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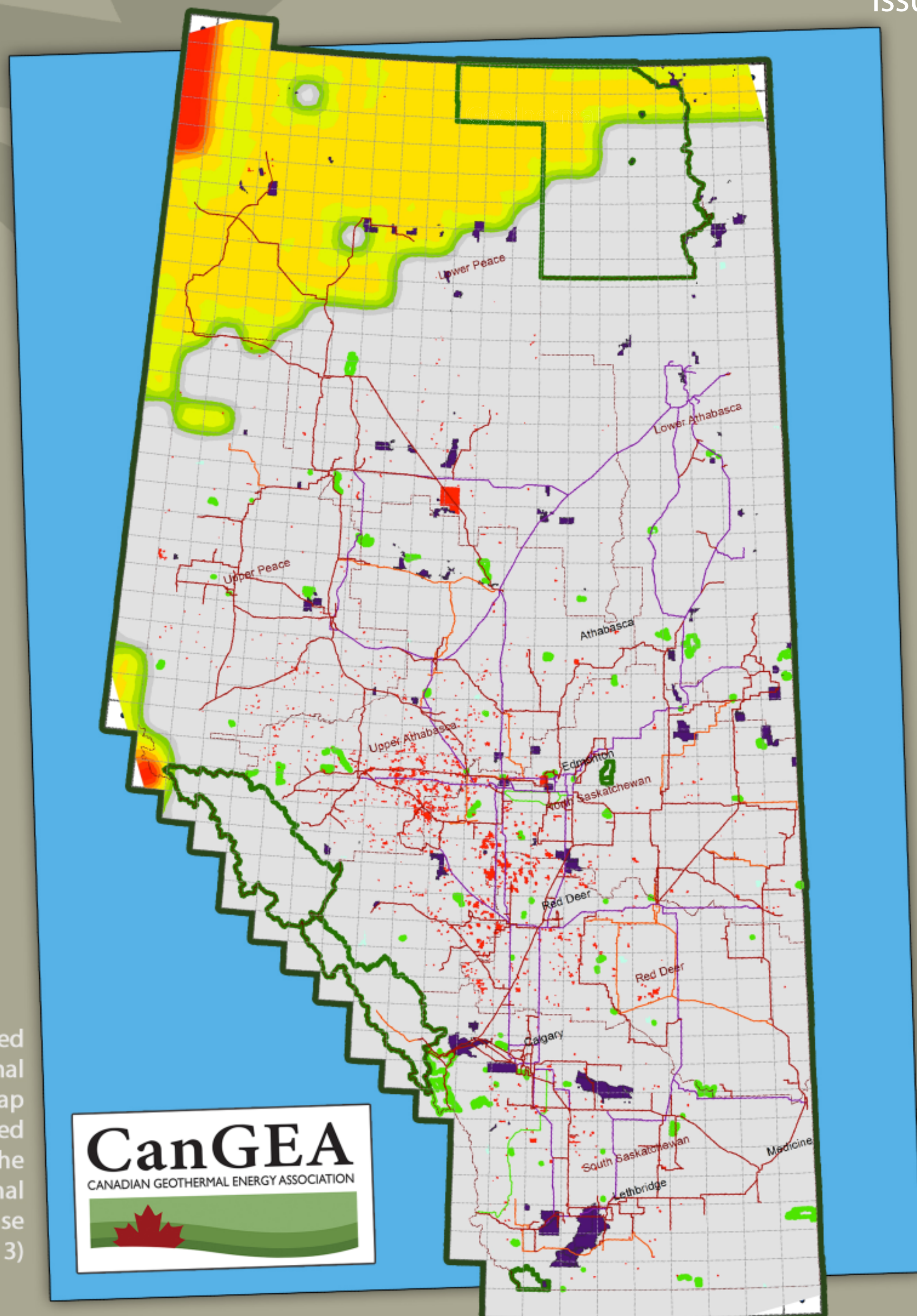
CanGRC Review

Issue 4 • Spring 2013



The newly released Alberta Geothermal Favourability Index Map - One of the maps released from the first phase of the Canadian National Geothermal Database Project (CanGEA, 2013)

In this issue:

- Basic Exploration Methodology That Can Improve the State of Geothermal Development in B.C. (Ron Yehia) *pg. 2*
- CanGRC at the 2013 CanGEA "Digging Deeper" Geothermal Conference, Calgary, Alberta (Yuliana Proenza) *pg. 3*
- The AB Geothermal Favourability Map: 1st Phase of the Canadian National Geothermal Database (Ashley Derry) *pg. 5*
- The Technology, Politics and Policy of Enhanced Geothermal Electricity in Canada (Jesse Good) *pg. 8*
- The Pacific Center for Geothermal Education and Research (PCGER) First Student Essay Competition (Lena Patsa) *pg. 9*
- Three Ideas for a Canadian Geothermal Energy Roadmap (Nathaniel James Lindsey) *pg. 10*
- New Canadian Thermal Springs Online Map (Ron Yehia) *pg. 12*
- CanGRC Suggested Reading - Articles Relevant to this Issue and New Publications by Canadian Researchers *pg. 13*

FREE

Canadian Geothermal Research Council Mission Statement

Written by Ryan Libbey, Yuliana Proenza and Lena Patsa
CanGRC Co-Founders

Geothermal technologies are clean and reliable energy sources that take advantage of the thermal properties of the Earth's subsurface for direct use heating and cooling applications and electricity generation. Canada has already begun to utilize these technologies for heating and cooling purposes; however, it remains one of the only countries on the Pacific Rim to not produce electricity from geothermal resources. Studies released by the Geological Survey of Canada show these untapped subterranean resources to be vast, and new reservoir technologies may make geothermal electricity generation feasible nation-wide. Needless to say, geothermal research in Canada is a pertinent and stimulating field of study.

The Canadian Geothermal Research Council (CanGRC) is a voluntarily-run organization dedicated to serving Canada's geothermal research community. It does not exist as a government lobby group, nor is it intended to represent a unified voice of the research community. Rather, CanGRC exists to raise awareness about geothermal research in Canada, to showcase Canadian geothermal research and to elevate communication within the research community.

CanGRC is an initiative by 3 graduate students from across the country - Ryan Libbey (McGill University), Yuliana Proenza (University of British Columbia) and Lena Patsa (University of British Columbia). CanGRC operations are guided by an esteemed Board of Directors, which includes geothermal scientists from academic, government and industry positions. Currently serving on this Board is Dr. Alan Jessop (Geological Survey of Canada), Dr. Grant Ferguson (University of Saskatchewan), Dr. Catherine Hickson (Alterra Power Corp.), Mr. Craig Dunn (Borealis Geopower) and Dr. Steve Grasby (Geological Survey of Canada / Natural Resources Canada / University of Calgary). Dr. Jasmin Raymond (L'École de Technologie Supérieure/HydroGeoPro) serves as our GeoExchange Representative.

Membership to CanGRC is completely free and includes a subscription to this semi-annual newsletter. We encourage everyone interested in geothermal research to join. If you haven't already done so, simply head to our website at www.cangrc.ca/members.html and fill out the form.

We greatly appreciate your interest and feedback, and hope that you enjoy this issue of the *CanGRC Review*.

Best wishes,
The CanGRC Team

Chief Editor. Ryan Libbey
Content Managers. Yuliana Proenza, Lena Patsa and Ryan Libbey
Graphic Design. Ryan Libbey

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To contribute an article to the CanGRC Review, please email your submission to info@cangrc.ca. Submissions should be in .doc format. Please send all related images as separate high-quality attachments.

All are welcome and encouraged to submit. It is the intention of this publication to showcase members from a range of sectors and disciplines. Student submissions are welcome.

CanGRCReview

Opinion: Basic Exploration Methodology That Can Improve the State of Geothermal Development in British Columbia

Written by Mr. Ron Yehia (geothermal@telus.net),
Geothermal Exploration and Data Consultant

Once again the status of geothermal development in Canada is challenging. A decline in investment in renewable energy and an abundant natural gas supply have made it difficult to pursue geothermal exploration and development financing. This article presents a methodology to improve geothermal development in Western Canada, by performing grassroots exploration to assess large and small areas at low cost. This assessment can be done using non-profit, research or educational organizations, preferably those with a dedicated focus. The data collected from this research will help to lay a new foundation for achieving geothermal energy production.

Background

As a province that has been extensively explored for mining and oil and gas, an abundance of geodata is available for review. Unfortunately much of the data is unsuitable for geothermal analysis. In published soil and water data, some of the indicators needed for this analysis are missing or incomplete, detection limits are too low, or coverage is spotty. This is significant for geothermal exploration, as regional surveys have to be redone, which is generally time and cost intensive. Partly because of these issues, and coupled with the short exploration season and high exploration operational costs for some areas, most geothermal exploration has utilized available geodata collection and sampling of hot springs. Typically, geothermometry results have been reviewed and found to be lacking to pursue high priority projects, so geothermal development either slowed down or ceased. In some instances, geothermal permit applications were submitted to secure land in order to justify continuation of exploration by way of exclusive rights.

Additional challenges of geothermal exploration in Western Canada include hard to access areas and thickness of canopy. Large areas survey techniques such as remote sensing using satellite or airborne can be very expensive and might not succeed well in the BC terrain; further, these surveys usually require a ground reconnaissance. For example, in the author's experience, the 9m resolution for ASTER imagery does not provide good results due to the thick canopy in most exploration areas, and existing ASTER coverage provides inadequate coverage. Even HyperSpectral and or other high resolution techniques such as LiDAR or FLIR may not work as well. On a few occasions, FLIR has identified large hot springs but the imagery may not be suited for smaller, lower temperature thermal anomalies.

Proposed Methodology

To address the lack of appropriate data for geothermal analysis and the difficulties of the BC terrain, an exploration methodology can be used that requires minimal budget and time commitment: performing real-time surveys using multiple data points from a single data collection location. This idea combines established and new exploration experiences, and uses new real-time data collection and analysis - to be quality controlled by traditional means – to create larger data sets for analysis and correlation for each location. The methodology also takes advantage of something that Western Canada has in abundance: water.

Figure 1. Photometer (lower right) and other instrumentation used in the propsed methodology. Photo by Ron Yehia.

Depending on the area, a single survey team can cover one to two dozen sample points per day on foot, while collecting numerous types of different data sets. Sampling can include soil, soil gas, CO2 Flux, Biological, temperature and liquid. The real-time data can be collected on site by devices such as a hand held XRF, soil gas and CO2 Flux analysers, 2m temperature probe (for limited areas), and a portable photometer for liquid. Instrumentation that requires additional time for data collection can be set up, while the rest of the data can be sampled during the analyser device data collection time. A small pilot survey should be conducted in advance to assess the feasibility and suitability of each technique to the study area, and to establish indicators detection limits by using lab analysis and for data comparison. During the full survey, a percentage of the samples are sent to labs for quality control and subsequent analysis.

Using a portable photometer for water analysis, real-time surveys can cover large areas looking for geothermal indicators (such as Chloride, Sulphate, Boron Fluoride and Silica) in

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streams, creeks and springs. The real-time aspect of the survey means getting results the same day or the next, instead of waiting for lab analysis results, enabling the survey team to compile and map the data on a daily basis and make follow-up decisions while in the field. Using off-roads will enable the survey team to cover large areas by vehicle and follow-up on foot when favourable results are found, in order to ascertain the origin of the thermal waters. Finding additional thermal seeps or springs will improve the resolution of a thermal anomaly, allowing a better estimation of its potential while at the same time providing additional thermal data for analysis.

The initial cost for the instrumentation for this methodology is in the range of a $4000-$5000 CDN, and each photometer data point analysis costs a fraction (at least one tenth) of a traditional lab analysis. As well, this technique could avoid considerable time spent executing walking surveys in difficult access areas; instead, using flowing water as a transport mechanism for geothermal indicators to pinpoint areas for further focus and analysis. This methodology could have implications for the mineral exploration industry as well, but further study is needed. A paper on this technique as applied to geothermal development has been submitted for the GRC 2013 conference.

Once the surveys above are performed and analyzed, the results may locate a suitable spot for gradient drilling. Thus, an estimate of the heat potential of the thermal anomaly can be achieved within a reasonable cost.

The methodology also allows for exploration companies to better determine borders for geothermal permit applications within a single exploration season or campaign, instead of applying for a large permits and paying rental and exploration fees on ultimately unproductive areas.

Question of Sponsors

The question of who should perform geothermal exploration research is still the subject of debate. The author is of the view that geothermal research would be best performed by a dedicated institute that is focused specifically on geothermal research, with the data provided for all to use.

This approach has been demonstrated successfully south of the border with the Great Basin Center for Geothermal Energy (Nevada) and the Southern Methodist Geothermal Laboratory (Utah). Dedicated organizations exist in Canada that could take on this challenge, but funding has been lacking. Funding challenges can be overcome by applying the proposed methodology and having that dedicated institute further refine the procedures for BC and/or Western Canada.

As well, due to the simple nature of these grassroots exploration surveys, local governments and First Nations could support or undertake the surveys to understand the geothermal potential in their area, including for district heating. Results would then be analyzed by qualified personnel and linked to local economic development efforts for clean energy.

Finally, as many examples around the world have shown, government support has been fundamental to geothermal development. Even in challenging fiscal times, the results from these low cost basic surveys will far outweigh their expenditure.

Conclusion

The persistence of some dedicated individuals and the commitment of First Nations to renewable energy provides some measure of hope for proponents of clean energy and the future of clean energy in Canada. Even with the current decline in investment interest in renewables, progress can still be achieved in geothermal exploration now. Performing the type of regional surveys mentioned above will advance needed geothermal development, and provide a solid foundation of data on which to make progress into the future.

CanGRC at the CanGEA 2013 Geothermal Conference 'Digging Deeper', Calgary Alberta

Written by Yuliana Proenza
CanGRC Co-Founder

CanGRC

The 2013 CanGEA geothermal conference was a chance for industry, government, researchers and students to learn and educate each other about geothermal data systems, resource mapping initiatives and project development news in the Canadian high temperature geothermal power sector.

All of the CanGRC Co-Founders had the pleasure of attending the event alongside several members from our Board of Directors. It was a fantastic opportunity to connect with industry friends and some CanGRC members. Below is a summary of the event. Many thanks to CanGEA for inviting us to such a worthwhile and well-executed conference.

Please welcome our newest Director, Dr. Alan Jessop

Dr. Alan Jessop attended this year's event and we formally invited him to come on board as a Director for the CanGRC. He leads geothermal energy research in Canada having worked with the Geological Survey of Canada (GSC) for over 30 years and led Canada's only geothermal energy program with the GSC

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(Geological Survey of Canada) from 1974 to 1986 . He was the first to publish research on geothermal energy with over 90 documents in the field of heat flow and geothermal energy. Although retired, Dr. Jessop continues to contribute to the geothermal energy industry in Canada.

Tour of Calgary's Hotel St. Germain ground source heat pump (GSHP) system

The highlight of the icebreaker event was a tour through the Hotel St. Germain's GSHP system used for heating and cooling. The system design includes dozens of vertical wells up to 600 feet deep drilled under the foundation of the building (a closed vertical loop design). This type of design is advantageous for multi-story buildings with small footprints but large energy requirements. The building manager was very open to discussion and follow up questions and it was great to see everyone interested in the direct application of low temperature geothermal systems. More projects like this may be the bridge that is required for development of power generation from high temperature geothermal energy.

Figure 1. Members of the CanGRC Team. From left to right: Yuliana Proenza, Ryan Libbey, Lena Patsa, Craig Dunn, Dr. Alan Jessop, and Dr. Jasmin Raymond.

Mapping & Database Workshop reflected on government and academic contributions for global geothermal databases and the difficulties encountered: a model for Canada

The workshop event was well attended with members from industry, government and academia. The daylong event was an excellent opportunity to get international perspectives (Europe, Australia and the US), and the advantages and challenges of creating national and global geothermal databases.

Dr. Ladislaus Rybach, a global expert in geothermics and Emeritus Professor at ETH, Zurich, spoke on the importance of a systematic implementation of an agreed template for global geothermal database systems. University researchers Dr. Graeme Beardsmore and Maria Richards provided Australian and American viewpoints of assembling national geothermal data systems to stimulate industry exploration and development. These speakers led a discussion panel about the issues surrounding the accumulation of different data sources from various contributors, data storage and long term data hosting, data ownership, data sharing and distribution. The importance of a global geothermal reporting code was emphasized and the reader is referred to a recent publication "Global Review of Geothermal Reporting Terminology[2].

The US National Geothermal Data System (NGDS) was a focus for discussion by Arlene Anderson (US Department of Energy physical scientist), Dr. Steve Richard and Dr. Lee Allison (Arizona Geological Survey). The NGDS is a national network of data contributors (academia, private sectors, state and federal agencies), with the goal of aiding geothermal exploration and development companies to minimize financial risk. The Arizona Geological Survey and the Association of American State Geologists lead the development of the NGDS by coordinating the digitization and public accessibility of geothermal relevant data contributed by universities and national agencies. In May 2013, Scientific American[3] published an article on the geothermal data system[4].

Dr. Daniel Yang gave a talk about the Alberta Geothermal Favorability Map, a fantastic CanGEA initiative that is discussed in a separate article in this issue of the CanGRC Review.

One of the questions this event aimed to answer is: "Is it possible to create a truly global database for geothermal?" With other similar international attempts to develop global geological and geophysical databases (e.g. OneGeology[5] and the World Digital Magnetic Anomaly Map[6]), we hope to see a global geothermal resource compilation available in the future. This arduous task will have to take place on a country-by-country basis, and thanks to CanGEA, Canada has already begun this effort.

Canadian Geothermal Industry Highlights

Deep Earth Energy Production (DEEP) Corporation's Kirsten Marcia gave an update on their project in the Williston Basin in Saskatchewan. A hot sedimentary basin resource that will be produced from a depth of ~3 km. Recently featured at Bloomberg[7], Global BC[8] and the CBC[9], Deep Earth is on its way to becoming Canada's first geothermal power producer, with construction slated to begin in 2014.

Borealis GeoPower receives $2.4M from Sustainable Development Technology Canada (SDTC) for development of an optimized geothermal exploration methodology[10]. Borealis

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defines this methodology as a "carefully ordered set of processes and technologies that builds up an increasingly accurate picture of a geothermal resource, allowing the drilling of production wells precisely where they have the highest probability of hitting commercially-viable amounts of hot water".

Alterra Power's Oscar Cerritos gave a presentation on the status of their current projects. Recent news regarding Alterra's Chilean Mariposa geothermal project and Peruvian projects announced a joint venture with Energy Development Corporation (EDC)[11]. The agreement allows EDC to earn 70% interest by funding the projects for a total of $64.3 million.

1 Craig Dunn and Dr. Jessop to present at the Vancouver Island Forum on Geopower", October 15, 2012. http://www.borealisgeopower.com/news/details/craig-dunn-dr.-jessop-to-present-at-the-vancouver-island-forum-on-geopower-/ Accessed May, 2013

2 Beardsmore, G. 2013. "Global Review of Geothermal Reporting Terminology", 53 p. http://iea-gia.org/wp-content/uploads/2013/05/IEAGIA-ReportingFrameworkReport-Feb13-Beardsmore-6Feb13.pdf

3 Ferguson, W. 2013. "Heated to the Core". Scientific American 308, 21. http://www.nature.com/scientificamerican/journal/v308/n5/full/scientificamerican0513-21.html Accessed May, 2013

4 "NDGDS featured in May 2013 Scientific American article". http://www.stategeothermaldata.org/content/ngds_featured_may_2013_scientific_american_article Accessed May, 2013

5 Making Geological Map Data for the Earth Accessible. http://www.onegeology.org/ Accessed May, 2013

6 World Digital Magnetic Anomaly Map. http://models.geomag.us/wdmam.html Accessed May, 2013

7 Deep Earth plans Canada's first geothermal power amid oil wells. http://www.bloomberg.com/news/2013-05-24/deep-earth-plans-canada-s-first-geothermal-power-amid-oil-wells.html Accessed May, 2013

8 Company studies Saskatchewan geothermal potential. http://globalnews.ca/news/536992/company-studies-saskatchewans-geothermal-potential/ Accessed May, 2013

9 Saskatchewan's 1st geothermal energy plant coming? http://www.cbc.ca/news/canada/saskatchewan/story/2013/05/28/sk-geothermal-energy-plant-1305.html Accessed May, 2013

10 Borealis Geopower receives $2.4 million from SDTC for geothermal exploration. http://www.borealisgeopower.com/news/details/borealis-geopower-receives-2.4m-from-sdtc-for-geothermal-exploration/ Accessed May, 2013

11 Alterra Power and EDC complete joint venture agreement for geothermal assets in Chile and Peru. http://www.alterrapower.ca/news/Press-Release/News-Releases/News-Releases-Details/2013/Alterra-Power-and-EDC-Complete-Joint-Venture-Agreement-for-Geothermal-Assets-in-Chile-and-Peru/default.aspx Accessed May, 2013

The Alberta Geothermal Favourability Map: First Phase of the Canadian National Geothermal Database

Written by Ashley Derry
Chief Geophysicist & Operations Manager, CanGEA

The Canadian Geothermal Energy Association (CanGEA) recently completed the first phase of the Canadian National Geothermal Database (CNGD), the Alberta Geothermal Favourability Map project. This project is a compilation of 52 maps that demonstrate the temperature at depth, temperature gradient, technical and theoretical potential, conductivity, heat generation, heat flow and favourability index values across the province of Alberta. The data has been made available to download for personal, academic and business venture use in order to assess and identify geothermal resource potential. The data is intended to serve as a geothermal exploration tool for making informed business decisions and mitigating investment risks.

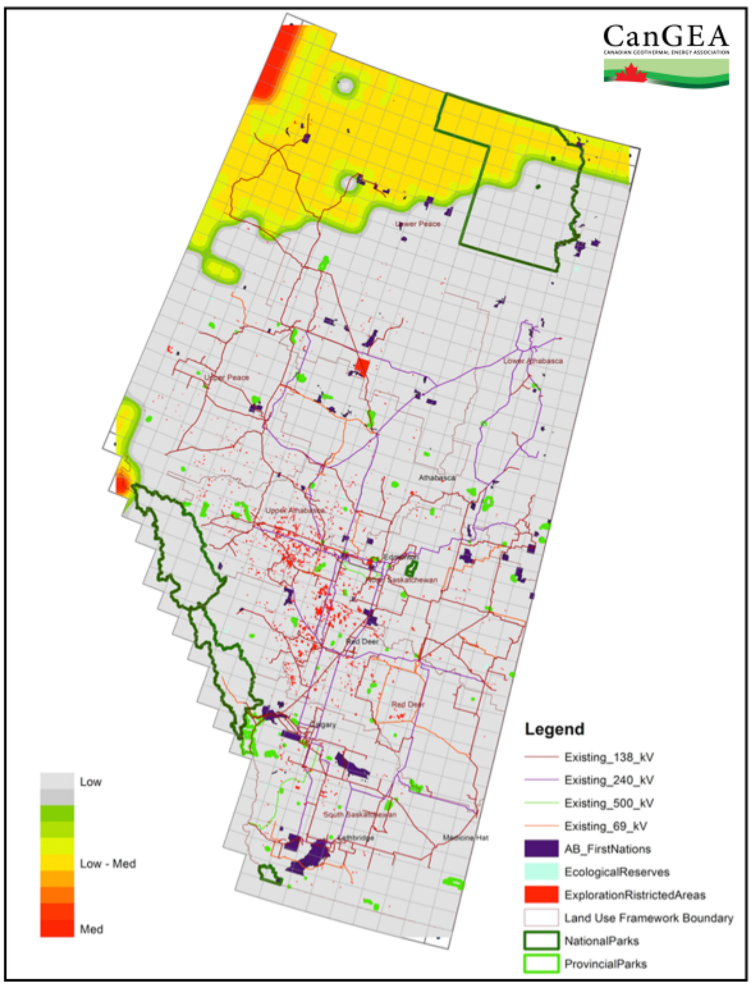

Figure 1. CanGEA's Alberta Geothermal Favourability Index Map.

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Details concerning the project, a summary of the data, the methodology and data sources as well as the database and all of the produced maps can be viewed and downloaded from the CNGD page of the CanGEA website:
http://www.cangea.ca/cngd-data/.

The maps have been released in a Google Earth format; the Google Earth program is free and is required to view these versions of the maps. Due to size limitations, the maps have been broken into 5 different map packages: Temperature at Depth maps, Technical Potential maps, Theoretical Potential maps, Favourability map and Supplemental maps. For those unable to download and/or run Google Earth, the maps have also been released in a PDF format as one complete document containing all generated maps. *The database has been released in both .xls and .csv versions.*

This project was supported by the following organizations: Suncor Energy, National Research Council- Industrial Research Assistance Program (NRC-IRAP), Energy Resources Conservation Board- Alberta Geological Survey (ERCB-AGS), Alberta Innovates Energy and Environmental Solutions, Borealis GeoPower and the Pembina Institute.

Summary of Results

The Alberta Favourability Map project has included an estimate of Theoretical and Technical Potential as detailed by the methodology in the Global Protocol for Estimating and Mapping Geothermal Potential. Theoretical and Technical potential being defined as follows:

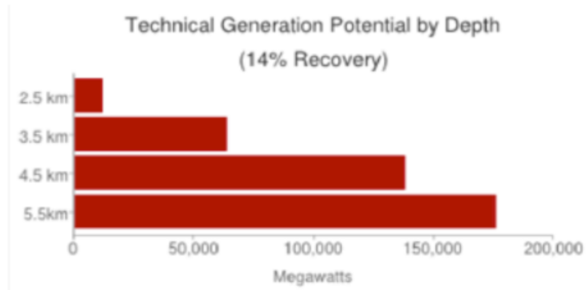
- **Theoretical potential**: an estimate of "the physically usable energy supply over a certain time span in a given region. It is defined solely by the physical limits of use and thus marks the upper limit of the theoretically realizable energy supply contribution" (Rybach, 2010).

- **Technical potential**: "the fraction of the theoretical potential that can be used under the existing technical restrictions… structural and ecologic restrictions as well as legal and regulatory allowances" (Rybach, 2010).

Following the Canadian Geothermal Code for Public Reporting, the Reporting Code maps represent the level of confidence that has been assigned to the data found within each grid block. This was done by analyzing the data points according to the Reporting Code and subsequently classifying each block as an Inferred or an Indicated Resource, suggesting a lower or higher level of confidence, respectively.

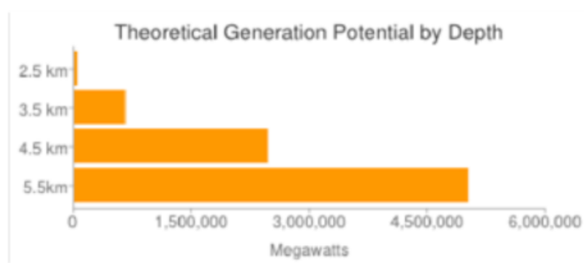
A Geothermal Resource is a geothermal play that exists in a form, quality and quantity where there are reasonable prospects of eventual economic extraction. The location, quantity, temperature, geological characteristics and extent of the Geothermal Resource are known, estimated or interpreted from specific geological knowledge and evidence. Geothermal Resources are subdivided in order of increasing confidence into:

- Inferred Resources
- Indicated Resources
- Measured Resources



Technical Potential for Geothermal in Alberta *where values represent Potential (Indicated + Inferred Resources)		
Recovery	**Depth**	**Generation Potential**
5%	2,500m:	4,200 MW
	3,500m:	22,800 MW
	4,500m:	49,400 MW
	5,500m:	62,600 MW
	Total	139,000 MW
14%	2,500m:	11,800 MW
	3,500m:	63,700 MW
	4,500m:	138,000 MW
	5,500m:	175,000 MW
	Total	388,500 MW
20%	2,500m:	16,800 MW
	3,500m:	91,000 MW
	4,500m:	198,000 MW
	5,500m:	250,000 MW
	Total	555,800 MW
	Installed Generation Capacity (all sources):	**0 MW**

*According to the Canadian Geothermal Reporting Code



Theoretical Potential for Geothermal in Alberta *where values represent Potential (Indicated + Inferred Resources)	
Depth	**Generation Potential**
2,500m:	41,000 MW
3,500m:	655,000 MW
4,500m:	2,470,000 MW
5,500m:	5,010,000 MW
Total	8,176,000 MW
Installed Generation Capacity (all sources):	**0 MW**

*According to the Canadian Geothermal Reporting Code

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Potential for *Indicated Geothermal Resources in Alberta

Recovery	Depth	Generation Potential
5%	2,500m:	2,000 MW
	3,500m:	8,800 MW
	4,500m:	12,800 MW
	5,500m:	6,400 MW
	Total	30,000 MW
14%	2,500m:	5,700 MW
	3,500m:	24,600 MW
	4,500m:	36,000 MW
	5,500m:	18,000 MW
	Total	84,300 MW
20%	2,500m:	8,200 MW
	3,500m:	35,200 MW
	4,500m:	51,400 MW
	5,500m:	25,700 MW
	Total	120,500 MW
Installed Generation Capacity (all sources):		**0 MW**

*According to the Canadian Geothermal Reporting Code

The Inferred category is intended to cover situations where a Geothermal Play has been identified and limited measurements and sampling completed, but where the data are insufficient to allow the extent of the Geothermal Resource to be confidently interpreted. It is based mainly on indirect measurements, such as the extrapolation of temperature profiles (to a reasonable degree and on a rational basis) and other associated measurements such as rock properties and heat flow, and requires a reasonably sound understanding of the subsurface geology in three dimensions derived, for example, from geophysical surveys, to indicate temperature and dimensions.

An 'Indicated Geothermal Resource' is that part of a geothermal resource that has been demonstrated to exist through direct measurements that indicate temperature and dimensions so that recoverable thermal energy (MWth-years) can be estimated with a reasonable level of confidence. Thermal energy in place has been estimated through direct measurements and assessments of volumes of hot rock and fluid with sufficient indicators to characterize the temperature and chemistry. Direct measurements are sufficiently spaced so as to indicate the extent of the thermal energy in place.

The next phase of the CNGD is the British Columbia Favourability Map project, which is currently underway and is set to be completed this fall.

For more information, please contact CanGEA at info@cangea.ca.

Work such as this is key to moving the geothermal energy industry forward in Canada and shows just how great of a resource that we have here. Our members are a vital part of keeping this work going, so if you're interested in being involved in supporting work like this then join CanGEA as a member today! http://www.cangea.ca/join/

CanGEA
CANADIAN GEOTHERMAL ENERGY ASSOCIATION

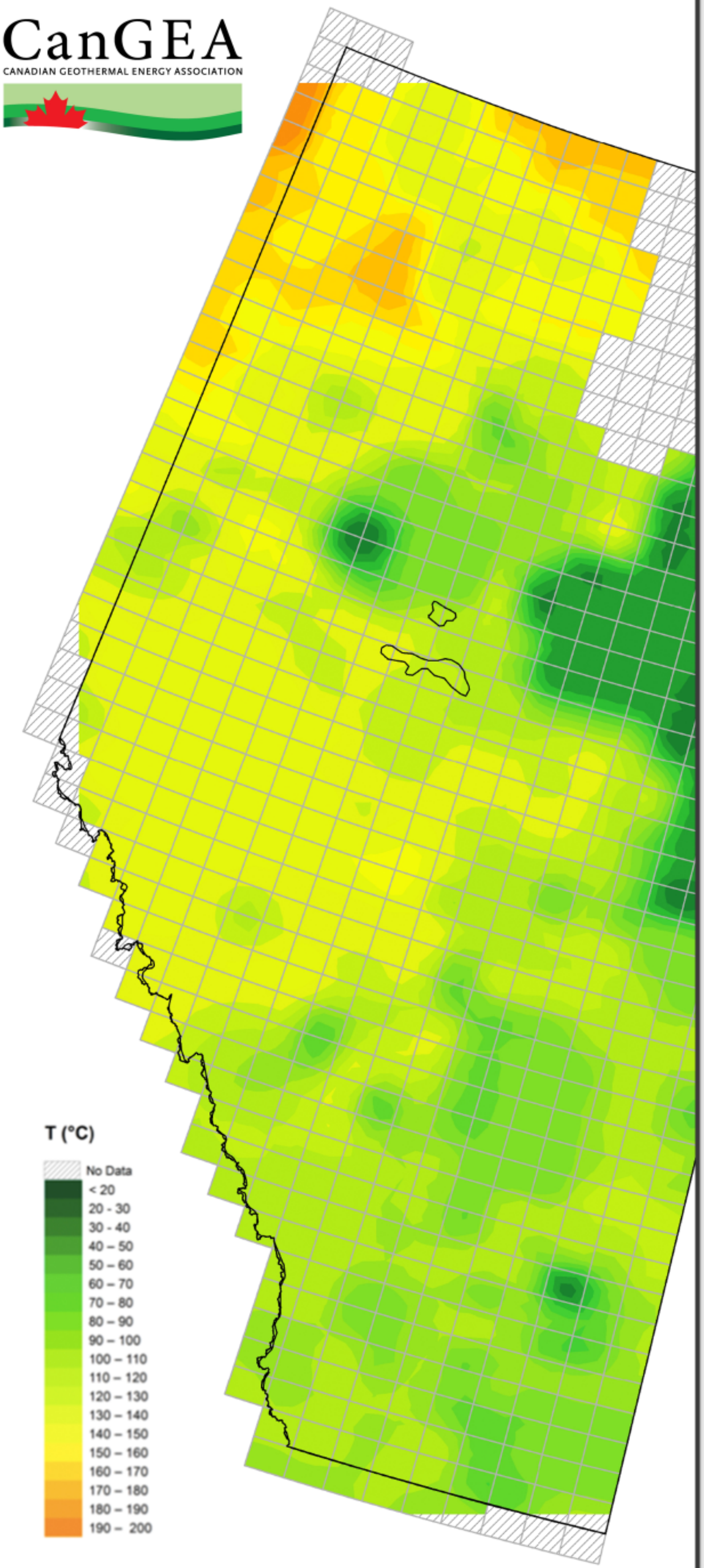

Figure 2. Map showing the predicted temperature at a depth of 5500 m, part of CanGEA's Alberta Favourability Map.

The Technology, Politics and Policy of Enhanced Geothermal Electricity in Canada: Applying an Energy Systems Approach

Written by Jesse Good,
Graduate, Carleton University: M.A. Sustainable Energy Policy

This paper, originally published in Carleton University's ISEMA Perspectives on Innovation, Science, and Environment journal (http://goo.gl/Tljbb), set out to explore the technology and science of enhanced geothermal systems in Canada, their current and potential use in the domestic energy system, and how social actors have engaged in political argumentation to frame the technology and its potential in the Canadian discourse. The full article is available as a free download.

EGS is described as an infant, niche technology that is currently in the research and development stage. Based on its ability to provide base load electricity with minimal environmental impacts, EGS would likely displace fossil-fuel fired electricity and aid the ongoing electrification of society. Governments around the world are getting engaged in supporting and promoting EGS, but not in Canada. While non-governmental actors, in particular the geosciences and engineering research communities and the geothermal industry, have been trying to convince politicians, bureaucrats, investors and the public that geothermal electricity is a legitimate and viable energy technology, Canadian government actors have been slow to respond.

Figure 1. Parliament Hill, Ottawa.

Due to the infant nature of EGS technology, the support of governments would improve the chances that EGS will fulfill its potential as an alternative energy source in Canada's energy system. There are many policy instruments that federal and provincial governments can employ to support basic research, mitigate private and public risk, stimulate investment, and provide legislative and regulatory certainty to EGS stakeholders with the goal of spurring development for domestic energy production. This has been done with other strategically important energy technologies, such as carbon capture and sequestration, which has benefitted from active government support. This paper demonstrates that federal and provincial governments have been largely absent from the EGS policy discourse. This has left industry and academia actors struggling to develop and sustain interest in EGS research and development in the absence of supportive government attention and involvement.

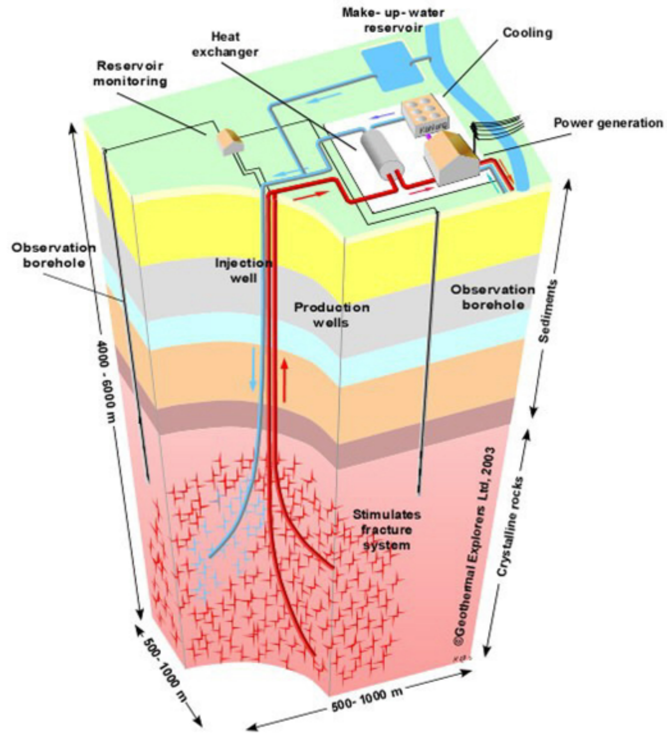

Figure 2. Conceptual model of an electricity-grade enhanced geothermal system. Image source: hotrockenergy.com.

What this analysis highlights is that the development of new technologies is not value neutral, but rather inherently political. Although EGS may seem like an ideal technology for producing electricity for many reasons, gaining and maintaining support in the polis for a vision of what the technology could become (and more importantly, what government should do about it) is critical to its advancement. For this reason, actors with a stake in EGS use rhetorical argumentation to influence how EGS is perceived, particularly in comparison to alternative technologies and even other geothermal technologies. Awareness of the potential of EGS seems to be increasing in Canada, and actor networks appear to be strengthening, but if the issue of EGS does not capture the attention of federal and provincial governments then it has little chance of advancing. In order for EGS development to progress, governments must clarify policy and regulatory frameworks related to EGS; fund basic research into EGS science and technology that the private sector alone cannot support; provide high quality information and data about geothermal resources; mitigate public and private risk associated with EGS development; and provide political support by considering how EGS can be applied for national and provincial benefit.

The First PCGER Student Essay Competition on Geothermal Energy, University of British Columbia

the pacific center for geothermal education & research

Written by Lena Patsa,
PCGER Technical Lead, CanGRC Co-Founder

The 1st Student Essay Competition on Geothermal Energy held at the University of British Columbia (UBC) came to a successful close this past fall. Full-time and part-time students registered in a university undergraduate or graduate program, as well as postdoctoral fellows from all over the world were invited to submit an essay to the UBC Pacific Centre for Geothermal Education and Research (PCGER), addressing the following topic: "What should Canada do within the next 2 years to foster the development of geothermal energy systems, including power production and direct use?" Students were encouraged to explore a variety of perspectives for their answers, including technical, economic, social, political and public policy considerations. The aim of the competition was to engage college and university students from around the world to help identify the immediate steps which need to be taken in order to promote the development of geothermal energy in Canada.

At the first stage of the competition, participants were asked to submit a short vision letter addressing the problem statement. Qualifying letter entries were also entered into a random draw and one lucky UBC student won a a 16GB Apple iPad tablet. The highest scoring proposals were subsequently chosen to compete for a total of $5,000 in cash prizes. Nine participants were invited to expand on the ideas presented in their vision letter and provide an answer to the problem statement in essay format. Submissions were evaluated for their content, clarity, originality and applicability by a three-panel judging committee comprising of executive members of the PCGER and CanGRC. Two of the submitted essays satisfied all four criteria and were deemed of merit to win full awards. Two honorary awards were granted for essays worthy of consideration. Two additional awards were granted in appreciation for the students' participation. The results from the judging committee were as follows:

Full Award Recipients
1st Prize Winner (CAN $2,500): Nathaniel Lindsey, University of Edinburgh
2nd Prize Winners (CAN $1,500): Michael Phang, University of British Columbia

Honorary Prize Winners ($150 Gift Certificate)
Juan Garcia, University of British Columbia
Sarah Thomson, University of British Columbia

Participation Prize ($50 Gift Certificate) Recipients
Maurizio Vaccaro, University of Pisa
Nasim Arianpoo, University of British Columbia

Further details on the competition can be found on the PCGER website at http://geothermal.mining.ubc.ca/activities/competition2012.

CanGRC Review

Three Ideas for a Canadian Geothermal Energy Roadmap

Written by Nathaniel James Lindsey,
University of Edinburgh

The following is the 1st-place submission from the 2013 PCGER Essay Competition on Geothermal Energy, University of British Columbia.

Introduction

The 2011 Geological Survey of Canada (GSC) report[1] is a catalyst for geothermal development. It advertises a $25B market opportunity, tens of thousands of new jobs, broad resource availability and sustainable carbon offsets. However, there are two primary criticisms of this optimistic forecast: Canada's available resources are not conclusively understood; and the cost of the incumbent energy (i.e., coal) is very low. The result is a geothermal market labeled as high risk. The race to geothermal market parity (both for heating and electricity) will be won through direct application of cutting-edge research to geothermal problems, and legislating progressive energy policies. The critical question before the Canadian geothermal industry is how to stimulate initiative on these two fronts.

This essay argues for the inclusion of three bold ideas in a short-term (2-year) Canadian geothermal roadmap:
1. Capitalize on Geothermal Energy Targets with Feed-In Tariffs
2. Pool Resources
3. Educate the Next Generation of Geothermal Leaders

To understand how these ideas could work in Canada over the next few years, consider how they have worked in Kenya since 2004. Today, Kenya generates 202 MW of the 217 MW of geothermal electricity produced on the African continent. In spite of a lack of access to health care, education, potable water and a stable economy, Kenya became a shining example of geothermal development shortly after it adopted a forward-thinking attitude. It is this attitude that led to creative opportunities for companies and individuals in the early stages of Kenya's geothermal industry.

Canada cannot afford to take a chance on untested concepts. Therefore, each of the ideas forwarded here has contributed to the acceleration of geothermal energy markets, either in Kenya or another country. However, 'one-size does not fit all, therefore each of these ideas was selected because it matched the unique strengths of Canada, as well as the hurdles that lie ahead. The overarching aim is to initiate an academic and industry-wide focus on the technical and policy challenges facing the Canadian geothermal industry, while making it easier for projects to obtain the capital needed to locate, drill, and begin extracting geothermal energy.

Capitalize on Geothermal Energy Targets with Feed-In Tariffs

Kenya set their sights on firm, top-down goals; by 2030 they want to produce 5000 MWe from geothermal electricity. Although this political statement appears to be similar to the rhetoric of the 2011 GSC report, the Kenyan government used their energy targets to make it easier for companies to develop geothermal energy (e.g., by establishing the Geothermal Development Company, and enacting economic feed-in tariffs). Loudly supporting government-level targets can also raise public awareness[3]: Kenyans now know that among the available energy options, geothermal is a key player; Canadians should too.

Some might argue that the economic problems facing Canadian geothermal energy cannot be overcome, that coal will always be too cheap, regardless of the mindset of the government. Historic evidence from certainly supports this viewpoint. Yet that is exactly why Canada must enact creative and progressive economic policies that seek to level the playing field with hydrocarbons. Economic feed-in tariffs (FITs), like those implemented for geothermal energy in the renewable energy markets of Germany[4] and Kenya, are one means to that end. FITs are long-term graduated subsidies that aim to efficiently ease the economic emergence of a technology, by fixing the price of the electricity that is produced. The cost of coal has been heavily subsidized since its beginning; geothermal markets should be given a fair shot to compete while they are in their infancy.The two most important aspects of a FIT are the price point for the sale of electricity and the duration of the policy[5]. Based on geothermal FIT policy planning in Europe and the US, a Canadian geothermal FIT should set the cost per kWh equal to the cost of electricity generated using coal-fired power plants. The lifetime of the FIT should be at least 15 years, with a gradual increase to the natural price of geothermal electricity over the following 10 years.

Pool Resources

Most East African countries have geothermal energy resources, and many have set bold targets, yet Kenya's geothermal industry is by far the most advanced. Why is this? Perhaps the answer lies in the Geothermal Development Company (GDC). The GDC is the pioneering force behind Kenya's geothermal industry, providing an instrument pool[6] for geothermal exploration (geophysical, geochemical and well- based equipment), drilling rigs to exploit new resources, the trained workforce to carry out these projects, and expert consultants to inform the entire process. Instrument pools like that of the GDC are common practice among university collaborators in the worldwide geoscience community, where the cost of equipment is a significant barrier to research. Another successful

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example of an instrument pool is the IRIS PASSCAL Instrument Center at New Mexico Tech[7], which supports many National Science Foundation research projects.

Consider the advantages of a Canadian Geothermal Technology Pool. The expense of a drill rig -- a multi-million dollar piece of equipment -- could be shared between several companies. This not only distributes risk, easing the upfront costs of exploration and drilling, it also results in collaboration across industry. If a potential geothermal field needs to be better understood, the equipment can easily be shipped to the site. The Geothermal Technology Pool could be managed by an industry sponsor, or the IGI partner universities (see below).

Educate the Next Generation

A third lesson that Canada should learn from the Kenyan roadmap is how to refuse to reinvent the geothermal wheel. Instead of wasting time on problems that had already been solved, Kenya fostered international partnerships with geothermal experts who had decades of experience, both in academia and industry. In 2011 Kenya sent their 62nd student to Iceland's Geothermal Training Programme (GTP)[8], part of the United Nations University (UNU). Many of these students worked on Kenyan geothermal problems for their thesis projects. After graduating from the GTP, Kenyan students were sent as delegates to international geothermal conferences (e.g., Geothermal Resources Council's Annual Meeting, USA). Conferences of this scale are an excellent learning environment, and offer the opportunity to network with foreign geothermal industries. In 2009, Kenya co-sponsored the first East African Geothermal Conference in Ethiopia[9], in an effort to promote geothermal development along the entire 4000-km length of the East African Rift.

Building on this example of pragmatic education, Canada should immediately begin the Interdisciplinary Geothermal Initiative (IGI), a training program for Canadian graduate students at universities across the country. The IGI would be ideologically located at the intersection of geoscience, geochemistry, mechanical engineering, energy/public policy, and economics. It would award PhD fellowships for applied and frontier research, travel grants for international conferences and short courses, and grants to students who found innovative ways of exploring for, extracting, or incentivizing geothermal energy. One example of where this type of interdisciplinary PhD fellowship has succeeded is the US National Science Foundation's Integrated Graduate Education and Research Training (IGERT) program, specifically the Earth-Energy Systems IGERT at Cornell University that focuses on geothermal energy[10]. Four recommendations to enhance the IGI, which are not part of the Earth-Energy Systems IGERT model, include:

1) Sponsorship of online journal publication reading groups hosted on the IGI website, where IGI fellows can read and discuss papers with one another (e.g., recent publications in Geothermics and G3: Geochemistry, Geophysics, Geosystems). This could be organized within disciplines, or across them.

2) Sponsorship of a rotating IGI Fellow Intern position in Parliament, to work on energy legislation.

3) Hosting an annual conference to share IGI-affiliated research, and connect with geothermal energy companies.

4) Sponsorship of an International IGI Fellow to study any geothermal-related discipline for a period of 6 months at a leading university in another country. Strong choices would include University of Adelaide (AUS), University of Wellington (NZ), Reykjavik University (Iceland), Cornell University (USA), Stanford University (USA), University of Reno (USA).

Figure 1. Victoria University of Wellington, New Zealand.

It is important to note that IGI member schools maintain their unique strengths. Quite often an energy curriculum focuses on breadth rather than depth; however, there is greater value in specialist knowledge, especially in the geothermal industry. This philosophy is central to the IGI. PhD students can focus on geochemical tracer modeling at a particular high enthalpy Canadian geothermal field, or undertake rigorous economic analysis of geothermal FITs in British Columbia, or investigate the questions of induced seismicity as they relate to public perception and regulation. IGI fellows would be located at Canadian institutions that have elevated themselves to the forefront of an array of fields, meaning that IGI graduates will be experts in their disciplines. For example, an IGI Fellow with a physics background could study at the University of Alberta, where she might work on a 3-D magnetotelluric geothermal exploration project with Dr. Martyn Unsworth11. However, this geophysicist would also foster a broader understanding of how

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CanGRCReview

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her skills fit into the wider purview of the geothermal industry, through coursework and an annual IGI conference. Thus, the caliber of a Canadian doctoral degree is not sacrificed, while graduates become more conversant and engaged with multiple aspects of the industry.

Finally, Canada must strive to connect students with the industry, if this investment in training is to flow into geothermal development. That is why IGI grants will be made to students and industries that participate in internships over the summer months. Students have valuable ideas and knowledge. The employment of these skills at an early age in a professional's life not only benefits the company in the short term, it is also an investment in the future of the industry. Moreover, the best way to learn is through an applied research project that forces students to close the textbook and work in the real world.

Conclusion

To jumpstart a successful geothermal program, Canada should study Kenya's roadmap from the past decade. Canada should immediately begin to take three assertive steps: establish a national geothermal target and back it up with economic incentives (e.g. feed-in tariffs); create an instrument pool that mitigates the cost of initial exploration and drilling phases; empower its world-class academic institutions to work toward geothermal energy solutions as members of the Interdisciplinary Geothermal Initiative, while educating conversant geothermal experts.

1 CanGEA Press Release, 2011
http://www.cangea.ca/images/uploads/CanGEA_Release_GSC_GeothermalEnergyResourcePotential.pdf

2 GDC Business Plan,
http://www.gdc.co.ke/index.php?option=com_content&view=article&id=161&Itemid=155

3 Blodgett, L., 2012. "Budding Geothermal Markets Light Up East Africa",
http://thinkprogress.org/climate/2012/09/09/512010/budding-geothermal-markets-light-up-east-africa/?mobile=nc

4 Mitchell, C., Bauknecht, D. & Connor, P.M., 2006. Effectiveness through risk reduction: a comparison of the renewable obligation in England and Wales and the feed-in system in Germany. Energy Policy, 34 (3), 297-305.

5 Rickerson, W., Gifford, J., Grace, R., Cory, K, 2012. Geothermal FIT Design: International Experience and U.S. Considerations. National Renewable Energy Laboratory, Technical Report, NREL/TP-6A20-53320.

6 GDC Instrument Pool,
http://www.gdc.co.ke/index.php?option=com_content&view=article&id=141&Itemid=152

7 IRIS PASSCAL Instrument Center, ttp://www.passcal.nmt.edu/
8 United Nation's University – Geothermal Technology Program,
http://unugtp.is/page/organization_history

9 African Rift Geothermal Conference,
http://www.bgr.de/geotherm/ArGeoC1/welcome.html

10 Cornell University Earth-Energy Systems IGERT,
http://earthenergyigert.cornell.edu/index.php 11Unsworth, M., University of Alberta, updated 2010. http://www.ualberta.ca/~unsworth/

Canadian Thermal Springs Online Map

Written by Ron Yehia,
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Over the past few years in geothermal exploration the author has collected much public data about geothermal resources in Canada. Using Esri's free online mapping tools, he has developed a list of thermal springs in Canada to share this data with the rest of the geothermal community. Additional individual springs data will be added, and other geothermal data as time permits. The site can be found at http://bit.ly/12slfxR or go to http://www.arcgis.com/home/ and search for Canada geothermal. All feedback, corrections and additions are welcome to geothermal@telus.net.

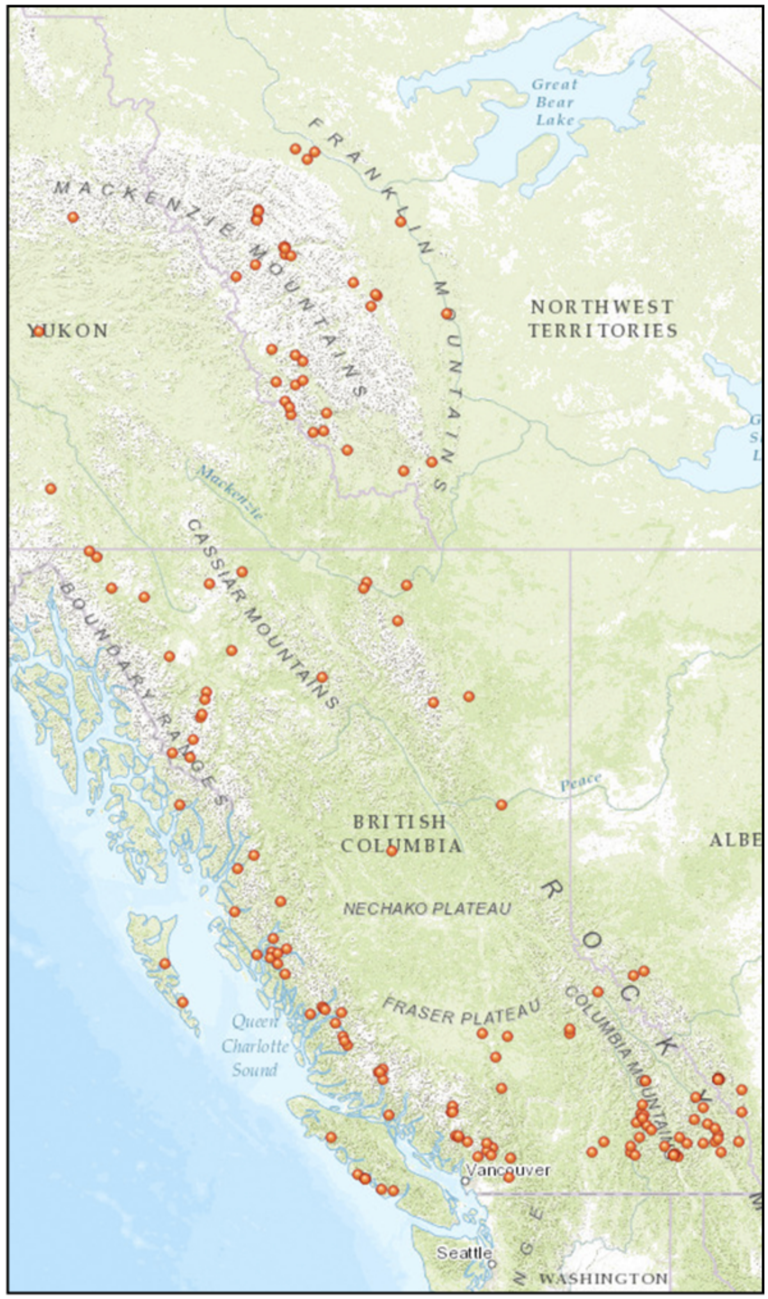

Figure 1. The Canadian Thermal Springs Online Map developed by Ron Yehia.

CanGRC Suggested Reading

Compiled by Ryan Libbey (CanGRC Co-Founder)

This section provides a list of articles related to the subject material in this issue of the CanGRC Review, as well as other recent geothermal-related publications by Canadian researchers.

Recent Publications by Canadian Researchers

Libbey, R.B., Longstaffe, F.J., and Flemming (2013) Clay mineralogy, oxygen isotope geochemistry, and water/rock ratio estimates, Te Mihi area, Wairakei Geothermal Field, New Zealand. Clays and Clay Minerals, 61(3), 204-217.

Dioctahedral clays from an active continental geothermal system have been studied to assess their usefulness as proxies of paleo-hydrological and thermal conditions in the subsurface. Drill cuttings from Well WK244 in the Te Mihi area of the Wairakei Geothermal Field, New Zealand, were analyzed to determine the mineralogical, morphological, and isotopic characteristics of hydrothermal clays in these samples. Mixed-layer illite-dioctahedral smectite (I-S) and R0 chlorite-trioctahedral smectite are the main clay minerals, with I-S clays varying downward from R1 to R3 ordering and 50 to >90% illite over 160 m. The proportion of illite in I-S correlates positively with downhole temperature (r=0.98) and I-S morphology changes from high aspect ratio ribbons, laths, and hairy fibers to pseudo-hexagonal plates with depth. Swelling clay percentages determined using the methylene blue method show a strong positive correlation with %S in I-S (r=0.91), validating use of methylene blue as a rapid field tool for characterizing the smectite to illite transition in this active geothermal environment. The oxygen isotopic composition of I-S (δ18OI-S) decreases systematically with depth, and mostly reflects a progressive increase in subsurface temperature during clay formation. Estimates of water/rock ratios calculated using δ 18OI-S values display stratigraphic variability that corresponds to variations in permeability. Oxygen isotopic measurements of I-S are a useful tool for understanding reservoir and permeability evolution in such geothermal systems and their related fossil analogs.

Majorowicz, J. and Grasby, S.E. (2013) Geothermal Energy for Northern Canada: Is it Economical?. Natural Resources Research,, DOI: 10.1007/s11053-013-9199-3.

We examined the potential of geothermal energy development in northern Canadian communities to support local energy demand, along with providing an initial assessment of the economic viability of geothermal energy resources for (a) low enthalpy heating systems and (b) electrical power generation from high temperature resources. We estimate yearly energy production and cost per kWh for geothermal systems using scenarios for thermal and electrical production sustained over 15 years from temperatures reached in the 2–6-km depth range. All the calculations are based on a borehole fluid productivity of 30 kg/s. We assume this to be feasible in sedimentary aquifers and through fractured granites. Under such an assumption and assumptions made on the efficiency of heat exchangers, our modeling shows that thermal energy output for 120C from 3- to 5-km wells can be as low as 5–8 cents/kWh thermal. For a 6 km depth, the cost of thermal energy can be as low as 1–2 cents/kW thermal for thermal energy production of 100–200 MWh annually.

Raymond, J. (2012) Assessing the geothermal potential of the St. Lawrence Lowlands sedimentary basin in Quebec, Canada. IAH 2012 Congress, Niagara Falls, 8 p.

Geothermal power generation from subsurface fluids at moderate temperature can now be considered due to technological developments. Hydraulic fracturing enhances the permeability of a reservoir, which leads to greater groundwater production, and increases heat extraction. Hybrid binary power plants, where the fluid that drives the turbine is heated by warm groundwater and other energy sources, such as bio- or natural gas, can increase the efficiency of power cycles to produce electricity. Sedimentary basins with groundwater at temperatures from 80 to 120 °C are thus becoming targets for geothermal power generation. One such target is the Cambro-Ordovician sedimentary basin of the St. Lawrence Lowlands (SLL) in Quebec, where the geothermal potential is assessed by defining the depth distribution of permeable rock units within this temperature range. A 3D geological model of the SLL basin was built by combining the regional surface geological map, the structural map of the basement top defined by seismic wave travel times and the elevation of 441 geological contacts identified with geophysical well logs from 164 oil and gas exploration wells. Depths of geological units were extracted from the 3D model and mapped in 2D horizontal planes, over which 41 bottom-hole temperature measurements that were uncorrected have been superimposed.

The most permeable rock units with greater geothermal potential are the Cambrian sandstones of the Cairnside and Covey Hill Formations of the Postdam Group that are unconformably lying on the Precambrian basement at the base of the SLL sedimentary sequence. A series of steeply dipping southeastern normal faults, located at the border and within the basin, affect the basement and its sedimentary cover. The Cairnside and Covey Hill Formations are located at depths of less than 1 km to more than 5 km, with an increasing depth toward the southeast. Temperatures between 70 and 100 °C have been measured at depths of 3 to 4 km in these units. The in situ formation temperature can, however, be higher since

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CanGRC Review

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Raymond, J. and Lamarche, L. (2013) Simulation of thermal response tests in a layered subsurface. Applied Energy, in press, 9 p.

A conventional thermal response test (TRT) provides a bulk estimate of the subsurface and borehole thermal properties over the length of the ground heat exchanger (GHE). The measurement of temperature inside the borehole during a TRT can be carried out to further determine thermal properties at different depths. The analysis of the transient temperature response is commonly performed with an analytical solution assuming a constant heat injection rate, which does not reproduce the effect of water flow along the pipe of the GHE. This heat transport mechanism can induce a temporal variation of the heat injection rate at depth although heat injection remains constant at the surface. Analysis of synthetic data generated with numerical simulations of TRTs in a layered subsurface was consequently carried out to verify this analytical approach. The program MLU was selected for analyzing the TRTs because of its capacity to take into account multiple layers. Results indicated that the analysis can be improved by accounting for variable heat injection rates determined inside the GHE. Estimation of both the subsurface thermal conductivity and the borehole thermal resistance was within 20% of the expected values, except when the thermal conductivity of the subsurface is low. For a simulation case carried out with a subsurface layer that had a thermal conductivity as low as 1 W m-1K 1, the borehole thermal resistance could not be determined with significant accuracy.

Publications Relevant to Articles Found in This Issue of the CanGRC Review

CanGEA (2013) Canadian Geothermal Projects Overview 2013 .http://www.cangea.ca/wpcontent/uploads/2013/01/CanGEA_CanadianGeothermalProjects2013_final.pdf.

There are a number of geothermal projects in Canada for both power generation and direct use. Canada has plentiful geothermal resources, yet it has seen not nearly enough development. There are, however, several projects under way by Canadian developers. The following gives an overview of the different projects for power generation and the direct use of heat.

Grasby, S.E., Allen, D.M., Bell, S., Chen, Z., Ferguson, G., Jessop, A., Kelman, M Majorowicz, J., Moore, M., Raymond, J., Therrien, R. (2011) Geothermal Energy Resource Potential of Canada. Geological Survey of Canada, Open File 6914, 322 .

Canada has enormous geothermal energy resources that could supply a renewable and clean source of power. There are many constraints, however, in utilizing this energy resource, including geological, technical, and regulatory issues. The intent of this report is to examine the geothermal potential in Canada, and the geological controls on the distribution of high grade resources as well as controls on the economic development and production of geothermal energy. This assessment is based on a new compilation and digitization of data produced through over 48 years of geothermal research in Canada. Recommendations on current and future research needs to reduce barriers to resource production are made at the end of the report. Currently Canada has no geothermal electrical

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production; however, direct use and heat exchange systems are used widely. Several projects are currently being examined by industry and government to develop electrical potential in Canada. A key economic constraint for these projects is the high risk of exploration due to costs of deep drilling. The cost of delivered geothermal power is projected to decline and be competitive with coal fired production within the next 15 years, given current levels of technology. Canada's in-place geothermal power exceeds one million times Canada's current electrical consumption. However, only a fraction of this total potential could be developed. Much of the resource lies beyond current drilling technology, outside of areas served by high-capacity transmission lines, and at some distance from load centres. Nonetheless, the available high grade geothermal resource is considerable. High temperature hydrothermal systems can be brought on line with proven technology. Many of the tools required to bring geothermal energy to full realization, however, are not commercially proven to date and require further research and technology development. We can expect a strong learning curve and price response as geothermal energy is developed while other energy sources such as coal and nuclear will begin to see fleet and capacity retirements.

Majorowicz, J., Gosnold, W., Gray, A., Safanda, J., Klenner, R. and Unsworth, M. (2012) Implications of post-glacial warming for northern Alberta heat flow—correcting for the underestimate of the geothermal potential. GRC Transactions, 36, 693-698.

The research into a geothermal energy option for Northern Alberta basin is currently underway. Correct estimates of heat flow and geothermal gradient for the sedimentary strata (direct heat energy option) and deeper crystalline basement are needed. A series of detailed geophysical logs and boreholes studies have recently been collected in the Hunt well AOC GRANITE 7-32-89-10. The well was drilled 2.36 km into basement granitic rocks just west of Fort McMurray. A temperature log acquired as part of the University of Alberta Helmholtz-Alberta Initiative (HAI) geothermal energy project in 2010-2011shows that there is a significant increase in thermal gradient in the granites. Inversion of the measured T-z profile between 550 m – 2320 m indicates a temperature increase of 9.6+/- 0.3 ^{o}C, at 13.0 +/- 0.6 ka and that the glacial base surface temperature was -4.4+/- 0.3 ^{o}C. This inversion computation accounted for granite heat production of 3 W/m3. We find from the Hunt well study that heat flow in the basin has been underestimated for wells shallower than 2 km due to the paleoclimatic effect. A significant increase in surface temperatures since the end of the last ice age in northern North America causes a perturbation of shallow <2 km heat flows. For this reason, estimates of gradient based on single or numerous data from different depths are not necessary characteristic of the whole sedimentary column and can lead to spurious predictions of temperature at depth needed for geothermal energy or hydrocarbon models.

Majorowicz, J.A., Jones, F.W., Lam, H.L., and Jessop, A.M. (1985) Terrestrial heat flow and geothermal gradients in relation to hydrodynamics in the Alberta Basin, Canada. Journal of Geodynamics, 4, 265-283.

Geothermal gradients in the Alberta part of the Western Canadian sedimentary basin have been studied on the basis of 55,244 bottom-hole temperature values from 28,260 petroleum exploration wells. Gradient estimates for different depth and stratigraphic intervals together with a study of the heat conductivity distribution indicate both regional heat flow variations and variations with depth. The regional hydrodynamics of the basin strongly influences both grad T and heat flow. It is found that the geothermal gradient and heat flow increase with depth in water recharge areas to the west and decrease with depth in discharge areas to the north and east. The results indicate that heat flow in the central part of the basin should be approximately equal to the deep crustal heat flow.

Weides, S., Moeck, I., Huenges, E. (2011) Exploration of geothermal resources in the central Alberta basin (Canada). GRC Transactions, 35, 1061-1063.

The utilization of deep geothermal energy holds the potential to conserve conventional energy resources and decrease the emission of carbon dioxide. The aim of this study is to explore geothermal resources of the central Alberta Basin and to evaluate the feasibility of developing geothermal heat production from deep hydrothermal systems in this region.The study focuses on an area in the central part of the Alberta Basin around the city of Edmonton. In this research area of approx. 150 km * 200 km size the basin is between 1.8 km and 3.5 km deep. Potential reservoir rocks for a geothermal development are found in the deep aquifers of the Basal Cambrian Sandstone and overlying Devonian carbonate layers. A 3D geological model of the research area was developed based on stratigraphic picks from more than 7000 wells that were drilled by the petroleum industry. Consistency of the stratigraphic framework was established through revision of the data by the Alberta Geological Survey (AGS). Through population of the model with poro / perm data from core analyses and well logs it will be possible to delineate areas in the deep aquifers that have a higher porosity and permeability and are favourable for a geothermal utilization.

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