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Imaging the Underground Coal Gasification Zone with Microgravity Surveys

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Abstract

The paper describes results of microgravity measurements made on the surface over an underground geo reactor where experimental coal gasification was performed in a shallow seam of coal. The aim of the research was to determine whether, and to what extent, the microgravity method can be used to detect and image a coal gasification zone, especially caverns where the coal was burnt out. In theory, the effects of coal gasification process create caverns and cracks, *e.g.*, zones of altered bulk density. Before the measurements, theoretical density models of completely and partially gasified coal were analysed. Results of the calculations of gravity field response showed that in both cases on the surface over the gasification zone there should be local gravimetric anomalies. Over the geo reactor, two series of gravimetric measurements prior to and after gasification were conducted. Comparison of the results of two measurement series revealed the presence of gravimetric anomalies that could be related to the cavern formation process. Data from these measurements were used to verify theoretical models. After the experiment, a small cavern was detected at the depth of the coal seam by the test borehole drilled in one of the anomalous areas.

Key words: microgravity, time lapse data, coal, gasification, control.

Ownership: Institute of Geophysics, Polish Academy of Sciences;

1. INTRODUCTION

Underground coal gasification (UCG) is a process of converting a solid body into an energy fuel in gas form, which occurs in a seam (Gregg and Edgar 1978, Burton *et al.* 2005, Shafirovich and Varma 2009). The very essence of the technology is to ignite coal in a seam, then maintaining the gasification process, and extracting the obtained gases to the surface, to some power devices, or a chemical processing installation. To gasify the coal, it is necessary to supply oxygen to the gasification area. It may be supplied either in the pure form as O_2 or in a jet of air. Additionally, steam can be also used as a gasifying factor. Depending on the type of medium introduced to the coal, output gas of different composition is obtained. The components of gas of energy value are: methane CH_4, hydrogen H_2, and carbon oxide CO. The processes occurring in a coal seam during underground gasification cause transformation and loss of its mass. The transformation may be complete and then a cavern formation is observed in the area where the coal had been gasified. It may be also a partial process, and then a zone of structurally and chemically transformed coal together with solid products such as char and ash remains in the coal seam. The combustion process is a dynamic phenomena accompanied by cracking of a coal block. Therefore, in some laboratory trials performed in Japan a seismoacoustic method was applied to observe and monitor the fissures creation and development (Itakura *et al.* 2010, Su *et al.* 2013). Recently, many articles dealing with UCG aspects are published. The current state of knowledge was summarized last year in a paper published in the journal *Progress in Energy and Combustion Science* (Bhutto *et al.* 2013). Among 123 references to this paper only one provides brief information concerning practical application of ground penetrating radar for imaging and monitoring the UCG process (Stańczyk *et al.* 2010).

Shape and structure of the coal transformation zone are crucial for assessing influence of underground coal gasification process on the geological environment. That is why, to use the technology, the methods which enable remote imaging of a gasification zone and controlling its development in a coal seam are so important, which in fact means testing the area with geophysical methods. One of them is the gravimetric method, because the results of measurements made with the method reflect density differentiation of geological formations adjacent to the surface (Jacoby and Smilde 2009). The method was successfully used in detecting underground caverns (Fajklewicz 1989, Styles *et al.* 2005). The process of underground coal gasification leads to mass loss in the volume of a seam where the process takes place. It increases differentiation of average bulk density of a layer of rock mass between the surface, where the measurement is made, and the area of the seam undergoing gasification.

Efficiency of the microgravity method in detecting caverns and zones of locally decreased density in relation to the surrounding rocks, *e.g.*, fracture zone, is limited by the depth of a seam and the size of the zones of locally altered density, caused by the coal gasification process. Hitherto applications of the gravimetric method show that it should be effective in case of shallow coal seams, located up to a few dozen meters deep, depending on the dimensions of the gasification zone. In the case of seams located deeper, the method may be also useful to record secondary effects of the gasification process which may occur in overlying rocks, *i.e.*, deformations of rock layers, changes in humidity resulting from heat propagation, *etc*. Information on the lack of such effects is also very important to assess the impact on the environment.

The tests were conducted during a gasification experiment on a block of coal in a seam called "geo reactor" limited by roadways at a depth of approx. 16 m, in Barbara experimental colliery. Location of a colliery on the map of Poland is shown in Fig. 1a. Their scope was to make two series of gravimetric measurements on the surface, above the place where gasification experiment took place. The first series of measurements was made before initiating the gasification process at the end of July 2013. The second series was made after finishing the gasification process in late August 2013.

2. GEOLOGICAL AND MINING CONDITIONS AT THE SITE OF EXPERIMENT

In the area of the underground coal gasification experiment, Carboniferous strata are covered with a thin layer of Quaternary sediments of a thickness of approximately 1-2 m. Carboniferous formations show regular stratification and appear in form of beds of sandstones, mudstones, and shales. Between the lithologic layers there are numerous coal seams of variable thickness, between a few centimeters and a few meters. The shallowest at the site is coal seam 310 which lies approx. 16 m below ground level of thickness ranging between 1.3 and 2.0 m. According to the mining plan shown in Fig. 1b the seam is oriented almost horizontally and not faulted. The nearest fault in coal deposit was encountered about 3 km to the east from the site of experiment. Seam 310 is accessible with two shafts and is cut with numerous roadways which are currently used for research and development purposes. The part of the seam where the gasification experiment was conducted is limited by roadways with a leak-tight concrete lining.

The geological structure of the overburden at the site of experiment was examined by a borehole B1, performed after experiment termination. Its lithological log is shown in Fig. 1c. According to the borehole data, the shale layer acts as the proximate roof of a coal seam. The shale beds dominate also

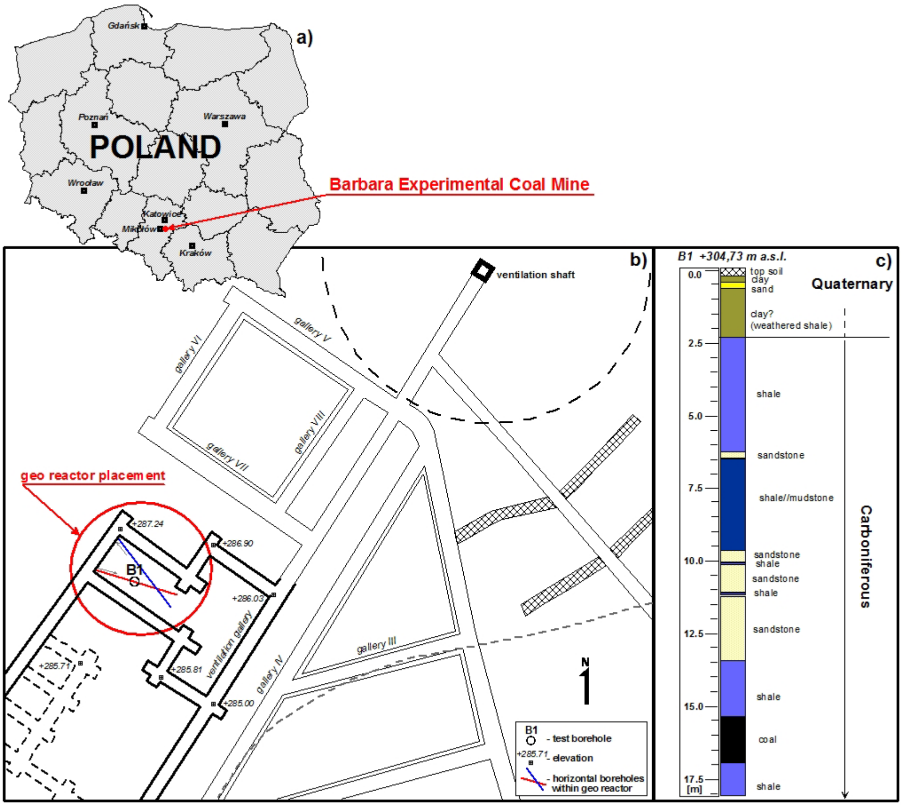

Fig. 1. Location of coal gasification experiment and its geological and mining conditions: (a) location of Barbara experimental mine on the map of Poland, (b) mining plan of the coal seam 310, and (c) geological log of the borehole B1.

in upper parts of the overburden. The water table in Quaternary sands was not detected in the borehole. Therefore, it can be assumed that it occurs in sand layer periodically. No water was also met in carboniferous beds. During the drilling a flush disappeared just when the coal seam was reached. The borehole data allow to assess that the overburden of a seam 310 was impermeable in a close vicinity of the gasification panel. It does not exclude the possibility of fissures presence in the strata surrounding the gasification panel.

3. COAL GASIFICATION TECHNOLOGY

In the seam, two horizontal boreholes were drilled crossing approximately in the axis of symmetry of the coal seam. In one of the boreholes, coal was ignited with an explosive charge and then oxygen was supplied to borehole by pipes connected with surface installation. The borehole is marked red in

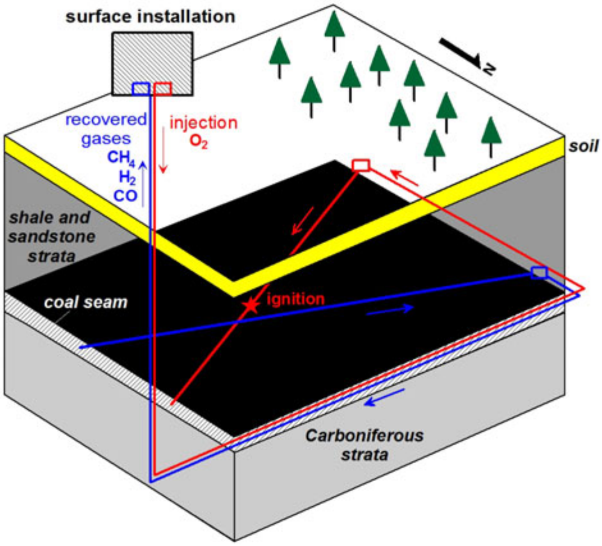

Fig. 2. Schematic diagram of a coal gasification system in an underground seam, Barbara experimental coal mine.

Fig. 2. The other borehole marked in blue color was used to receive gases produced in the process and then transport them to the surface with pipes.

The coal gasification process in the seam lasted for 142 hours. For the initial 101 hours the process was stable and the composition of the flue gases was stable too. Then, as a result of leakages, in the geo reactor there was a gradual decrease in the quality of flue gases, *i.e.*, much higher concentration of nitrogen in flue gases and lower concentration of hydrogen and carbon oxide. The chemical composition of the obtained products is presented in Table 1. Temperature of the process changed within the range of between 800 and 1500°C. After finishing the gasification process, with the borehole which was used to supply oxygen (blue in Fig. 2), the pumping of gaseous nitrogen commenced. The operation lasted for approximately four weeks and finally resulted in extinguishing fire in the coal seam.

Table 1

Average concentration of gaseous components

	Average concentration [% volume]							
Stage	H_2	CO	CH_4	C_2H_6	H_2S	CO_2	N_2	O_2
I. 0-101 hrs	42.17	37.74	2.50	0.07	0.27	15.53	1.34	0.38
II. 101-142 hrs	21.87	17.41	2.34	0.14	0.05	14.39	41.27	2.53
Total (0-142 hrs)	36.30	31.87	2.45	0.09	0.21	15.20	12.88	1.00

Analysis of the composition of gas evolved in a UCG together with other parameters of the process enable to balance the mass of burnt coal and its products. This theoretical thermo-dynamical approach is applied in estimation of combustion cavern shape and size by numerical modelling (Perkins and Sahajwalla 2006, Bhutto *et al*. 2013). In view of possible negative effects on the environment, theoretical models of the process have to be verified by the *in situ* measurement methods. They can be used also for the control of process in real time. The microgravity seems to be one of the methods suitable for this task.

4. FIELD MEASUREMENTS

The test site where gravimetric measurements were made is located in Mikołów within former Barbara coal mine which at present is used for research and development purposes. The area where the gasification experiment was conducted is shown in Fig. 3.

Fig. 3. Location of gravimetric measurements in the test site, Barbara experimental mine. In red – gravimetric points, in green – surveying benchmarks.

Observations of microgravity in the test area were made with CG-5 Autograv gravimeter produced by Scintrex, Canada. The CG-5 gravimeter, according to its manufacturer, enables measurements with accuracy of up to 0.005 mGal and repeatability of read-outs up to ±0.001 mGal (Scintrex 2006). Boundaries of the test area are marked with surveying benchmarks nos. I, II, VII, and VIII (green in Fig. 3), which indicate the corners of the roadways in coal seam 310. The test area was roughly rectangular of 9.60 × 16.00 m. *In situ* tests were planned in such a way that the measuring points were directly above the expected caverns, *i.e.*, at the junction of the flues and around the place.

Gravimetric points (red in Fig. 3) in the test site were determined in a rectangular but irregular measuring grid. Ten rows of six points each were marked. The grid included 61 points altogether, numbered from 1 to 60, as well as a base point marked no. 100. The distances between the points were 2 m and met the assumptions of a detailed gravimetric survey. Distances between the measurement lines ranged between 1 and 5 m and were adapted to perform geophysical tests with other methods to facilitate matching and complex interpretation of the obtained results. The points were marked directly on the ground. More detailed layout of measuring points in the test site is presented in Fig. 3. Gravimetric profiles were parallel to the roadway support, *i.e.*, to the line between surveying benchmarks nos. I and VIII, where the inlet and the outlet, used in the coal gasification process, were located. According to the base map for the test area, in the western corner of the area in the ground there is a power cable, oriented NNW-SSE. The lower density of soil filling the trench could cause anomalies in records obtained in that part of the test site.

The point chosen as the base one and numbered 100 was outside the experiment influence zone, 10 m SW of the boundary of the research area. Basing on this point, additional gap-filling observations were made. The gap-filling measurements were made with the intermediate point method according to the schematics: 100, 1, 2, 3, …, n, 100, where 100 is base point, and 1, 2, 3, …, n are scattered points. Linking the series allowed eliminating short-term drifts of zero point of the gravimeter. Medium- and long term-changes of zero point of the gravimeter, caused mainly by the vertical component of lunisolar forces, were eliminated during measurements. The software installed on CG-5 gravimeter allowed calculating according to Longman's algorithm, and considering corrections for Earth tides during read-outs. The corrections may reach ±0.04 mGal/h, and during a day they may change by even ±0.3 mGal. The long-time drift correction was applied automatically during the measurements. It was taken as constant and equal to 0.51 mGal/day basing on calibration done few days before taking the measurements. The short-time drift was calculated according to changes of the readings on the base point for each measurement cycle and was applied during the data processing.

In the tests made, it was not necessary to calculate topographic corrections for gravity, due to a generally flat surface of the tested area. Maximum amplitude of the elevation difference was 0.52 m due to the slight terrain dipping to NE. To reduce the measured values to the physical level of the Earth, it was enough to measure the height of the tripod where the device was mounted. Apart from that, a differential map was used for final interpretation. Therefore, it could be assumed that the difference in altitudes of particular stations had no influence on final image.

According to the methodology, measurements were made in one point until an identical read-out of accuracy of 0.005 mGal was observed. It resulted in approximately 200 recorded values of gravity for each of the measurement series. Such a procedure ensures high quality and accuracy of microgravity measurements. After recording the data *in situ* and uploading them on a PC, correct values of measurements were selected for all of the points. Values burdened with the biggest error, considering mainly standard deviation of a single measurement approximated from a series of 30-second read-outs, were discarded.

The measurements were conducted in two separate series. Series I was taken prior the ignition of the coal on 29 July 2013, and Series II was performed after the gasification on 21 August same year.

To determine the accuracy of measurements, in some of the points, the gravimetric observations before and after the gasification were made twice. Basing on the values obtained in the repeated measurements, mean square error (MSE) of a single measurement was obtained according to the equation:

$$\mu_0 = \pm\sqrt{\frac{\sum_{i=1}^{n} v^2}{2n}}\ , \tag{1}$$

where v is the differences between repeated measurements, and n is the number of repeated observations.

The repeated gravimetric measurements within each series allowed to calculate mean square error of a single measurement, which in the first series was ±0.0028, and in the second merely ±0.0021 mGal. The value is lower than the one which is specified by the manufacturer of CG-5 apparatus. This is most probably caused by a relatively low number of the set of repeated measurements, although similar values of measurement errors are reported by other users of the apparatus (Parseliunas *et al.* 2011). The next stage of *in situ* works was to determine XY coordinates of the points and their altitude above sea level with technical levelling method. It is an extremely important step for the accuracy of the gravimetric measurements as the height of the point determines the value of correction in Bouguer reduction. For small anomalies, oscillating slightly above the error range, incorrect determination of the height of the measuring point may result in an incorrect image of distribution of anomalies in the area and incorrect interpretation of the data. Appropriate corrections were then made to the measurement data. Finally, we obtained relative values of gravity in the so-called Bouguer reduction.

5. DATA PROCESSING

Within the framework of the calculations, relative values of gravity for all the gap-filling measurement points were calculated. The calculations were made basing on the local value of gravity assumed in the base point. Then the value of anomaly of gravity in Bouguer reduction was calculated with the equation:

$$\delta g = g + \left(0.3086 - 0.04187\rho\right)h - \gamma_0 \ , \tag{2}$$

where g is measured value of gravity [mGal]; h – altitude above sea level of a measuring point [m] in Baltic system; ρ – density of the reduced layer [g/cm^3], in the reported tests the value of $\rho = 2.0$ g/cm^3 was assumed; 0.3086 h – free-air anomaly (Faye's anomaly) [mGal], eliminating influence of altitude of a measuring point in relation to the reference level; 0.04187 ρh – Bouguer anomaly [mGal], eliminating component of vertical attractive force of a rock complex limited with horizontal planes going through the measuring point and the reference level; γ_0 – normal value of gravity [mGal], in the documented gravimetric tests local normal gravity was assumed, with relative values increasing towards north by 0.0008 mGal.

Mean square error (MSE) of determining the value of anomaly in Bouguer reduction for density of 2.0 g/cm^3 for both measurement series was respectively:

$$\begin{aligned} v_0 &= \pm\sqrt{\mu_0^2 + \left(0.3086 - 0.0419\rho\right)^2 \cdot m_h^2 + m_{\gamma_0}^2} \\ &= \pm 0.0036 \text{ mGal (series I)} \\ &= \pm 0.0029 \text{ mGal (series II)} \end{aligned} \tag{3}$$

where μ_0 is error of determining value of gravity (±0.0028, ±0.0021 mGal), m_h – error of determining height (±0.005 m), m_{γ_0} – error of determining normal value (±0.0008 mGal).

Interpreting the results of tests, the value of measurement error of ±0.005 mGal, provided by the manufacturer of CG-5 gravimeter, was assumed.

6. TEORETICAL MODELS OF A GASIFICATION ZONE AND ITS INFLUENCE ON THE LOCAL GRAVITY FIELD

Earlier researches made with the radar method in a large-scale model simulating conditions in the deposit show that in a block of pure coal (without impurities of other minerals) which undergoes the gasification process, in the limited volume there are at least three areas of different structure and physicochemical properties (Kotyrba and Stańczyk 2013):

- coal in natural form,
- physically and chemically transformed coal with char of various rank,
- cavern.

Because of that, before the measurements we analysed theoretically, using a 2D modelling method, the influence of the three types of structure of a coal seam − models 1, 2, and 3 − on the local gravity field in the area where the gasification process occurs. In all the three models we assumed that the seam is 2 m thick and its roof strata are oriented horizontally at a depth of 15 m. We also assumed that gasification occurs in the whole cross-section of the seam and the occurrence of a cavern covering its whole thickness is possible. In the models, the gasification zone is a regular 9 m long rectangular. In the intermediate stage of the process, in the central part of the zone there forms a 3-meter long cavern. In the final stage of the experiment, in the area of gasified coal, there is a 12-meter long cavern.

In natural conditions, the geometry of gasification areas in a coal seam is not going to be regular due to the occurrence of other rocks in coal seams, such as thin layers of gangue. That is why a model assumption of the geometry of a gasification zone is a highly idealised one. Nevertheless, it allows assessing possibility of using the gravimetric method and formulate preliminary criteria to interpret data obtained during in situ measurements.

Such assumptions reflect the general character of changes occurring in gasified coal as the process continues. At the beginning of the experiment, a zone of degasified coal is created in a seam. The process results from the phenomenon of oxidation of carbon particles. Within the zone, an area of increased porosity, comparing with the surrounding, is created. Then, it is a cavern surrounded by areas of transformed coal and gasification products. In natural conditions, solid products of the process as ash and slag, or fragments of the surrounding rocks falling from the roof, may be collected inside the cavern. In the final stage of the process, when all the coal undergoes conversion from solid body into gas, the cavern should cover the whole gasification zone. Density parameters for coal assumed in the model are shown in Table 2.

Theoretical calculations were conducted using a module for presurvey modelling (Geotools 1999), based on 2D modelling concept (Talwani *et al.* 1959). Their results are presented in Fig. 4.

Table 2

Values of rock density assumed in computational models

Type of rock	Bulk density [g/cm^3]
coal *in situ*	1.40
degasified coal	1.00
adjacent rock	2.00

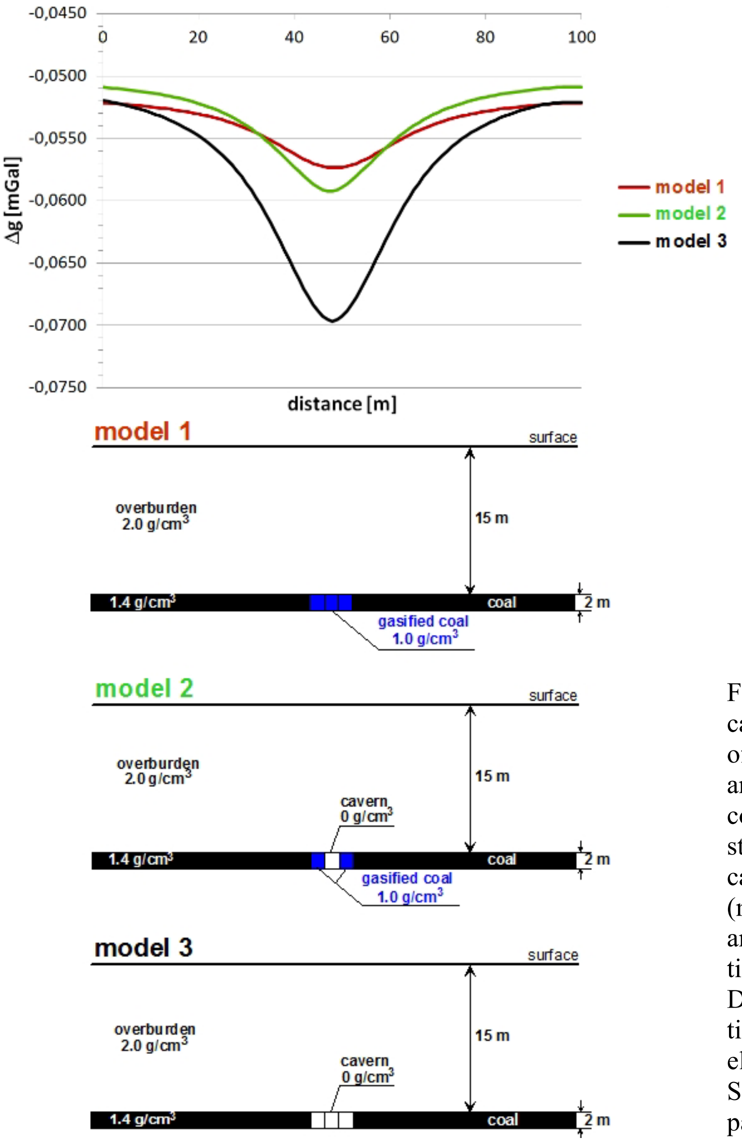

Fig. 4. Theoretical distribution of gravity field anomalies over a coal seam in the stages of gasification process (models 1, 2, 3) and a computational models. Detailed description of all models is given in Section 6 of the paper.

In model 1, which represents only the area of gasified coal, a local decrease in the value of gravity reaches its maximum amplitude of approx. 0.0055 mGal. It is the value that is nearly equal to the value of an error in a single read-out of CG-5 gravimeter. Formation of a cavern within the gasification zone only slightly increases the value of the amplitude of anomalies to the level of approx. 0.0083 mGal in model 2. A significant change occurs only after all the mass in all the gasification area disappears as a result of its conversion into gas, which is represented in model 3. This reflects the situation when the whole gasification zone turns into a cavern of height equal to the thickness of the seam. In that case, the value of amplitude of anomalies reaches 0.0178 mGal and it is a value significantly exceeding the value of a field measurement error for a standard land gravimeter.

7. RESULTS OF THE MEASUREMENTS AND THEIR INTERPRETATION

Table 3 contains the lowest and the highest values of gravity in Bouguer reduction Δg in the databases for given measurement series. It is apparent that maximum amplitudes of changes in relative values of gravity – anomalies in column 2 are by approximately an order of magnitude higher than the maximum values of the error of determining them showed in column 4. This allows, despite low numerical values, conducting both qualitative and quantitative interpretation of the data.

Table 3

Changes in relative values of gravity in Bouguer reduction Δg in databases for the measurement series

Series	Range of changes in relative values Δg [mGal]	MSE of single measurement μ_0 [mGal]	MSE of determining value of anomaly in Bouguer reduction v_0 [mGal]
1	2	3	4
I	–0.0123-0.0125	± 0.0028	± 0.0036
II	–0.0042- 0.0178	± 0.0021	± 0.0029
II – I	–0.0163- 0.0158	± 0.0028	± 0.0036

In the obtained map of anomalies in Bouguer reduction for data of measurement series I (Fig. 5) we can see three areas of anomalously lowered value of relative gravity. The first one is located in the northern corner of the test site with the centre of the anomaly in points 11-12. The second one is near the junction of the flues and north of the place with the maximum in point 40. The third one is in the eastern corner with the centre in point 59.

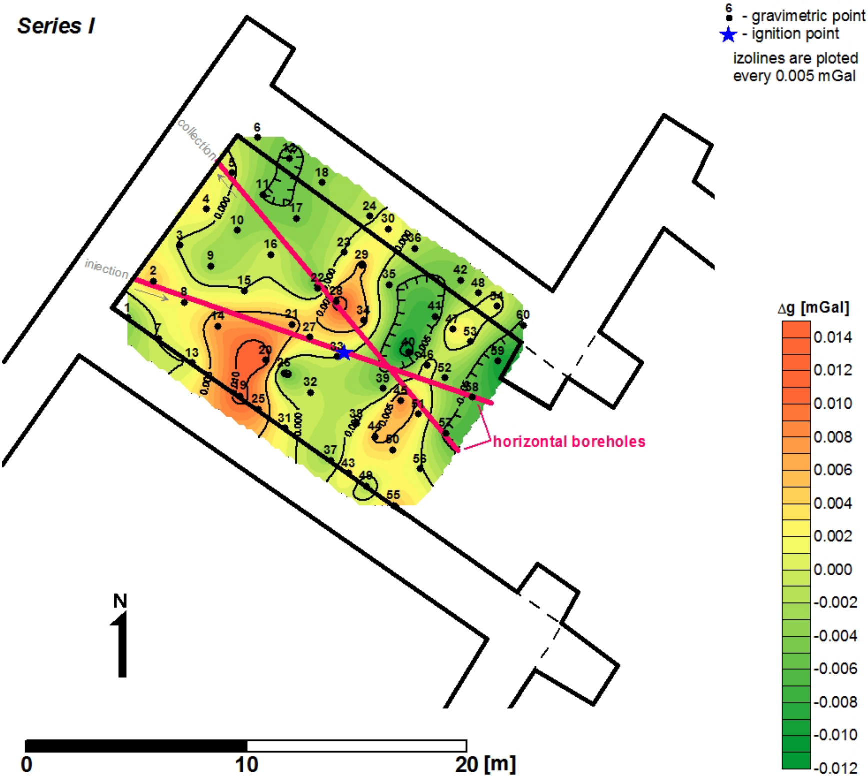

Fig. 5. Distribution of Bouguer anomaly before gasification – series I.

The highest amplitude of changes was observed for anomaly 2. In point 40, the relative value of gravity is negative, and it is –0.01226 mGal. There are also two positive anomalies in the distribution of the gravity field. They are located around points 19-20 and 28. The anomaly has the highest values, of 0.01248 mGal, in point 20. The genesis of the anomalies is most probably connected with the heterogeneity of geological layers forming the rock mass and in their density fluctuations. The distribution of Bouguer anomalies shows that the rock mass in the tested area is not homogenous. It causes local changes in the value of Bouguer anomaly of amplitude of ±0.005 mGal, similar to the values of measurement error.

Figure 6 shows distribution of relative values of gravity recorded in series II, *i.e.*, after termination the coal gasification process in the seam 24 days after series I. To visualise the data we used the same colour patterns for the values of gravity field to facilitate comparing measurement series.

Generally, in the map of anomalies in Bouguer reduction, made after termination of the experiment, we can see a slight increase in relative values

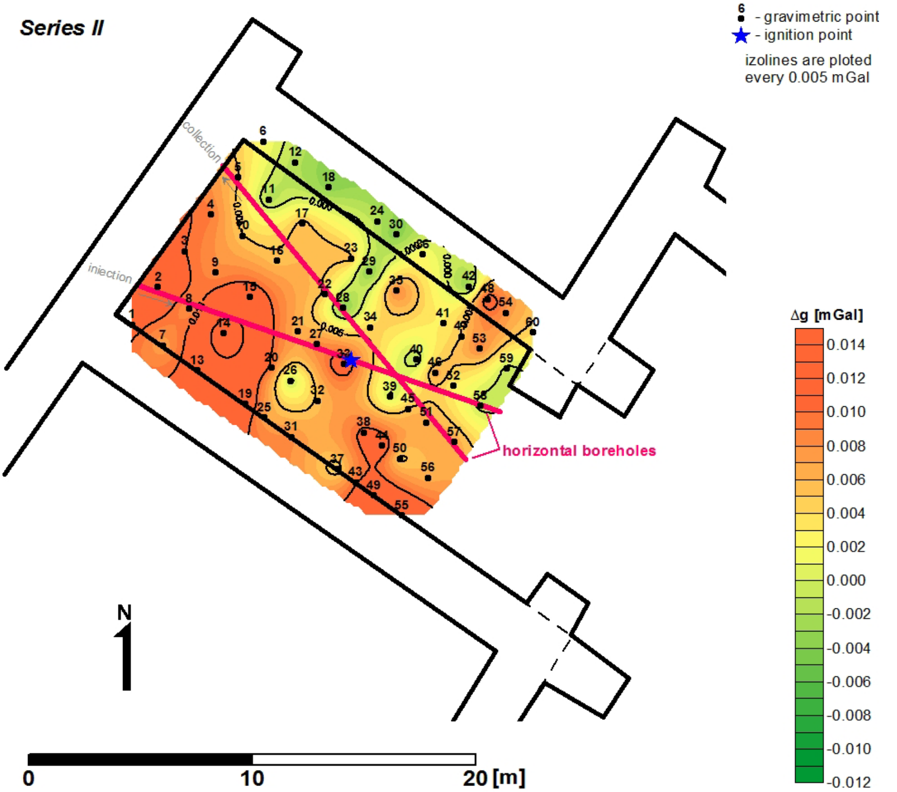

Fig. 6. Distribution of Bouguer anomaly after gasification – series II.

of gravity comparing with the data obtained in the measurement series made before gasification. In the image of isolines for series II, there is a new distinct negative anomaly spreading from the roadway bordering the block of gasified coal from the north towards its centre. The anomaly contains the points: 28, 29, and 30, which had apparently positive relative values (>0.003 mGal) in series I. In series II, in those points, relative values of gravity dropped below –0.004 mGal. The difference in values between series I and II is approx. 0.007 mGal in the area.

As far as the assessment of effects of coal gasification in a seam is concerned, the map of differential anomalies of gravity in Bouguer reduction is the most useful (Fig. 7).

Within the map we can distinguish two areas, marked A and B, where the difference in values of anomalies is negative. Area A is located in the vicinity of the junction of the flues and behind the place where gasification process is initiated in a seam. Its surface area is rather small, of approx. 3 m^2.

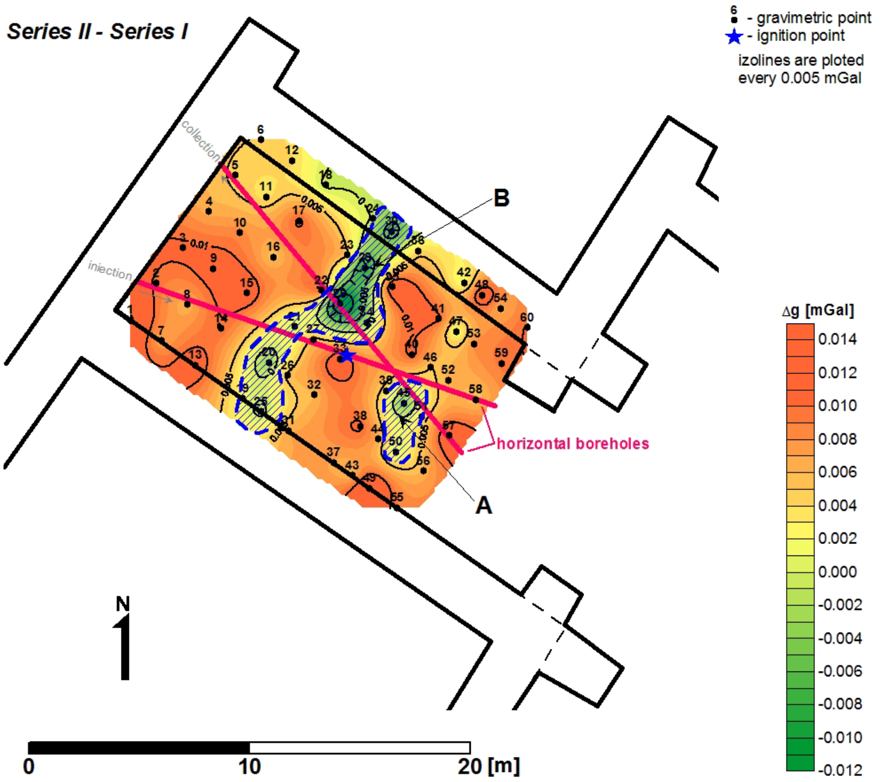

Fig. 7. Differential map of Bouguer anomaly (series II – series I) with interpretation.

The amplitude of differential anomaly in the centre of the anomalous area is 0.007 mGal. The area of differential anomaly B runs perpendicular towards the roadways bordering the gasified coal block, and covers its whole width. It has a much bigger surface area than anomalous area A. Relative amplitude of differential anomaly reaches its maximum value in the vicinity of an outlet. Its local decrease, in comparison with the values in the surrounding rock mass, is by 0.012 mGal.

The recorded anomaly in the vicinity of the place where the coal is ignited may mean that there is an area of transformed coal of relatively lower density. It is possible that the flow of gas within the seam was different than it was assumed due to a leakage in the roadway support. It could lead to a situation when the process of coal oxidation developed in two areas of the block to be gasified within the coal seam. While gases being the product of the process occurring within anomalous area A flowed properly along the flue to the receiving installation, the gases from the central part of anomalous area B migrated towards the sidewalls of roadways surrounding the block of coal.

The interpretation of the results of gravimetric measurements is consistent with the simulations of the size of the coal gasification zone recreated basing on the amount of process gases received. Observations made in the roadways after extinguishing fire in the coal block confirm it too. In some places of the support there were visible leaks of tar – a by-product of the gasification. With the test borehole B1, whose location and log are given in Fig. 1, drilled in anomalous area A, a small cavern was detected of a height of 0.15 m at a depth of 15.4 m. In its surroundings there was only coal transformed during the gasification process. Generally, this is consistent with the image of a gasified coal seam described with model 2 in theoretical considerations.

8. SUMMARY

Results of the conducted tests confirm the initial assumptions that the microgravity method can be used for imaging and controlling the development of coal gasification process in a shallow seam. In the case described in the paper, the gasification experiment lasted too short to cover a bigger volume of coal. During the experiment in the seam, transformation of solid mass into gas occurred in a limited space. That is why coal probably underwent mainly chemical transformation in anomalous areas A and B. In those areas, only small caverns could be formed which could not have a significant influence on gravity field since their values are beyond measuring capabilities of land gravimeters. Anomaly A was detected in the place located behind the point of ignition. Test borehole drilled within the range of that anomaly revealed the presence of a small cavern at the depth of the coal seam. Anomaly B is located in front of this point. Furthermore, it transects both flues and the faces of the surrounding galleries. It can be assumed that the development of this undesired zone led to termination of the experiment untimely. This happened when in the gaseous products of combustion have increased the nitrogen content significantly (Table 1).

The data obtained in the tests confirmed model analyses made at the stage of designing the measurements. The final effect of gasifying a coal seam on changes in gravity field is well described by model 2, in which a local transformation zone is formed in the seam. The zone contains degasified coal with micro pores and small caverns in regions where the combustion took place. The zone, in the described experiment, is relatively small. That is why the amplitudes of changes in the field of differential Bouguer anomaly in anomalous areas are relatively small, yet similar to model 2 analysed prior to the tests. In the model we assumed that the cavern within the gasification zone covers the whole thickness of the seam. In model analyses we *a priori* assumed the value of bulk density of 1.00 g/cm^3 for the gasified coal zone. In reality it can be smaller and in such a case quantitative changes in the distribution of differential anomalies will be bigger than the ones described with a theoretical model. This may explain the fact that within differential anomaly B the amplitude reaches a higher value than in theoretical models.

The tests described in the paper allow to conclude that in industrial applications of the gasification in the seam, where processing coal into gas will occur in areas of much larger volume, gravimetric anomalies will have similar and higher values to the ones described with model 3 for a 2-meter-thick seam completely transformed into gas. The amplitude of differential anomaly will increase with the thickness of coal deposit.

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