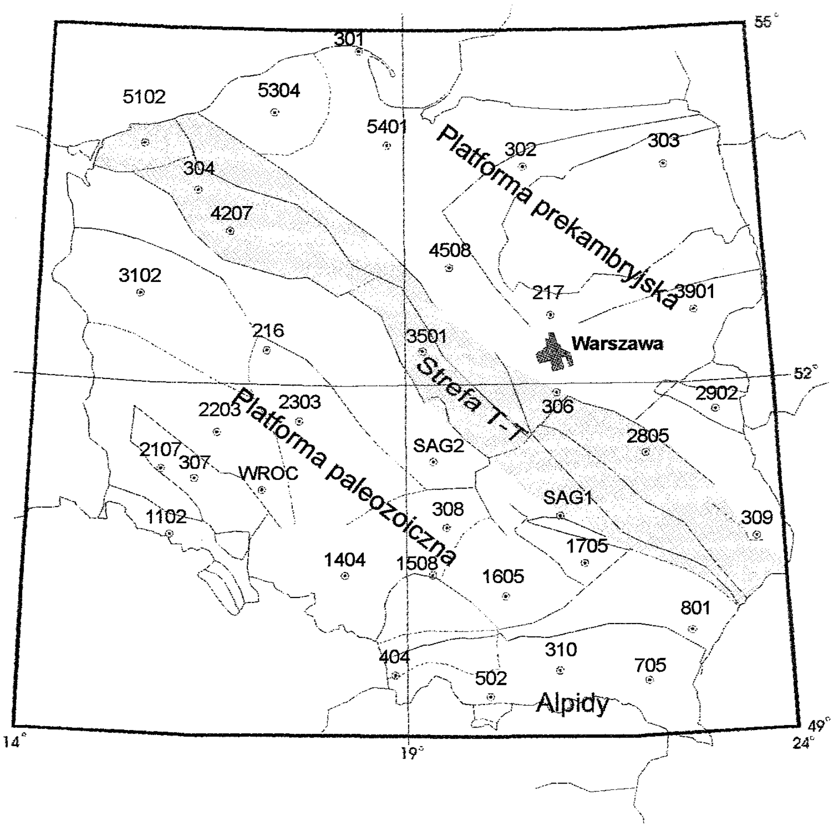

Fig 5 PSG network.

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