Frontiers + Innovation
2009 CSPG CSEG CWLS CONVENTION • CALGARY, ALBERTA, CANADA

Saglek Basin: At Least ONE Petroleum System in an Ultra-frontier Basin with Great Potential

Hans J.B.W. Wielens*
hwielens@nrcan.gc.ca
and
Chris D. Jauer
Geological Survey of Canada Atlantic
Dartmouth, NS, Canada

Summary

The Saglek Basin, off the southern tip of Baffin Island, Nunavut, in the northern Labrador Sea, has one proven petroleum system, a structure tapped by the Hekja O-71 well with an estimate of 2.3 Tcf of gas found in the lower Eocene Gudrid sandstone. A similar, but much larger structure has been identified from seismic mapping south-east of the Hekja discovery. Petroleum system modeling suggests that this newly identified structure may contain a few hundred times more gas. There are also additional significant structures present that likely form a prospect fairway.

The gas composition from the Hekja discovery indicates a Type III source (land-plant material, likely with resinites). Potential source rocks (Upper Cretaceous Markland Formation) are present at the very bottom of the Gjoa G-37 well in the eastern edge of the Saglek Basin. Type I and II source rocks are also present in the Bjarni Formation within the southernmost Saglek and Hopedale basins.

The 4-D petroleum modeling results suggest that the sandstone reservoir rocks at Hekja discovery never reached a thermal maturity to enter the gas window. Thus, the Hekja gas must have moved in from greater depths, which implies long-distance migration. The basin modeling results show that the gas migration should also have filled other reservoirs. The presence of a regional petroleum system is evident on seismic images from gas chimneys and possible mud volcanoes. In addition, Radarsat images have identified numerous sea-surface slick features, interpreted to be caused by active oil seeps.

No active slick features have been observed over the Hekja discovery although at least four vent-like structures are present (**Figure 1**)

A final validation for the basin's potential is statistical. In the ultra-frontier Saglek Basin, the success ratio is 33% for the 3 wells drilled. If combined with the wells in Hopedale Basin, the ratio is 25%, which indicates that this whole area has huge potential. With the three types of source rocks, several petroleum systems are quite likely. The biggest risk appears to be the seal integrity; trap, seal and reservoir are present in almost every one of the 28 wells drilled in both basins.

Introduction

Saglek and Hopedale basins underwent their first exploration cycle from 1971 until 1983, with oil as the target. Mainly gas was found and, even with the very high success ratio, exploration waned because gas was not considered economical to produce. Because of the ever increasing interest in gas accumulations in the last decade, a review of this area was due. A recent land sale along the Labrador Margin shows a renewed interest by industry in this area. New ideas about the rifting and sedimentation history of the area have changed the understanding of these geologically complex basins. Therefore, an assessment of the petroleum system(s) was undertaken by GSC to determine the hydrocarbon potential of the area and their risk factors.

Method

The main data sources are seismic reflection profiles, drilling data and cores/drill cuttings. An initial study of seismic data and the construction of a 4-D basin model showed significant hydrocarbon potential within the Saglek Basin. A detailed reinterpretation of the seismic data was integrated with new analyses of drill cutting samples for biostratigraphic ages (e.g. Williams, 2007), thermal maturity (e.g. Avery, 2005), organic geochemistry (Fowler et al., 2005), and geophysical and well data available in GSC's Basin Database to constrain a new 4-D petroleum system model. Radarsat data, taken over a several month period, were used to detect and interpret sea surface oil slicks. (Jauer and Budkewitsch, 2009, in press)

Results

Seismic structure maps were produced for several significant seismic marker horizons within the Saglek Basin and converted to depth using sonic logs from the exploration wells. The seismic structure mapping of the Gudrid Sandstone reservoir unit identified several previously unknown structural closures that are orders of magnitude larger than the structure at the Hekja O-71 well (**Figure 1**). These different surfaces were integrated with the well stratigraphy, organic geochemistry and thermal maturity data to construct a digital geological model.

The source rock type for the Hekja discovery is attributed to Type III, dispersed land-plant material and likely resinites, but this was not found in any abundance outside the Gudrid Sandstone interval. Rock Eval data from wells in the Hopedale basin to the south showed several wells with large intervals of Type I and Type II source rocks, suggesting a possible alternative source material within the Saglek Basin. However, a Type III source material would best match the chemical signature of the discovered gas (Fowler et al., 2005). The Upper Cretaceous Markland Formation shales found in the Gjoa G-37 well may represent this source material.

The Hekja well bottoms in over 1 km of basalt. Above the basalts, the Gudrid Sandstone reservoir has dispersed Type III organic matter with vitrinite reflectance values of .55 to .72%. These values are too low to explain the thermal maturity of the petroleum samples retrieved from the discovery well. The modeling shows that peak of oil generation for the area was at 30 Ma and that the Gudrid Sandstone unit barely ever entered the oil window. This means that the gas in Hekja well must have derived from a deeper source, and migrated through the basalt unit. This extensive vertical (and lateral) migration would have charged the Gudrid Sandstone reservoir with gas. The amounts of gas calculated for the larger structures are hundreds of times larger than at Hekja. The model predicts there is little oil within the basin, based on the Type III source rock.

Indirect hydrocarbon indicators are visible on the seismic profiles, in the form of gas chimneys and eruption cones at the sea-floor (**Figure 2**). Oil on sea water dampens the surface waves, and Radarsat detects this as a reduced backscatter measurement. Images collected on separate dates were compared to increase the confidence that the sea-surface features are the result of active oil seeps. In this region there are several oil seep related features around the area with the largest structure, suggesting there may be structural breaching of the reservoir rocks or filling beyond spill points. The oil seeps, in an area where only gas has been found so far, implies a separate petroleum system with oil. The Ralegh N-18 was drilled off of a structural high and, although excellent reservoir rocks were found, the well was dry.

Most of the 28 wells in the Saglek and Hopedale basins were drilled on structural traps well imaged on seismic data. There is no salt in these basins and most of the trap structures were formed due to rifting along the margin. It is logical to assume that the hydrocarbon generation was after trap formation. In every well, reservoir rocks and sealing rock layers are present. The evidence of several oil seeps, gas chimneys and sediment-surface cones suggests that the integrity of the seals is likely the highest risk factor along the margin. Several of these chimneys penetrate over 1 km of sediment, so a biogenic origin of the gas is unlikely. The very high discovery rates of 25 to 30 % in this area, where a 5% rate would be expected, provide an independent indicator of the high hydrocarbon potential.

Conclusions

Exploratory drilling from 1980 has proven one gas prone petroleum system in the Saglek Basin. The interpretation of new seismic and radar data points to there being at least one additional petroleum system present in the region, associated with very large but as yet untested subsurface structures. The use of 4-D petroleum modeling based on these new interpretations indicates a high probability of significant amounts of mainly gas reserves but with oil also present, that has yet to be proved by drilling.

References

AVERY, M.P., 2004, Vitrinite reflectance data for Aquitaine *et al* Hekja O-71. Geological Survey of Canada Open File 4842, 15 p.

Fowler, M., Stasiuk, L. And Avery, M. 2005, Potential petroleum systems in the Labrador and Baffin Shelf areas, offshore north eastern Canada. In: Organic Geochemistry: Challenges for the 21st Century Vol. 1. Book of Abstracts for 22nd International Meeting on Organic Geochemistry, Seville, Spain, September 2005, p. 463-464.

Jauer, C. D. and Budkewitsch, P. 2009, in press, Old Marine Seismic and New Satellite Radar Data: Petroleum Exploration Offshore Baffin Bay

Williams, G.L., 2007, Palynological analysis of Aquitane et al Hekja O-71, Saglek Basin, Davis Strait, Geological Survey of Canada Open File Report 5448, 18p, 1 sheet

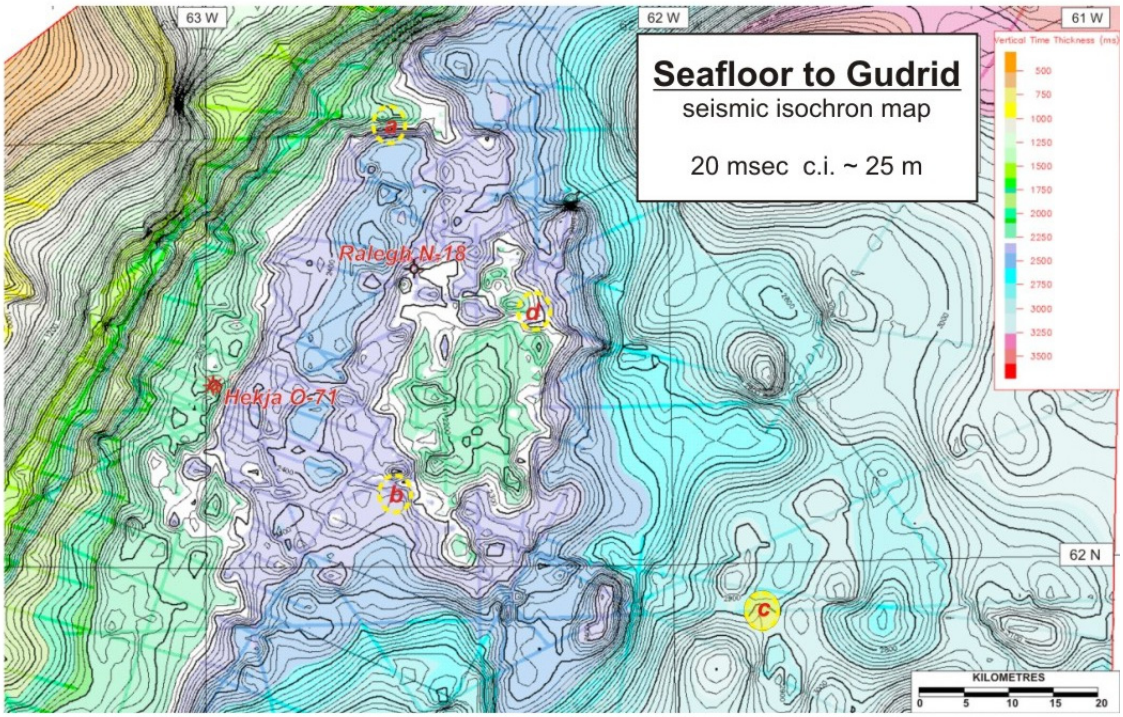

Figure 1 Seismic isochron map of the lower Eocene Gudrid sandstone shown contoured at 20 msec two way time. Note that the Hekja structure is much smaller than the feature to the east and that Ralegh is not at the crest. Overlain are four dormant seafloor vents (***a-d***), example ***c*** is shown in Fig. 2

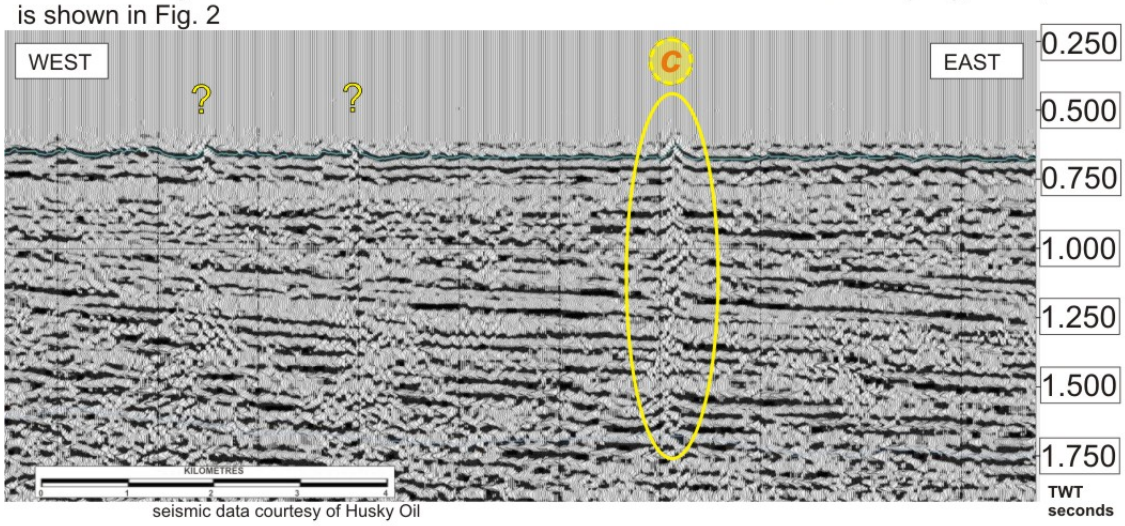

Figure 2 Seismic data from 1982 showing major inactive seafloor seep structure “c” that is offset from the Hekja structural complex to the west. Note the distinct chevron style seismic signature of this feature which has about 40m of relief above the local seafloor; two additional vent structures may lie to the west of the main structure at a distance of 3 and 5 kilometres.