Lithotypes, Macerals and Coal Facies Studies of Lower Cretaceous Medicine River Coals in South Central Alberta:

Applications in CBM Exploration, Depositional Environments and Tectonic History Studies

Judith Potter*
JP PetroGraphics, Calgary, AB
jpp@sitogeo.com

and

Ian McIlreath and Thanos Natras
Encana Corporation, Calgary, AB, Canada

Summary

Lithotype analysis of cores from the Upper Mannville Medicine River coal in a CBM well from the Huxley area of south central Alberta shows that the MR target coal seam is dominated by dull banded coal (27.7%); bright coal, bright banded and banded coals also occur in approximately equal proportions (18%) throughout the coal seam. Inorganic minerals (predominantly clay minerals) are minor components (< 5%) and include post-diagenetic pyrite and traces of calcite and kaolinite. Brightness logs reveal brightening-upwards sequences; dull wet coals mark the basal units and they grade vertically into banded coals and ultimately bright coals. Relationships between coal facies and water levels in the peat swamps are reflected in TPI vs GI plots which suggest that the coal-forming peats at this location initially accumulated in open water or marshes which were succeeded by fens and ultimately terrestrial swamps in which conifers were a dominant flora. The brightening-upwards cycles represent "drying-upwards" cycles in terms of groundwater levels and reflect low accommodation rates. Repetition of the brightening upwards cycles therefore suggests repeated subsidence commonly associated with normal faults.

Introduction

Coal composition has a major impact on the CBM potential. It is controlled by the depositional environment as well as post-diagenetic factors including the burial history, local and regional geothermal histories and tectonic activity. Coal composition is known to vary vertically within a seam as well as laterally and so also, therefore, does the CBM potential of a coal seam.

Detailed petrographic studies of the Upper Mannville Medicine River coal were carried out on cores from a CBM well in the Huxley area of south central Alberta in order to examine the CBM potential of the coal and to determine the depositional environment from the standpoint of CBM exploration. These studies included mineral and lithotype analyses of slabbed cores and maceral and mineral analyses of samples selected from dominant lithotypes, as well as dull coals, in order to determine the coal facies and depositional settings of the target coal. Brightness logs were compiled from the lithotype analyses and coal facies diagrams from maceral analyses in order to determine the depositional settings. Coal facies were also used to assess the CBM potential.

Methods

Lithotype analysis was carried out on clean, slabbed core. The cores were photographed and described using Diessel's lithotype classification and brightness logs compiled to show vertical variations in coal composition, after Diessel. 1992 (p.134).

Relative proportions of coal macerals and minerals were determined by point counting using polished pellets. Forty six samples selected from 5.61 m of core were viewed under a Zeiss Universal, reflected light microscope with oil immersion (n=15156, at 25^{o}C) objectives at a magnification of X600, using white and blue excitation and standard techniques (ASTM, 1975; ICCP 1963, 1993). Maceral analyses were used to determine Tissue Preservation (TPI) and Gelification (GI) indices and to construct coal facies diagrams (TPI v. GI plots) after Diessel,1986; Diessel, 1992, p.181-192; and Marchioni D.L. and Kalkreuth, W. D., 1991.

Coal Composition

Lithotype analyses show that the lower MR target coal seam is dominated by dull banded coal (27.7%); subordinate intervals of bright coal, bright banded and banded coals occur in approximately equal proportions (18%) throughout the coal seam (Figure 1). Mineral components are minor (generally less than 5%), predominantly authigenic clay minerals and minor detrital clays which have little effect on the CBM potential; post-diagenetic pyrite occurs mostly as pyritized wood and wood chars throughout the seam, and more rarely, as cleat fillings along with minor calcite in the upper portion of the seam; traces of kaolinite and gypsum are also present.

Brightness logs depicting vertical changes in coal lithotypes reveal six vertically-stacked, brightening-upwards sequences within the target coal seam. Brightening upwards sequences reflect changes in the water table over time and result from terrestrialization of a wetland due to low accommodation rates. Six vertically stacked sequences can be recognized.

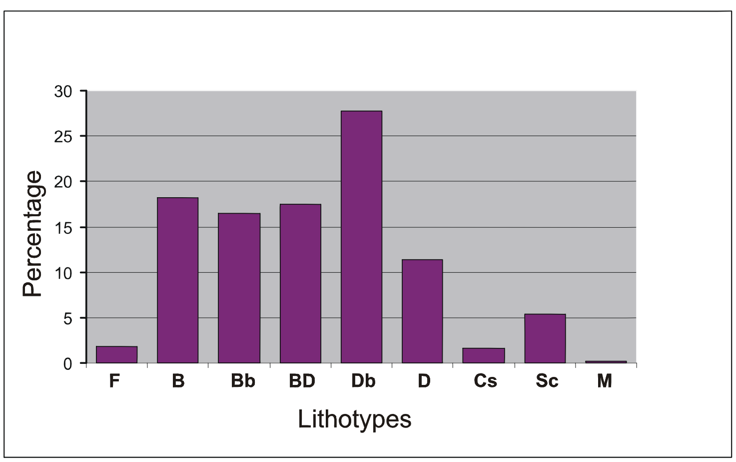

Figure1: Lithotype distributions in Medicine River coal at Huxley. (F=Fibrous coal; B=Bright coal; Bb=Banded Bright coal; BD=Banded coal; Db=Banded Dull coal; D=Dull coal: Cs=Shaley coal; Sc= Coaly shale; M=Mineral matter).

Coal Facies

In the Huxley well, dull coal forms the base of each sequence. Maceral analyses, TPI and GI indicate that the dull coals consist of dull *wet* coal (Diessel, 1982), derived from peat that accumulates from sub-aquatic and/or floating vegetation and plant debris under limnic conditions, e.g. in standing water or marshes (Figure 2). Further coal facies analysis suggests that peats subsequently accumulated in limnotelmatic fens yielding dull banded and banded coals; and in

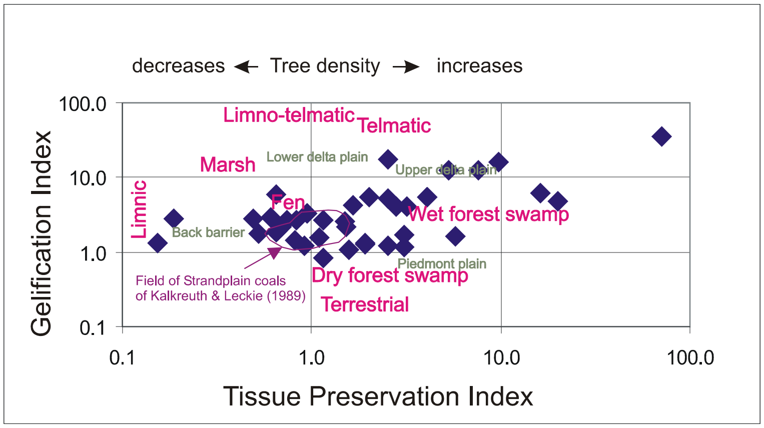

Figure 2: Coal facies indicators (TPI vs GI) for MR target coal at Huxley (after Diessel, 1982; Marchioni & Kalkreuth, 1991, modified).

the uppermost part of the sequence, banded bright and bright coals were formed from peats that accumulated in telmatic wet- and subsequently, dry-forest swamps that included conifers (Figure 2).

The vertical changes in lithotypes therefore represent repeated terrestrialization (and drying) of the wetland. The wet coal marking the base of each cycle represents an abrupt increase in the water table consistent with subsidence; and the brightening-upwards cycles with repeated subsidence.

Conclusions

Brightening-upwards cycles in lithotypes from coal cores from the Medicine River Formation in the Huxley area, reflect drying-upwards cycles in groundwater levels within the wetlands. Dull, wet coals marking the base of each drying-upwards cycle indicate high water levels, likely representing episodes of subsidence. Vertical stacking of drying-upwards cycles therefore infers repeated subsidence. These conclusions support the hypotheses that normal faults controlled the under-lying paleogeography (Wadsworth *et al.*, 2002) and syn-depositional normal faults exerted significant controls on peat accumulations, coal occurrence and the composition of coals in the Mannville Group in this region (M^{c}Ilreath and Natras, 2007).

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