# Endogenous Fires in Hard Coal Mines as a Source of Greenhouse Gas Emissions

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**1. Introduction -** The mining industry, especially hard coal mining, constitutes one of the activities in which the most dangerous events and accidents occur, both in terms of the number of injuries and fatalities as well as material losses [1]. One of the most serious hazards in underground coal mines is endogenous fire, which occurs in both large masses of coal conducive to heat accumulation and places inaccessible to humans. The fire in coal bed appears as a result of coal self-oxidation process. During the exothermic reaction of coal with oxygen from air, the heat is released, which initiates a slow increase of coal temperature from the original rock mass temperature to the critical temperature at the range of 333K353K. The low value of thermal conduction coefficient of coal (at the range of 0.090-0.70W/m$^3$/K) causes that under certain conditions the heat accumulates, which results in self-heating of coal and consequently a fire. With the increase of coal temperature, a characteristic emission of gaseous products, typically CO, $CO_2$, $CH_4$, and other hydrocarbons is observed [2]. Hence, it can be claimed that the rise up of these gases concentration in mine air may suggest the development of coal self-heating process, but on the other hand it may contribute to the increase of global warming. Toxic gases emission problem does not concern only the active mines but also the closed ones in which coal can burn uncontrollably for many years. In this study, the emission of fire gases coming from a simulated coal self-heating process under laboratory conditions was analyzed.

**2. Experimental –** The laboratory tests were conducted on eight samples of coal collected from different coal mines, located in Upper Silesian Coal Basin in southern Poland. The experimental study consisted in filling the reactor with a coal sample of particle size below 2mm and a weight 0.4kg and heating it to the desired temperatures of: 323K, 373K, 423K, 473K and 523K. When the required temperature was obtained, the synthetic air was injected as an oxidizing medium. The gas mixtures flowing out of the reactor were collected into air tight Tedlar bags and analyzed with the application of gas chromatography.

**3. Results and Discussion –** The experimental findings display that during the coal self-heating phenomenon the toxic gases are released. It was found that under the conditions of oxygen at a level below 1%, the concentration of carbon monoxide reached the highest values at the range of 1-5%$_{vol.}$ The permissible concentration of carbon monoxide in the mine atmosphere equals 0.0026%; a higher value indicates a fire hazard. At the outlet of the reactor, the concentration of carbon dioxide was 2-4 fold higher than carbon monoxide – at the range of 7-16%$_{vol.}$ On the basis of the results, it can be said that the largest carbon dioxide emissions (> 16%$_{vol.}$) were observed for samples with the lowest carbon content (< 70%$_{vol.}$) and the highest oxygen content above 10%$_{vol.}$. By contrast, the smallest amount of hazardous gases (7-9%$_{vol.}$) was released from samples with the carbon content of above 80%$_{w/w}$. Among all of the measured hydrocarbons, methane and ethane demonstrated the highest share in the toxic gases emissions, particularly at the temperatures of 473K and 523K.

**4. Conclusions –** Spontaneous combustion of coal in underground mines leads to the loss of a potentially valuable resource, the increment of production costs, the increase of temperature of surrounding rock and, as presented in this work, to the emission of many toxic gases which may contribute to global warming. However, the occurrence of the gases may be useful for the assessment of underground fire hazard.

**5. References**

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