Akademia Górniczo-Hutnicza im. Stanisława Staszica w Krakowie

Wydział Geologii, Geofizyki i Ochrony Środowiska

Katedra Mineralogii, Petrografii i Geochemii

DOCTORAL DISSERTATION ABSTRACT

IMPACT OF COAL FIRES ON COAL PETROLOGICAL PROPERTIES BASED ON EXAMPLES FROM NORTH CHINA

Jolanta Kuś, MSC., DIC.

Promotor:

prof. dr hab. inż. Barbara Kwiecińska

Coal seam fires occur worldwide and exert a substantial environmental, economic, and social impact. The phenomenon of coal fires is widely documented by geophysical and geochemical methods but little is known about the *in-situ* influence of coal fires on coal petrographic characteristics and parameters.

The main aim of this dissertation is to examine the impact of coal seam fires on high volatile bituminous coals by means of coal petrographic methods based on the example of coals from the Wuda Coalfield, Inner Mongolia Autonomous Region, China. The attempt to apply standard coal petrographic methods to evaluate and assess the degree of impact of coal seam fires was motivated by the following reasons: (1) derivation of condition promoting self-heating and spontaneous combustion, (2) detection of coal-fire sites within coal fire zones, and (3) identification and quantification of coal-fire related effects.

The first publication entitled “Impact of an underground coal fire on coal petrographic properties of high volatile bituminous coals: A case study from coal fire zone No. 3.2 in the Wuda Coalfield, Inner Mongolia Autonomous Region, North China” of the doctoral dissertation contains an example of the impact of a low-temperature (about 400° C) coal fire zone No. 3.2. The widespread occurrence of non-tectonic microfissures and non-tectonic microfractures, followed by a presence of dark oxidation rims and presence of micropores define the distinct petrographic characteristics of the examined coal-fire affected coals. Also a significant lateral variation of random vitrinite reflectance is well-noticed for (1) coal grains and (2) dark-rimmed vitrinite at non-tectonic fissures and non-tectonic fractures. In addition, the presence of low-temperature semi-coke confirms the thermal alteration induced by the underground coal fire. The results obtained from the coal examination point to both low-temperature oxidation and low-temperature-pyrolysis processes.

The second manuscript entitled “Oxidatively and thermally altered high-volatile bituminous coals in high-temperature coal fire zone No. 8 of the Wuda Coalfield (North China)” submitted to the International Journal of Coal Geology with reviews already completed (current status 17.03.2017) illustrates the impact of a high-temperature (over 800° C) coal fire zone No. 8. The submitted manuscript signifies, yet again an extensive occurrence of non-tectonic microfissures and nontectonic microfractures, dark oxidation rims, and presence of micropores, as well as more

importantly the formation of bright spots interpreted as incipient mesophases. The photometric measurements documented a dominant increase as well as a minor decrease in both random and maximum vitrinite reflectances obtained for (1) coal grains and (2) dark-rimmed vitrinite at non-tectonic fissures and non-tectonic fractures. It points in addition to an increase in coal rank from a high volatile A bituminous coal to a low-volatile bituminous coal. Another characteristic novelty for the high-temperature coal fire zone is the specific bimodal vitrinite population and an increase in bireflectance observed in two sub-zones within the coal fire zone. The Kilby's cross-plots indicated a large overlapping of the data sets of R′max and R′min, pointing to heterogeneity of the structure of vitrinite. The coal-fire related changes are attributed in general to low-temperature oxidation and thermal degradation under varying oxygen conditions.

The conclusions of the performed research study document a number of different coal petrographic methods applied to coal samples from both coal fire zones. A comparison with the previously published literature on both laboratory experiments and on self-heated coal wastes enabled an assessment of coal-fire related processes based on the observed and determined coal petrographic characteristics and coal petrographic parameters. It also permitted an identification of sub-zones within the coal fire zone, defining the most pronounced impact of the coal fire. The applied coal petrographic methods proved to be suitable to identify and determine the coal fire-related effects. The presented work can serve as a general reference for the understanding of the *in situ* processes associated with underground coal gasification (UCG) and the composition of the resulting syngas.

The analytical approach presented in this research study was part of the interdisciplinary project of the “The Sino-German Coal Fire Research Initiative, Innovative Technologies for Exploration, Extinction, and Monitoring of Coal Fires in North China” (“Sino German Coal Fire Research Initiative”), focusing on the development of methods to detect, analyze and monitor coal seam fires in Inner Mongolia and Ningxia Autonomous Regions of the People’s Republic of China.

Keywords: Coal fires, coal oxidation, vitrinite, low-temperature coke