International Journal of Coal Geology 84 (2010) 16–24

Contents lists available at ScienceDirect

International Journal of Coal Geology

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

Variation of moisture content of the bituminous coals with depth: A case study from the Czech part of the Upper Silesian Coal Basin

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ARTICLE INFO

Article history:
Received 18 January 2010
Received in revised form 20 April 2010
Accepted 13 July 2010
Available online 24 July 2010

Keywords:
Moisture content
Schürmann's rule
Coalification
Bituminous coal
Anthracite
Upper Silesian Coal Basin
Czech Republic

ABSTRACT

The paper discusses the validity of Schurmann's rule–the relation between the moisture content in coal beds and their depth at the given site–using the bituminous coals in the seams of the Czech part of the Upper Silesian Coal Basin as an example. The statistical treatment of analytical data has demonstrated that this relationship between the depth and the moisture content of coals in the seams of the Upper Silesian Coal Basin exists. This study describes the patterns observed in the correlation of the respective parameters and the way in which these patterns can be used to interpret the geological development of coal basins. The patterns are not easy to recognize in all cases. This is particularly evident where low moisture contents are found in bituminous coal from areas with a higher rank of coalification. In contrast, high volatile bituminous coals show a systematic increase in the coefficient of correlation between their moisture content and their depth so that in this case the parameter can be used with greater confidence for modelling the history of coalification in coal basins.

Therefore, the moisture content of coal can be used only as a complementary parameter in coal basin studies.

1. Introduction

The content of moisture (water) in coal is a parameter which, like the content of volatile matter or the reflectance of vitrinite, can be used as a measure of the degree of coalification (rank) of organic matter. In the literature, the relationship between the decrease in moisture content and the increase in the depth of burial of coal is known as Schürmann's rule. Schürmann (1927), when studying Tertiary coals in eastern Borneo, came to the conclusion that "the content of water in brown coal seams from an undisturbed site of deposition decreases systematically with increasing depth". This rule is an analogue of Hilt's Law that defines a similar relationship between the content of volatile matter in bituminous coal and depth of burial. However, Schürmann's rule, as follows from its wording, is applied specifically to brown coals (lignite).

In general, the reflectance of vitrinite is considered to be the best parameter for studying the degree of coalification of coal beds and thus, by inference, the best tool for interpreting the development and history of formation of coal basins. However, systematic studies of this parameter were made in the Czech part of the Upper Silesian Coal Basin (in common with other coal basins) only towards the end of the exploratory drilling operations so that data on the reflectance of vitrinite are not available for the majority of boreholes. The content of volatile matter is therefore used as an alternative when reflectance is not available. Under these conditions, subject to certain constraints, measurement of the moisture content in coal may also be a suitable tool for use in interpreting the formation and development of a coal basin. The first experience gained in the use of moisture contents in geological studies of the Upper Silesian Coal Basin was published by Čáslavský et al. (2005) in connection with the application of Hilt's Law in the Czech part of the Upper Silesian Coal Basin (Sivek et al., 2008). Since that time new information has been acquired which can be applied retrospectively to the study of moisture content in relation to the formation and development of coal basins. The intention is to supplement the earlier data and test the possibility of using the measurement of moisture content in coal beds for interpreting the process of coalification in the Czech part of the Upper Silesian Coal Basin (hereafter referred to as USCB), specifically with the intention of finding out whether Schürmann's rule can be extended to the geological environment of black coal basins.

The moisture contained in coal governs a number of its physical properties and behavior. The most significant of these are described by van Krevelen (1993). A given increase in the content of moisture in coal causes the coefficient of thermal conductivity and heat capacity to increase dramatically, and this obviously affects the time needed for coking, as well as the rate of sorption processes on the coal surface and its effective specific gravity. The content of moisture established by analysis is also used for recalculation of individual parameters of coal quality to a water-free basis.

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doi:10.1016/j.coal.2010.07.006

If the moisture content in coal beds decreases with the depth of their burial (Schürmann, 1927), then this means (apart from other parameters and also accepting the validity of Hilt's Law) that the depletion in moisture must simultaneously indicate an increasing degree of coalification of the organic matter. However, in the case of moisture content, this status is not irreversible. In bituminous coal the content of moisture may gradually increases (for instance, due to weathering processes) depending on the type of coal (e.g. Bratek et al., 2002). A major increase in moisture due to weathering takes place in sub-bituminous coals, whereas the lowest increase in moisture content is reported in fat and coking coals. Gas and hard ash coal exposed to weathering show a moderate increase in moisture content. Enhanced contents of moisture (2–9%) are reported in altered coals at contacts with units of variegated strata and in oxidized coal from coal seams exposed in Carboniferous outcrops (Klika, 1998). The content of moisture evidently also depends on ambient conditions, particularly on temperature and water vapor pressure in the environment where the coal beds crop out. Assuming that the moisture contained in coal (with the exception of added moisture) is mostly bound on the surface of organic matter by absorption and capillary forces, then the volume of this moisture must depend on the relative humidity of the air. As the content of moisture depends on a number of external factors, the comparability of analyses is maintained by adopting consistent and appropriate methods of collection, preparation and storage of the coal samples.

2. Geological setting of the Czech part of the USCB

The USCB with bituminous coal deposits was formed in final stages of the evolution of the extensive Moravo–Silesian Paleozoic Basin in the eastern block of the Central European Variscides. It was formed in the foreland of the Variscan orogen and became a part of its outer zones, the Rhenohercynicum and Subvariscicum (Grygar and Vavro, 1995; Fig. 1). In this aspect, the USCB occupies a similar structural position as other European bituminous coal basins aligned in a belt stretching from the British Isles across Germany and Poland to the eastern part of the European Variscides.

The post-erosional boundary of the USCB has a roughly triangular shape extending from Poland southwards into Czech territory. The area of this important European bituminous coal basin exceeds 7000 km^2, of which 1550 km^2 lies in the territory of the Czech Republic. The larger part lies in the neighbouring territory of Poland.

The Czech part of the USCB is located within the Moravo–Silesian region of the Bohemian Massif. The basin is filled by some of the youngest sediments overlying the Brunovistulicum (Kalvoda et al., 2008). These post-date the main phases of the Variscan orogeny and range in age from the Mississippian onwards. The floor of the basin is formed by the older sedimentary cover of the Brunovistulicum, specifically sediments of Devonian and Lower Carboniferous age. The basin fill is overlain by Neogene deposits of the Carpathian Foredeep and, further south, also by nappes of the Outer Carpathians.

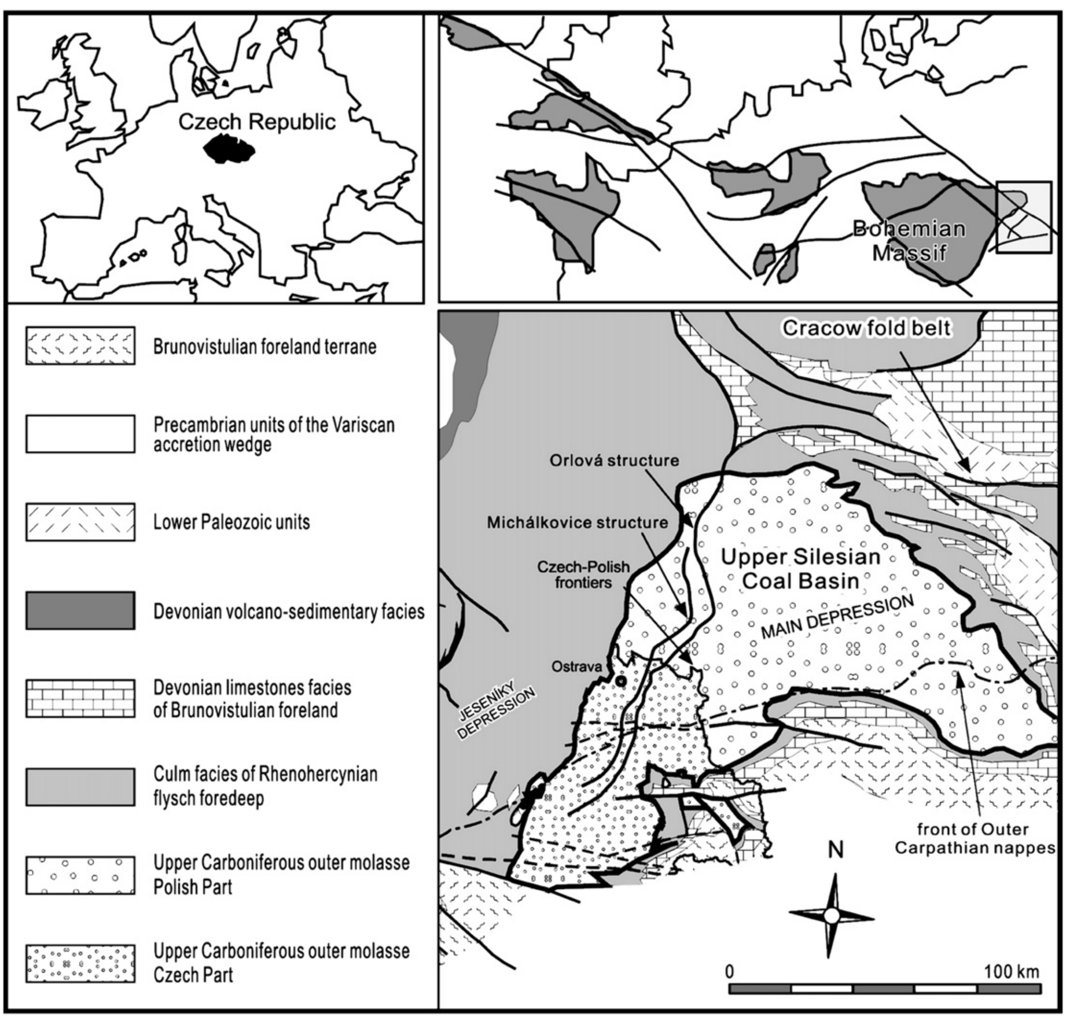

Fig. 1. Location of the Czech Republic within Europe. Location of the Bohemian Massif within European Variscides. Simplified geological map showing major tectonic zones, geological units and the position of the USCB (according to Kandarachevová et al., 2009).