The Geothermal Heating Resource for Cornell University, Tompkins County, New York: Exploiting and Analyzing Available Geological and Geophysical Data Sets for Pre-Drill Site Characterization

Teresa Jordan[1], Jared Smith[1], Jood Al Aswad[1], J. Olaf Gustafson[1], Jefferson Tester[1], and Stephen Beyers[1]

[1]Cornell University

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Abstract

Cornell University aspires to fully heat and cool its main campus with renewable energy. Cornell is a 30,000-person community, in >14 million ft2 of buildings, that annually consumes ˜240,000 MWth-hrs of heat. Successful geothermal district heating at Cornell would provide a model for other communities in the cold-climate Northeast U.S.. A geothermal Play Fairway Analysis (GPFA) of the sedimentary aquifer geothermal potential of the Appalachian Basin (https://bit.ly/2JHOiVH) for NY, PA, and WV demonstrated that Cornell's campus is located in a favorable sub-region of the basin. The GPFA found that, for Cornell, the expected rock temperature at 3 km depth was 70–85°C, with suitable natural permeability in sedimentary units most likely near 2.4 km depth; indirect indicators of the propensity for induced seismicity revealed no unusual risk. In 2017-2018 we have used geological and geophysical data sets to more robustly analyze the nature of the geological resources, their potential fit to the heating needs, and risks. Data for deep wells in Tompkins County and six abutting counties, archived in New York's Empire State Organized Geologic Information System, improve the thermal resource estimate. Within 20 km distance, one well log, assumed equilibrated, lists 118 °C rock at 3369 m depth, and another borehole lists a non-equilibrated 93 °C at 3600 m. These underpin revised Cornell temperature-at-depth estimates. Sedimentary reservoir data for units from the Ordovician Trenton Formation to the top of metamorphic basement are under evaluation based on gamma, neutron, sonic and density logs. The estimated depth to the basement is 2865 +/- 200 m. We are evaluating potential reservoirs within basement rocks for heat extraction using Enhanced Geothermal System techniques. Direct basement data are limited to petrology of cuttings from 5 wells. For pre-drill analysis, those data are supplemented by analogous metamorphic rocks in the Adirondack Mountains; we assume a mixture of granitic gneiss, marble, amphibolite and/or anorthosite. Fracture aperture, spacing, and orientation dispersion are estimated based on observations in the southern Adirondacks, to which fracture analysis based on high resolution DEMs is being added. Seismic, gravity and magnetic field studies of potential well field sites are in progress.

Cornell University

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Exploiting and Analyzing Available Geological and Geophysical Data Sets for Pre-Drill Site Characterization

Teresa E. Jordan[1], Jared D. Smith[2], Jood A. Al Aswad[1], J. Olaf Gustafson[3], Jefferson W. Tester[4] & Stephen M. Beyers[3]

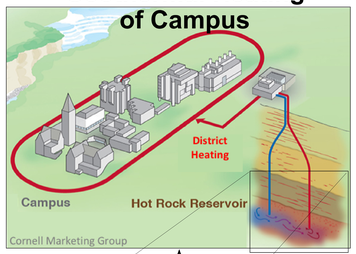
Cornell University, Ithaca, NY, United States: [1]Earth & Atmospheric Sciences, [2]Civil & Environmental Engineering, [3]Facilities Engineering, [4]Chemical & Biomolecular Engineering

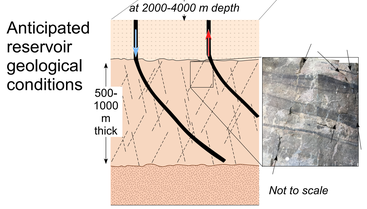
CornellEngineering

Current research focuses on reducing uncertainties and analyzing risks:

Reservoir quality; Depths to adequate temperature(s); Costs to match campus heat need to resource potential; Environmental and social outcomes

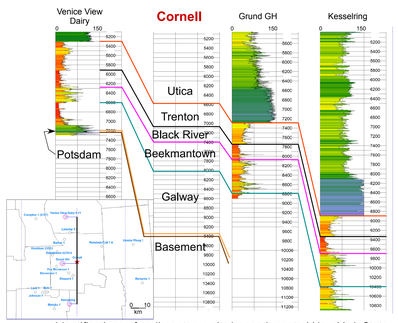
Cornell Aspiration: Geothermal Heating of Campus





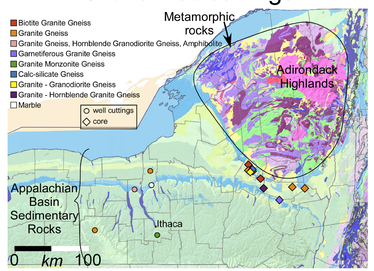
1) Reservoir Performance and Heat Flux Potential

Sedimentary Reservoirs Analysis
Utilize O&G well logs



Identifications of sedimentary units beneath central New York State based on gamma ray logs. Depths in feet below local surface. Colors correspond to bulk lithologies. Formation contacts identified in the wells in neighboring counties (map) are used to predict lithologies to be encountered in a borehole at Cornell, and depths of those units.
Porosity data are provided by neutron porosity and density logs, corrected for the effects of lithology, the composition of fluids in the pores, bound-water in shales, and participation of feldspar in some sandstones.

Basement Reservoir Analysis
What rock type underlies Cornell?
Utilize well cuttings

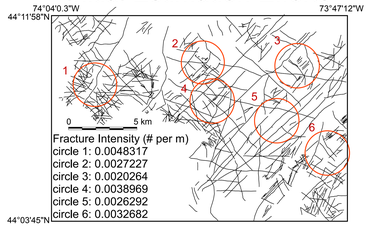


Adirondack Lithologies

- Metanorthosite & anorthositic gneiss
- Interlayered metasedimentary rock & granitic, charnockitic, mangeritic, or syenitic gneiss
- Charnockite, mangerite, pyroxene-quartz syenite gneiss
- Biotite and/or hornblende granite gneiss
- Mangerite, pyroxene-(hornblende) syenite gneiss

USGS Geologic map of New York State with locations of wells whose cutting samples were studied by B. Valentino (2016, Cornell University). The color of the well marker (legend top left) indicates the major basement lithologies present in the borehole samples. Legend for colors of some of the major lithologic units exposed in the Adirondack Mountains shown below map. Colors of well samples do not match geologic map colors.

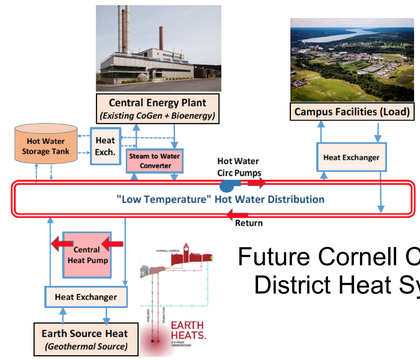
Fracture Distribution?
Initial Estimation Efforts



Large scale fractures (N=601) mapped based on LiDAR DEM of the Mt. Marcy region, Adirondack Mountains, NY.

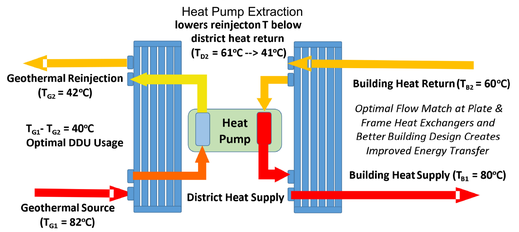
Work by T. Ming Khan and R. W. Allmendinger, with data provided by B. L. Isacks (2018, Cornell University)

2) Engineering Research to Optimize Matching Heat Requirements to Geological Opportunities

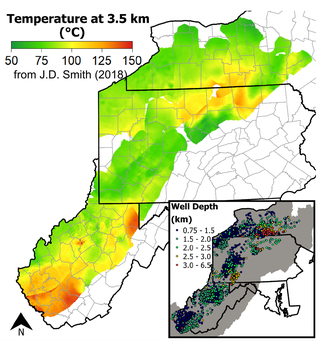


Future Cornell Campus District Heat System

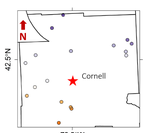
Efficient & Cost-effective Design Requires Maximizing Heat Extraction



Geothermal Play Fairway Analysis Temperature Prediction for the Appalachian Basin

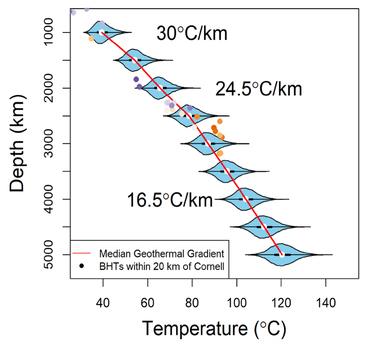


Probabilities of Temperatures at Depths

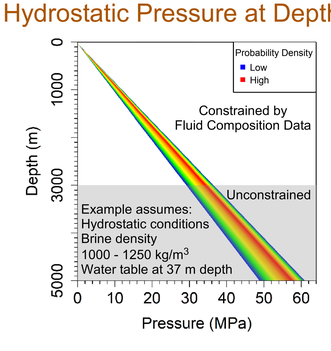


Tompkins County map: Wells within 20 km of Ithaca with Bottom Hole Temperature data. Data have been corrected based on Whealton et al. (2015).

Whealton, C.A., Stedinger, J.R., Horowitz, F.G., 2015. Application of Generalized Least Squares Regression in Bottom-Hole Temperature Corrections, in: Final Report: Low Temperature Geothermal Play Fairway Analysis for the Appalachian Basin. pp. 130–144.



Probabilities of Hydrostatic Pressure at Depth



Future Research: Science Opportunities!!

Site Selection:
Geophysical analyses in progress

Pilot borehole:
Let's talk!

see Horowitz et al. PA43B-1369: A Gravity Survey Nearby Cornell University Looking for Structures Potentially Interfering with a Proposed Geothermal Campus Heating Project

L.D. Brown: Seismic reflection survey collected September 2018

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