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Simulation of macerals effects on methane emission during gas drainage in coal mines

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ABSTRACT

The methane found in coal is regarded as one of the clean energy resources. Methane forms inside coal beds according to geological conditions through coalification. The lifecycle of coalification and source of coal formation directly affect macerals. Coal is classified based on its maceral content. In this study, firstly macerals were identified in coal samples from two different mines. Then, the permeability of each sample was measured. Subsequently, parameters obtained from experiments were introduced as input numerical data into COMSOL Multiphysics commercial software. This study was intended to measure the impact of macerals on the level of methane emission in an attempt to remove gas from coal beds. It was found that vitrinite levels in Tabas and Shahrood mines coal were 81.34% and 69.31% respectively. The methane emission rate was 0.00269 m/s in Tabas coal and 0.00258 m/s in Shahrood coal, a variation of 12% increase in vitrinite. The increase in vitrinite content in Tabas Mine has contributed to the rate of emission increase by about 0.00011 m/s or 0.66 m^3/min. This variation in methane emission was due to the maceral content.

1. Introduction

Coal is regarded as one of the crucial resources of energy and an important element in steel metallurgical process. Despite remarkable progress that has been made in development of new types of renewable energy, coal mining is yet considered as a strategic energy resource for the foreseeable future.

Different types of coal deposit have formed in sedimentary basins at various geological periods. Such diversity in origin, time and location of coal formation affect its chemical composition [19]. As the burial depth increases, there will be higher temperature and pressure, which subsequently influences the physicochemical parameters in coal. Coal forms at different degrees of maturity, ranging from lignite (brown coal), sub-bituminous (semi-tar coal), bituminous (tar coal) to anthracite [21,7].

As coal mining operation is inclined toward deeper resources, various problems such as outburst is emerged, hindering efficient and safe underground mining operation. In order to understand the probability of having an outburst incident in an underground coal layer, a proper simulation of gas flow within the layer is required. The accuracy of simulation is explicitly related to the accuracy of the input parameters such as permeability and porosity.

In most classifications, coal is regarded as a two-component system consisting of organic material (maceral) and inorganic material (mineral) [8,16,29]. In another classification, the coal composition is considered as organic macerals, inorganic minerals and moisture [22]. Macerals are the key to understanding the nature of coal (type and grade) and determining its capabilities for different applications [6]. In terms of macerals, coal samples are grouped as liptinite, inertinite and vitrinite. Properties of coal such as cokification and permeability depend on the type and level of macerals constituting the coal [5]. Coal acts as both source rock and reservoir rock for methane deposited in coal beds. The methane produced in coal is categorised as surface adsorption in coal matrix and free gas (i.e. dissolved gas). However, the first type has greater volume of methane when compared to the second type. The level of methane depends on various factors such as the amount of organic material, degree of maturity, composition, pressure, heat, moisture and coal ash.

Methane is produced through various stages of coalification and surface absorption. Exploration and production of methane go back to several decades ago. Methane explosion is known as a major underground coal mining dilemma. Such explosions tend to be more dangerous in larger and deeper coal mines where coal possesses higher degree of maturity [3]. The presence of methane in coal mines not only

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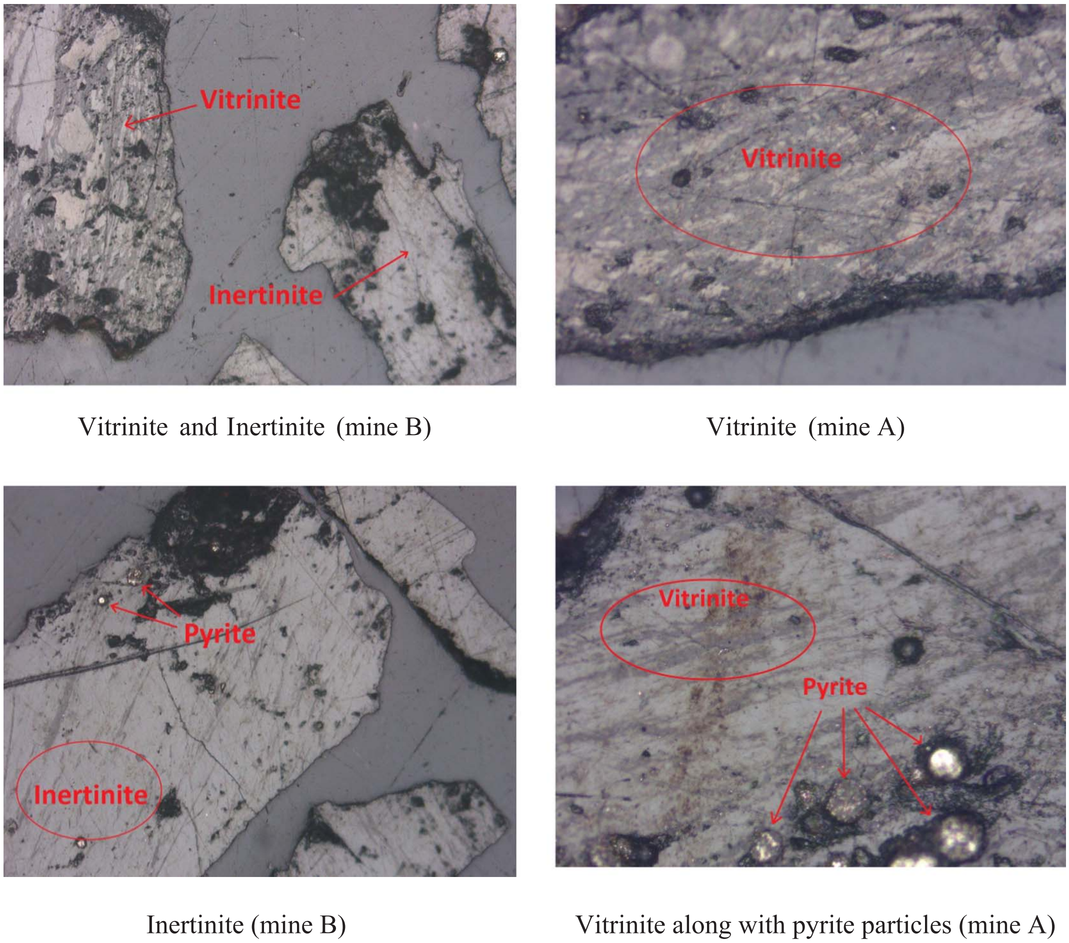

Fig. 1. Macerals and minerals found in samples from mines A and B.

Table 1
Composition of macerals for samples tested in this study.

Sample No.	Vitrinite (%)	Inertinite (%)	Pyrite (%)	Carbonate (%)	Fractures (%)	Total (%)
Mine A (Tabas basin)						
1	82.1	7.4	3.5	2.3	4.7	100
2	78.9	11.7	2.8	2.2	4.4	100
3	75.6	16	2.9	2.2	3.3	100
4	79.4	10.8	2.7	2.8	4.3	100
5	79.8	10.2	2.2	3	4.8	100
6	81.3	11	2.6	2.1	3	100
7	83.4	11.2	2.4	1.4	1.6	100
8	82.8	9.4	1.7	3.2	2.9	100
9	85.8	8.5	1.4	3.1	1.2	100
10	85.8	9	1.6	2.5	2.6	100
Mean	81.34	10.52	2.38	2.48	3.28	100
Mine B (Shahrood basin)						
1	72.4	18	2.8	3.2	3.6	100
2	72.2	19	2.6	3	3.2	100
3	76	13	2.3	5.7	3	100
4	70.7	21.9	2.3	2	3.1	100
5	65.5	28.3	2.2	1.1	2.9	100
6	67.8	24.7	3	1.5	3	100
7	70	23.1	2.8	1	3.1	100
8	72.2	20.3	2.5	2	3	100
9	66.5	24.2	3.2	2.9	3.2	100
10	59.8	32.2	2.5	2.5	3	100
Mean	69.31	22.47	2.62	2.49	3.11	100