ABSTRACT

1. Name.

   Beata Orlecka-Sikora

2. Diplomas, academic degrees – including name, location and year of award, as well as the title of the doctor's thesis.

Doctor of Earth Sciences (PhD) 2005	AGH University of Science and Technology in Cracow, Doctoral Studies in the Department of Geology, Geophysics and Environmental Protection (GGiOŚ), Al. Mickiewicza 30, 30-059 Cracow, title of the doctoral thesis: "*Resampling methods for improving accuracy of the probabilistic seismic hazard analysis*", thesis supervisor – Prof. Stanisław Lasocki PhD. Thesis awarded by the Department Council at GGiOŚ AGH.
MEng 2000	AGH University of Science and Technology in Cracow, PhD Studies in the Department of Geology, Geophysics and Environmental Protection, Al. Mickiewicza 30, 30-059 Cracow, specialty: Environmental Engineering, title of the master's thesis: *"Analysis of general dimensions and singularity spectrum of local seismic activity induced by mining works on the example of the Halemba Coal Mine*", supervisor – Zofia Mortimer PhD. Eng. Thesis awarded in the competition of the Student's Scientific Association for "The best theoretical thesis".
1998 - 2000	Interdepartmental School of Teacher Training, AGH University of Science and Technology in Cracow, Al. Mickiewicza 30, 30-059 Cracow.

3. Information on employment in scientific units.

since 2010 until now	Assistant Professor, Department of Seismology and Physics of the Earth's Interior, Institute of Geophysics at the Polish Academy of Sciences (PAN), from April 2010 - Head of the Research Team for Induced Seismicity and Seismic Hazard.

2005 – 2009	Assistant Professor, Department of Geology, Geophysics and Environmental Protection, AGH University of Science and Technology in Cracow.
2004 – 2005	Assistant, Department of Geology, Geophysics and Environmental Protection, AGH University of Science and Technology in Cracow.

4. Indication of research achievement resulting from Art. 16 item 2 of the Act dated 14 March 2003 on the academic degrees and the academic title as well as on the degrees and the title within the scope of art (Journal of Laws No. 65, item 595, as amended):

a) (author/authors, title/titles of publication(s), year of publication, publishing house),

The common title of the papers: *"The role of static stress transfer in a various-scale seismogenic process"*

[4I] Orlecka-Sikora, B, Papadimitriou, E.E., Kwiatek, G. A study of the interaction among mining induced seismic events in the Legnica-Glogow Copper District, Poland, 2009, *Acta Geophysica*, vol. 57, z. 2, doi: 10.2478/s11600-008-0085-z.

[4II] Orlecka-Sikora, B. Significance of static stress transfer caused by coseismic slip of mining-induced seismic events in seismicity generation process in mines, 2009, *Geologia*, 35, z. 2/1, 519-525 (in Polish).

[4III] Orlecka-Sikora, B, Perspectives of Coulomb Stress Transfer Approach in Studies of the Interaction Among Mining-Induced Seismic Events. 2009. In: *Controlling Seismic Hazard and Sustainable Development of Deep Mines*, C. Tang (Ed.): Proc. Seventh Int. Symp. on Rockburst and Seismicity in Mines 21-23 August 2009, Dalian, China, Rinton Press, New York, 59-72.

[4IV] Orlecka-Sikora, B. The role of static stress transfer in mining induced seismic events occurrence, a case study of the Rudna mine in the Legnica-Glogow Copper District in Poland, 2010, *Geophys. J. Int.* 182, 1087–1095, doi: 10.1111/j.1365-246X.2010.04672.x.

[4V] Leptokaropoulos, K. M., Papadimitriou E. E., Orlecka–Sikora, B, Karakostas V. G. Seismicity rate changes in association with time dependent stress transfer in the region of Northern Aegean Sea, Greece. 2010, *Bull. Geol. Soc. Greece*, XLIII, 2093–2103, 12th International Congress, Patras, Greece, 2010.

[4VI] Orlecka-Sikora B., Lizurek G., Rudziński Ł. Static stress transfer in the seismogenic process in Rudna mine, 2011, *Polish Mining Review*, 6/2011, 76-85 (in Polish).

[4VII] Leptokaropoulos, K. M., Papadimitriou E. E., Orlecka–Sikora, B, Karakostas V. G. Time dependent seismicity rate changes in association with stress transfer in the region of Northern Aegean Sea, Greece, 2011, *Geophys. J. Int.* doi: 10.1111/j.1365-246X.2011.05337.x.

b) discussion of the research goal in the above-mentioned papers and obtained results, including discussion of their possible use.

"The role of static stress transfer in a various-scale seismogenic process"

The main subject of the seven papers that constitute the research achievements is the *role of static stress transfer in a various-scale seismogenic process*. *Stress transfer* means redistribution of stresses induced by seismic events, observed in an area that is significantly larger than the fault zone (e.g. Chinnery, 1963). Change of stresses is caused by propagation of seismic waves and coseismic displacement along the rupture plane. The first cause is temporary and leads to instantaneous stress changes in the shock impact zone, referred to as *dynamic stress transfer*. The second cause is permanent and the change induced by it is referred to as *static stress transfer*. The static stress transfer is currently considered to be the main cause of earthquake interactions (e.g. King *et al*, 1994; King and Cocco, 2001). If the seismogenic zone is impacted by the static stress transfer caused by another earthquake, the stress in this zone may rise or decrease, which will in consequence accelerate or delay the occurrence of subsequent shocks (fig. 1). Even minor changes in static stress in a given area may impact region's seismic activity in future (e.g. Das and Scholz, 1981; Stein and Lisowski, 1983). The theory of static stress transfer revolutionized the approach to the issue of time-dependent seismic hazard (e.g. Parson, 2000). In recent years, the analysis of static stress transfer has been one of the basic methods applied in predicting earthquakes by international *Collaboratory for the Study of Earthquake Predictability* (*CSEP*).

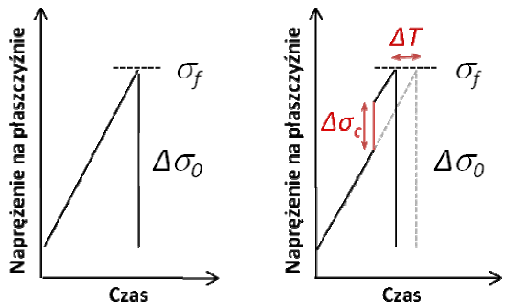

Fig. 1. The scheme of influence of static stress transfer on hypothetical rupture plane of future earthquake. σ_f - critical stress, $\Delta\sigma_0$ - stress drop, $\Delta\sigma_c$ - stress change impacted by another shock, ΔT - time change while reaching the critical stress.

Static stress changes caused by coseismic displacement of events is calculated based on the equation of dislocation in elastic and isotropic half-space. In such conditions, the displacement field u_k for homogenous dislocation U across surface plane Σ can be specified in the following formula (Steketee, 1958a, b):

$$u_k = \frac{U_i}{8\pi\mu} \iint_\Sigma w_{ij}^k v_j d\Sigma \qquad (1)$$

where μ is the elastic module of the medium, v_j are directional *cos* of the normal of dislocation plane, U_i is the *i*-th component of *U*, w_{ij}^k are Green's functions.

The displacement and deformation field is derived after integration of equation (1) (Okada, 1985, 1992). The stress is evaluated based on the deformation in accordance with Hooke's formula.

A shock occurs when the stress in the fault plane exceeds the resistance of the rock mass. As the criterion of rock mass strength in the issue of static stress transfer the Coulomb's criterion is used (Jaeger and Cook, 1979). According to this criterion, a seismic shock occurs when the shear stress in the rupture plane, τ, is equalized by the normal stress in surface σ_n, which together with the friction coefficient, μ, blocks the fault against slip. This balance is described by the ***C**oulomb **F**ailure **F**unction* (*CFF*):

$$CFF = \tau - \mu \cdot (\sigma_n - p) - c \qquad (2)$$

where *p* is pore fluid pressure, *c* is cohesion, τ is positive in the slip direction of failure plane, σ_n is positive for tension.

In practice, the real values of the shear and normal stress on a given plane are not known, but the magnitude of changes caused by the occurrence of a seismic event can be evaluated and used to calculate the changes in the failure function:

$$\Delta CFF = \Delta\tau - \mu \cdot (\Delta\sigma_n - \Delta p), \qquad (3)$$

where $\Delta\tau$ means a change in shear stress, positive in the slip direction on the failure plane, $\Delta\sigma_n$ is a change in normal stress on the examined surface, positive for tension, Δp means a change in pore fluid pressure.

It is assumed that pore fluid pressure changes are proportional to changes in normal stress (Cocco and Rice, 2002) and are included in an effective friction coefficient, μ':

$$\mu' = \mu \cdot (1 - B) \tag{4}$$

where $B = \frac{\Delta p}{\Delta \sigma_n}$ is the Skempton's parameter.

Thus, ΔCFF is:

$$\Delta CFF = \Delta\tau - \mu' \cdot \Delta\sigma_n \tag{5}$$

Positive changes in *CFF* result in higher probability of another shock, while negative changes in *CFF* reduce this probability.

In natural seismicity, the phenomenon of stress transfer has been examined for more than 25 years. Such model interaction between earthquakes brought major predictability success, for example in predicting the location of earthquake on Sumatra in 2005 (McCloskey *et al.,* 2005). In the papers with results presented in the publications, which are the basis for my habilitation process, I have examined the possibility of using the static stress model both in natural seismicity and human-induced seismicity. In 2007 I started, and still continue, to examine the role of stress transfer in mining-induced seismic activity and possibility of using this concept in seismic hazard analysis. These examinations were the first attempt in the world to apply the concept of stress transfer in induced seismic activity. The results of examinations are presented in publications identified as [4I] – [4IV] and [4VI], as well as in the paper submitted for publication to the *International Journal of Rock Mechanics and Mining Sciences* (first review completed): Orlecka-Sikora B., Lasocki, S., Lizurek G., Rudziński Ł. "Response of seismic activity in mines to the stress changes due to mining induced strong seismic events", *International Journal of Rock Mechanics and Mining Sciences*.

Seismic activity in mining areas appears in response to stress changes induced by mining, compared to stress drops during mining shocks (e.g. McGarr and Simpson, 1997). Many studies of time and space structure of the seismogenic process in mines provided evidence for internal interrelations among seismic events. These include the phenomenon of grouping of events in time and space clusters (e.g. Gibowicz, 1997; Orlecka–Sikora and Lasocki, 2002), the existence of memory in the process of tremor occurrence (e.g. Kijko 1997; Węglarczyk and Lasocki, 2009), stress diffusion and its impact on the occurrence of strong events (Marsan *et al.*, 1999), occurrence of doublets and multiplets (e.g. Gibowicz, 2006). One of the mechanisms responsible for the relationships between mining tremors can be, like in natural seismic activity, the static stress transfer. The main general conclusion of my studies is a statement that despite the fact that in mining-induced seismic activity the dominating role in stress field redistribution is taken by mining, the static stress transfer resulting from preceding shocks significantly changes the distribution of stresses around the working and determines further seismic processes to a major extent. Strong seismic events result in static stress changes in an area larger than the source, which can make further mining shock occur sooner or later. A strong correlation between static stress changes and location of seismic activity indicates that the static stress transfer should be included in the assessment of seismic hazard in mines. Estimation of static stress changes will help predicting changes in seismic activity and defining areas with increased risk of strong shocks in future. Detailed analysis of static stress transfer integrated with the tectonics characteristics of the mining field can also help in optimization of mining works in terms of workings area stability.

The papers related to the static stress transfer in a mining rock mass are completely new input to the development of the static stress transfer model for two reasons. Primarily, they were the first to show the influence of coseismic displacements on the process of generating tremors in mines with rockbursts. Secondly, they concern lower magnitudes, thus, smaller changes of static stresses. They show that such smaller changes cause releasing effects also in the seismic process. Therefore, they supplement the results of examinations of stress transfer in natural seismic activity and relate to the stream of research papers devoted to independence of the rupture process from the scale of the event. All papers have been led and largely prepared by myself. Obtained results brought considerable interest in research groups dealing with both human-induced seismic activity and interactions between natural earthquakes. For example, thanks to Massimo Cocco (INGV Rome) PhD, one of the key persons introducing the static stress transfer to the seismology, we are in contact and discuss the results of my papers and their consequences.

Conclusions on the impact of small changes of stresses on the seismogenic process gathered in the studies of mining-induced seismic activity have been the basis for my examination of the stress transfer issue in natural seismic activity. These examinations were possible thanks to the long cooperation with seismologists from the Aristotle University in Thessaloniki, Greece. Together with Prof. Eleftheria Papadimitriou, Prof. Vassilis Karakostas and PhD student Konstantinos Leptokaropoulos, we study the impact of static stress transfer on the time-dependent evolution of seismic activity in the area of Greece. In papers [4V] and [4VII], for the first time the concept of static stress transfer was used to evaluate time-dependent seismic activity rate changes in the region of the Northern Aegean Sea. The analysis of seismic data and major part of the text have been prepared by Konstantinos Leptokaropoulos, doctoral student. Since 2009 I have been a member of the Advisory Committee for the doctoral thesis of Konstantinos Leptokaropoulos. My contribution into the enclosed papers is participation in the development of studies concept and papers, the incorporation of statistical methods for the evaluation of significance achieved results and their uncertainties, discussion on the results, participation in paper editing, participation in paper reviewing/revising. Between 16.11.2010 and 15.12.2010, the doctoral student visited the Institute of Geophysics at the Polish Academy of Sciences, during which he tested various seismic activity models of Greece and the impact of parameter values on the analysis results under my supervision. The visit was an important stage in the development of paper [4VII].

Contribution of co-authors to the individual papers was recorded in the enclosed statements. Presentation of the scientific aims of individual papers and the input into the knowledge of static stress transfer is presented below.

[4I] Orlecka-Sikora, B, Papadimitriou, E.E., Kwiatek, G. A study of the interaction among mining induced seismic events in the Legnica-Glogow Copper District, Poland, 2009, *Acta Geophysica*, vol. 57, z. 2, doi: 10.2478/s11600-008-0085-z.

The paper contains the first results of the study of static stress transfer for mining-induced seismic activity. For the analysis, the authors considered a series of events with energy greater than $1.0 \cdot 10^5$J, recoded by the Mine Geophysics Station in the Rudna Mine in the Legnica-Glogow Copper District. The paper included examination of the cumulative static stress changes due to previous events and their impact on the time and locations of subsequent seismic events. Seismic events were modeled as rectangular faults with dimensions equal to the circular fault radius evaluated in spectral analysis. In order to assess if the location of subsequent strong events in the series was associated with the static stress changes caused by earlier seismic events, *ΔCFF* was calculated for a surface representing the fault plane of the subsequent shock. If the tremor occurred in an area where static stresses increased, it was assumed that timing of tremor occurrence could be shorter due to additional stresses in the fault surface, causing the strength of rock mass to be exceeded. Over 60% of analyzed shocks occurred in regions with positive static stress changes. Such results suggested that the transfer of static stresses can also impact the seismic generation process in mines and encouraged to continue the study of this phenomenon.

[4II] Orlecka-Sikora, B. Significance of static stress transfer caused by coseismic slip of mining-induced seismic events in seismicity generation process in mines, 2009, *Geologia*, 35, z. 2/1, 519-525 (in Polish).

The paper presents the results of analysis of the impact of static stress transfer caused by strong seismic events that occurred in a 30-day period backwards in time. The reason for such an approach is the fact that the seismogenic process in mines is dependent on the mining and thus varies in time. Changes in static stress are permanent, but in mining conditions they are also impacted by mining works changing in time. However, examination of a series of mining tremors indicated that seismic activity changed in time slowly enough to consider tremor occurrence process as stationary in shorter time periods. In such periods, the impact of changing mining works on the coseismic stress changes can be neglected. Proportion of the analyzed tremors in the paper, located in areas with increased static stresses due to earlier seismic activity was 53%, while for strong shocks it was 58%. A statistical test developed for the examined series of events proved at the significance level of 5% that in areas with static stresses rise at least by 0.002 MPa due to earlier seismic activity there is a statistically significant relationship between locations of seismic events and ΔCFF. This means that in the Rudna Mine area stronger mining tremors change the stress field and can increase the probability of the occurrence of a strong future seismic event.

[4III] Orlecka-Sikora, B, Perspectives of Coulomb Stress Transfer Approach in Studies of the Interaction Among Mining-Induced Seismic Events. 2009. In: *Controlling Seismic Hazard and Sustainable Development of Deep Mines*, C. Tang (Ed.): Proc. Seventh Int. Symp. on Rockburst and Seismicity in Mines 21-23 August 2009, Dalian, China, Rinton Press, New York, 59-72.

The paper presents an attempt to apply a rate/state model with static stress transfer in induced seismic activity for the evaluation of time-dependent changes in seismic activity. The seismic activity model based on the rate/state law (Dieterich, 1979, 1992, 1994) with static stress transfer allows examination of the impact of subsequent stress peaks associated with multiple seismic sources on the seismic activity as well as analysis of this effect in time and space. According to this theory, a sudden increase of static stresses causes the increase of seismic activity, which decays back toward its initial rate with time, while a sudden stress drop causes the seismicity rate to decrease, also recovering toward its reference rate. In such model of seismogenic process, evolution of seismic activity depends also on the reference level of seismic activity preceding the stress change, on the constitutive parameter and stress changing rate. All these parameters have been described with a state variable, which changes after a sudden

stress change to a new value. The lower state variable before stress change, the higher impact of stress changes on the level of seismic activity.
Studies presented in paper [4III] include selection of a series of seismic events located in one of the seismogenic zones determined in the area of Rudna Mine, where two strong events occurred with local magnitudes of 4.1 and 3.7. Both events occurs one shortly after another, causing an increase in region's seismic activity. The results of preliminary study indicated that the modeled seismic activity changes reflect the observed seismic activity changes after strong tremors both with respect to time and space. These results indicate the potential of the rate/state approach for the evaluation of seismic hazard. Following the occurrence of a strong event one can evaluate which areas are exposed to increased seismic activity, how the level of seismic activity changes and after what time may be expected for the seismic activity to drop to the level preceding the strong seismic event.

[4IV] Orlecka-Sikora, B. The role of static stress transfer in mining induced seismic events occurrence, a case study of the Rudna mine in the Legnica-Glogow Copper District in Poland, 2010, *Geophys. J. Int.* 182, 1087–1095, doi: 10.1111/j.1365-246X.2010.04672.x.

The paper presents the test results for the statistical significance of the impact of static stress transfer on the seismic generation process in the Rudna Mine. The analysis was based on a sequence of 153 tremors in the Rudna Mine with M_L over 2.0 for the period between 01.07.2005 and 12.12.2006. Coseismic dislocation caused by the tremors was calculated with an assumption of seismic event sources as point source. The accelerating (triggering) and delaying mechanism influencing future seismic events was defined in quantitive terms by the proportion of seismic events located in areas with positive and negative static stress changes respectively. In order to evaluate the statistical significance of the relationship between ΔCFF and locations of shocks, a statistical test was developed based on 2000 control series constructed by reordering at random the events from the original data series. For individual control series the same method was used as for the original data set to evaluate the proportion of events located in areas with positive ΔCFF and proportion of events in areas with negative ΔCFF. Next, the real proportion of events was compared to corresponding quantiles of empirical distributions of synthetic proportions and based on that the statistical significance of obtained proportion differences was calculated. On the assumed level of significance of 5%, the statistical test confirmed that positive static stress changes over 0.005 MPa have a significant influence on the seismogenic process in the area of Rudna Mine. The test did not confirm any significant influence of the negative static stress changes on the seismic activity in Rudna. The paper also included evaluation of the influence of ambiguities and errors in the solutions of the tremor source mechanism on test results.

[4V] Leptokaropoulos, K. M., Papadimitriou E. E., Orlecka–Sikora, B, Karakostas V. G. Seismicity rate changes in association with time dependent stress transfer in the region of Northern Aegean Sea, Greece. 2010, *Bull. Geol. Soc. Greece*, XLIII, 2093–2103, 12th International Congress, Patras, Greece, 2010.

The paper presents preliminary results of modeling seismic activity changes in the area of the Northern Aegean Sea in years 1964 to 2008 based on the changing field of coseismic stresses and stresses generated by the movement of tectonic plates with the rate/state approach. Evolution of the stress field was evaluated based on 11 earthquakes with $M_w > 5.8$. Expected changes in seismic activity that should result from the evolution of the stress field were compared to the observed changes in activity with $M_w > 3.8$ shocks. The correspondence of those two parameters was evaluated based on the value of Pearson's linear correlation coefficient. Obtained results indicated that for the periods with complete seismologic catalogs the applied approach may explain the observed seismic activity in more than 70%, which is important for the evaluation of time-variable seismic hazard in the analyzed area.

[4VI] Orlecka-Sikora B., Lizurek G., Rudziński Ł. Static stress transfer in the seismogenic process in Rudna Mine, 2011, *Polish Mining Review*, 6/2011, 76-85 (in Polish).

The first part of the paper includes a review of earlier results for the static stress transfer in mining-induced seismic activity. The second part of the paper presents the results of analysis of static stress changes in the field of G-11/8 at Rudna Mine and its impact on the development of weaker seismic activity in several months. The example of G-11/8 section shows that apart from the impact of positive *CFF* changes, which had been confirmed earlier in statistical terms, the impact of negative *CFF* changes on subsequent seismic activity due to mining operations is also observed. Negative values of *ΔCFF* resulted in weakening or stopping of seismic activity in the area of concentration of mining-induced stresses in the area of mining front. Such results extend the possibilities of practical application of the static stress transfer in the evaluation of seismic activity in mines.

[4VII] Leptokaropoulos, K. M., Papadimitriou E. E., Orlecka–Sikora, B, Karakostas V. G. Time dependent seismicity rate changes in association with stress transfer in the region of Northern Aegean Sea, Greece, 2011, *Geophys. J. Int.* doi: 10.1111/j.1365-246X.2011.05337.x.

The paper presents the results of evaluation of changes in the average seismic activity in time in the area of the Northern Aegean Sea based on Dieterich's rate/state formula (1994). The analyzed area was divided into 4 seismogenic zones. According to the assumed model of seismic activity, changes in the stress field caused by coseismic displacement during M_w>5.8 events in 12.1981-08.2010 and tectonic loading, resulted in step changes in seismic activity in the analyzed area. These changes estimated based on the rate/state model for each seismogenic area were compared against the observed seismic activity in the analyzed period. Qualitative and quantitative assessment of the correspondence of estimated and real changes in average seismic activity was performed. The paper also includes assessment of the impact of individual model parameters on the results. The assumed model of static stress change interaction with the seismic activity of the Northern Aegean Sea area provided satisfactory compliance of the estimated and observed seismic activity and important input into the evaluation of time-dependent seismic hazard in the analyzed area.

Beside the issues discussed in the mentioned papers, the analysis covered also the impact of the effective friction coefficient value on the results of modeled static stress changes in mines, which has been presented on the conference of the International Association of Seismology and Physics of the Earth's Interior (ISAPEI) on 10-16.01.2009, Cape Town, RSA in the presentation entitled *"Significance of Static Stress Transfer in Mining-Induced Seismicity Generation Process, the Case Study of Rudna Mine in the Legnica-Glogow Copper District in Poland"*. In order to assume a more accurate horizon for the impact of static stress changes on subsequent induced seismic activity tests were performed on various models of shock interaction, constructed based on varying length of seismic data series. The results of this stage of work were presented in two separate presentations: *"Study of the interaction among mining induced seismic events in the Legnica Glogow Copper District, Poland"* on the 31st General Assembly of the European Seismological Commission (ESC) in Hersonissos, Greece, 07–14.09.08 and *"Triggering Effect of the Static Stress Transfer in Mining-Induced Seismicity from Rudna Mine in the Legnica-Glogow Copper District, in Poland"* on the Meeting of the American Geophysical Union in San Francisco, USA, 15-19.12.08.

The results of tests of static stress transfer interaction with the process of mining seismic event generation were also presented on other seismological conferences:

1. International Workshops on Statistical Seismology (STATSEI7), Fira, Greece, 25-27.05.2011, lecture: Orlecka-Sikora, B. "*Mining induced seismicity changes due to event-event triggering"*;
2. European Geosciences Union (EGU), Vienna, Austria, 03-09.04.2011, lecture: Orlecka-Sikora B., Lasocki, S., Lizurek G., Rudziński Ł. "*Response of seismic activity in mines to the stress changes due to mining induced strong seismic events"*;
3. International Workshop on Deep Scientific Drilling at Koyna, India, National Geophysical Research Institute, Hyderabad, India, March 21-25.2011, lecture: Lasocki, S., Orlecka-Sikora, B. *"Induced Seismicity in Mines: Some Collective Properties"*;
4. European Geosciences Union General Assembly 2010, Vienna, Austria, 02-07.05.2010, lecture: Lasocki, S., Karakostas, V.G., Papadimitriou, E.E., Orlecka-Sikora, B. (2010) Keynote lecture: *"Stress shadows - a controversial topic"*;
5. ESC 2010, 32nd General Assembly, Montpelier, France, 6-10.09.2010, lecture: Orlecka-Sikora, B., Lasocki, S., Wiejacz, P., Urban, P., Koziarz, E. *"Static Stress Transfer and Event Clusters In Mining Induced Seismicity"*;
6. 32nd Polish-Czech-Slovakian Symposium on Mining and Environmental Geophysics, 20-22.05.2009, Piechowice, lecture: Orlecka-Sikora, B. *"Preliminary study of the role of rate/state stress transfer in mining-induced seismicity"*;

and as an "invited talk" in the lecture entitled "*Static stress transfer due to mining induced seismic events and its implications on seismogenic process on mining areas"* during the workshops of *MINE* project*: MINing Environments: continuous monitoring and simultaneous inversion* financed by the BMBF/DFG Programme Geotechnologien, Tomographie des Nutzbaren Untergrundes, Germany (Hamburg University, 29.11-1.12.2010).

The results of tests of static stress transfer impact on the process of generating earthquakes in Greece were also presented on the following seismological conferences:

1. International Workshops on Statistical Seismology (STATSEI7), Fira, Greece, 25-27.05.2011, lecture: Leptokaropoulos, K. M., Papadimitriou E. E., Orlecka–Sikora, B., Karakostas V. G. *"Stress interactions among active fault zones of the Aegean Sea and their impact on seismicity rate changes and time–dependent seismic hazard"*;
2. The 19th Carpathian Balkan Geological Association Congress, Thessaloniki, Greece, 23-26.09.2010, lecture: Leptokaropoulos, K. M., Papadimitriou E. E., Orlecka–Sikora, B. and Karakostas V. G. *"Study of time dependent earthquake occurrence in Greece: Relationship between seismicity rate changes and stress transfer and implications for time dependent seismic hazard assessment"*.

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5. Discussion on other scientific and research achievements.

The area of my research interest is focused on seismic processes and evaluation of seismic hazard. The first group relates to the evaluation of uncertainty in estimation of seismic source magnitude for the probabilistic seismic hazard analysis. In my doctoral thesis, for improvement of nonparametric estimation of magnitude cumulative distribution function I have applied resampling methods based on random sampling with replacement from the original data points. These methods have been applied very rarely in seismology so far and their use for the analysis of seismic hazard in proposed procedure has been a completely new approach for the examined field (papers [5I]-[5VI]).

In 2003 I was granted Marie Curie's scholarship in the 5th edition of the EU Framework Program in Italy and I took part in the international research project entitled *"Estimates of ground motion and hazard assessment through earthquake scenarios"* under the supervision of Prof. Peter Suhadolc in the Faculty of Earth Sciences at Trieste University, Italy. During the project I carried out research work related to the deterministic analysis of seismic hazard ([5VII]).

In 2007 I started a study of the interaction among earthquakes and mining shocks. Since 2009 I have led a research project for the Ministry of Science and Higher Education No. N N307 234937: *"Analysis of static stress transfer induced by coseismic displacement of mining shocks and its role in the seismic generation process"*. Beside the research achievement described in item 4, I have prepared, together with co-authors, a research paper describing the evolution of seismic activity in one of the sections of Rudna Mine in relation to cumulative static stress changes induced by two strong events from the selected region [5VIII]. This publication has passed the phase of the first review.

I have been specializing in the issue of probabilistic analysis of seismic hazard since the start of my academic work. Based on the performed analyses, I have prepared, together with co-authors, publications for the review journals, [5IX] - [5XI] and 3 chapters of Polish monograph entitled *"Genesis and characteristics of seismic hazard in the Upper Silesian Coal Basin"* under the supervision of Prof. W.M. Zuberka ([5XII]-[5XIV]). In years 2001 – 2005 I participated in a research project financed by the State Committee for Scientific Research (KBN) *"Quantitative analysis of multimodal structure of natural and induced seismic activity distribution, as well as its implications on the estimation of seismic hazard"*, supervised by Prof. S. Lasocki and the project under promoter's grant No. 5 T12A 046 25 KBN *"The use of resampling methods in improvement of accuracy in seismic hazard probabilistic analysis"*. In years 2007 - 2009 I participated in the research project No. PBS-Greece/10/2007 *"Examination of time-dependency of seismic hazard for natural and induced seismic activity in mines, using* *nonparametric methods"* and since 2010 I have taken part in the project for the Ministry of Science and Higher Education No. 3935/B/T02/2010/39 *"Analysis of interactions between shocks in natural and mining-induced seismic activity for the evaluation of time-dependent seismic hazard"*, both projects supervised by Prof. S. Lasocki. Additionally, I took part in 9 research projects related to the issue of post-floatation waste reservoir *"Żelazny Most"*, 3 projects related to forecasts of seismic activity and estimation of ground motion in the city of Polkowice and 2 projects concerning evaluation of the seismic hazard in Knurów and Piekary mines.

In 2007 I signed the charter to access the *Triggered and Induced Seismicity* (*TAIS*) working group operating within the International Association of Seismology and Physics of the Earth Interior (IASPEI). In 2010 I initiated and co-create, until now, the international initiative of *"THAIS - Teamwork for Hazard Estimation for Triggered and Induced Seismicity"*. The initiative involves establishment of international research groups gathered around physical hazard problems resulting from induced seismic activity. Thanks to the modern communication technologies there will be build conditions allowing the researchers from different locations in the world to cooperate effectively within a single working group. The new initiative received official infrastructural support of the largest European infrastructural project in the field of Earth Sciences "*European Plate Observing System* (*EPOS*)". I have presented this initiative on special open meetings during the ESC General Assembly in Montpelier and the ECGS-FKPE Induced Seismicity Workshops in Luxembourg. So far the initiative has won nine EU and eight non-EU partners and obtained the IASPEI support.

The cited papers:

[5I] Orlecka-Sikora, B. (2008) Resampling methods for evaluating the uncertainty of the nonparametric magnitude distribution estimation in the Probabilistic Seismic Hazard Analysis. *Tectonophysics*, 456, 38-51, doi:10.1016/j.tecto.2007.01.026.

[5II] Orlecka-Sikora B. (2006) Resampling methods for improving the accuracy of probabilistic seismic hazard analysis. *Publs. Inst. Geophys. Pol. Acad Sci.* M-29, (395), 63-76.

[5III] Orlecka-Sikora, B. (2005) The use of the bootstrap method in nonparametric representation of source for improvement of accuracy in seismic hazard probabilistic analysis. *Reports of the meeting of the Committee of Geological Sciences Polish Academy of Sciences*, vol. XLVII/1, ISSN 0079-354X, 161–165 (in Polish).

[5IV] Orlecka-Sikora, B. (2004) Resampling methods in nonparametric seismic hazard estimation, *Acta Geophys. Pol.*, vol. 52, No. 1. 15 – 27.

[5V] Orlecka-Sikora, B., Lasocki, S. (2005) Nonparametric characterization of mining induced seismic sources. The Sixth International Symposium on Rockbursts and Seismicity in Mines "*Controlling Seismic Risk*" Proceedings (Y. Potvin, M. Hudyma, eds.) ACG, Perth, 555-560.

[5VI] Orlecka-Sikora, B. (2004) Bootstrap and jackknife resampling for improving in the nonparametric seismic hazard estimation. The IUGG 2003 Proceedings Volume "*Earthquake. Hazard, Risk, and Strong Ground Motion*" (Y.T. Chen, G.F. Panza, Z.L. Wu., eds.), Seismological Press, 81-92.

[5VII] Moratto, L., Orlecka-Sikora, B., Costa, G., Suhadolc, P., Papaioannou, Ch., Papazachos, C.B. (2007) A deterministic seismic hazard analysis for shallow earthquakes in Greece. *Tectonophysics*, 442, 66-82.

[5VIII] Orlecka-Sikora B., Lasocki, S., Lizurek G., Rudziński Ł. (2011) Response of seismic activity in mines to the stress changes due to mining induced strong seismic events, *International Journal of Rock Mechanics and Mining Sciences* (under review).

[5IX] Orlecka-Sikora B., Lasocki S. (2002) Clustered structure of seismicity from the Legnica-Glogow Copper District. *Publs. Inst. Geophys. Pol. Acad Sci.* M-27 (340), 105-119 (in Polish).

[5X] Lasocki S., Orlecka-Sikora B. (2002) Prediction of soil vibrations for Polkowice in 2001 – 2013. Proc. the 15th Winter School of Rock Mechanics. Cracow 2002, *Geotechnics and Special Construction*, 369-384, (in Polish).

[5XI] Lasocki, S., Orlecka-Sikora B. (2008) Seismic hazard assessment under complex source size distribution of mining-induced seismicity. *Tectonophysics*, 456, 28-37, doi: 10.1016/j.tecto.2006.08.013.

[5XII] Lasocki, S., Orlecka-Sikora, B. (2010) Testing the complexity of seismic source distribution magnitude in the area of the Upper Silesian Coal Basin. W: W.M. Zuberek, K. Jochymczyk (red.), *Genesis and characteristics of seismic hazard in the Upper Silesian Coal Basin*. Silesian University Publishing House, Katowice 2010 (in Polish).

[5XIII] Mirek, J., Orlecka-Sikora, B., Lasocki, S. (2010) Examination of directions of tectonic shock sources migration for explanation of conditions and mechanisms of their generation. W: W.M. Zuberek, K. Jochymczyk (red.), Genesis and characteristics of seismic hazard in the Upper Silesian Coal Basin. Silesian University Publishing House, Katowice 2010 (in Polish).

[5XIV] Orlecka-Sikora, B., Lasocki, S. (2010) Estimation of the upper limit of seismic source magnitude in the area of the Main Saddle. W: W.M. Zuberek, K. Jochymczyk (red.), Genesis and characteristics of seismic hazard in the Upper Silesian Coal Basin. Silesian University Publishing House, Katowice 2010 (in Polish).

Table of all publications

		Type of publication			
		Articles in Reviewed Journals	Papers in Reviewed Conference Proceedings	Chapters in Books	Conferences Abstracts
Number of publication	Before PhD (before 06.2005)	2	4	0	5
	After PhD (since 06.2005)	9	2	3	20
	Together	11	6	3	25