Petrographic and Chemical Changes Induced by Artificial Coalification of Peats: With Emphasis on a Liptinite-Rich Peat from a Domed Peat Deposit in the Okefenokee Swamp, Georgia

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Purpose and Scope The purpose of this on-going study is to investigate the petrographic and chemical changes that can occur in different types of peat during various stages of coalification. A series of peat samples representing distinctly different compositions were subjected to stepwise increasing pressures and temperatures (from 30°C and 300psi, to 60°C and 2100psi, and to 175°C and 5000psi) in a semi-open reaction vessel. Organic chemical changes were investigated during these experiments by combined pyr. GC/MS and pyr. GC/FT-IR/FID analysis, gradient mode ion chromatography, 13C NMR, and elemental and lignin phenol analysis. Petrographic changes were investigated in transmitted, reflected, and fluorescent light using combined microtomed/polished sections for the unaltered peats (Maestes et al., 1987) and polished thin sections for the artificially coalified samples.

In previous studies, we reported on organic and inorganic chemical changes induced by these experiments and also on certain changes in reflectance and maceral composition (Rollins et al., 1991, Willis et al., 1991, Bailey and Cohen, 1993, Bailey et al., 1994; Bailey et al., 1995). The first four references represent experiments at pressures and temperatures up to 60°C and 2100psi and the latter reports some early chemical results at higher temperatures and pressures (to 175°C and 5000psi). In this paper, we review these results and relate them to results of petrographic and chemical analyses of a liptinite-rich peat obtained from a slightly domed portion of a peat deposit from the Okefenokee Swamp of Georgia.

Results and Discussion Identification of 115 organic compounds by combined pyr. GC/MS and pyr. GC/FT-IR/FID analysis revealed differences in response to the coalification experiments depending on the peat type (Rollins et al., 1991). The degree of alteration of the peats, as expressed by summing percentage values of the changes in the pyrolysis compound groups, was (from least to greatest): 1) Taxodium peat, Louisiana; 2) Siak peat, Indonesia; 3) woody/sapric peat, Minnesota; 4) Rhizophora (mangrove) peat, Florida; 5) Sphagnum peat, Minn.; and, 6) Cladium (sawgrass) peat, Florida. With regard to consistency of changes in compound groups, lignin and hexose groups changed in an unpredictable way; whereas, the polysaccharide group decreased for all peat types; and the cellulose group (which includes polysaccharides and hexoses) decreased for six out of seven of the peat types. The above experiments were conducted only to temperatures up to the 60°C level. Results from 13C NMR analyses showed only small bulk changes in spectra up to the 60°C level; but, large changes were observed at the 175°C level, especially involving nearly complete losses of O-bonded aliphatic carbons in carbohydrates, confirming results of Shearer et al., 1994 for an artificially coalified Indonesian peat. Also observed at this level of coalification was loss of elemental O content, and large changes in lignin phenol yield and composition (Bailey et al., 1994).

The behavior of the inorganic constituents during these experiments is also being assessed (Willis et al., 1991; Bailey et al., 1995). Concentrations of minor inorganics generally increase with step; whereas, releases of Na, Ca, Mg, Si, Cl, and sulfates is strongly related to the way the constituents are held in the peat and also to changes in the organics during coalification. Where pore solution concentrations are high, mobilization with increasing step is related to loss of these solutions. Where concentrations of exchangeable metals are high, mobilization with increasing step may be through modification of organic structures (Bailey et al., In Preparation). Furthermore, ion chromatography results for three peat types, Cladium, Rhizophora, and Cyrlilla (the liptinite-rich type), reveals increased concentrations of organic acids (acetate, formate, oxalate) for the Cyrlilla and Rhizophora peats and lower concentrations of acetate and formate for the Cladium peat (Bailey et al., 1994; 1995). These organic acids may act as organic complexors and thus contribute to mobilization of the inorganic constituents in associated minerals.

Significant petrographic changes were noted in all peat samples after coalification. The most obvious change was a decrease in porosity, with the least decomposed types exhibiting the greatest decreases. This loss of porosity results not only from compression but also from infilling with a structureless, non-birefringent, organic material derived from an unknown source (perhaps breakdown of certain layers of the cell walls, as per Spackman and Barghoorn, 1966 or Cohen and Spackman, 1980).