Thank you!

- Squamish and Lil’wat First Nations
- Maxine Bruce, Tammie Jenkins
- Geoscience BC and NRCan Emerging Renewable Power Program
- Innergex Renewable Energy
- No Limits Helicopters
The Garibaldi Team

• 34 researchers from the Geological Survey of Canada plus 7 Universities (UBC, SFU, DC, UofA, UofC, ETH, Quest)
• 34 people in the field (>400 person days)

Training the next generation
• 3 Post Docs, 6 PhDs, 1 MSc, 1 BSc
The Garibaldi Team

S.M. Ansari, Geological Survey of Canada, Ottawa
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Z. Chen, Geological Survey of Canada, Calgary
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G. Savard, University of Calgary
V. Tschirhart, Geological Survey of Canada, Ottawa
M.J. Unsworth, University of Alberta
N. Vigouroux-Caillibot, Douglas College
G. Williams-Jones, Simon Fraser University
Supporting the transition to a low carbon economy

Net-Zero Emissions by 2050
Expanding renewables

Canada’s energy production is 89% non-renewable
Geothermal is cost competitive

Source: IRENA 2020
Geothermal potential of Canada

Grasby et al. 2012
doi.org/10.4095/292840
Volcanic belts of Canada

- Canada has abundant, volcanoes
- Largely dormant since the Holocene (12,000 years ago)
Garibaldi Volcanic Belt

- Northern Termination of Cascades
- Related to Subduction of ocean crust under North America
- Focus on Mount Meager ~60 km from Pemberton, 140 km from Vancouver

Andrews et al. (2014)  
Hetherington (2014)
Mount Meager Volcanic Complex

• Active 2.2 Ma to present
• Most recent eruption 2350 BP (Bridge River event)
• Extensive hydrothermal system (alteration, fumaroles, hot springs) suggest geothermal potential.
South Meager Geothermal Exploration

- Early research and drilling by NRCan and BC Hydro
- Subsequent industry exploration and drilling
- Data public – available at Geoscience BC

Witter, 2019
Mount Meager research well

- NRCan/BC Hydro Collaboration
- World class thermal resource > 250 °C
- First geothermal power production in Canada (250 kw)
Looking into the Heart of the Mountain
Garibaldi Project - Reducing Exploration Risk

Predicting Permeability
- fracture/stress system analyses
- aquifer systems

Heat Resources
- regional thermal properties
- volcanic history

Resource Production
- crustal-scale flow systems
- thermal spring systems

Resource Assessment Methodology

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Where we went

[Map showing various locations and activities labeled with icons such as geologic mapping (348), fracture measurements (54), gravity measurements (126), etc.]
Geologic mapping

- Four new geologic maps
- Studies of faults and fractures that can control fluid flow
- New age dating to provide eruption history
- Underpins all work – informs rock type and characteristics
Fracture studies

- Understanding dominant orientations and frequency of fractures that control fluid flow
- 1500 new measurements
Gravity Survey

- Variations in Earth gravity show low gravity anomalies at the South Meager geothermal area and to the north under Plinth Peak
- Potential signatures of melt and geothermal system
Passive Seismic

- Deployed 59 seismic stations
- Detects shaking from earthquakes (also rock fall, people jumping around sensor…)
- Provides baseline knowledge of natural seismicity in region
Magnetotellurics

- Deep focus examining 2 to ~ 10 km depth
- Results show deep conductor and pathways to shallow level

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Shallow Magnetotellurics

- Shallow focus examining upper 2 km
- Looking for the geothermal reservoir
Shallow Magnetotellurics

- Prominent conductive unit in subsurface
- Hydrothermal zone/fluid filled fractures?
- Need to model data in context of rock properties to resolve

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Remote Sensing

- Defined thermal anomalies in satellite images
- Defined lineaments assuming they represent fractures in rock
AI/ML-enabled geothermal resource evaluation

Multi-Seasonal Landsat images

ML algorithms for automatic feature extraction/characterization/classification

Regional & Field Geology

Geochemistry & Geophysics

AI-assisted data integration and validation

Geological Models

GHF Anomalies

Permeable Network

Geothermal Anomaly Detection

Computer picked geothermal anomalies & AI-assisted interpretation
Resource Modeling

Preliminary results suggest:
- 6-13 MW power for 1 well
- Production for > 30 years
Closed-loop type system

- Rock permeability and water availability are irrelevant to production
- Lower environmental footprint
- Untested in volcanic system but high thermal conductivity is favourable
Closed-loop - Preliminary model results

- Outlet water >200 °C for over 30 years
- Energy production capacity >13 MW
Summary

• Mount Meager is a world class thermal resource
• Potential for world class geothermal system
• All new data available online at GeoScience BC (thousands of measurements and terabytes of data).
Next steps

- **Phase 2** – examine the Mount Cayley area to test methods in a less data rich environment
- Use results to extrapolate geothermal potential over broader Garibaldi Volcanic Belt
- Assess the total potential renewable clean energy supply from BC’s volcanoes and how it can contribute to achieving a Net Zero economy
Questions?