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The Physics of Heavy Oils: Implications for Recovery and Geophysical Monitoring

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Our capacity to find and produce conventional light petroleum oils are unable to keep pace with the growth in the growing global demand for energy. With the breakpoint between petroleum production and consumption imminent, a good deal of recent efforts have focused on developing the 'heavy' hydrocarbon reserves. Such resources include the extensive heavy oil deposits of Venezuela, the bitumen resources of Canada, and even the solid kerogens (oil shale) of the United States. Capital investments, in particular, have been large in Canada's oil sands due in part to the extensive nature of the resource and already in excess of 30% of Canada's production comes from heavier hydrocarbon deposits. The larger input costs associated with such projects, however, requires that the production be monitored more fully; and this necessitates that both the oils and the porous media which hold them be understood. Geophysical 'time-lapse' monitoring seeks to better constrain the areal distribution and movements of fluids in the subsurface by examining the changes in a geophysical response such as seismic reflectivity, micro-gravity variations, or electrical conductivity that arise during production. For example, a changed geophysical seismic character directly depends on relies on variations in the longitudinal and transverse wave speeds and attenuation and mass densities of the materials in the earth. These are controlled by a number of extrinsic conditions such as temperature, fluid pressure, confining stress, and fluid phase and saturation state. Understanding the geophysical signature over a given reservoir requires that the behavior of the porous rock physical properties be well understood and a variety of measurements are being made in laboratories. In current practice, the interpretation of the geophysical field responses is assisted by combined modeling of fluid flow and seismic wave fields. The least understood link in this process, however, is the lack of knowledge on rock physical properties under the conditions encountered within a reservoir.