

A SIMPLE AND EFFECTIVE METHOD FOR PORTRAYING AND QUANTIFYING THE MACROPETROGRAPHY OF LIGNITES: A NEW TOOL FOR COAL SEAM FACIES ANALYSIS

RICHARD SYKES¹ AND KEN C. PRATT²

¹ Institute of Geological and Nuclear Sciences, PO Box 30 368, Lower Hutt, New Zealand

² Institute of Sedimentary and Petroleum Geology, 3303-33rd St. N.W., Calgary, Alberta T2L 2A7 Canada

INTRODUCTION

All coal seams contain internal successions of lithologically distinct layers, although the layering in many seams may not be obvious in exposed faces or cores. The layers represent seam facies, and their detailed analysis can provide useful insight into the autogenic and allogenic controls on peat and coal formation. Nevertheless, the facies concept has not been extensively applied to coal seams, and hence the development of coal seam facies models has been slow. A major reason for this has been the lack of established methods for portraying the macropetrographic composition and texture of coal.

Successful facies analysis of coal seams begins at the macroscopic scale with the identification of lithofacies, because these provide the only visible and intact record of the original peat facies, including their texture and in-seam distributions. All coals consist of one to three main macropetrographic components, xylite/vitrain (humified plant parts; *xylite* in lignites, *vitrain* in black coals), fusain (fusinitized plant parts, or "charcoal"), and attrital matrix (Schopf 1960). Seam lithofacies are defined by assemblages of these components, with lithofacies boundaries marked by changes in component proportions, in the size distributions of vitrain/xylite or fusain, and/or in the nature of the matrix. Accordingly, for the identification and analysis of lithofacies, graphical methods of logging coal seam profiles should portray the vitrain/xylite and fusain components, and enable quantification of their size and content. No existing methods satisfy these requirements because they use symbols to portray coal types (see Bustin et al. 1985, p. 49–61, for selected examples), so we have devised a new method for use with lignites, which has proved effective in identifying and characterizing seam lithofacies.

The method has been applied to lignite seams in the Ravenscrag Formation (Paleocene) of southern Saskatchewan, Canada. A newly exposed face of one seam and fresh cores of 18 other seams showed only indistinct layering, but dry sawing of the lignites revealed much greater proportions of xylite and fusain and the layering became obvious. The clarity of detail revealed in the sawn faces enabled the xylite, fusain, and coal/clastic contacts to be readily traced, providing true-scale graphic representations of the macropetrography. The representations of individual samples are referred to as *lith-graphs* (Fig. 1), whereas those of seam profiles are termed *lith-logs* (Fig. 2).

PROCEDURE

Sampling Requirements

Lith-graphs and lith-logs can be produced from cores or from blocks collected from seam faces. For lith-graphs, the only sampling requirement is that samples should be as coherent as possible. To produce lith-logs for complete seam profiles, a continuous sequence of oriented blocks or cores, from the seam floor to the roof, is required. From seam faces, sample blocks should be as wide and as thick as possible, to maximize both the section available for study and the internal continuity of the log. Sampling from cores is easier and more convenient because the cores can be subdivided for sectioning in the laboratory. Cores also produce a neat, straight-sided lith-log (Fig. 2) but limits the maximum width of the log, typically to 75 mm. To minimize desiccation and break-up, the samples should be analyzed as soon as possible, or stored in a refrigerator until use.

Preparation of Lith-Graphs and Lith-Logs

The oriented blocks or cores are sectioned through their maximum thickness using a dry circular saw, and any sawdust concealing the face to be studied is removed with an air gun. Dry sawing enhances the contrast between the xylite, fusain, and attrital matrix, allowing ready identification. The xylite is light brown to brown, hard, and may show internal wood structure (Fig. 1), whereas the fusain appears soft and black. This appearance of fusain, however, is an artifact of the sawing, for in its natural state, as seen on bedding planes, the fusain is silvery gray, with silky luster and fibrous habit. Mineral matter, such as clay and sulfides, and blobs of resin, may also be visible (Fig. 1). It is important that the sectioned faces be described well because even though the final lith-graphs and lith-logs are detailed, they cannot portray adequately all features relevant to the distinction of

seam lithofacies. In particular, the purity (clastic content), luster, and surface texture of the matrix should be described because these features are difficult to portray graphically. Procedures and terminology for the description of coal were discussed by Schopf (1960, 1978) and Cameron (1978).

Once sectioned, the blocks or cores may need to be split into convenient vertical thicknesses (< ca. 250 mm) for tracing. Where possible, splits should coincide with lithofacies boundaries to facilitate subsequent analysis of lithofacies compositions. The equipment and materials required for tracing include drafting film (as transparent as possible), a lead pencil, several colored pencils, a strong light, and latex disposable gloves. Despite the strong light, the components are not easily seen through the film and so, before tracing, it is first necessary to outline the components on the sawn face with a lead pencil; the lead outlines shine through the film and can readily be traced. Outlining and tracing of each component is done stepwise, because xylite and fusain streaks (≤ 0.5 mm thick) become indistinguishable once they are drawn over. For convenience, the edges of the blocks or cores and outlines of xylite can be traced with a lead pencil, and colored pencils used for each of the less abundant components (e.g., fusain, clay, resin). About 1.0–1.5 m of 75 mm-diameter core can be sectioned, described, and traced in a day, or about 0.6–1.0 m for blocks, depending on their width. Latex gloves help to keep the film clean, and an air gun quickly frees the finished tracing of the inevitable coating of dust and dirt.

For compilation, analysis, and publication of lith-graphs and lith-logs, the tracings can be drafted manually and/or digitized or scanned into a PC CAD or graphics program. Figures 1 and 2 were compiled by digitizing the original pencil tracings into AutoCAD® (1992) (two tracings for Figure 1 and four for Figure 2), then exporting the AutoCAD files into CorelDraw® (1992) to add shading and text, and in the case of Figure 2, to join the four interval tracings into a single log.

Quantification of Macropetrography

The lith-graphs and lith-logs provide a more accurate portrayal of coal macropetrography than is possible by standard photography (Fig. 1), and allow quantification of both composition and texture. Xylite, fusain, and matrix proportions can be determined from lith-graphs and lith-logs simply by visual estimation, or more accurately by image analysis of the lith-graph and lith-log computer files in bitmap format. The compositions of the two blocks in Figure 1, and of the four lithofacies layers in Figure 2, were determined using Optimas® (1992) and IBAS® (1990) image-analysis programs (Table 1). The results obtained by the two programs are closely comparable (to within $\pm 2\%$ for xylite and matrix, and $\pm 1\%$ for fusain) but are expected to show much closer agreement once file-conversion problems with the IBAS program are overcome.

The texture of individual samples or seam lithofacies can be expressed by the ratio of preserved plant parts to attrital matrix, and/or by the size distributions of the xylite and fusain components. The ratio of plant parts to matrix is given simply by (xylite + fusain)/matrix, using component proportions as determined above. The size distributions of xylite and fusain are best expressed in terms of thickness, because both the length and perimeter of lensoidal components are dependent on the line of section (i.e., transverse vs. longitudinal). Component thicknesses can be measured from the lith-graphs and lith-logs manually, or more accurately and conveniently by image analysis.

DISCUSSION

The lith-graphs and lith-logs provide detailed graphic representation of the macropetrography of lignites, and enable accurate quantification of macroscopic composition and texture by computer image analysis. The key to the method is the dry sawing, which, by reducing the moisture content of the lignite surface, enhances the contrast between the macropetrographic components and between seam lithofacies layers.

The method will assist the standardized description and classification of lignites at the macroscopic scale. Its greatest value, however, is in the identification, characterization, and mapping of seam lithofacies, and their interpretation through