THE ESTABLISHMENT OF A VERTICAL GRAVITY CALIBRATION BASELINE IN TATRA MOUNTAINS, NEW ADJUSTMENT OF THE POLISH GRAVITY CONTROL NETWORK

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Abstract

In October 2004, the Polish gravity control network, containing 354 gravity field stations and 12 stations for absolute gravity measurements, was enlarged by one more absolute station in Zakopane, at the foothills of the Tatra Mountains. The absolute station was also established at the Tatra Meteorological Observatory on Kasprowy Wierch. Both new stations will constitute the vertical gravity calibration baseline (of the range of about 248 mGal), which is indispensable for research of mountain dynamics. The absolute measurements have been performed together with the Finnish Geodetic Institute using the ballistic gravimeter FG5 No. 221. At both stations the mean errors of measurements have not exceeded ±3 mGal. Establishing the new station in Zakopane has made possible to extend the Central Gravity Calibration Baseline Gdansk - Borowa Gora - Ojcow to the southern border of the country and thereby to cover the whole Polish territory with its range. The absolute gravity station in Zakopane has been tied to three neighbouring field stations of the gravity control network. Besides, two more gravity stations, one in Kuznice and the other one in Warsaw were established. They were tied to the existing gravity control with relative gravity measurements. The new adjustment (2004) of the Polish gravity control network, with use new absolute and relative gravity survey on the sites at Zakopane, Kuznice and Warsaw has been performed.

1. Relative measurements at the absolute gravity stations Zakopane and Kasprowy Wierch

1.1 Introduction

Establishment and survey of the new gravity control network in Poland have been finished in 1999. The network consists of 354 stations, monumented with solid marks, 12 absolute gravity stations and 2 meridional calibration baselines Western and Central ones. (Fig.1). Existing calibration baselines did not cover the whole range of gravity on the territory of Poland. The southern regions, from the line Ksiaz - Ojcow - Sieniawa were out of range of the calibration baselines.

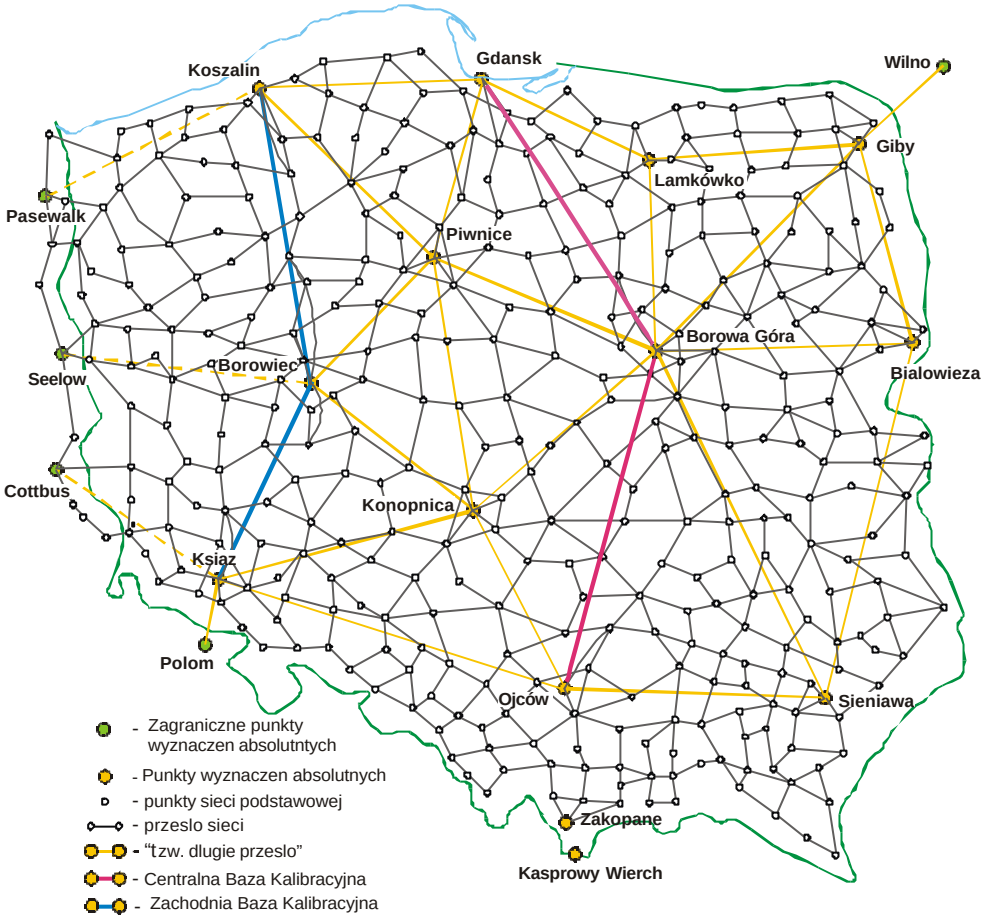

Fig. 1 Gravity control network for Poland

To improve the accuracy of gravity measurements in southern Poland, the Central baselane has been extended to the border with Czech Republic (Fig.2) by estabilishing two absolute gravity stations one in Zakopane and the second on the Kasprowy Wierch, Tatra Mountains. These two stations create also the vertical calibration baseline, which is needed for geodynamic research in the mountains.

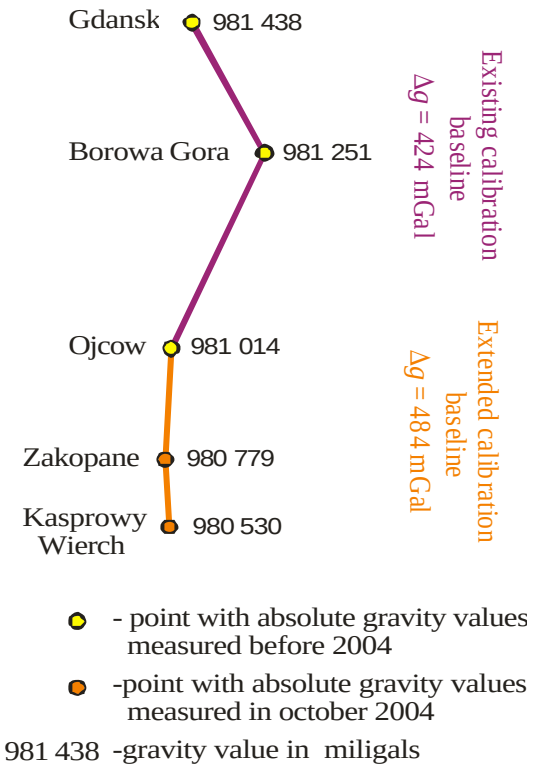

Fig.2. Central Gravity Calibration Baseline

1.2 Field reconnaissance (selection of two stations).

The field reconnaissance for the selection of sites for measurements of absolute gravity (g) in Zakopane and on Kasprowy Wierch was performed in January 2000 by the team from the Institute of Geodesy and Cartography. The station was selected at the Hight-Mountain Meteorological Observatory, which is located at the same room, where gravity survey with pendulum apparatus was performed 47 years ago (Bokun, 1957), (Zabek, Dobaczewska, 1957). In Zakopane, the cellar of the Hydrometeorological station was selected for gravity measurements. Descriptions of both locations are given in Fig. 3 and Fig. 4.

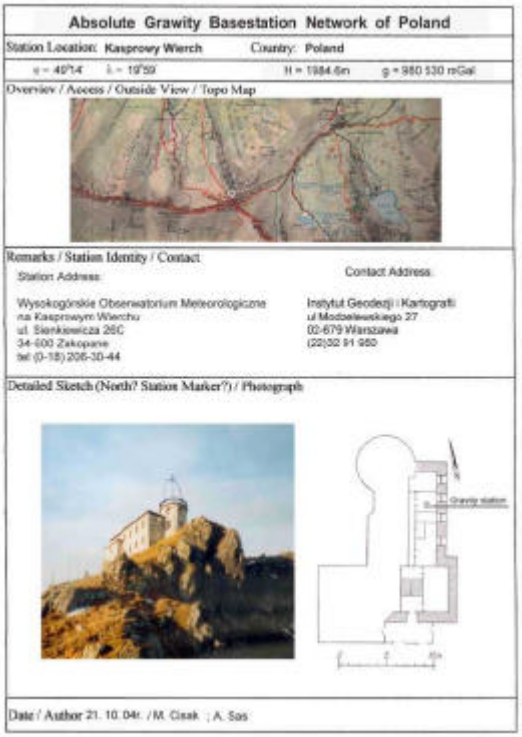

Fig.3 Graphical description of the absolute gravity station A-KASP

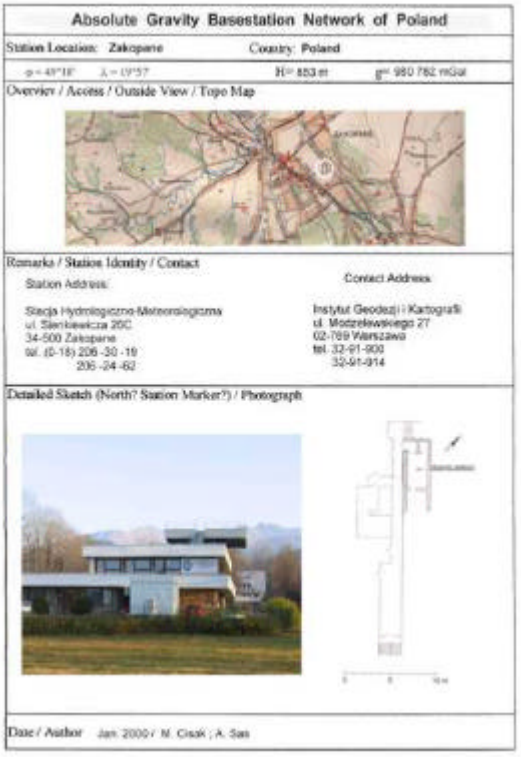

Fig.4. Graphical description of the absolute gravity station A-ZAKO

1.3 Connection of absolute gravity station in Zakopane with four stations of Polish gravity control network

The new selected point named A-ZAKO in Zakopane was connected to four points of Polish gravity control network: *320 Jablonka Orawska, 321 Nowy Targ, 327 Kroscienko* and *354 Zakopane* (Fig.5). The measurements were performed in 2002 using a group of three gravimeters L&R. The gravity value "g" obtained from the measurements at A-ZAKO Zakopane baseline station in POGK-99 System is:

g = 980778.750 ±0.006 mGal

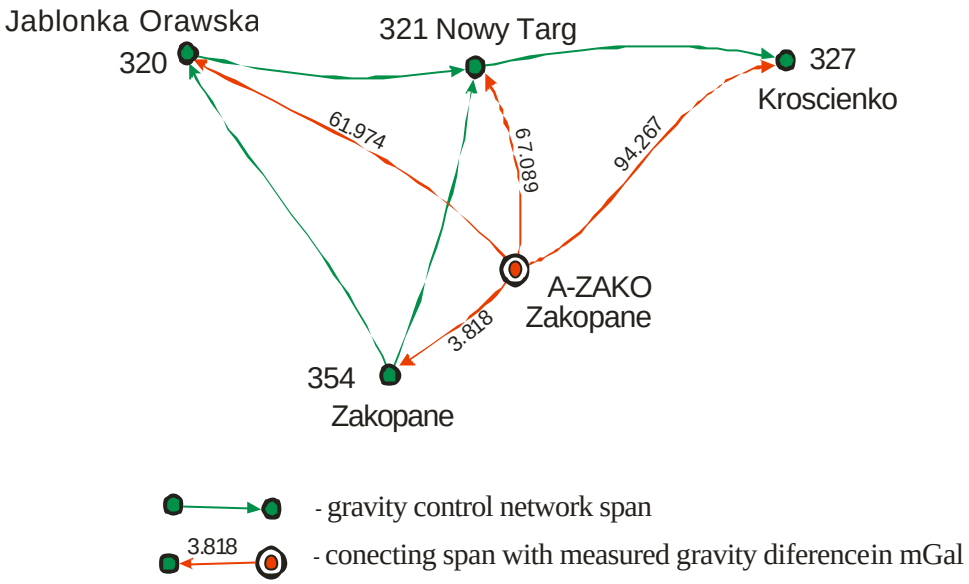

Fig.5. Connection of absolute gravity station in Zakopane with national gravity control

1.4 Spare absolute stations

Two spare absolute gravity stations have been established in the neighborhood of each main station. They have been tied with each other using L&R gravimeters (Fig. 6)

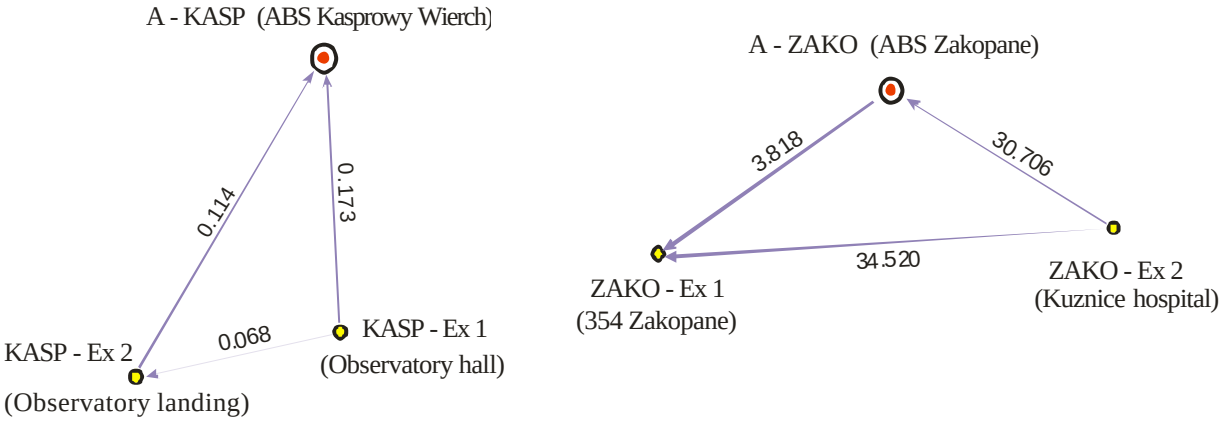

Fig 6. Connection of eccentric points in Kasprowy Wierch and Zakopane

At each main and spare stations, the vertical gravity gradients have been determined twice using two L&R gravimeters. The results are shown in the Tables 1 and 2.

Table 1

No	ID	Name of point	Gradient in [mGal/m]	Error in [mGal/m]
1	A - KASP	ABS Kasprowy Wierch	0.479	±0.004
2	KASP-Ex1	Observatory - hall	0.479	±0.007
3	KASP-Ex2	Observatory - landing	0.494	±0.002

Table 2

No	ID	Name of point	Gradient in [mGal/m]	Error in [mGal/m]
1	A - ZAKO	ABS Zakopane	0.249	±0.001
2	ZAKO-Ex1	354 Zakopane	0.296	±0.003
3	ZAKO-Ex2	Kuznice hospital	0.267	±0.005

2 Absolute gravity measurements in October 2004

2.1 Scope of work:

- transport of FG-5 ballistic gravimeter by car from Zakopane to cablecar station in Kuznice,
- transport the gravimeter by cablecar to Kasprowy Wierch,
- transport the gravimeter on foot from upper cablecar station Kasprowy Wierch up to the site of measurements of Kasprowy Wierch Observatory (the total weight of 15 boxes of the equippement was about 650 kg),
- gravity measurements with FG-5 ballistic gravimeter at the station KW,
- gradient measurements with a set of L&R gravimeters at the station KW,
- return to Zakopane,
- gravity measurements with FG-5 ballistic gravimeter at the station in Zakopane,
- gradient measurements with L&R gravimeters at Zakopane station.

2.2 Absolute gravity measurements at the Kasprowy Wierch station

The measurements have begun 21 October 2004 and have finished 22 Oktober 2004 Fig.7 and 8). 59 measuring series, 50 drops each were made. Every series lasted 0.5 hour.

Fig.7 Transportation of the equipment to Kasprowy Wierch Observatory

Fig. 8 Absolute gravity measurements on Kasprowy Wierch point

The dispersion of average values of gravity obtained in each series of measurements, are shown in Fig. 9.

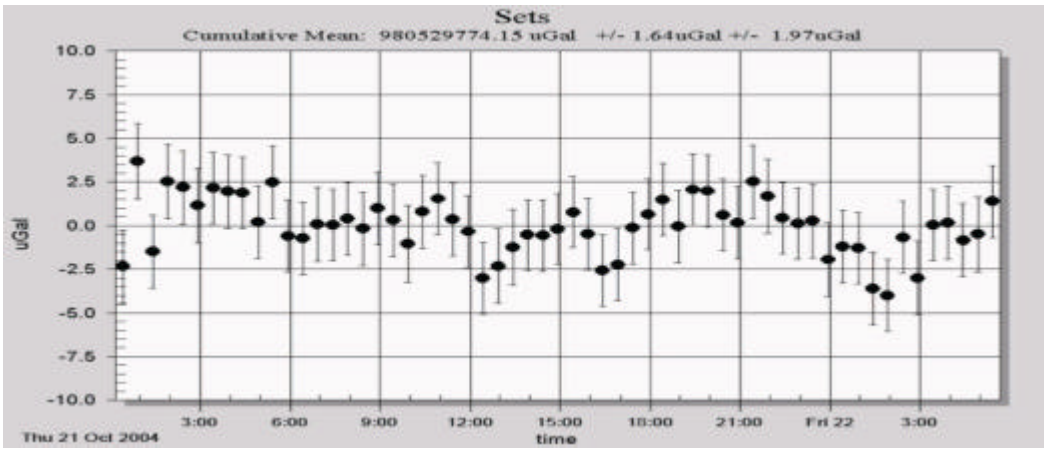

Fig.9. Discrepancies of average values of gravity at Kasprowy Wierch

In the headline the average value of gravity at the measuring height is given, as well as standard deviation and the summed up error of corrections. The total error of gravity obtained at the KW station is ±2.56mGal. To reduce the gravity to the level of the mark on the floor, the vertical gradient was determined at the KW station; its estimated value is -473.3 mGal/m. The gravity value on the floor level is thus:

g = 980 530342.1 ±4.8 µGal

2.3 Absolute gravity measurements at the Zakopane station

The measurements at the station located in the Hydrometeorological Station in Zakopane begun 23 October 2004 and finished 24 October 2004 (Fig. 10).

Fig. 10 Absolute gravity measurements on Zakopane point

53 measuring series, 50 drops each were performed. Every series lasted 0.5 hour. The dispersion of average values obtained in each series of measurements are shown in Fig. 11.

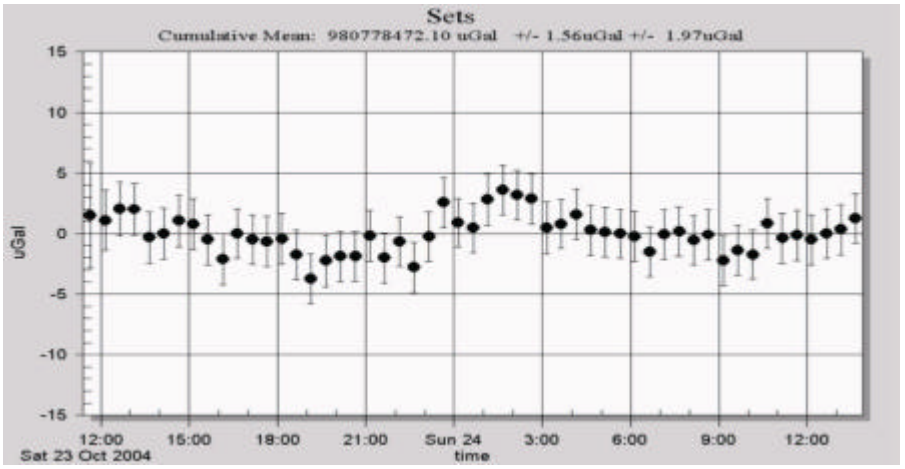

Fig.11 Discrepancies of average values of gravity at Zakopane point

The total error of gravity at Zakopane is ±2.51μGal. Mean value of vertical gradient is -248.5 mGal/m. The gravity value on the floor level is:

g = 980 778770.3 ±2.6 μGal

2.4 Results

The measurements at both KW and Zakopane stations have been performed with very high accuracy. It proves, among others, that the localization of both stations is appropriate in terms of the criteria required for absolute gravity measuring site.

The gravity values obtained from absolute and relative measurements at the Kasprowy Wierch and Zakopane stations as well as at the eccentric points are presented in Table 3.

Table 3

No	ID	Name of point	Value of g (mGal)	Error (mGal)
1	A - KASP	ABS Kasprowy Wierch	980530.342	±0.005
2	KA SP - Ex1	Observatory - hall	980530.166	±0.007
3	KASP - Ex2	Observatory- landing	980530.231	±0.009
4	A - ZAKO	ABS Zakopane	980778.770	±0.003
5	ZAKO - Ex1	354 Zakopane	980782.588	±0.003
6	ZAKO - Ex2	Kuznice - hospital	980748.066	±0.007

3 New adjustment of gravity control network

The new absolute station in Zakopane and two UNIGRACE absolute stations Jozefoslaw and Krokowa, as well as several new field stations have been included to the gravity control network. The total number of field stations increased to 361 and absolute stations to 13. The new set of data containing 963 values of Δg has been adjusted using the classical least squares method. The network has been tied to 16 absolute stations, among them 3 in Germany close to the common border. Borowa Gora station has been assumed as fixed. The remaining absolute gravity stations (15) have been given the weights being the function of the accuracy of measured gravity. The histogram of mean errors of computed gravity is shown in Fig. 12. 96% of errors do not exceed 10 mGal. 4% of errors are in the range of 11-13 mGal. The contour lines of error distribution on the territory of Poland are shown in Fig. 13.

The gravity value of the point A-ZAKO after the adjustment is:

g = 980778.768 ±0.005 mGal

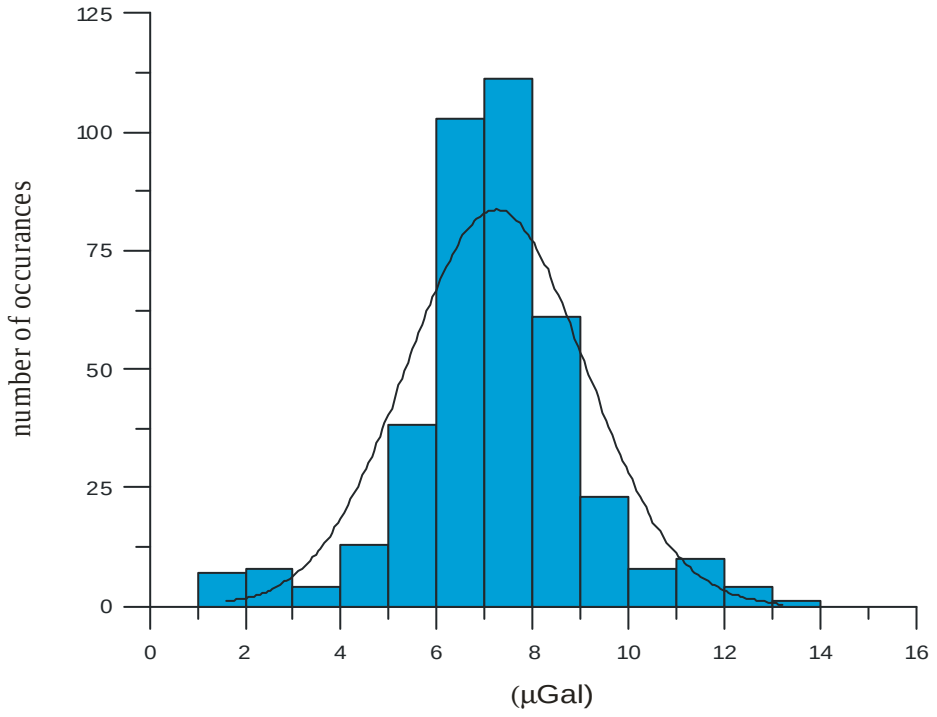

Fig.12. The histogram of mean errors

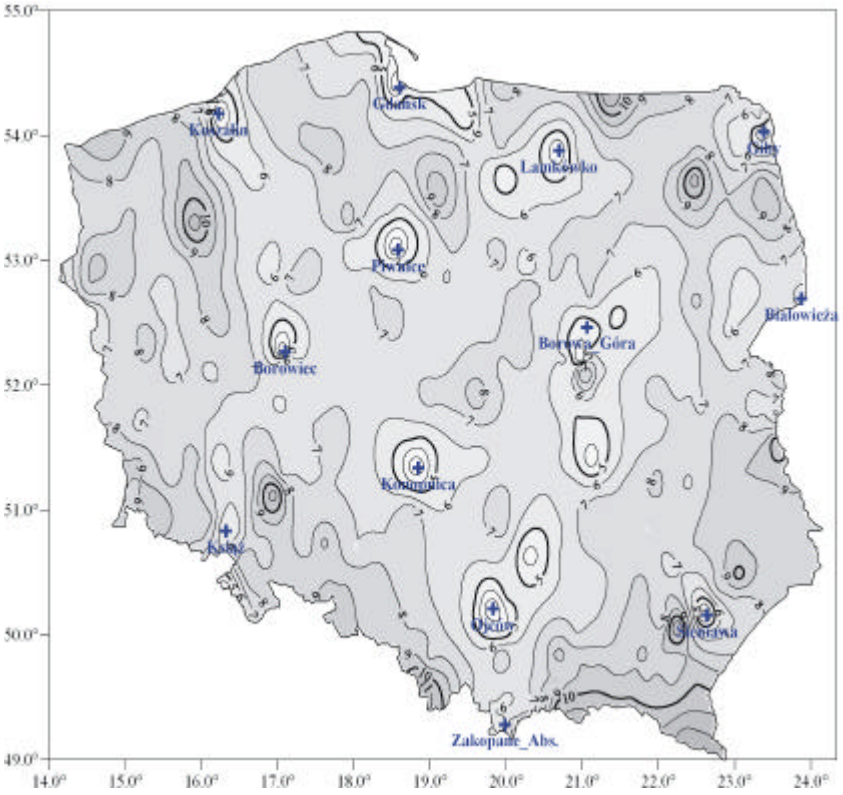

Fig.13. Distribution of mean errors of gravity in Poland (in mGal)

4 Final conclusions

The absolute gravity survey in Zakopane has extended the Central Gravity Baseline to the southern border by 235 mGal. The baseline covers now the whole variability range of gravity in Poland. The new absolute and relative measurements have enabled making new adjustment of Polish gravity control network. The measurements at the KW station will enable to establish the vertical calibration baseline in the Tatra Montains (Fig. 14), of the gravity range of 249 mGal and the vertical distance of ~1000 m. The baseline will be applied for precise calibration of gravimeters used to geodynamics research in Tatra mountains performed by Polish, Slovak and Czech specialists.

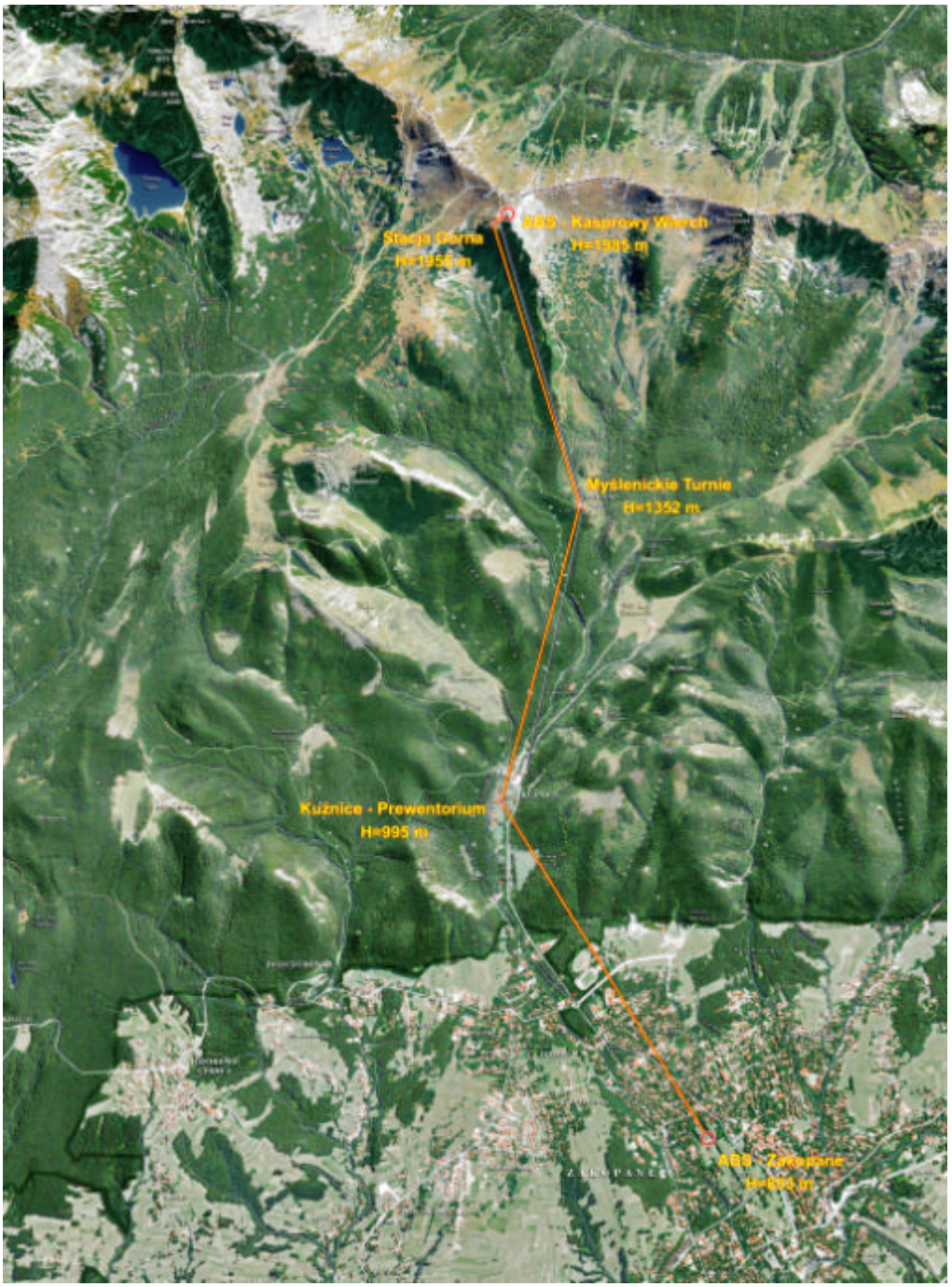

Fig. 11. High Mountains Calibration Baseline presented on the photomap of Polish part of Tatra Mountains elaborated in the Institute of Geodesy and Cartography in the scale of 1:20 000

References

Bokun J., (1957): *Baza grawimetryczna Gdansk-Kasprowy Wierch;* Prace IGiK, 1957, tom V zeszyt 2, pp 119 – 132.

Zabek Z., Dobaczewska W., (1957): *Pomiary aparatem czterowahadlowym na punktach bazy grawimetrycznej;* Prace IGiK, 1957, tom V zeszyt 2, pp 133 – 213.