ANALYSIS OF TREND CHANGES OF GROUND DEFORMATION IN THE SELECTED MINING AREAS IN DABROWSKI COAL BASIN (SOUTH POLAND)

Stanisława Porzycka, Andrzej Leśniak

AGH University of Science and Technology Krakow, Poland
Department of Geoinformatics and Applied Computer Science

ABSTRACT

In presented work the analysis of temporal trend changes of small, long period ground deformation was shown. The general analysis concerns the selected mining areas of Dabrowski Coal Basin (south Poland) and more detailed analysis was performed for “Grodziec” coal mine. The ground deformations for time period between 1992 and 2003 were determined using PSInSAR technique. Performed analysis revealed that for some stable scatterers in analysed period of time the changes of deformation’s trend occurred. The location of PS points with trend changes is not random (both in time and space). It was found that for first part of studied time period when the “Grodziec” coal mine was working for most PS points the increase of subsidence velocity was detected. The situation has changed after abandon the mine. After 1998 for most stable scatterers the decrease of subsidence velocity was revealed.

Index Terms—PSInSAR, ground deformations, coal exploitation

1. INTRODUCTION

The ground deformations that occur in the mining and post-mining areas can be generally divided into two groups. The first group includes the strong and abrupt ground deformations (usually discontinuous) while the second group includes very small, continuous, long-period deformations that can occur even several years after finished exploitation. In this work the analysis of secondly mentioned kind of deformations was performed. The general analysis concerns the selected seven mining areas located in the Dabrowski Coal Basin in South Poland (Fig. 1). The more detailed analysis was done for one of them: the “Grodziec” coal mine. The values of deformations were measured using PSInSAR (Permanent Scatterer Interferometry Synthetic Aperture Radar) technique for the period of time between years 1992 and 2003. The aim of this work is to study the trend changes of ground deformations (in time) in relations to mining activity. Presented work is a continuation of research described in [5].

2. DATA SET

The values of small, long period ground deformations in the Dabrowski Coal Basin were measured using PSInSAR technique. The detailed description of this technique can be found in numerous articles, for example [2][3]. Generally the PSInSAR method is based on the processing of stack of satellite SAR images and derives point data (PS points) which locations correspond mainly with the man made features on the ground like buildings, bridges etc. The values of ground deformations at fixed time intervals are determined for each PS point. This technique gives the possibility to study the values of ground deformations throughout long time periods. The PSInSAR method derives information only about small deformations not larger than several centimetres per year. In the studied region that covers area of 150 km² the values of ground deformations were determined at 6105 PS points nearly in every month between years 1992 and 2003. Location of the PS points is very irregular (Fig. 1).
25.1 [mm/year]. The minus sign indicates the subsidence motion that is characteristic for most part of Dabrowski Coal Basin. The mean value of average annual motion rate in studied region is equal to -2.18 [mm/year].

3. MINING ACTIVITY IN THE STUDIED REGION

Dabrowski Coal Basin is located in South Poland within the Upper Silesian Coal Basin. The studied region includes seven coal mines: “Jowisz”, “Grodziec”, “Paryz”, “Saturn”, “Sosnowiec”, “Porabka-Klimontow”, “Kazimierz-Juliusz” (Fig. 1). The coal exploitation in this area was performed for more than 200 years. Nowadays only “Kazimierz-Juliusz” is a productive coal mine. Other coal mines were closed between years 1995-2004 (“Jowisz” - 2000, “Grodziec” - 1998, “Paryz” - 1995, “Saturn” - 2004, “Sosnowiec” -1997, “Porabka-Klimontow” - 2000). Despite the end of their operation the water pumping was still conducted in majority of them. The performed analysis of ground deformations in this region covers the years 1992-2003. Near the beginning of this period (in 1991), coal productions in these mines were about (in thousand tons per year): “Jowisz” – 1.00, “Grodziec” – 0.563, “Paryz” – 0.907, “Saturn” – 0.997, “Sosnowiec” – 0.993, “Porabka-Klimontow” – 1.593 and “Kazimierz-Juliusz” – 1.175. The elongate longwall system of exploitation with fall of roof is commonly used in the studied region. Only small percent of coal comes from exploitation with the filling. The significant difficulty in the exploitation of coal in the Dabrowski Coal Basin is its complex tectonic structure. The coal deposit is cut by numerous faults [4].

In presented work the detailed analysis of trend changes was performed for mining area of “Grodziec” coal mine. This studied area covers approximately 22.4 km². In this region the 535 PS points were identified. Their location was presented in the figure 2. In The “Grodziec” coal mine the exploitation was carried on since 1901. The last ton of coal was exploited in this mine in December 1998. Within mining area there are two large faults: Grodziecki fault and Wojkownicko-Bedzinski fault (Fig. 2). The throw of first of them varies from 170m to 250m and throw of Grodzki fault is equal about 200m. The faults divide the mining area into four exploitation tectonic blocks: A, B, C and D (Fig. 2) [1]. In the studied period of time the exploitation was carried on in the B part. During last year of exploitation the coal mine had three operating shafts: I, II and VII (Fig. 2). The coal was exploited from coal bed with number 816 located at the depth of 500 m. The amounts of exploitation in the last in year 1992 –1998 were presented in the table 1.

<table>
<thead>
<tr>
<th>Year</th>
<th>Annual production [ton]</th>
<th>Daily production [ton/day]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1992</td>
<td>627 300</td>
<td>2 571</td>
</tr>
<tr>
<td>1993</td>
<td>757 313</td>
<td>2 974</td>
</tr>
<tr>
<td>1998</td>
<td>449 740</td>
<td>1 771</td>
</tr>
</tbody>
</table>

Tab 1 The amount of exploited coal in the years 1992-1998 [1]

It is worth to underline that in the B tectonic block there are very unfavourable geological conditions (lot of faults, nips and folding) that made the exploitation very difficult. These conditions influenced the decision to finish the exploitation.

4. PERFORMED ANALYSIS

The previous research revealed that for 40% of PS points from analyzed area of Dabrowski Coal Basin the ground deformation trend changes occurred in the studied time period [5]. Most of the changes occurred between X.1993 and XII.1995 (mainly increase of subsidence velocity) and between dates III.1999 and IV.2000 (mainly decrease the subsidence velocity) (Fig 3). Previous research pointed out that the ground deformation trend changes are consistent with the direction of Bedzinski fault that is a main fault of this region [4]. The further analysis of ground deformations trend changes revealed also different (but much less pronounced) relation. It can be seen that in the time period between X.1993 and XII.1995 when the most cases of increase of subsidence velocity were revealed all seven coal mines were operating. In subsequent years, when the following coal mines were liquidated, more and more cases were found to reduce the rate of deformation.
The detailed analysis of ground deformations trend changes was performed for “Grodziec” coal mine. It was done for six time periods: X.1993-XI.1994, XI.1994-XII.1995, XI.1994-XII.1995, XII.1995-I.1997, II.1998-III.1999 and III.1999-IV.2000. For each of them the maps of relative density of PS points with trend changes were prepared. In this work only two categories of trend changes were analysed: category I – increase of subsidence velocity and category II – decrease of subsidence velocity. The changes that concern the uplift motions were revealed in studied region only for very small percent of PS points and therefore they were not taken into consideration in the further analysis. The most important maps of relative density of PS points for which trend changes occurred were presented together with the location of exploitation parcels, main faults and pit shafts in the Fig.4-6.

It can be seen in the figure 4 that in the time period between X.1993-XI.1994 the increase of subsidence values is characteristic for large part of mining area of “Grodziec” coal mine. Such changes occurred in and around the exploitation field (block B). During the time the situation has completely changed. In the figure 5 (that concerns time period between II.1998 - III.1999) it can be seen that for south part of mining area the decrease of subsidence velocity is characteristic. In this time period the daily amount of exploited coal was being significantly decreased down to zero in the end of December 1998. After 1998 the decrease of subsidence velocity was revealed for greater part of the mining area (Fig.6).

6. CONCLUSIONS

The study of the ground deformation trend changes is helpful in clarifying the mechanism of ground deformations. In case of Dabrowski Coal Basin the obtained results indicate the strong correlation of values of deformations.
with the location of main faults. However detailed analysis of coal exploitation history can reveal further regularity that can give possibility to asses the impact of coal exploitation on the values of small, long-period ground deformations that occur in the mining and postmining areas.

7. REFERENCES


