Application of Airborne Electromagnetics to Oil Sands Exploration and Development

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ABSTRACT

This paper outlines the approach taken at a particular oil sands lease in the Fort McMurray area. Two complementary airborne electromagnetic surveys were flown. The first was a fixed frequency horizontal loop electromagnetic survey with an anticipated depth of exploration on the order of 60 metres. The primary objectives of the survey were to differentiate the surficial geology to provide more detailed information as part of an environmental impact assessment as well as identify potential ground water sources. A secondary objective was to define areas, which may pose drilling problems such as areas possessing increased sand thickness in the overburden.

In addition, a transient electromagnetic survey was undertaken having an effective exploration depth on the order of 250 metres. This survey was not capable of accurately resolving the upper 50 metres and as a result the data from the two surveys provided complementary information. The primary objective of this survey was to map the continuity and thickness of the cap rock, variations in oil saturation within the McMurray Formation, and define the Paleozoic surface.

In order for electromagnetic methods to be successful, there must be a mappable contrast in physical properties corresponding to one of the exploration objectives for oil sand exploration and development programs. Forward modeling using the available geophysical well logs helps determine if any of the desired objectives can be achieved using electromagnetic methods. Once the forward modeling has been reviewed, the airborne electromagnetic survey can be optimally designed.

To be effective, the survey results had to be presented in a user-friendly format, which required collaboration between the geologists and geophysicists. A good framework for collaboration was established at the outset of the investigation to bridge the gap between the geophysical acquisition and processing of the data and its geological significance. Throughout the interpretation phase of the investigation, the results were discussed and an iterative approach to interpretation was developed.

This paper illustrates that it was possible to achieve most but not all of the survey objectives in a cost effective manner. The successes and failures are outlined and related back to the mappable physical properties of the horizons of interest. The results of an airborne electromagnetic survey provide evidence that such data sets offer a cost effective means of enhancing information for both exploration and development at an oil sands lease. A survey of two townships comprising approximately 950 line kilometres of data costs the equivalent of three drill holes. A comparison of maps for various stratigraphic horizons prepared before and after the airborne survey clearly illustrate the value added to the program. The results of the airborne electromagnetic survey have already been incorporated into the design of a recent drilling program to better locate drill holes, optimize the information obtained and reduce risk.