Coal & Organic Petrology Laboratories

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General Description

Petrology is a branch of geology that deals with understanding the origin, occurrence, structure, and history of materials, and is a science that typically employs a combination of microscopy and chemical analyses. Naturally occurring carbon-bearing substances, like coal and petroleum source rocks, are complex mixtures of organic chemicals that retain a distant resemblance to the organisms from which they were derived. However, biological and geological processes over time serves to alter these substances into individual resources that can have markedly different quality and commercial value.

Microscopy and petrologic techniques are employed by the Coal and Organic Petrology Laboratories (COPL) as a unifying thread that relates biological origin, depositional and geologic history to the composition and structure of the resulting raw material. Consequently, these analytical procedures are used in resource exploration and/or mine planning, resource selection and quality control. Taken a step further, these techniques can be used to evaluate the efficiency of industrial processes and to predict the behavior of organic resources during utilization.

Key Equipment

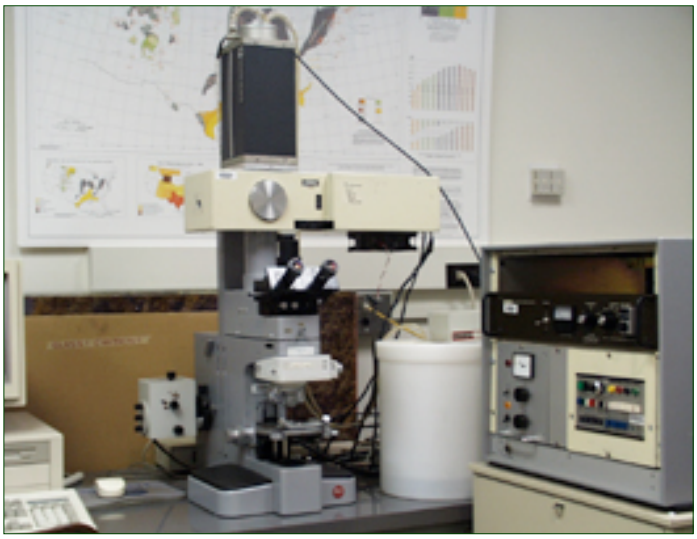
The COPL emphasizes the reflected-light microscopy of solid, carbonaceous, natural or man-made materials. Following procedures and classification schemes established by The American Society for Testing of Materials (ASTM), the International Standards Organization (ISO) and The International Committee on Coal and Organic Petrology, quantitative information can be developed from a diversity of materials, i.e., coals, organic sediments, and industrial- and research- derived products and residues. COPL maintains a variety of microscopes that are distinctive in their purpose and design, including:

Leitz Orthoplan MPV2 Microscope with computer-interface photometric capability for the quantitative measurement of reflected white-light or fluorescence emission intensity from blue- or ultraviolet-light illumination. The instrument is employed to determine the maturity of coals and sediments for resource utilization, petroleum exploration, basin analysis, as well as the influence of thermal processes on carbon-bearing materials.

The microscope also provides photometric capability for spectral analysis of fluorescence emission from blue- or ultraviolet light excitation. This microscope passes the filtered emission through a monochromator that divides the light into narrow bandwidths. This instrument has been used for the characterization of solid state materials such as coal, petroleum source rocks, roadway asphalts and model compounds.

Zeiss Axiophot Microscope with white/blue/UV- light capabilities, microprocessor photometric and photographic controls for general reflected-light microscopy at 400X and 500X magnification. The instrument is used to characterize carbonaceous raw materials, petroleum source rocks, industrial residues and carbon products.

Zeiss Universal Microscopes with reflected white- and blue- light illumination using a series of oil and/or air immersion objectives providing magnifications from 100X to 1000X. These microscopes are used for materials characterization as well as to determine organic composition following point-counting procedures.



Orthoplan MPV2 Research Microscope for Spectral Analysis

Leitz Ortholux MPV1 Microscopes designed for reflected white light illumination at 100X to 500X magnification and having photometric capabilities are available for general research characterization. Hot-stage cells have been adapted to both of these microscopes and hot-stage microscopy films have been generated to show the thermal behavior of coal constituents and the growth and development of mesophase from petroleum pitches.

Nikon Microphot FXA Microscope is available for reflected white-light illumination in a range of magnification from 50X to 1000X. This instrument has a microprocessor controlled camera system for general characterization as well as a color video camera for image capture and automated image analysis. This instrument is used for textural analysis of carbon materials employed in the production of electrodes and anodes for the steel and aluminum industries.

Equipment Capabilities

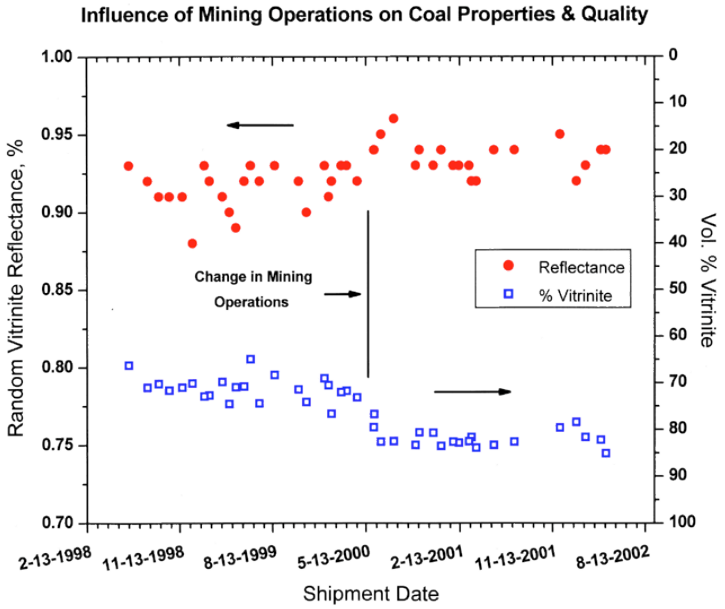
Application of Reflectance Analysis

The amount of light reflected from the surface of humic substances contained in coal or dispersed in sediments provides a sensitive measure of rank or maturity in response to regional thermal history. When the photometer system is calibrated against standards of known reflectance, a distribution of reflectance values can provide a unique mean value for a given material. Reflectance analyses are used to predict the behavior of a coal for the production of metallurgical coke; to establish the quality and uniformity of coal products; and, to establish the maturity of sediments with regard to the generation and migration of petroleum and gas. Consequently, the technique establishes a relationship between geologic history, exploration and resource assessment. Because reflectance is strongly related to the aromatic structure of organic material, the technique has been used effectively to evaluate changes in carbonaceous materials during processing and for process optimization.

Composition Analysis

Analysis of organic sediments in terms of their different plant- or organism- derived constituents has been used to reconstruct the environments of deposition and to predict the behavior of coals in industrial processes. Using a variety of classification schemes, standard point-counting techniques can be employed to determine the composition of organic materials. Compositional analysis has found many applications, but the most significant is that of determining the relative reactivity of a bituminous coal with respect to its ability to become thermoplastic during coke making. The concept of reactive and inert macerals (presence or absence of thermoplastic properties) has been shown to be an important consideration for many industrial applications. Furthermore, the types and amounts of organic material associated with sedimentary rocks dictates the quality of a source rock for the production and migration of petroleum, i.e., carbon derived from terrestrial sources can be inferior to algal marine source rocks.

The point counting technique can be applied to the production of man-made materials as well, whether they are derived from petroleum or coal sources. The ability of a material to develop an ordered intermediate (mesophase) can have a profound influence on the quality of a value-added carbon. The size and shape of areas of equal molecular alignment in the resulting



carbon can be determined by point counting or image analysis techniques. Those carbons having a higher concentration of elongated regions provide superior filler-materials for the production of electrodes or anodes.

Fluorescence Microscopy

Fluorescence microscopy is based upon the concept that ultraviolet or blue light is absorbed by certain organic functional groups and then readmitted at a higher wavelength. If the excitation light is filtered from the light path, then the surface can be expressed by an emission image based upon the organic chemistry of the material. This allows us to visualize fairly immature organic materials that normally would not be observed using white light illumination. Such observations are used to classify the potential quality of petroleum source rocks. Fluorescence intensity and spectral distribution are very sensitive to surface oxidation (natural, thermal or chemical). Consequently, the techniques have been used to evaluate the quality and storage deterioration of coals and the thermal sensitivity of roadway asphalts. As both of these materials become oxidized they lose their thermoplastic properties, thus effecting their quality and service life.

Key Contact

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Key Publications

Mitchell, G.D., Davis, A. and Chander, S., 2005, "*Surface Properties of Photo-oxidized Bituminous Vitrains*," International Journal of Coal Geology, v.62, pp. 33-47.

Karacan, C.O., and Mitchell, G.D., 2003, "*Behavior and Effect of Different Coal Microlithotypes During Gas Transport for Carbon Dioxide Sequestration into Coal Seams*," International Journal of Coal Geology, v.53, pp. 201-217.