Quarterly No. 70

October - December 2007

IGA NEWS

Newsletter of the International Geothermal Association

IGA ACTIVITIES

Message from the President

Ladislaus "Ladsi" Rybach

Dear IGA member

This is the first Message of your new President. First of all, I would like to thank all those of you who elected me to the IGA Board of Directors (BoD) and especially those who voted for me to become IGA President. I will do my best to live up to your expectations.

Our main challenge today, as IGA, is to strive for wider recognition, by politicians, decision makers as well as by the general public, of the great potential, the environmental advantages, and economic benefits of geothermal energy. Another task to be tackled by all IGA members is to prepare for participation in the World Geothermal Congress 2010 (WGC2010) in Bali, Indonesia. This key event – where hopefully most IGA members will meet – will take place 25-29 April 2010 at the International Conference Center in Nusa Dua. Bali is already known as a superb tourist destination but "our" Conference Center has become famous world-wide, thanks to the UN Climate Summit (December 2007). IGA is fortunate that our Indonesian colleagues selected this venue for WGC2010. The preparatory work of the IGA Steering Committee, along with the Indonesian Organizing Committee, is already in full swing; many useful details and further information can be found on the WGC2010 website www.wgc2010.org where a Questionnaire for prospective participants can be downloaded.

Let me extend a special welcome to the new and "old" (incumbent) BoD members. The new Board already had its first meeting in Reykjavik, Iceland on October 11, 2007 with most members present. The Board also has lots of work ahead, especially as regards the obligations of IGA towards the World Bank GeoFund. This task we inherited from the old Board; we must now see how the deliverables can be produced to the satisfaction of the

IGA ACTIVITIES

Bank as well as of IGA. Here, especially the Finance and Education Committees will be involved, assisted by the IGA Treasurer and by the expert IGA-World Bank fund administrator, our Executive Director. The Table below shows the composition of all newly formed IGA Committees, along with their Chairs (in bold); some more members still need to be added in order to comply with the Bylaws.

I also look forward to working closely with the IGA Officers Ruggero Bertani (Vice President), Gestur Gislason (Secretary), Colin Harvey (Treasurer) and, especially, with Executive Director Arni Ragnarsson, who already provided his highly valuable expertise and support to the previous Board. IGA is grateful that the well-established operation of its Secretariat at Samorka, Reykjavik has been recently extended until 31 December 2010.

Let me end on a personal note: some of the readers might know that I am also a music conductor, so I know how to lead. But whenever I am standing and acting in front of an orchestra, I always realize that the players are producing the sound, not me. So I will need all your input and cooperation. I can only coordinate, look for the right tempo, establish balance etc., in other words lead IGA at the right speed and in the right direction. Together we can, I'm convinced, perform well to further develop geothermal energy for the benefit of mankind, fully complying with the theme of WGC2010 "Geothermal: the Energy to Change the World".

Audit	Bylaws	Education	Finance
Ogena	**Boissavy**	**Rüter**	**Brophy**
Ginting	Antics	Bahati	Antics
Mertoglu	Garnish	Beardsmore	Bloomquist
Yamada	Harvey	Hirtz	Boissavy
	Lawless	Horne	Harvey
		Kepinska	Kreuter
		Montalvo Lopez	
		Mwangi	
		Popovska	
		Povarov	
		Steingrimson	
		Vuataz	
		Yamada	

Information	Membership	Nominating	Programme & Planning
Steingrimsson	**Horne**	**Beardsmore**	**Antics**
Beardsmore	Bahati	Harvey	Boissavy
Garnish	Barragan	Povarov	Hirtz
Ginting	Bertani	Ragnarsson	Kepinska
Gislason	Brophy	Rüter	Ogena
Horne	Kreuter	Simsek	Suryadarma
Hirtz	Lopez	Yasukawa	Uchida
Iglesias	Montalvo Lopez		
Kepinska	Mwangi		
Lawless	Povarov		
Malolepszy	Suryadarma		
Montalvo Lopez	Yamada		
Mwangi	Zheng		
Uchida			
Vuataz			
Yasukawa			

EUROPE

Switzerland

BDFGeotherm: the Database of Geothermal Fluids in Switzerland

Romain Sonney & François-D. Vuataz, Centre for Geothermal Research – CREGE, University of Neuchâtel, Switzerland (www.crege.ch), e-mail: romain.sonney@crege.ch

Objectives

The principal motivation to create a database of geothermal fluids was to put at the disposal of the geothermal community a comprehensive set of data on the deep fluids of Switzerland and of some neighbouring areas, which are generally widely dispersed and often difficult to reach. Many data exist on geothermal fluids in Switzerland. These data come from deep boreholes realized for geological evaluations, geothermal prospects, oil exploration wells and spas, as well as thermal springs and fluids outflow from tunnel drainage systems. All these data are contained in many reports and papers, often not published and not very accessible to potential users of this information.

The objective of this project was to gather the maximum amount of data on deep fluids and to integrate them in a relational database. This database can be useful to all geothermal projects planning to prospect, to produce or to inject fluids at depth. It may concern any permeable geological formation as well as projects based on the technology of enhanced geothermal systems (EGS). This tool will also be used to estimate and forecast the chemical composition of the geothermal fluids. The interest is obvious for studies related to the risks of mineral deposits or corrosion in boreholes and in surface installations, and also for studies on interactions between rocks and thermal waters. Users will be able to complete or to introduce new information into the BDFGeotherm database with their own documentation and on-going projects. Search, addition, export and exploitation of data are explained in the user's manual provided with BDFGeotherm. This handbook describes all the steps to follow for an optimum use of this database.

In Switzerland, the estimate of geothermal direct use for 2006 reached about 650 MWt installed capacity and 5,500 TJ/yr heat production, mostly installations coupled to geothermal heat pumps (GHP). This corresponds to a fossil fuel saving of 130,000 toe. Geothermal energy in Switzerland thus reduces the emission of CO_2 by about 400,000 tons per year. So far there is no electricity generation from geothermal resources in Switzerland. Finally, deep aquifers and hot springs resources are also used in small district heating networks and for the heating of several spas.

Structure of the database

The BDFGeotherm database has been built under Microsoft ACCESS code and consists of 203 thermal springs or deep boreholes from 82 geothermal sites implemented into nine tables connected with a primary key: the field "Code". A selection of parameters has been chosen from the following fields: general and geographical description, geology, hydrogeology, hydraulics, hydrochemistry, isotopes as well as geothermal parameters (Table 1). Geographically, all Switzerland was covered although the distribution of data is quite heterogeneous. Among the 68 Swiss sites, a large majority of them are located in the northern part of the Jura range and in the Upper Rhone valley (Fig. 1). Some sites, in Germany (5), France (3) and Italy (6), were selected for the following reasons: located near Swiss hot springs or deep boreholes, having similar geological features or representing a significant geothermal potential.

Geologically, each formation containing groundwater was considered, from the crystalline basement to Tertiary sediments. Moreover, all springs with a temperature higher than 15 °C, or slightly below if the production yields are important, were included into this database.

Potential geothermal resources

The 203 water catchments recorded into BDFGeotherm have temperatures ranging from 10 °C in the folded Jura limestones to 112 °C in the deep crystalline basement below the Molasse Basin. Measured temperatures in thermal springs, boreholes and thermal springs in tunnels are illustrated on the simplified tectonic map of Switzerland and show that warmer fluids (> 60 °C) are met in deeper boreholes (> 1 km) except for one site in the External Alps where water at 68 °C inflows at a depth of 200-400 meters due to a deep subvertical fracture system in gneissic rocks (Fig. 1). This same process also gives rise to numerous thermal springs within the Alps. Regarding thermal springs in tunnels, their measured temperatures do not exceed 40°C. However, these tunnels drain significant quantities of water (> 10 l/s), which enables them to be potential geothermal resources. In the Tertiary sandstones of the Molasse Basin, measured water temperatures do not exceed 30 °C, but potential deep aquifers still remain unexplored beneath these formations

(Muschelkalk, Dogger and Malm limestones) and the level of respective production rates is mostly unknown. In the Tabular Jura, north of Switzerland, warm groundwaters (> 40 °C) are collected at relatively low depth due to the presence of high heat flow conditions (> 150 mW/m^2).

Low temperature geothermal resources (< 120°C) in Switzerland are potentially important and all the sectors are more or less concerned. The main recognized resource areas are located in the northern part of Switzerland and the Rhine and Rhone valleys. Some deep aquifers (fractured or porous reservoirs) are used in small district heating networks and in spas. Some areas, like the southern part of the folded Jura and the high Alpine reliefs, seem less favourable at first sight. The Alpine valleys drain large amounts of water infiltrated from the mountainsides and can contain warm waters at depth, but the identification of potential deep upflow remains difficult because fluvio-glacial deposits hide the bedrock in many places.

Reference

Sonney R. and Vuataz F.-D., 2007. BDFGeotherm: the Database of Geothermal Fluids in Switzerland. Proc. European Geothermal Congress 2007, Unterhaching, Germany, 30 May - 1 June 2007.

Table 1: Structure of BDFGeotherm database

Table name	*List of fields*
1. Description	Code, site name, country, canton, coordinates X and Y, altitude, type and name of groundwater point, year of realisation, depth, primary and secondary use of fluid.
2. Geology	Code, surface formation, age of surface formation, reservoir formation, age of reservoir formation, regional and local tectonics, lithological log.
3. Hydraulics	Code, flow rate, surface and maximum measured temperature, permeability, production type, static and dynamic water levels.
4. Hydrochemistry	Code, name and sampling date, simplified and detailed geochemistry type, temperature, conductivity, pH, Ca, Mg, Na, K, Li, Sr, HCO_3, SO_4, Cl, F, SiO_2, TDS (Total Dissolved Solids), ionic balance, TDS variability, comments.
5. Isotope	Code, name and sampling date, ^{18}O, ^{2}H, ^{3}H, ^{14}C, residence time, altitude of infiltration, comments.
6. Geothermal parameters	Code, surface and maximum measured temperature, minimum and maximum reservoir temperature, reservoir depth, geothermal gradient and geothermal potential.
7.1. Author	Number of author, author.
7.2. Table-links	Code, number of author and reference.
7.3. Bibliography	Number of reference, reference (70 references used).

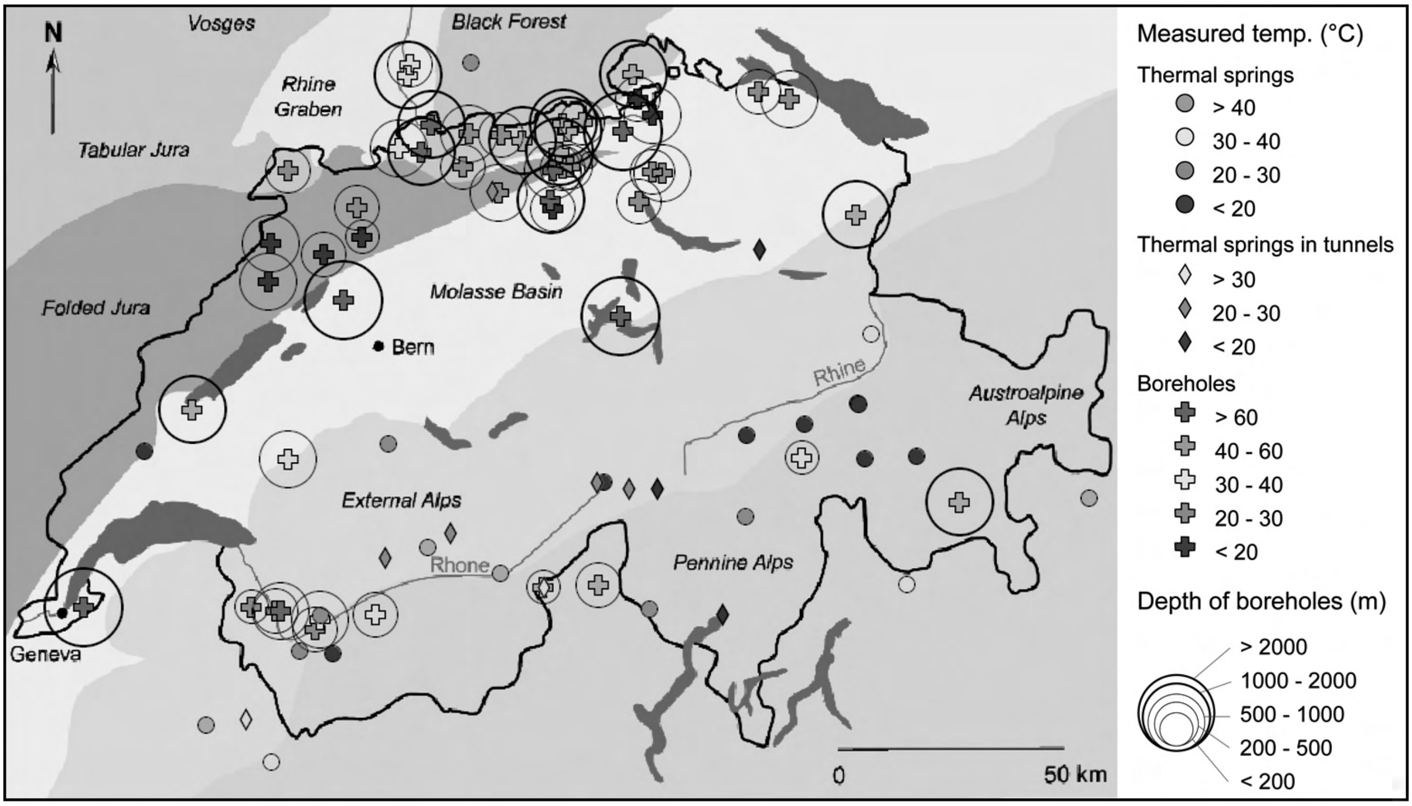


Fig. 1. Location and temperature of the thermal water catchments on data implemented into BDFGeotherm

Iceland

REYST – A new energy graduate school in Iceland

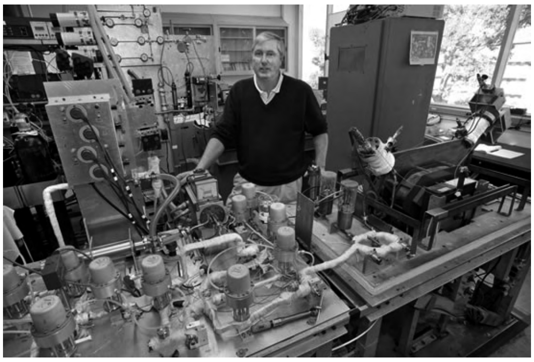
Reykjavik Energy Graduate School of Sustainable Systems (REYST) was officially launched December 3rd 2007 at Reykjavik Energy headquarters in Reykjavik, Iceland. REYST is an interdisciplinary school, founded by Reykjavik Energy in collaboration with Reykjavik University and the University of Iceland. The objective is to promote education and research in sustainable energy use, emphasizing practicality, innovation and interdisciplinary thinking. REYST offers higher education for engineers and scientists in order to create leading experts in management, design and research in the field of sustainable energy. The international graduate program is based on the three pillars of engineering, earth science and business. MSc programme will start in August this year and deadline for application is March 15th. Further information is available at http://en.reyst.is.

AMERICA

USA

Helium Isotopes Point to New Sources of Geothermal Energy

Paul Preuss, Berkeley, Ca.



Berkeley Lab geochemist B. Mack Kennedy used this mass spectrometer (foreground) to determine helium isotope ratios in samples of surface fluids from the northern Basin and Range. (Photo Roy Kaltschmidt)

In a survey of the northern Basin and Range province of the western United States, geochemists Mack Kennedy of the Department of Energy's Lawrence Berkeley National Laboratory and Matthijs van Soest of Arizona State University have discovered a new tool for identifying potential geothermal energy resources.

Currently, most developed geothermal energy comes from regions of volcanic activity, such as The Geysers in Northern California. The potential resources identified by Kennedy and van Soest arise not from volcanism but from the flow of surface fluids through deep fractures that penetrate the earth's lower crust, in regions far from current or recent volcanic activity. The researchers report their findings in the November 30, 2007 issue of Science.

"A good geothermal energy source has three basic requirements: a high thermal gradient — which means accessible hot rock — plus a rechargeable reservoir fluid, usually water, and finally, deep permeable pathways for the fluid to circulate through the hot rock," says Kennedy, a staff scientist in Berkeley Lab's Earth Sciences Division. "We believe we have found a way to map and quantify zones of permeability deep in the lower crust that result not from volcanic activity but from tectonic activity, the movement of pieces of the Earth's crust."

Kennedy and van Soest made their discovery by comparing the ratios of helium isotopes in samples gathered from wells, surface springs, and vents across the northern Basin and Range. Helium-three, whose nucleus has just one neutron, is made only in stars, and Earth's mantle retains a high proportion of primordial helium-three (compared to the minuscule amount found in air) left over from the formation of the solar system. Earth's crust, on the other hand, is rich in radioactive elements like uranium and thorium that decay by emitting alpha particles, which are helium-four nuclei. Thus a high ratio of helium-three to helium-four in a fluid sample indicates that much of the fluid came from the mantle.

High helium ratios are common in active volcanic regions, where mantle fluids intrude through the ductile boundary of the lower crust. But when Kennedy and van Soest found high ratios in places far from volcanism, they knew that mantle fluids must be penetrating the ductile boundary by other means.

The geology of the region was the clue. The Basin and Range is characterized by mountain ranges that mostly run north and south, separated by broad, relatively flat-floored valleys (basins), which are blocks of crust that have sunk and become filled with sediment eroded from the uplifted mountains. The alternating topography is the result of crustal spreading by east to west extension, which has occurred over the past approximately 30 million years. The Earth's crust in the Basin and Range is some of the thinnest in the world, resulting in unusually high thermal gradients.

The faces of mountain blocks in the Basin and Range clearly exhibit the normal faults that result as the blocks are pulled apart by the extension of the crust. Normal faults form high-angle pathways deep down into the brittle upper crust. But as the fault plane approaches the ductile lower crust, changes in the density and viscosity of the rock refract the principle stress acting on the fault, deflecting the fault plane, which becomes more horizontal. It is from these deep, horizontally-trending faults that Kennedy thinks permeable passageways may emanate, penetrating the ductile boundary into the mantle.

One of the most seismically active areas in the Basin and Range occurs in what is called the central Nevada seismic belt. The researchers' detailed studies in this area, notably at the Dixie Valley thermal system next to the Stillwater range, established that the highest helium ratios were restricted to fluids emerging from the Stillwater range-front fault system.

The northern Basin and Range, which Kennedy and van Soest surveyed on behalf of DOE's Office of Basic Energy Sciences and Office of Geothermal Technologies, includes parts of California, Nevada, Oregon, Idaho, and Utah. In their survey the researchers mapped the steady progression from low helium ratios in the east to high ratios in the west. The distribution of the increasing ratios corresponds remarkably with an increase in the rate and a change in the direction of crustal extension, which shifts from an east to west trend across the Basin and Range to a northwest trend.

This change in rate and direction reflects the added shear strain induced by the northward movement of the Pacific Plate past the North American Plate. Kennedy and van Soest believe that the added component of shear strain and increasing extension rate tear open fluid pathways through the ductile lower crust, into the mantle. The high helium isotope ratios they found, indicating potential new sources of geothermal energy, were superimposed upon the general background trend: anomalously high ratios map zones of higher than average permeability.

Arizona State geochemist Matthijs van Soest samples surface water in the northern Basin and Range. The sample is collected without direct exposure to air and stored in the copper tube, foreground left, which will be sealed by crimping.

"We have never seen such a clear correlation of surface geochemical signals with tectonic activity, nor have we ever been able to quantify deep permeability from surface measurements of any kind," says Kennedy. The samples they collected on the surface gave the researchers a window into the structure of the rocks far below, with no need to drill.

With the urgent need to find energy sources that are renewable and don't emit greenhouse gases, geothermal energy is ideal — "the best renewable energy source besides the sun," Kennedy says. Accessible geothermal energy in the United States, excluding Alaska and Hawaii, has been estimated at 9×10^{16} (90 quadrillion) kilowatt-hours, 3,000 times more than the country's total annual energy consumption. Determining helium ratios from surface measurements is a practical way to locate some of the most promising new resources.

"Flow of Mantle Fluids Through the Ductile Lower Crust: Helium Isotope Trends," by B. Mack Kennedy and Matthijs C. van Soest, appears in the 30 November 2007 issue of *Science* and is available to subscribers at http://dx.doi.org/10.1126/science.1147537.

Berkeley Lab is a U.S. Department of Energy national laboratory located in Berkeley, California. It conducts unclassified scientific research and is managed by the University of California. Visit our website at http://www.lbl.gov/.

Mexico

Commissioning of Unit 8 at Los Humeros

Luis C.A. Gutiérrez-Negrín, CFE, Mexico

Unit 8 was commissioned at the Los Humeros geothermal field in late July 2007. This is a back pressure power unit of 5 MWe net, made by Mitsubishi. The installation project included the construction of a steam-pipe, separation equipment, injection line, electric substation and 200 meters of transmission line at 115 kV. All the mechanical, civil, and electric works for the installation were made by the Comisión Federal de Electricidad (CFE). Like the other units in the field, Unit 8 is operated by the CFE.

View of Unit 8 and its steam-pipe in Los Humeros

The turbine is fed by 64 tons per hour (t/h) of steam at 165°C and 0.7 MPa as the minimum inlet temperature and pressure. The electric generator has two poles, an exit voltage of 4.16 kV and spins at 3600 revolutions per minute (rpm). The steam-pipe gathers the fluids of three production wells and delivers to both Unit 2 and Unit 8. The separation installations consist of a Webre separator and a dryer. The electric substation includes a power transformer (4.16 to 115 kV).

This is the first geothermal-electric unit to be commissioned in Mexico in the last four years. With it, the installed capacity in Los Humeros increases by 14% to reach 40 MWe, and the installed capacity in Mexico totals 958 MWe.

ASIA/PACIFIC RIM

Australia

The Burgeoning Australian Geothermal Energy Industry

Graeme Beardsmore, Senior Research Fellow, Monash University, and Technical Director, Hot Dry Rocks Pty Ltd, Victoria, Australia

Introduction

Australia has historically been considered a very "cold" country, geologically speaking; not a place that immediately conjures thoughts of geothermal power generation. It is not surprising, therefore, that geothermal energy has not historically played a large role in Australia's energy mix, nor Australia in the global geothermal community. The past decade, however, has seen first a trickle and then a flood of interest in geothermal. This interest has been fuelled by a growing realization that Australia is blessed with world class "hot dry rock" and low temperature hydrothermal resources, coupled with a growing imperative to reduce Australia's carbon footprint. The result has been new State and Federal legislation, escalating levels of public and private investment, a spate of new companies dedicated to the identification and development of geothermal energy, and a growing number of commercial projects aimed at geothermal power generation.

Geology of Australia

The impression of Australia as a cold continent comes from the continent's position in the middle of the Australian Tectonic Plate (Figure 1), and the fact that the continent has large areas of exposed Archaean and Proterozoic crust. There are no plate margins, active volcanoes or surface geothermal manifestations (with the exception of a handful of warm to hot springs) on the Australian continental land mass. In spite of the lack of surface signs, however, there is a significant body of geological evidence to suggest that the continent may not be as cold as initially thought. Some of this evidence is presented below.

Borehole temperatures

An assessment of the thermal resource beneath the Australian continent is hampered by the fact that there are relatively few published conductive heat flow measurements for the continent. The global heat flow data base lists just over 100 measurements across an area roughly equal in size to the 48 contiguous states of the USA. In comparison, there are many thousands of points published for the USA. This paucity of data makes it difficult to quantify the actual energy in the ground, but related data provide a broad indication that heat flow, and potential temperature resource, varies significantly across the continent. Chopra and Holgate (2005) published a GIS analysis of temperatures reported from over 4,000 boreholes across the continent. They used a simple linear extrapolation method to estimate the temperature of the crust at a depth of 5 km. The results (Figure 2) suggest that large sections of the continent are underlain by relatively hot crust. Temperatures in excess of 200°C have, indeed, been intersected by petroleum exploration wells at depths little more than 3 km in the Cooper Basin in central Australia. In addition, Geodynamics Limited have reported temperatures approaching 250°C at a depth of about 4,400 m in the geothermal exploration well Habanero 1 in the same region. Figure 2 suggests that large tracts of the continent may be underlain by crust of similar temperature, although wells to the appropriate depth have not yet been drilled in any of the other areas.

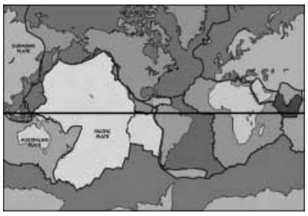


Figure 1.
Tectonic plate boundaries, showing the Australian continent in a central position on the Australian Plate. Image modified after USGS.

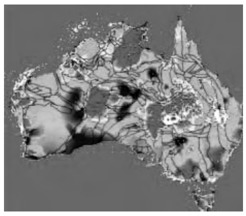


Figure 2.
Approximate temperature distribution at a depth of 5 km in the Australian crust, against broad tectonic elements (black lines). Data points shown as white + symbols. Red is relatively hot crust, blue is relatively cold. From Chopra and Holgate (2005).

Tertiary eruption centers

Australia is not generally considered an active volcanic region, but the eastern side of the continent, from the state of Queensland in the north to Tasmania and South Australia in the south, plays host to a large number of relatively young basaltic eruption centers. The state of Victoria in the southeast of continental Australia, for example, shows evidence of intermittent volcanism over the past 190 Ma (million years), with volumetric peaks between 57-42 Ma and 5-0 Ma. (Price et al., 2003). The most recent event, at Mount Gambier just over the border in South Australia, has been dated at less than 5,000 years (Sheard, 1995). These volcanic features appear to be related in some manner to a series of rifted marginal basins along the same coast. The exact relationship is far from obvious but, with such a long and potentially ongoing history of volcanic activity throughout the region, it is tempting to conclude that there may be young intracrustal igneous bodies or areas of elevated mantle heating, though no direct evidence of such phenomena has yet been found. The most tantalising evidence that young volcanic features are associated with geothermal energy sources lies in the northern part of the state of Queensland, in the northeast of the country. A number of hot springs in the area known as the Atherton Tablelands discharge water at temperatures in excess of 70°C. The same area hosts some very young volcanic rocks (on the order of 10,000 years), including some spectacular lava tubes.

Great Artesian Basin

The Great Artesian Basin (GAB) is the world's largest artesian groundwater basin, underlying about 22% of the Australian continental landmass. Groundwater from the GAB comes out at wellhead temperatures ranging from 30°C to 100° C (Figure 3), and in most cases has to be cooled before it can be used as town or stock water. The sheer size and temperature of the underground water resource makes it an attractive geothermal target. The geothermal potential of the GAB was highlighted in the June 2002 edition of the GeoHeat Center Bulletin (Habermehl and Pestov, 2002).

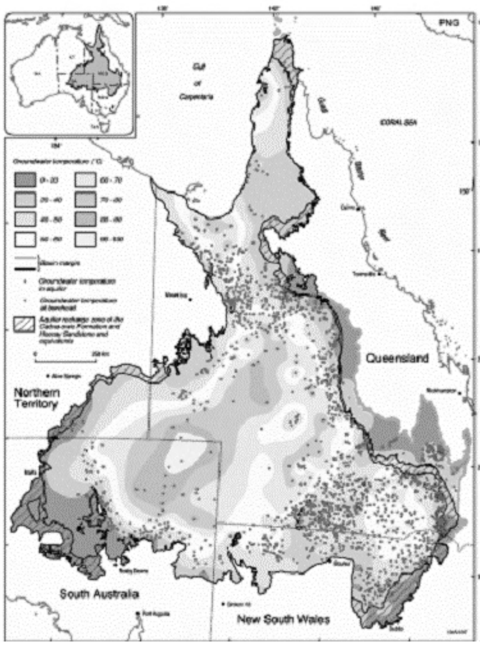


Figure 3.
Groundwater temperature from the Great Artesian Basin. From Habermehl and Pestov (2002).

Current uses of geothermal energy in Australia

Chopra (2005a) described the state of the geothermal industry in Australia in 2005. Little has changed between then and now in the number of commercial operations, but governments and organizations across the country are beginning to recognize the potential of geothermal resources and are exploring new possibilities for utilization. Geothermal utilization in Australia is currently restricted to a single small binary cycle power generator and a handful of direct uses. Some examples follow.

Birdsville Geothermal Power Plant

Ergon Energy, the state-owned electrical power company in the state of Queensland, owns and operates the Birdsville Geothermal Power Plant. Birdsville (25°54´S, 139°22´E, population 100) is a small town in southwest Queensland, near the border with South Australia. The town lies more than 1,500 km from the nearest state capital city and many hundreds of kilometres from the nearest point on the national electricity network, so all electrical power is locally generated. A simple binary cycle geothermal generator supplies a net 80 kW of electricity, sufficient to supply Birdsville's off-peak demand. Diesel generators cut in at times of higher demand. The heat source for the geothermal plant is the town's water supply bore, which flows 98°C water at 27 litres per second. (see also Chopra, 2005b). At the time of writing, Ergon Energy is funding a study into the feasibility of improving the capacity and efficiency of the geothermal plant. The study is looking at such things as improving the temperature and flow rate of the resource, potential for reinjection (currently most of the spent fluid is discharged to a surface stream), and decreasing the parasitic load from the cooling fans (current parasitic cooling load is on the order of 30% of gross power output).

Portland Space Heating Facility

Portland (38°20′S, 141°36′E, population 8,800) is a town on the west coast of the state of Victoria. It was host to Australia's only geothermal district heating system, operated by the Glenelg Shire Council. Bore water at 58°C was drawn at a rate of 90 litres per second from 1,400 metres in the Dilwyn Formation aquifer of the Otway Basin. The water was used between 1985 and 2006 to heat council buildings, a hospital, a police station, a motel and a public swimming pool. The capacity of the facility was 10.4 MWt. Initially, the geothermal water was used as Portland's drinking water after passing through the heating system, but this practice was discontinued in 1997 due to water quality concerns. Ironically, between 1997 and 2006 the spent geothermal water was air-cooled (with energy intensive fans which contributed a net positive amount of greenhouse gas to the atmosphere) and discharged to surface drainage. The system has been decommissioned since January 2006 because of the poor condition of the bore, the energy intensive cooling system, and because it was no longer deemed environmentally sustainable to discharge the spent geothermal water into surface drainage. There is growing political pressure to recommission the system, but it will require significant investment to drill a new production bore, and redesign of the system to incorporate reinjection.

Innot Hot Springs

The Innot Hot Springs (17°40'S, 145°14'E) lie in the Atherton Tablelands inland from Cairns in the state of Queensland. It is one of a handful of natural warm to hot springs that are utilized around the country for tourism purposes. The Innot Spa Resort is primarily a trailer and camping park, with an outdoor heated spa pool and three indoor heated spa pools (Figure 4). The source of the geothermal water is a 50 metre deep bore from which 70°C water is drawn. Natural hot water (also about 70°C) discharges along a short section of stream bed about 100 metres from the bore, and this natural warm "beach" has been used by visitors and locals alike for relaxation since being discovered by European settlers in the late nineteenth century. The source of the water and the heat is poorly understood, and the subject of a current research project by the Geological Survey of Queensland. Other commercial hot spring operations are located at Maree in New South Wales, Hastings in Tasmania, Rye in Victoria (Davidson, 2006), and a new, multi-million dollar development is underway at Warrnambool in Victoria. This is not an exhaustive list, and there are early indications that a geothermal spa industry may develop.

Figure 4.
The spa house at the Hot Springs Resort, Innot Hot Springs, Queensland.

Robarra Pty Ltd

Barramundi (giant perch, or Australian seabass) is a very popular eating fish native to northern Australian fresh waters. The optimum growth temperature for barramundi is about 28°C, typical of the tropical inland waters of the north. A thriving barramundi farm operates on the south coast of South Australia, however, where the average surface water temperature is around 12°C. Robarra Pty Ltd operates the farm at Robe (37°09′S, 139°45′E), utilizing warm water flowing at 30°C from several hundred metres down in the Dilwyn Formation of the Otway Basin. The fresh geothermal water passes through adjustable boom jets directly into the grow out tanks. The operation provides employment for about 22 local people, and turns over about AU$ 2 million annually.

Sources of electrical power

In spite of the majority of geothermal energy being directly utilized at present, most attention is currently on developing new sources of electrical power. Australia's electricity demand is about 50,000 MW (CSIRO 2006). About 7,000 MW is generated from renewable sources (mostly hydro and bio-waste from sugar processing facilities), but the great bulk of demand is met by fossil fuel sources; dominantly black and brown coal, but with a significant proportion of natural gas (Figure 5). This great reliance on fossil fuels for electricity generation is the primary reason that Australia rates as one of the most greenhouse gas polluting countries in the world. At 17.35 tonnes CO_2 per capita per year in 2003, it ranked fourth amongst Organization for Economic Co-operation and Development (OECD) countries (Source: OECD), behind Canada (17.49), the USA (19.68) and Luxembourg (21.96): The state of Victoria, where about 70% of electricity is generated from brown coal, is a particularly noteworthy polluter. Australia's domestic supply of coal and natural gas is sufficient to provide electricity at current levels for over 500 years. Under the current pricing regime, the cost of electricity production from coal, in particular, is significantly lower than any current alternative. The current Federal Government, however, aims to introduce a carbon trading scheme by 2012, and such a scheme will force the coal-fired power industry to internalize the cost of carbon emissions. Several economic studies (e.g. McLennan Magasanik Associates Pty Ltd, 2006) have concluded that, in a carbon-constrained economy, geothermal energy could provide the lowest cost base-load power. With demand increasing, therefore, there is scope for geothermal power to provide a significant portion of base load electricity capacity into the future.

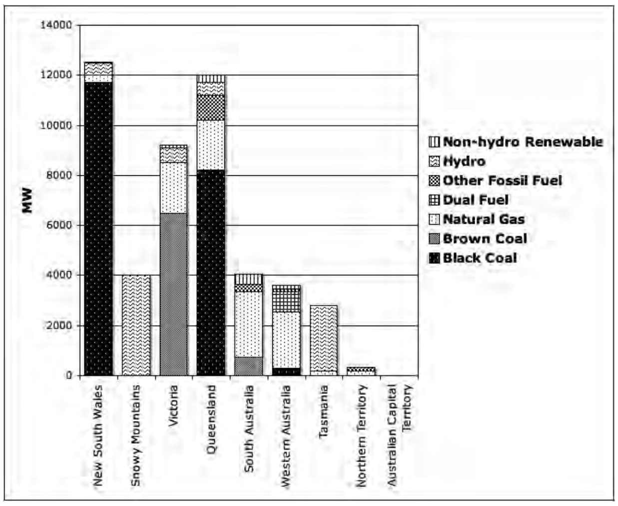


Figure 5.
Sources of Australia's electricity generation, listed by state. Source CSIRO (2006).

Political support

The Australian political system is divided into three levels; local, state and federal. Geothermal energy development is receiving significant support at all three levels. Local councils increasingly view sustainability and renewability as important parameters for development, often giving more weight to these over and above purely financial arguments. As an example, in 2006 Melbourne City Council opened Council House 2 ("CH2"), a ten storey building in the heart of Melbourne (a city of three and a half million people) with energy and water efficiency as its core design feature. 22.1% of the construction cost was directly attributed to efficiency features (Melbourne City Council, 2004). While geothermal energy was not utilized in CH2, the same council incorporated geothermal heat pumps into the air conditioning system of the East Melbourne Library during a refurbishment in 2005, in spite of the premium cost of the system compared to natural gas systems. At the state level, the Victorian Government introduced the Victorian Renewable Energy Target (VRET) scheme in late 2006. The VRET scheme requires energy retailers to purchase a minimum of 10% of their total power purchases from renewable sources by 2016. Since then, several other states have introduced equivalent schemes, with some setting more aggressive targets (e.g. South Australia's target is 20% renewable power by 2014). For geothermal energy, some states are matching legislation with financial support. South Australia and Queensland, for example, offer cost-sharing schemes to offset the cost of drilling. The Australian Federal Government introduced the Mandatory Renewable Energy Target (MRET) in 2004. MRET requires that 9,500 GWh per year of new renewable electricity be online by the year 2010. The country is well on track to achieve this goal, largely due to strong growth in the wind energy sector. Other Federal Government schemes offering financial support to the geothermal energy sector include the Renewable Energy Development Initiative (REDI), which provides grants for renewable energy innovation and commercialization; Renewable Remote Power Generation Programme (RRPGP), which supports renewable energy in remote areas; and Renewable Energy Equity Fund (REEF), which provides venture capital for small renewable energy companies. At the time of writing, six geothermal energy companies have received in excess of AU$ 21 million total in REDI grants alone. Australia had a change of Federal Government in late November; as well as ratifying the Kyoto Protocol, the new Government has also ear-marked AU$ 50 million for direct geothermal drilling subsidies. While the details have yet to be formalised, the industry's current understanding is that up to AU$ 5 million will be available per well on a dollar-for-dollar basis. The Federal Government's geoscience institution, Geoscience Australia, operates out of a building in Canberra that utilizes geothermal heating and cooling.

Commercial geothermal industry

At the time of writing there are six companies listed on the Australian Stock Exchange (ASX) with geothermal energy development as one of their core activities. A seventh company is currently in the middle of an IPO, and several others are preparing to follow suit. The money is being raised through the public markets primarily to fund desktop analyses, surface exploration and shallow drilling programs designed to shed light on the nature of the geothermal resource in different parts of the country. About 25 individual companies hold exploration rights or have made application for over 170 exploration licences across five states (Queensland, New South Wales, Victoria, Tasmania and South Australia.) The size of the exploration licences range from about 100 km2 to over 12,000 km2. At the time of writing, the remaining two states of Australia (Western Australia and Northern Territory) are in the process of developing legislation to allow geothermal energy exploration and development. Many geothermal companies have sprung from parent companies engaged in mineral or petroleum exploration, and almost without exception the focus is on electrical power generation. The distribution of activity, in terms of numbers of exploration licences applied for and granted, is strongly influenced by state boundaries, with by far the most activity in South Australia (99 licences granted, 39 current applications, and 10 retention licences). This is due in equal parts to attractive geology and an accommodating State Government. The Department of Primary Industries and Resources, South Australian (PIRSA), has actively encouraged the growth of a geothermal industry centered on South Australia; with generous drilling subsidies, a simple application procedure for licences, easily and freely accessible data packages, and by assuming a leadership role in coordinating the growth of the industry. The range of exploration and development strategies is almost as wide as the list of companies in the industry is long, but a small number of case studies will serve to illustrate the different strategies being pursued. Listed companies Geodynamics Limited, Petratherm Limited, Green Rock Energy Limited and Torrens Energy Limited each have very different development strategies. The following summaries also highlight the international expansion of a number of Australian companies.

Geodynamics Limited

Geodynamics (GDY) is the leading geothermal energy development company in Australia by any objective measure. The company was the first to list on the ASX, is most advanced in its development, has the highest market capitalization on the ASX (AU$ 286.5 million), and receives (arguably) the most media attention. The company holds two exploration licences and 10 retention licences (allowing them to maintain development rights for up to 15 years) in South Australia, but GDY's only project is near Innaminka in northeast South Australia. It is an engineered geothermal system project to extract power from 250°C granite at a depth of about 4,500 m. The company has successfully drilled a well (Habanero 1) into the granite to target depth, performed hydraulic stimulation to enhance the natural fracture network, and drilled a second well (Habanero 2) to intersect the fracture network. Unfortunate engineering difficulties resulted in the effective loss of Habanero 2 and set the project back almost two years. At the time of writing, however, drilling has commenced on Habanero 3 and the company is confident about achieving hydraulic connection with Habanero 1 within a few months. Their business plan calls for 40 MW of electrical power generation by 2010, with rapid expansion to at least 500 MW. The major perceived barrier to commercial success for GDY lies in the geographic location of their project. Innaminka is at least 400 km from the nearest point on the national electricity grid, and substantial capital will be required to transmit generated electricity to the market. This dictates that GDY's development will ultimately need to be several hundred megawatts capacity if they are to operate profitably, but the size of their resource will comfortably accommodate such output if the technology can be proven. GDY also has a subsidiary company (Exorka International Limited, now based in Germany) dedicated to the commercialization of the Kalina Cycle technology that will be utilized in the Habanero project.

Figure 6.
Drilling of Habanero 1 in the Cooper Basin (Geodynamics, Ltd.)

Petratherm Limited

Petratherm Limited (PTR) holds nine exploration licences in South Australia, has a subsidiary company exploring development opportunities in Spain, and has been endorsed by both the Australian and Chinese governments to investigate the development of hot rock technology in China. PTR was the second geothermal company to list on the ASX and has a market capitalization of AU$ 46 million. Their main project lies at a locality called Paralana in South Australia. Their single test hole to this stage (Paralana 1) is about 1,800 m deep, and they have demonstrated levels of heat flow more than sufficient to generate attractive geothermal temperatures at depths less than 4 km. PTR aims to deepen Paralana 1 and use it to stimulate the development of an underground heat exchanger within the sediment column. Paralana, like Innaminka, lies off the national electricity grid, but close to a major energy user in the Beverley uranium mine. PTR have signed a power purchase agreement with the operators of the Beverley mine, which values electricity generated at Paralana at a higher price than the normal national electricity price. This will allow PTR to receive a premium rate for generated electricity during their early commercialization stage, which will help them fund growth to the point where they can connect to the grid and compete on the national market.

Green Rock Energy Limited

Green Rock Energy Limited (GRK: market capitalization AU$20 million) holds a range of geothermal exploration tenements in South Australia; around the world's largest Uranium mine at Olympic Dam, around the top of the Spencer Gulf, and in the Cooper Basin. An early entrant into the geothermal industry in Australia, GRK is geographically positioned to take advantage of the enormous power requirements of a proposed four-fold expansion of the Olympic Dam mine. The company has drilled a 1,900 m deep hole into a granite body in their Olympic Dam area and demonstrated an attractive heat resource and stress regime for the development of an engineered geothermal system within the granite. As well as its Australian interests, GRK also holds 32% equity in a combined heat and power development in Hungary. There, they are seeking high flow rate fluids at about 140°C. The company's initial drilling operation in Hungary achieved disappointing results from the point of view of observed fluid flow rates, but the project was the inaugural recipient of World Bank geological risk insurance for geothermal development in Eastern Europe. As such, GRK should receive much of their invested capital back, to reinvest in further exploration in Hungary.

Torrens Energy Limited

Torrens Energy Limited (TEY: market capitalization AU$ 18 million) has the stated objective to find the hottest rocks possible close to population centers and on the national electricity grid. TEY achieved first mover advantage in recognizing the geothermal potential of a geological feature known as the Adelaide Geosyncline, part of which lies under the city of Adelaide, capital of South Australia. TEY were recently awarded a AU$ 3 million REDI grant to undertake a drilling program and develop computer software to accurately model the temperature resource beneath their tenements. TEY also holds an exploration licence under the northeastern suburbs of Melbourne, Australia's second largest city. They also intend to investigate the possibility of using geothermal energy to desalinate seawater.

The Australian Geothermal Energy Group

The geothermal industry in Australia is in the process of forming one or more collaborative organizations. At the time of writing, over forty companies, organizations and institutions are involved in a loose collaboration called the Australian Geothermal Energy Group (AGEG). AGEG has coalesced from a broad range of interested parties under the umbrella of Australia's involvement in the International Energy Agency Geothermal Implementing Agreement (IEAGIA). The group is chaired by PIRSA and includes commercial entities, state and federal government organizations, universities and research institutions. To date, the geothermal sector has been unofficially represented in Canberra by the Renewable Energy Generators Association (REGA), but this situation is now considered unsustainable with geothermal's increasingly high profile and number of commercial participants. At the time of writing, the commercial partners within AGEG are exploring the possibility of incorporating an industry association with a full time secretariat and political lobbying as part of its role.

Australian company Geodynamics Limited leads the Enhanced Geothermal Systems Annex of the IEA-GIA, at least three Australian companies have interests overseas, and the first Australian (the author) has just been elected to the Board of Directors of the International Geothermal Association. As a country, Australia looks set to play an increasingly important role in geothermal energy development on the global stage. Note: AU$1 = 0.881 US$ = 0.598 Euro (December 2007)

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Philippines

PNOC EDC now a private corporation

By PNOC EDC Corporate Communications

The PNOC EDC Energy Development Corporation has been fully privatized with the successful sale to Red Vulcan Holdings Corporation of the remaining 60% controlling interest. A consortium of First Gen Corp., Spalmare Holdings B.V. and Prime Terracota Holdings Corp., Red Vulcan Holdings Corp. bid PhP58.5 billion (USD 1.4 billion) for the controlling stake, equivalent to PhP9.75 per share.

Offering the second highest bid was FDC Geo-Energy Holdings, Inc. (Filinvest Development Corporation and Int'l Power Masinloc Holdings, Inc.) who bid PhP48.525 billion (USD 1.17 billion). Third and fourth placers were Panasia Energy Holdings, Inc. (San Miguel Energy Corp. and Beleggingsmaatchappij Broem B.V.) and AP Renewables (Aboitiz Power Corp.) who bid PhP39 billion (USD 0.94 billion) and PhP33.165 billion (USD 0.8 billion) respectively. Red Vulcan now gains the majority control of the operational and financial management of the company.

PNOC EDC's success story was best demonstrated when it tapped the domestic and foreign equity markets with the listing of its shares in the Philippine Stock Exchange (PSE) on December 13, 2006. The sale of 6 billion shares generated a total of PhP19.2 billion or USD 461.5 million. Over 160 institutional investors subscribed to the international part of the offer. At the end of its first trading day, PNOC EDC shares closed 42% higher at PhP4.55. The IPO is the most successful for the Philippine Government in 12 years, providing a template for other state firms intending to go public.

By July 2007, it had become a majority privately owned company with almost 53% of its outstanding shares being owned by about 170 institutional funds. The follow-on offering of additional 3 billion shares in July generated PhP 17 billion or USD 409 million to Government coffers.

"We are confident that the Company can maximize its growth potential once the benefits of full privatization set in. This is a step in the right direction - towards attaining PNOC EDC's vision to become an international geothermal energy company," according to PNOC EDC President and CEO Paul A. Aquino.

At 1,199 MWe, PNOC EDC presently controls 60% of the Philippines' total installed geothermal generating capacity. Even though this accounts for only about 7.3% of the country's total installed power generating capacity, it was able to contribute close to 12% of the total electricity production for 2006.

With 31 years of hands-on experience and industry leadership, the Company is capable of providing integrated services from geothermal exploration and development to power plant operation.

PNOC EDC is developing about 310 MWe of new capacity in the medium-term, to capitalize on demand growth and supply shortages. The Company's organic growth is expected to come from accelerated development of new geothermal projects. Included here is the development of the Nasulo and Mindanao III projects.

Banking on its technical expertise, PNOC EDC also aims to increase revenues from the sale of its services to the international market.

UPCOMING EVENTS

33rd Stanford Workshop on Geothermal Reservoir Engineering, Stanford, CA, USA, January 28-30, 2008. http://pangea.stanford.edu/ERE/research/geoth/conference/workshop.html

ENGINE Final Conference, Vilius, Lithuania, February 13-14, 2008. http://conferences-engine.brgm.fr/

29th PNOC-EDC Geothermal Conference, 6–7 March 2008, Makati City, Philippines. Website: http://www.energy.com.ph/?p=7&type=2&sec=1&aid=12

Prepare the Australian Geothermal Industry Development Framework. March 14, 2007, TBC, Australia. Website: www.geothermalframework.net.au

SEMP-AAPG Meeting, Poster Session on Geothermal Resources. 20–23 April 2008, San Antonio, TX, USA. Website: http://www.aapg.org/sanantonio/sanantonio1.pdf

IAHR International Groundwater Symposium, June 18-20, 2008, Istanbul, Turkey. Website: http://www.iahr-gw2008.net

XVII International Conference on Computational Methods in Water Resources, Special session on Mass and Heat Transport in Geothermal Systems, San Francisco, California, 6-10 July 2008. Website: http://esd.lbl.gov/CMWR08/special sessions/index.html

ENERGEX 2008, 6–10 July 2008, Vienna, Austria. Website: http://www.energex2008.com

33rd International Geological Congress, Oslo, Norway, August 6-14, 2008. www.33igc.org

GRC 2008 Annual Meeting/2008 Geothermal Energy Trade Show, 5–8 October 2008, Reno, NV, USA. Website: http://www.geothermal.org

World Energy Engineering Congress (WEEC), 8–10 October 2008, Washington, DC, USA. Website: http://www.energycongress.com/

8th Asian Geothermal Symposium, Hanoi City, Vietnam, December 9-12, 2008, contact: http://unit.aist.go.jp/georesenv/asia8.html

IGA News

IGA News is published quarterly by the International Geothermal Association. The function of IGA News is to disseminate timely information about geothermal activities throughout the world. To this end, a group of correspondents has agreed to supply news for each issue. The core of this group consists of the IGA Information Committee:

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The members of this group submit geothermal news from their parts of the world, or relevant to their areas of specialization. If you have some news, a report, or an article for IGA News, you can send it to any of the above individuals, or directly to the IGA Secretariat, whatever is most convenient. Please help us to become essential reading for anyone seeking the latest information on geothermal worldwide.

While the editorial team make every effort to ensure accuracy, the opinions expressed in contributed articles remain those of the authors and are not necessarily those of the IGA.

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Please complete the following form and return it with payment to:
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