Engineering Geology 245 (2018) 33–43

Contents lists available at ScienceDirect

Engineering Geology

journal homepage: www.elsevier.com/locate/enggeo

Estimation of methane emission from shallow gas-bearing sandstones

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ARTICLE INFO

Keywords:
Methane-bearing sandstones
Rock fracturing
Methane emission
Gas flow rate

ABSTRACT

This paper presents exponential model created by the author to estimate gas flow/time relationships for shallow methane-bearing Donetsk sandstones in Donetsk (Ukraine). Such estimation is indispensable in case of passing subway tunnels through these sandstones. The proposed model involves not only time, but also a ratio between average widths of shallow fractures in sandstones and average horizontal distances between these fractures. It is revealed that an increase in this ratio leads to an increase in gas volumetric flow rate, acceleration of gas emission, and an increase in the volume of methane emitted from borehole. It is shown that gas flow vs. time curves obtained for 17 boreholes drilled from the ground surface through sandstones are similar to those estimated by the proposed model. Observations show that the volume of methane extracted from each borehole is between 161 m^3 and 673 m^3, and maximum value of volumetric flow rate is ranged from 0.00265 m^3/min to 0.0455 m^3/min.

1. Introduction

Methane is a dangerous explosive gas which pollutes air and has an impact on the air quality in mines and underground constructions and on the ground surface and, hence, human health. One of the main sources of methane is coal mines. Methane is emitted from active underground and surface mines (e.g. Palchik, 2002; Sang et al., 2010; Karacan et al., 2011; Guo et al., 2012; Zhou, 2012; Xuan et al., 2016; Zhang et al., 2017) as well as from abandoned ones (Staff et al., 1991; Kirchgessner et al., 1993; Burrel and Friel, 1996; Judd et al., 2002; EPA, 2004; Leifer and Wilson, 2007; Etiope, 2009; Palchik, 2012, 2014; Shi et al., 2016). Karacan et al. (2011) have studied different aspects of methane emission in US longwall coal mines (prediction of gas emission, capture and utilization practices). Sang et al. (2010) and Guo et al. (2012) have studied gas flow dynamics and stress relief coalbed methane drainage using surface wells in China. Zhou (2012) performed numerical simulation study that demonstrates history matching and production prediction for an actual horizontal coalbed methane well located in Australia. Palchik (2012, 2014) has analyzed time-dependent gas emission parameters from an abandoned mine working at a shallow depth, and methane emission from coal pillars to the atmosphere through weathering-induced fractures in the surface rock layer. Shi et al. (2016) have developed a void-resistance model of gas pressure behavior of abandoned coal mines.

However, there is a limited number of studies of methane emission from shallow gas-bearing sandstones, since the production of methane from such sandstones is less significant than from coal seams. Nevertheless, methane-bearing sandstones are also sources of methane (Ulery and Molinda, 1984; Palchik, 2003; Birkedal et al., 2014), and some amounts of methane can be naturally released into the underground construction, shafts, boreholes, rock mass, and the atmosphere. In particular, emission of methane can occur from rock mass during the construction or operation of tunnels (Naqao et al., 1997; Doyle, 2001; Rodrigues and Lombardia, 2010). For this reason, the study of methane emission from sandstones is needed before shallow subway tunnels will be passed through such sandstones.

The goal of this study is to estimate gas emission from shallow gas-bearing sandstones in sites of possible tracing of shallow subway tunnels in Donetsk (Ukraine). This study shows how time-dependent gas emission is related with the intensity of fractures in shallow sandstones. A time-dependent exponential model for the estimation of the gas emission is proposed.

2. Geological settings, fracture intensity and gas emission

2.1. Geological settings

Some parts of the trace of shallow subway tunnels in Donetsk city (Ukraine) will be passed through methane-bearing thick Donetsk sandstones with different degrees of fracturing. In-situ fracturing of rock mass is one of the serious geological problems encountered in tunneling. It is necessary to examine core samples, and for this reason, prospecting vertical boreholes were drilled through fractured sandstones. Since penetration of methane from fractured sandstones into the

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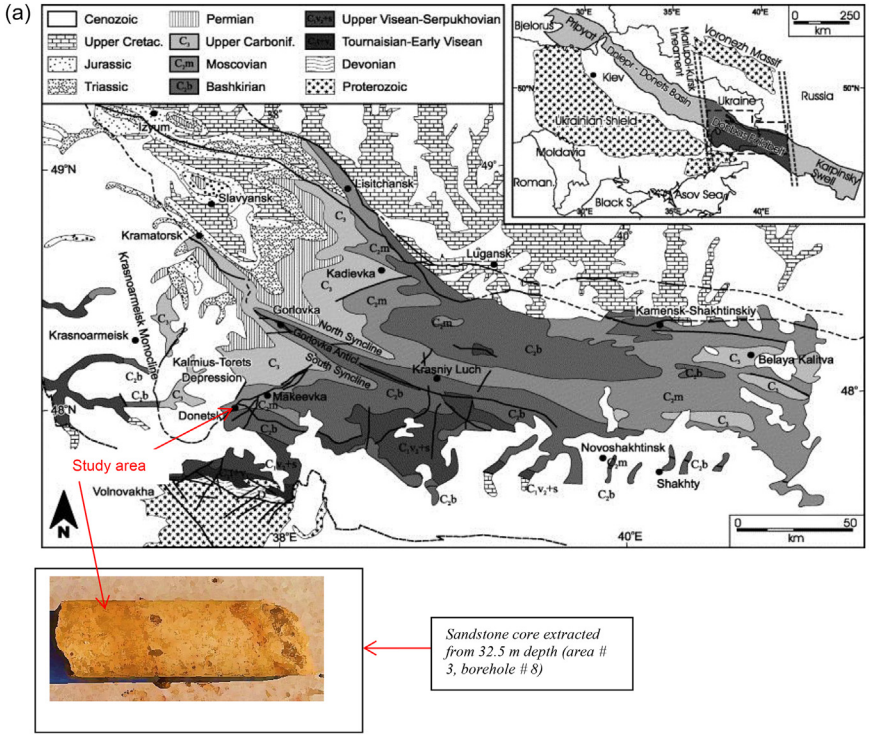
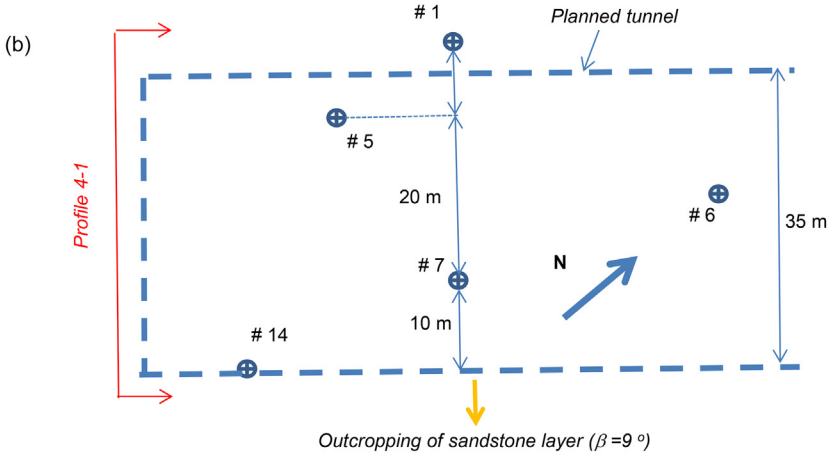
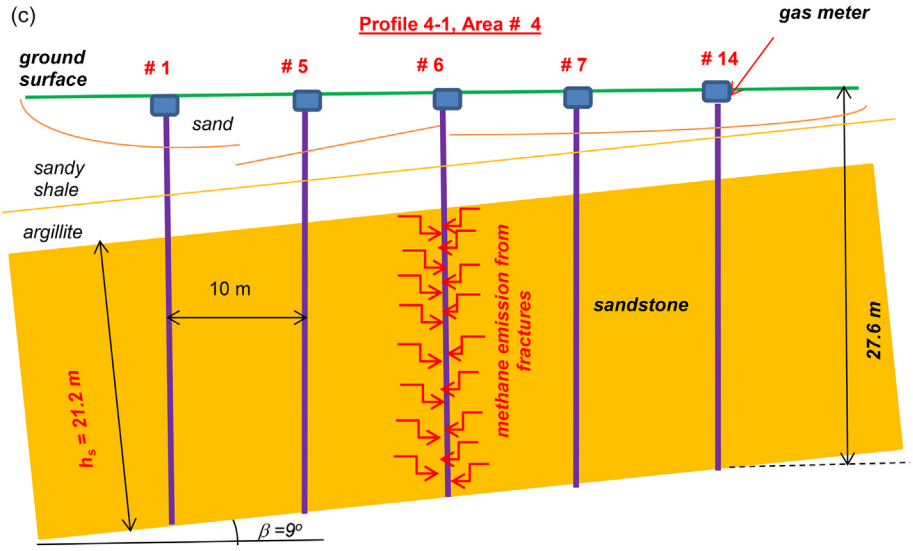
https://doi.org/10.1016/j.enggeo.2018.07.027
Received 19 December 2017; Received in revised form 28 July 2018; Accepted 30 July 2018
Available online 01 August 2018
0013-7952/







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