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Estimation of methane content in coal mines using supplementary physical measurements and multivariable geostatistics

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ABSTRACT

The volume of methane that can be released from coal during extraction is usually estimated only on the basis of measurements of methane content in coal seam. Usually, apart from methane measurements, numerous physical variables are also measured before coal extraction. Although physical variables do not produce straightforward information about methane concentration, they can be significantly correlated with it and therefore can also be used in methane content estimation. The goal of this paper was to analyze the possibility of using multivariable geostatistics to estimate methane content in coal seam using physical secondary measurements. To do so, two types of secondary measurements were used: the desorption factor and coal strength index, both of which were used in cokriging and sequential Gaussian co-simulation (SGcoS). Both secondary variables were sufficiently correlated with methane content, validating their use in the analyses. The use of the desorption factor as supplementary data produced an approximately 2% overestimation of values of methane content but only in the vicinity of the geological faults. The overestimation was lower in the case of SGcoS than in the case of cokriging. Application of the coal strength index as a secondary variable did not lead to overestimation. Methods that use supplementary data produced lower kriging variance and simulated standard deviation values of methane content compared to those obtained using kriging and sequential Gaussian simulation (SGS), respectively, where only methane measurements were used. Simulated standard deviations of methane content obtained using SGcoS with a desorption factor were significantly higher than those obtained using SGcoS with the coal strength index used as supplementary data.

1. Introduction

Methane hazards in the coal mining industry can result in rapid fires, explosions and other catastrophic events. These hazards depend on the volume of methane that is emitted into the mine atmosphere. One of the methods for decreasing the methane hazards in coal mines is diluting the methane using a sufficient amount of fresh air, i.e., ventilation, delivered to the mine. As a result, the concentration of methane in the air can be decreased below dangerous levels. A complementary method to ventilation uses a methane drainage system that captures methane from the unmined coal, rock and a gob. This portion of methane can later be used as a fuel gas.

For security reasons, it is essential to use precise methods to estimate methane content in coal seam before coal extraction. The knowledge about methane content in coal seam is necessary to ensure sufficient ventilation and to arrange all safety procedures during coal extraction. To date, the estimation of methane content in coal seam has been a topic of many studies (Gentzis, 2013; Karacan and Diamond, 2006; Karacan et al., 2011; Kissel, 2006). Many geostatistical methods have been applied to address problems with methane content estimation. In most cases, these methods used only one variable, i.e., measurements of methane content. As a recent study suggests (Karacan et al., 2012), sequential Gaussian simulation (SGS) is assumed as the most precise estimation method of methane content in coal seam. However, SGS makes use of only one variable, even though geostatistics also offers multivariate methods, e.g., cokriging (Journel and Kyriakidis, 2004; Wackernagel, 2010), that enable integration of information from different types of measurements, e.g., chemical and physical sources. This approach increases the precision of spatial interpolation (Webster and Oliver, 2007; Yalcin, 2005; Zawadzki et al., 2011). Multivariate geostatistics were also successfully used in mining applications (Heriawan and Koike, 2008; Karacan and Olea, 2013).

Apart from cokriging, it is also possible to use a simulation technique based on cokriging, i.e., sequential Gaussian co-simulation (SGcoS) (Remy et al., 2008). The main benefit of cokriging and co-

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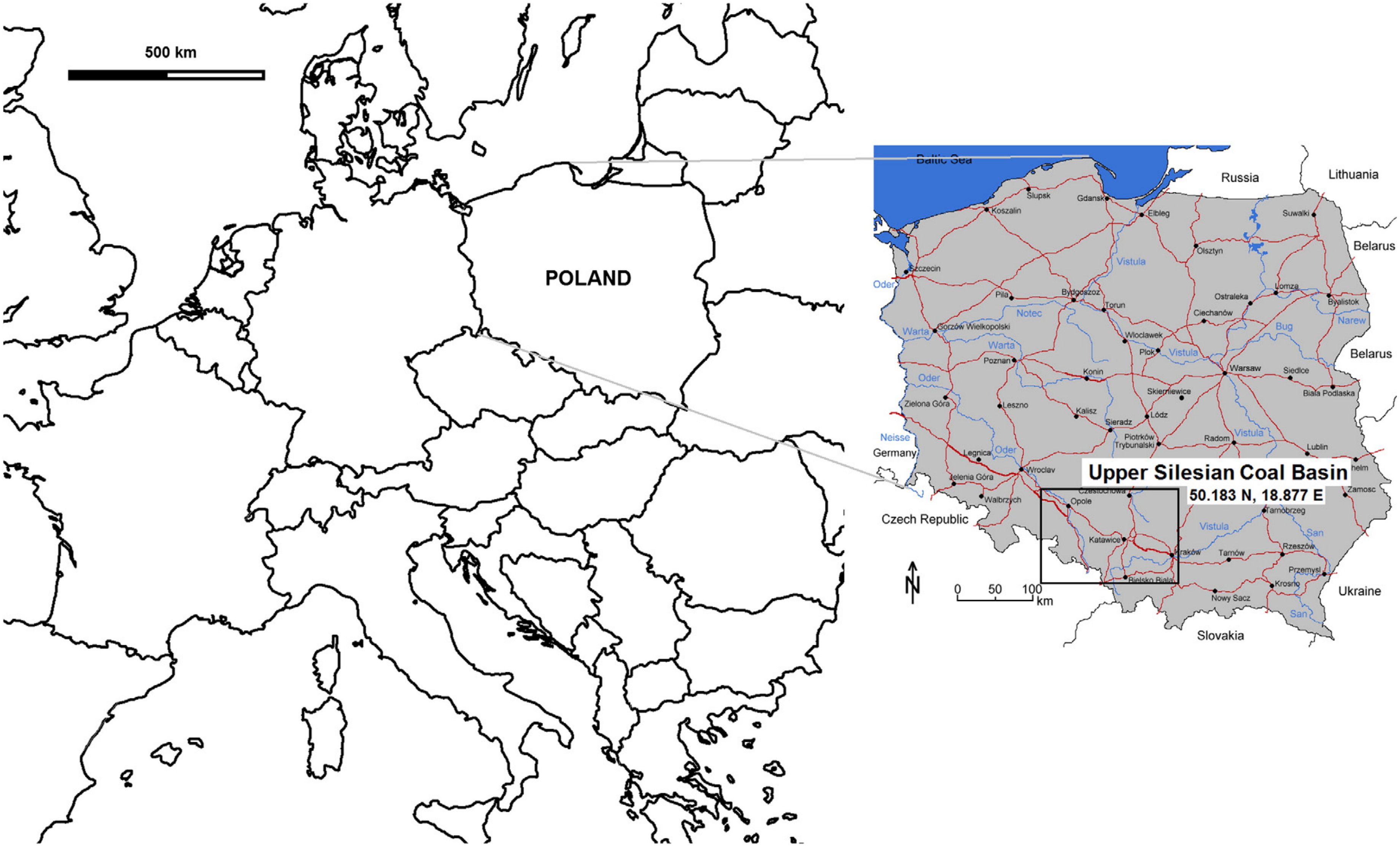

Fig. 1. The location of the Upper Silesian Coal Basin where analyzed coal seam was situated.