geoconvention
Calgary • Canada • May 12-14 2025

# Geothermal Potential for Resolute Bay, Nunavut

*Stephen E. Grasby, Krista Williscroft, Wanju Yuan, Kezhen Hu, Keith Dewing*
*Geological Survey of Canada, Natural Resources Canada*

## Introduction

Resolute Bay is the second northern most community in Canada. Located on the southwestern tip of Cornwallis Island, Nunavut (N74° 43' 6.492": W94° 59' 2.4"), the community has 183 residents (2021 census), along with a seasonal research facility (Polar Continental Shelf Project) and military training facility (Canadian Armed Forces Arctic Training Centre). The remote community has no road linkage. Food and supplies are delivered by sealift and airlift. Sea ice limits marine access to a narrow window in August and September, leaving airlift as the dominant year-round mode of transportation. The annual heating load reported for Resolute Bay is 5690 MWh, and electricity demand is ~4500 MWh, both of which are meet with imported oil/diesel. The high latitude location experiences 24 hours of darkness for 89 days/year, and this with common overcast conditions gives the community a 29.4% possible annual sunshine rating, ranging from 0 to 41.4% monthly (Environment and Climate Change Canada Climate Norms). These low values greatly limit solar production. The mean annual air temperature of −15.1 °C (monthly means of −31.4 to +4.9 °C) also creates issues with icing of windmill blades as well as the efficiency of battery packs required to stabilise intermittent renewable power sources at low temperatures. Other renewable energy solutions are required to meet decarbonisation goals.

Resolute Bay has been suggested to have higher thermal gradients (121 mW/m$^2$) than the broader arctic region based on shallow thermal gradient measurements made within permafrost. Modeling suggests that geothermal heating of greenhouses could yield fresh local produce with an average cost that is 50% lower than supplies shipped to the community from the south. These studies are built on numerous assumptions and historic data that tend to overestimate geothermal conditions, and lack a proper geologic resource assessment. Here we examine the historic data and local geology to develop a geologic and thermal model of Resolute Bay, to more clearly assess the resource potential.

## Results

Regional geothermal gradient data includes bottom hole temperature (BHT) and drill stem test (DST) data from petroleum wells in addition to high resolution shallow temperature survey data. Additional constraints include reservoir temperatures from discovery wells, temperature constraints inferred from the base of permafrost, and temperature constraints from the base of seafloor. These data show a wide variation, with a 40 °C temperature range at 2000 m depth. However, a linear model fit to the temperature–depth relationship gives an average temperature gradient for the Arctic Islands of 23 °C/km $r^2$ = 0.92. Consistent with this, Cornwallis Island has Curie Point depths from 25 to 30 km (unpublished data). In the Resolute Bay area the depth is ~ 26 km, suggesting an overall upper crustal thermal gradient of 22 °C/km.

Temperature data from Cornwallis Island are available from petroleum exploration wells and shallow permafrost research wells. There were two petroleum exploration wells drilled on Cornwallis Island, Resolute Bay L-41 (3 km east of Resolute Bay), and ‘Panarctic Deminex Cornwallis Central Dome K-40’ (short name: Central Dome K-40) 52 km north of Resolute Bay.

We examined these and five additional exploration wells in proximity to Cornwallis Island to help characterize local geothermal conditions (short names: Garnier O-21, Russel E-82, Allison R. N-12, Bathurst Caledonian River J-34, Devon E-45). A best fit line through the local petroleum well temperature data suggests a thermal gradient of 24.2 °C/Km.

The closest petroleum well to the community (3.3 km distant) is Resolute Bay L-41, which recorded a bottom hole temperature (BHT) of 40 °C, although this most likely reflects near surface temperatures affected by warm mud circulation (the temperature was recorded on a maximum recording thermometer). This is supported by the reported BHT of Resolute Bay L-41 being close to the highest temperature reported at the top of the well in the detailed temperature log that was run.

In the detailed temperature log base of permafrost is estimated at 515.7 m. From 515.7 m to total depth (TD) at 1473.5 m the well warms to a maximum of 12.6 °C, with one step in the gradient around 910 m. A linear fit to the temperature–depth relationship for the lower part of the log, below the temperature step, provides a geothermal gradient of 14.9 °C/km. The gradient from the interpreted base of permafrost to TD is 16.2 °C/km (Fig. 7B).

The now defunct Dominion Observatory, in co-operation with the then Meteorological Division, Department of Transport, conducted a permafrost research program at Resolute Bay in the early 1950's including drilling monitoring wells 2.5 km from Resolute Bay. Initial calculated thermal gradients of 39.4 °C/km in permafrost are shown to be affected by glacioisostatic rebound changing conditions of the well locations from subsea to subaerial, with a resultant propagation of a cold front into the ground that created pronounced anomalies in subsurface temperatures. A steady-state correction of the shallow (within permafrost) thermal gradient is 25.5 °C/Km.

In summary, the BHT and DST data from Resolute Bay L-41 DST are likely erroneous. Similar issues could explain high reported temperatures from other wells nearby petroleum wells, although some BHTs fall on the thermal gradient for the detailed temperature log from Resolute Bay L-41. Other shallow permafrost wells in the arctic have also been shown to have erroneously high thermal gradients due to glacioisostatic rebound, although the theoretical framework for corrections through heat flow modeling has been developed. For the geothermal resource assessment, we take the lower gradient from the detailed log of Resolute Bay L-41 as the most reasonable and conservative estimate (14.9 °C/km) but recognise potential for higher gradients similar to the regional average taken as the Curie Point gradient (22 °C/km).

Future work will include field studies to examine potential reservoir rocks where exposed in the Central Dome of Cornwallis Island.

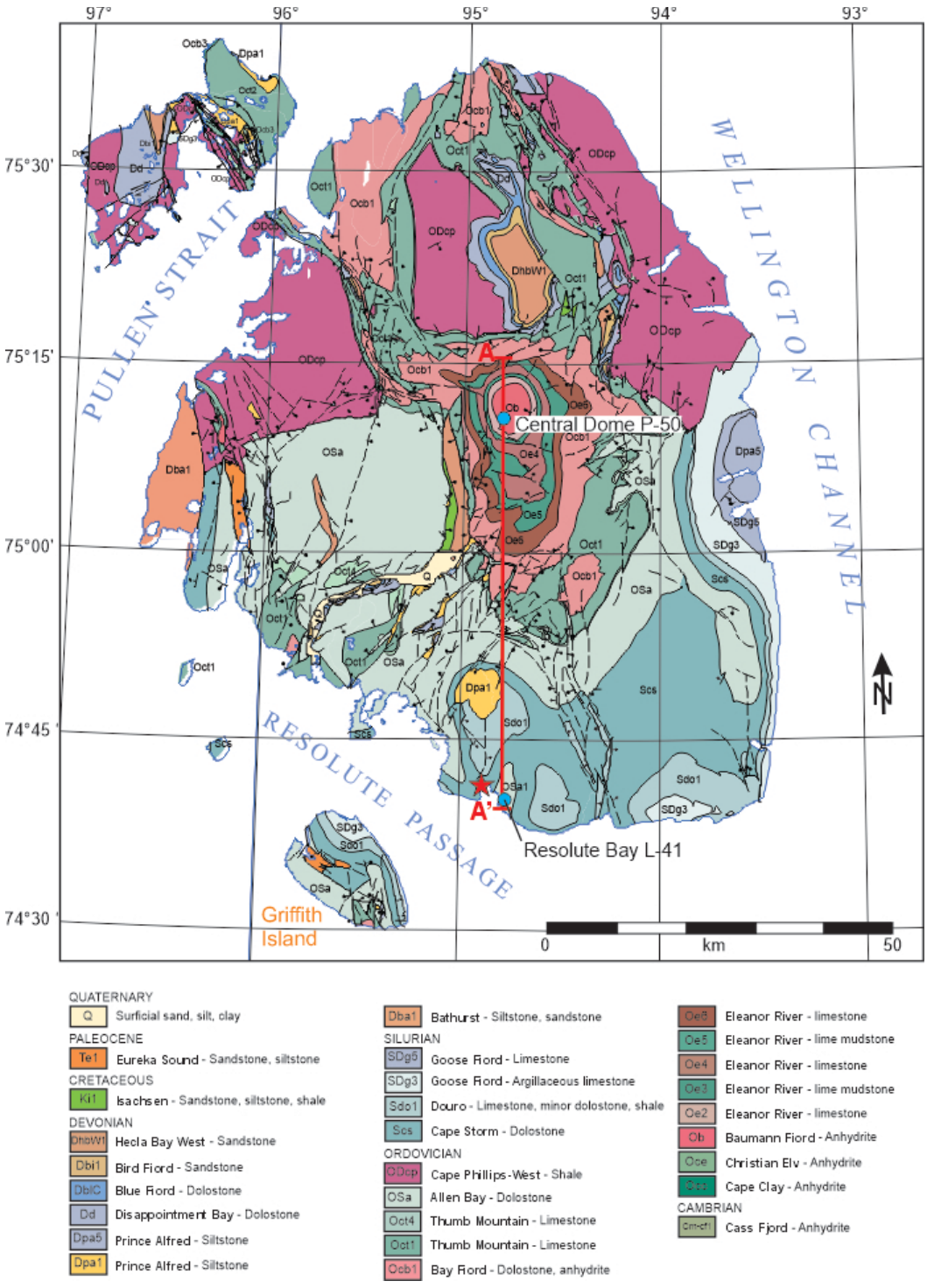


**Figure 1**. Geologic map of Cornwallis Island showing location of Resolute Bay (red star) and petroleum wells (blue dots), along with cross section line A-A' shown in Figure 2.

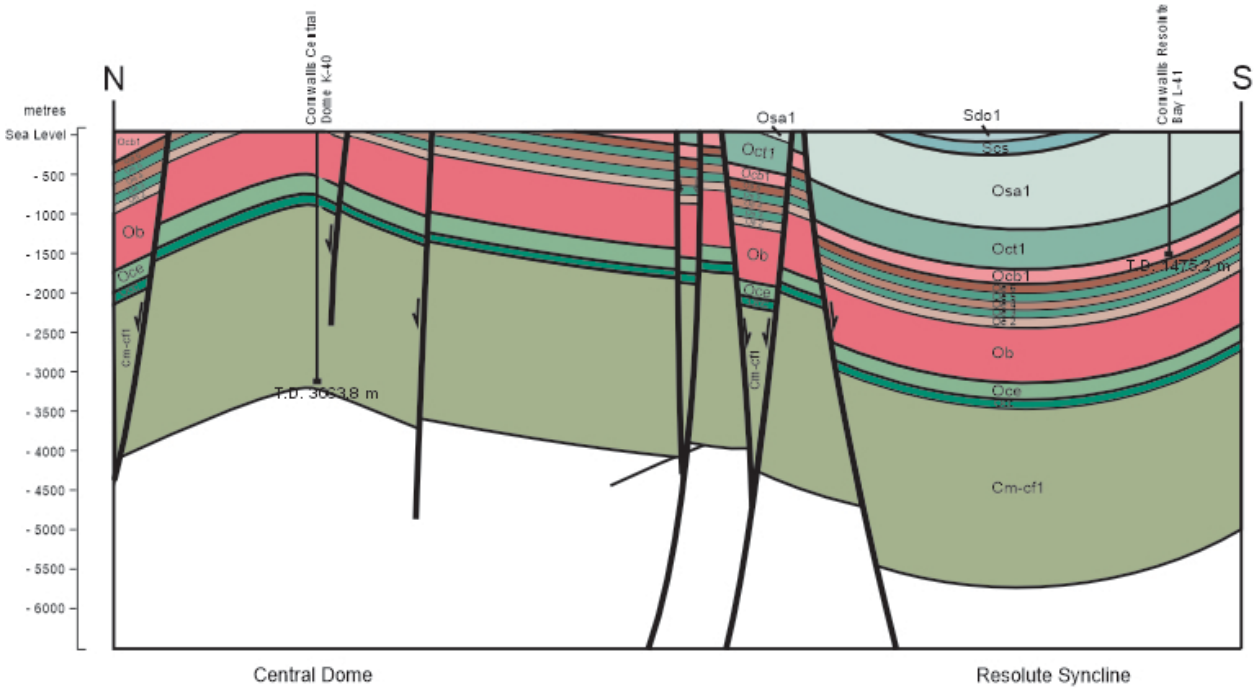


**Figure 2.** Geologic cross section A-A' as shown in Figure 1. Illustrating the two previous petroleum wells drilled on Cornwallis Island, and location of Resolute Bay overlying the Resolute Syncline. Legend is in Figure 1.