STATE OF ALASKA
Department of Natural Resources
Division of Geological & Geophysical Surveys

3354 College Road
Fairbanks, Alaska 99709-3707
907-451-5007
steve.masterman@alaska.gov
dggs.alaska.gov

LIQUID HYDROCARBON POTENTIAL OF ALASKA'S COAL

Coal has long been known to be an excellent source of gas, and many basins around the world, including Cook Inlet, host commercial gas fields sourced by coal and associated coaly mudstones. There has been much discussion of whether, and to what extent, coals function as effective source rocks for oil. It is undisputed that oil can be, and has been, extracted from certain types of coal particles in some sedimentary basins. Additionally, some commercial discoveries of conventional oil can be confidently correlated to coal source rocks, including the Cooper and Eromanga basins in Australia, the Danish North Sea, the San Juan basin in the United States, and the Taranaki basin in New Zealand, and it is likely that coals contributed to conventional oil accumulations in the Gippsland basin (Australia), Turpan basin (China), and several basins in Indonesia (Wilkins and George, 2002; Schenk and others, 2016, *in* U.S. Geological Survey Fact Sheet 2016-3028). Despite these accumulations, the general extent to which coals can generate and expel oil is poorly understood.

Previous investigations have suggested that certain coals in Alaska (in the Holitna, Nenana, Susitna, and Cook Inlet basins), if buried deeply enough to reach the right level of thermal maturity, might have potential to generate significant quantities of liquid hydrocarbons (Stanley, 1988; Stanley and others, 1990; LePain and others, 2003; LePain and Kirkham, 2015). These investigations used Rock-Eval pyrolysis, a widely used, inexpensive, rapid laboratory procedure for evaluating a rock's petroleum-generative potential. The Rock-Eval method relies on heating a rock sample in a chamber connected to a sensor that is used to detect hydrocarbons generated during the process (Peters, 1986). The method is conducted in the absence of water (anhydrous), and the resulting hydrocarbons do not resemble those produced in natural systems. Additionally, for reasons that are poorly understood, the Rock-Eval method appears to overestimate the liquid hydrocarbon potential of coal and the method may not provide a realistic indication of the coal's oil-generative potential (Peters, 1986).

In contrast, the hydrous pyrolysis (HP) procedure more closely replicates natural subsurface conditions, in part by conducting the pyrolysis experiment under water-saturated conditions (Lewan and others, 1979; Lewan, 1985). In the HP procedure a potential source rock, such as coal, is placed in a reactor vessel with water and heated to temperatures between 260 and 365 degrees Celsius (°C) for 72 hours (Lewan, 1985). Hydrocarbons generated during the HP procedure closely resemble petroleum compounds produced in natural systems, and the method provides a more realistic estimate of a coal's oil-generative potential. Few commercial laboratories in the United States currently have the ability to conduct HP experiments.

To investigate the oil potential of Alaska's vast coal resources, the Alaska Division of Geological & Geophysical Surveys (DGGS) and the U.S. Geological Survey (USGS) initiated a collaborative project to conduct HP experiments on selected samples of Alaska coal. HP experiments are time-consuming and require significant geochemical expertise and safety precautions to conduct. USGS petroleum geochemists have constructed the necessary laboratory setup for conducting HP experiments and recently analyzed four Cenozoic-age (roughly 3–66 million years old) coal samples from Alaska. Each sample generated oil; the USGS is currently analyzing the oils to determine their chemical characteristics (Lillis and others, 2017). The oil characteristics represent their geochemical "fingerprint" and will allow comparisons with future produced oils. The results of this work will be published after analytical work has been completed. With the exception of one lignite sample from the North Slope, these four coal samples may be the only coals from Alaska on which HP experiments have been conducted.

Revised 1-26-2017

The ultimate significance of the recent HP results from the four Alaska coal samples is unknown at present, as researchers typically lack unambiguous evidence of oil expulsion from coals, and the mechanisms that control this natural process of expulsion are poorly understood. Most coals have an extensive network of pores that collectively serve as a sponge capable of storing hydrocarbons generated in the coal, and research has shown that the pore networks are not interconnected and that expulsion may, in part, occur through a poorly understood diffusion process (Wilkins and George, 2002). Also, because of their chemical properties, the hydrocarbon molecules are strongly attracted (adsorbed) to the surface of the coal particles, serving to inhibit expulsion.

Possible future research will focus on conducting HP experiments on more coal samples from Alaska, including older coals from the North Slope, and on the conditions required for effective oil expulsion from coal. HP experiments are time-consuming and expensive, so it is unclear how many additional Alaska coal samples will be submitted for analysis. Despite the uncertainties outlined above, this research represents the first steps in the public domain to assess the oil source potential of Alaska's subsurface coal resources.

REFERENCES CITED

LePain, D.L., Blodgett, R.B., and Clough, J.G., 2003, Sedimentology and hydrocarbon source rock potential of Miocene–Oligocene strata, McGrath Quadrangle—An outcrop analog for the Holitna basin: Alaska Division of Geological & Geophysical Surveys Preliminary Interpretive Report 2002-5, 75 p. http://doi.org/10.14509/2870

LePain, D.L., and Kirkham, Russell, 2015, Rock-eval pyrolysis, vitrinite reflectance, and kerogen microscopy results from Miocene carbonaceous mudstones and coals in outcrop, McGrath Quadrangle, southwestern Alaska: Alaska Division of Geological & Geophysical Surveys Report of Investigation 2015-3, 60 p., 1 sheet. http://doi.org/10.14509/29406

Lewan, M.D., 1985, Evaluation of petroleum generation by hydrous pyrolysis experimentation: Philosophical Transactions of the Royal Society of London A, v. 315, p. 123–134. http://doi.org/10.1098/rsta.1985.0033

Lewan, M.D., Winter, J.C., and McDonald, J.H., 1979, Generation of oil-like pyrolyzates from organic-rich shales: Science, v. 203, no. 4383, p. 896–899. http://doi.org/10.1126/science.203.4383.897

Lillis, P.G., Lewan, M.D., Stanley, R.G., LePain, D.L., and Wartes, M.A., 2017, Are Tertiary coals from central and southern Alaska source rocks for oil?: American Association of Petroleum Geologists, Pacific Section Meeting, Anchorage, AK., May 2017, abstract.

Peters, K.E., 1986, Guidelines for evaluating petroleum source rock using programmed pyrolysis: American Association of Petroleum Geologists Bulletin, v. 70, p. 318–329.

Schenk, C.J., Tennyson, M.E., Mercier, T.J., Klett, T.R., Finn, T.M., Phuong, A.Le., Brownfield, M.E., Gaswirth, S.B., Marra, K.R., Hawkins, S.J., Leathers-Miller, H.M., and Pitman, J.K., 2016, Assessment of undiscovered conventional oil and gas resources of the Cooper and Eromanga basins, Australia, 2016: U.S. Geological Survey Fact Sheet 2016-3028, 2 p. https://pubs.er.usgs.gov/publication/fs20163028

Stanley, R.G., 1988, Hydrocarbon source potential and thermal maturity of the Sanctuary Formation (middle Miocene), northern foothills of the Alaska Range, *in* Galloway, J.P., and Hamilton, T.D., eds., Geologic studies in Alaska by the U.S. Geological Survey during 1987: U.S. Geological Survey Circular 1016, p. 117–120. https://pubs.usgs.gov/circ/1988/1016/

Stanley, R.G., McLean, Hugh, and Pawlewicz, M.J., 1990, Petroleum source potential and thermal maturity of the Tertiary Usibelli Group of Suntrana, central Alaska, *in* Dover, J.H., and Galloway, J.P., eds., Geologic studies in Alaska by the U.S. Geological Survey, 1989: U.S. Geological Survey Bulletin 1946, p. 65–76. https://pubs.usgs.gov/bul/1946/

Wilkins, R.W.T., and George, S.C., 2002, Coal as a source rock for oil—A review: International Journal of Coal Geology, v. 50, p. 317–361. http://doi.org/10.1016/S0166-5162(02)00134-9