geoconvention
Calgary • Canada • May 7-11 2018

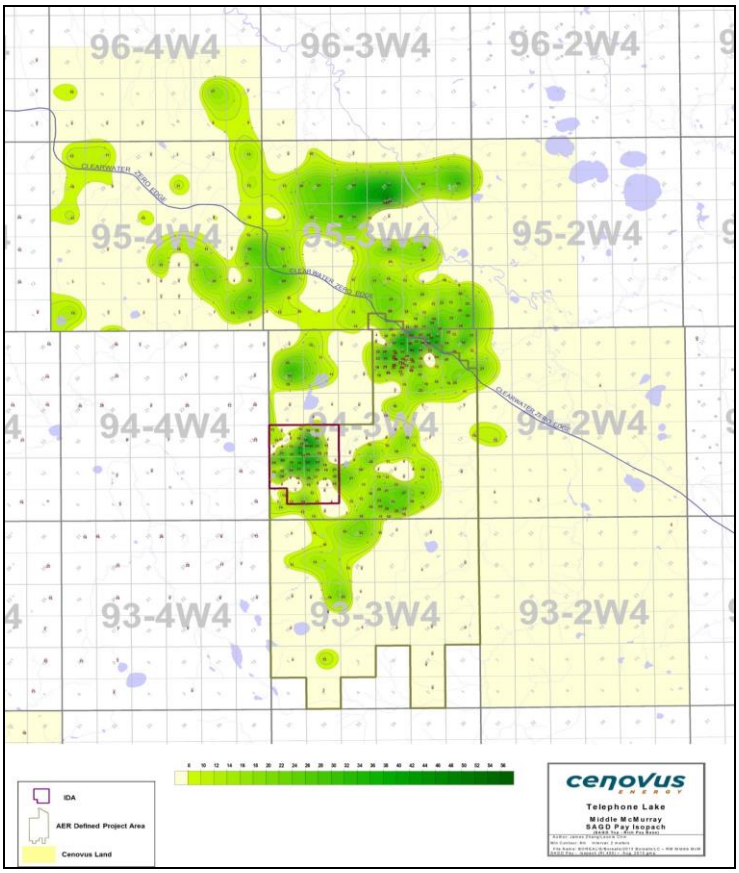
Atterberg Limits Testing for Characterization of Quaternary Till Caprock at Borealis Ridge

Rachelle Pinnow
CSPG, APEGA, SPE

Introduction

Many assets in the Northern Athabasca Oil Sands Area do not have conventional caprock as defined by the Alberta Energy Regulator's new directive (release date: December 16, 2016): *Directive 086 Reservoir Containment Application Requirements for Steam-Assisted Gravity Drainage Projects in the Shallow Athabasca Oil Sands Area*. There are billions of barrels of bitumen without conventional Clearwater shale caprock, one example is at Cenovus' Borealis Ridge, which is north of the Clearwater subcrop. For future development of the bitumen resource in Borealis Ridge via thermal operations, the Quaternary Till will need to be fully characterized and proven as an adequate caprock.

Atterberg Limits testing is a cost-effective and time-efficient method to derive geomechanical rock properties for caprock characterization. Atterberg Limits analysis can be used as a low-cost screening tool to determine where to focus the more costly analytical testing such as triaxial tests, mini-fracs/DFITs, Mercury Injection Capillary Pressure, and other special core analysis.

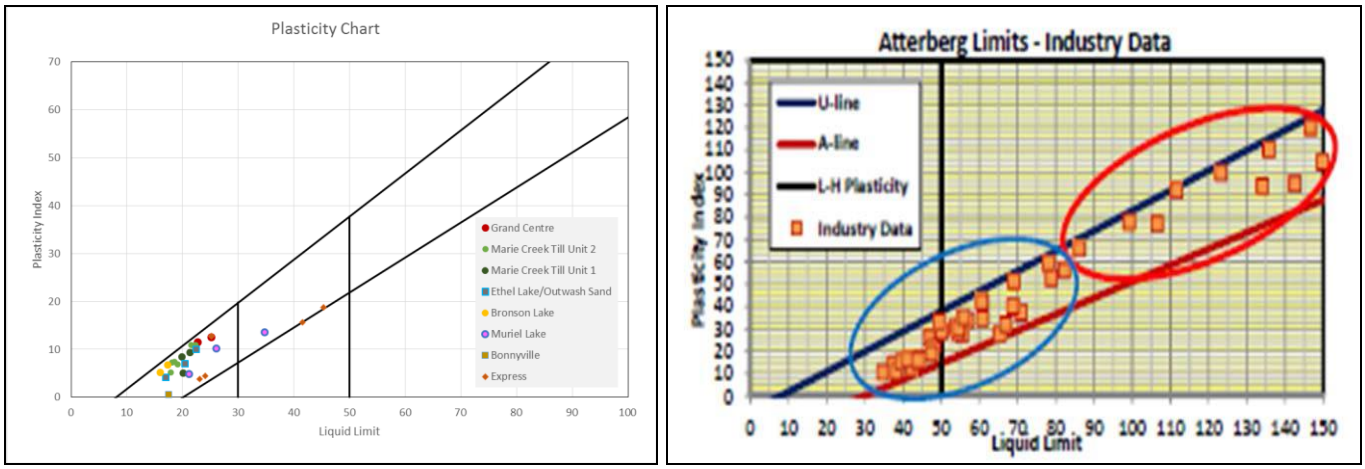


Cenovus' Telephone Lake and Borealis Ridge assets:Middle McMurray SAGD Pay Isopach with Clearwater Shale subcrop edge.

Theory and Method

Atterberg Limits are a basic measure of the critical water contents of a fine-grained soil: it's shrinkage limit, plastic limit, and liquid limit. As a dry, clayey soil takes on increasing amounts of water, it undergoes distinct changes in behaviour and consistency. Depending on the water content of the soil, it may appear in four states: solid, semi-solid, plastic, and liquid. In each state, the consistency and behaviour of a soil is different and consequently, so are its engineering properties. Atterberg Limits data correlate to the Mohr-Coulomb Stress-Strain Envelope; plasticity index correlates with the Unconfined Compressive Strength.

At Borealis Ridge, Atterberg Limits testing was completed on three Quaternary till wells (27 samples) in order to compare with geomechanical properties of conventional Clearwater shale caprock.



Casagrande Plasticity Charts: Left: Borealis Ridge Caprock Study, Trican; Right: Atterberg Limits Industry Data: Observed Trends in the Athabasca Oil Sands, Big Guns Energy Services.

Conclusions

At Borealis Ridge, Atterberg Limits testing on Quaternary aged core showed results of low to medium plasticity for multiple till, interglacial, and lake bottom samples. The Plasticity Index data correlates well with the interpreted geological facies and mineralogy.

The abundance of data points from Atterberg Limits testing enabled a profile of the plasticity index through the asset's potential Quaternary caprock and other shallow horizons. The plasticity index was added to the Heterolithic Rock Analysis models and was found to correlate well with the geomechanical properties derived from other laboratory and field tests. Through correlation of all geological data and engineering properties, Atterberg Limits testing ties into best practice for acquiring geomechanical properties of caprock.

Continued geomechanical testing and comparisons with the Clearwater Shale caprock at producing SAGD assets will aid in understanding the integrity and seal capacity of unconventional caprocks such as the Quaternary tills at Borealis Ridge.

Acknowledgements

The author would like to thank Cenovus Energy for permission to present this work, and the Borealis Ridge subsurface team for their contributions, especially Radu Buzea and Gordon Uswack. Acknowledgements

are also extended to Raphael Wust at Trican Laboratories (AGAT) and Rick Chalaturnyk, (RG)² Reservoir Geomechanics Research Group, University of Alberta.

References

Andriashek, L.D. and Atkinson, N. 2007. Buried Channels and Glacial-Drift Aquifers in the Fort McMurray Region, Northeast Alberta. EUB/AGS Earth Sciences Report 2007-01.

Andriashek, L.D. 2002. Quaternary Geological Setting of the Athabasca Oil Sands (In Situ) Area, Northeast Alberta. EUB/AGS Earth Sciences Report 2002-03, Alberta Geological Survey.

Chalaturnyk, R.J. 1996. Geomechanics of the steam assisted gravity drainage process in heavy oil reservoirs, Ph.D. dissertation, Dept. of Civil Engineering, University of Alberta, Edmonton, Alberta.

Collins, P.M., Waters, D.A., Perkins, T., Kuhach, J.D., and Veith, E. 2011. Effective Caprock Determination for SAGD Projects, CSUG/SPE 149226-PP, Society of Petroleum Engineers.

Cummings, D.I., Russell, H.A.J., and Sharpe, D.R. 2012. Buried valleys and till in the Canadian Prairies: geology, hydrogeology, and origin. Geological Survey of Canada, Current Research 2012-4.

Zoback, M.D. 2010. *Reservoir Geomechanics*. Cambridge University Press.