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GRÓ Geothermal Training Programme in Iceland: Geothermal Capacity Building in Developing Countries for 45 years

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ABSTRACT

The Geothermal Training Programme (GTP) in Iceland has been in continuous operation for 45 years, specializing in capacity building in all aspects of geothermal research and development for developing countries with geothermal potential. Since the beginning of 2000 it operates under GRÓ, International Centre for Capacity Development, Sustainability and Societal Change, along with its three Icelandic sister programmes, under the auspices of UNESCO. Since 1979, GTP's core activity has been the operation of a six-month training programme in Iceland. Through 2022, 766 fellows from 65 countries have graduated from the programme. In addition to general geothermal education, each of the fellows receives specialized training along one of eight lines of specialization on offer; geothermal geology, geophysical exploration, reservoir engineering and borehole geophysics, chemistry of thermal fluids, environmental science, geothermal utilization, drilling technology, and project management and finances. Finally, each fellow completes a full-scale research project under the guidance of an Icelandic geothermal expert. Since 1999 GTP has also supported outstanding six-month fellows for further studies at universities in Iceland, beginning with MSc-studies and adding PhD-studies to the roster in 2008. Since then, 81 students (early 2023) have completed MSc-studies and 5 PhD-studies (early 2023), with GTP support. Since 2005, GTP has offered short courses and workshops in other countries, both on a regular basis such as in Kenya and El Salvador, as well as based on specific needs, and online. Thus, an even larger audience has been reached with more than 3000 participants having benefitted from participating in 81 events. GTP has also contributed to regional training programmes in El Salvador, Kenya and China. Most of GTP's activities have been financed by the Government of Iceland, while a small part has been additionally financed through international support, or by local companies. The benefit of GTP's capacity building is clearly manifested by the progress of individual fellows, many of whom have become leading experts in their home countries, by advances in geothermal development in many supported countries, and as has been documented in appraisals performed.

1. INTRODUCTION

The Geothermal Training Programme (GTP) in Iceland started operating in 1979, more than 4 decades ago, specializing in capacity building in all aspects of geothermal research and development for developing countries (lower- and middle-income countries) with geothermal potential. For most of its existence the GTP was affiliated with the United Nations University but since the beginning of 2020 it operates under GRÓ, International Centre for Capacity Development, Sustainability and Societal Change, along with its three Icelandic sister programmes (https://www.grocentre.is/gro), namely the Fisheries Training Programme (FTP), the Land Restoration Training Programme (LRT) and the Gender Equality Studies & Training Programme (GEST), under the auspices of UNESCO. Most of GTP's activities have been financed by the Government of Iceland, while a small part has been additionally financed through international support, or by local companies.

The GTP was founded in 1978 and started operating in 1979, on a quite a small scale, with two fellows receiving comprehensive training for close to six months. Since then, this six-month training has been the core activity of the programme and has been operated on a yearly basis every year, except in 2020 when it had to be postponed due to the covid pandemic. During the approximately first three decades of the programme's operation it grew, both in size (number of trainees) and activities, as will be discussed below. During the last decade or so the operation has been more stable, even though advances have been made, e.g. with online courses and hybrid online/on-site activity.

The main purpose of the GTP can be summarized as follows:

- To assist developing nations with significant geothermal potential to build up or strengthen their geothermal expertise to be able to develop these important renewable energy resources for the benefit of their people.
- To provide university graduates engaged in geothermal work with intensive on-the-job training in their chosen field of specialization.
- To enhance the skills of the fellows by working side by side with geothermal professionals in Iceland.
- To tailor-make the training for the individual and the needs of his institution and country.

The main activities of GTP at present are:

1) Six-month training in Iceland of approximately 25 fellows yearly.
2) Fellowships for MSc- and PhD-studies at University of Iceland and Reykjavík University.
3) Short courses abroad in support of the United Nation's Sustainability Development Goals (SDGs).
4) Support for Diploma Course in El Salvador and for other comparable training programmes (e.g. in Kenya and China).
5) Other training activity, including customer designed courses and individual training.

Each of these will be specifically described in more detail below.

Dr. Ingvar B. Fridleifsson was the founding Director of GTP and served as such until his retirement in 2013. Dr. Jón S. Gudmundsson was acting Director for three years during 1986 – 1989, however, and Dr. Hjalti Franzson during a brief period in 1981. Lúdvík S. Georgsson took over as Director in 2013, having been Deputy Director since 1990, holding the position to the end of 2019. The first author of this paper has been the Director of the GTP since January 1st, 2020.

For the first 42 years the GTP was operated at Orkustofnun, the National Energy Authority of Iceland. It is now operated at Iceland GeoSurvey (ÍSOR) under a contract with the Ministry for Foreign Affairs in Iceland, through GRÓ mentioned above. ÍSOR is a research institute focusing on all aspects of geothermal resource exploration and development, hence ideally suited as a cooperative partner for the GTP. In addition to the Director, the GTP employs three full time staff members as well as temporary assistants. The academic activities of the programme are governed by an 8-member Studies Board and annually about 80 – 100 lecturers and support staff are hired from Iceland's leading geothermal institutes, universities, engineering companies or energy companies in line with the needs of the programme and its trainees at any given time. This pool of expertise constitutes the programme's resource base and greatest asset.

The covid-19 pandemic did affect GTP's operations, specifically in 2020 and 2021. In addition to the postponement of the 2020 six-month training, all in-person training activities abroad were cancelled in 2020, and again in 2021 with the exception of SDG Short Course V in Kenya (see later), which was successfully held in November 2021. The pandemic has, however, accelerated the development of on-line training activities (see below), enlarging the audience reached by GTP greatly.

This paper briefly describes the different activities of GTP at present and its role in geothermal capacity building in developing countries during the last four decades. For more details the reader is referred to recent papers by Georgsson et al. (2021) and Haraldsson et al. (2021), as well as the webpage of the programme (https://www.grocentre.is/gtp). The in-country and online training (short courses etc.) is reviewed in more detail in a separate paper at WGC2023 (Haraldsson et al., 2023). The beneficial aspects of GTP's training, including GTP's emphasis on gender equality, is discussed specifically in another WGC2023 paper (Ómarsdóttir et al., 2023).

The Geothermal Training Programme is the longest running of a few comparable geothermal training programs globally. The reader is referred to a recent paper by Newson and Green (2019) who review their history and current role. The first such programs were set up in Kyushu, Japan, and Pisa, Italy, in 1970, both partly funded by the UN and partly by the respective governments. The Japanese program was operated for three decades and then reinstated in 2016, while the one in Pisa operated for two decades. A training program has been operated at Auckland University in New Zealand since 1978, with a pause during 2002 – 2007, initially with UN support but mainly funded by the New Zealand government. In addition, Reykjavik University in Iceland has hosted the Iceland School of Energy (ISE) for a little over a decade, a graduate school focusing on renewable energy with a specialization in geothermal energy. Finally, the Geothermal Diploma Course in El Salvador, aimed at the Spanish-speaking world, should be mentioned. It is discussed in more detail below.

2. SIX-MONTH TRAINING IN ICELAND

Since its commencement, the core activity of GTP has been the operation of the six-month training programme in Iceland, as already noted. In addition to general geothermal education, each of the fellows receives specialized training along one of eight lines of specialization on offer;

- geothermal geology,
- geophysical exploration,
- chemistry of thermal fluids,
- reservoir engineering and borehole geophysics,
- drilling technology,
- geothermal utilization,
- environmental science, and
- project management and finances.

Finally, each fellow completes a twelve-week research project under the guidance of a geothermal expert or experts in Iceland.

Introductory lectures on all aspects of geothermal research and development continue for four weeks at the beginning of the six-month programme. Included in that part of the programme are a few fieldtrips to geothermal locations within or near Reykjavík and short lectures by the fellows on geothermal in their home countries. This is followed by work on a group project, lasting 10 days. Consequently, the group of fellows is split into 4 – 5 smaller group, each of which attends a specific line of specialization. This specialized training lasts for eight weeks but is broken up by a five-day field trip through the west and north of Iceland during which numerous sites of geothermal interest (high- and low-temperature resources as well as direct utilization and electricity generation) are visited. The last phase of the six-month programme, lasting 11 – 12 weeks, is devoted to the individual research projects. These are increasingly based on data from the fellow's home-countries, thus not only benefitting the education of the fellows but also geothermal development at home.

Figure 1 presents the graduation statistics of GTP, both the number of six-month fellows per year and active MSc- and PhD-fellows (see chapter 3 for a description of the MSc and PhD program). As of the end of 2022, 766 fellows from 65 countries have completed the six-month training. The home-countries of the fellow are presented in Figure 2.

Finally, it should be mentioned that the final project reports of the six-month fellows constitute an important part of the worldwide geothermal literature. The fellows often present results of studies at workshops and conferences that add to the advancement of knowledge on geothermal resources in various parts of the world (see map in Figure 2). These are accessible through the GTP's webpage (https://www.grocentre.is/gtp/publications) along with MSc- and PhD-theses of fellows supported for further studies by GTP (see next chapter) and various papers written in conjunction with GTP's short-courses and workshops abroad (see chapter 4). Through the years, the GTP publication database has become one of the largest open-access databases on geothermal research in the world.

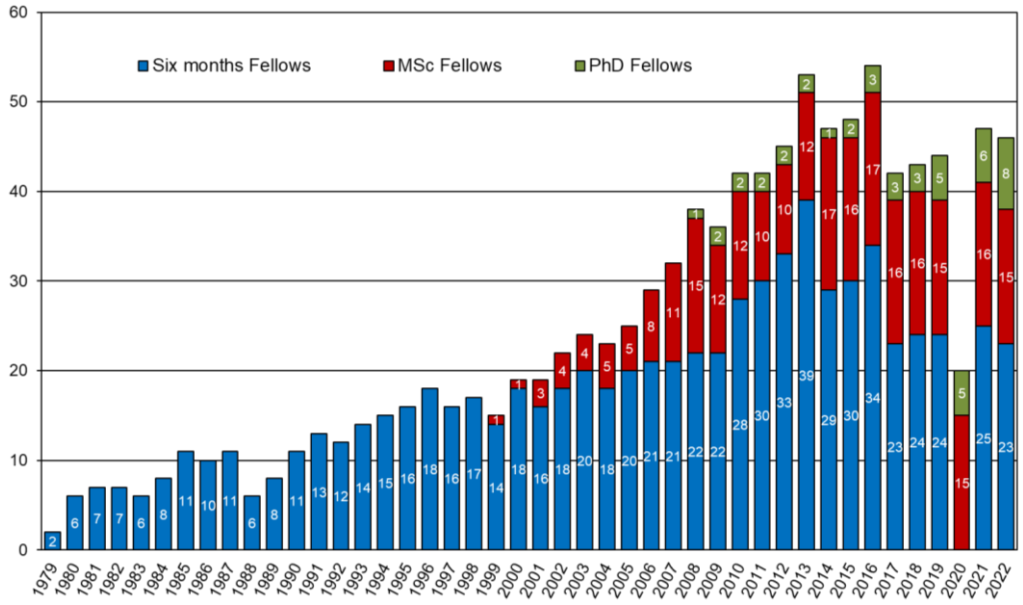

Figure 1: Yearly statistics for the number of GTP fellows, both six-month fellows (blue) and MSc- (red) and PhD-students (green) supported by GTP.

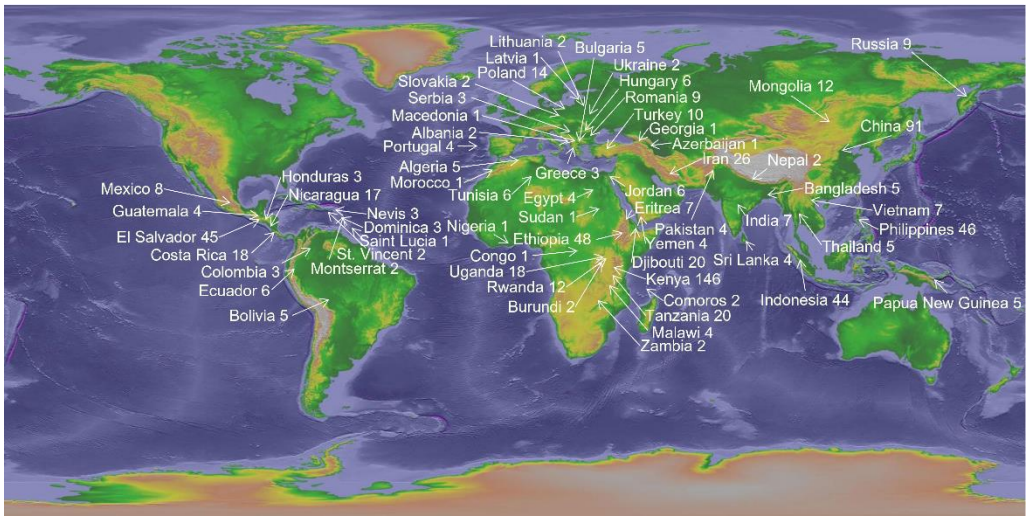

Figure 2: The 65 home-countries of 1979 – 2022 six-month fellows of the GTP along with the number of fellows per country.

3. SUPPORT FOR MSC- AND PHD-STUDIES

Since 1999, GTP has also supported outstanding six-month fellows for further studies at universities in Iceland, beginning with MSc-studies and adding PhD-studies to the roster in 2008 (see Figure 2 for the number of active MSc- and PhD-fellow per year). Since then, 81 students (early 2023) have completed MSc-studies and 5 PhD-studies (early 2023), with GTP support.

The GTP has active agreements regarding these studies with both of the main universities in Iceland, i.e. the University of Iceland (UI, see https://english.hi.is/) and Reykjavík University (RU, see https://en.ru.is/). The agreement with UI was signed in 2000 and the one with RU in 2013. The agreements include the provision that the previous six-month training can be used to fulfil 25% of the requirements for an MSc degree, being equivalent to up to 30 ECTS-units. The MSc- and PhD- fellowships provided by GTP cover costs associated with living and studying in Iceland, and Reykjavik University provides a fees scholarship.

Recently, about 4 – 5 MSc-fellowships are awarded per year along with 1 – 2 PhD-fellowships. The first GTP fellow to defend her thesis, was Dr. Pacifica F.A. Ogola, at the University of Iceland in 2013.

4. SHORT COURSES AND WORKSHOPS

Since 2005, GTP has offered short courses or workshops in other countries, both on a regular basis such as in Kenya and El Salvador, as well as on the basis of specific needs. Thus, an even larger audience has been reached with a total of close to 3000 participants having benefitted from participating in 81 events up to the end of 2022.

This started out with a short course series supporting the UN Millennium Development Goals (MDGs) beginning in 2005 in Kenya to benefit African countries. A similar series was started in 2006 in El Salvador to benefit Latin American and Caribbean countries. A workshop for decision makers on direct use of geothermal resources was, consequently, held in China in 2008 for Asian countries. The Short Course series in Kenya and El Salvador were overhauled in 2016 in support of the UN Sustainable Development Goals (SDGs). Close to 1630 participants have benefitted from the 31 Short Courses and Workshops dedicated to the UN Development Goals over the period 2005-2022.

The short courses in Kenya, which have been jointly operated by GTP as well as KenGen (Kenya Electricity Generation Company) and GDC (Geothermal Development Company) in Kenya, have focused on geothermal exploration, this being deemed the most beneficial for the region up to now. The short courses in El Salvador, which have been conducted in cooperation with LaGeo, have in contrast been focused on variable focus topics. Only one short course has been conducted in Asia so far, but GTP has the future goal of conducting short courses on a regular basis in Asia as well.

Since 2010, GRÓ GTP has offered tailored training on demand. These trainings have varied in topics, target groups and duration and have been financed by various bodies, including the Ministry for Foreign Affairs in Iceland, different power companies and international funding agencies. Forty-six workshops, short courses and extended training programmes had been conducted in four continents at the end of 2022, benefitting about 975 participants.

Since 2013, GRÓ GTP has contributed to a geothermal Diploma Course run within the academic framework of the University of El Salvador, first in an advisory role (2013-2015) and later as an implementing partner (2016-). The Diploma Course has greatly increased the possibilities for aspiring Latin American geothermal professionals to obtain dedicated training in the geothermal disciplines in their native tongue. Likewise, the African Geothermal Centre of Excellence (AGCE) has been gaining momentum in recent years. GRÓ GTP has had an advisory role in its conceptualization and conducted one of two opening short courses under the interim phase in cooperation with local partners in 2017. In November 2019, GTP contributed to the 5-week-long Sino-Icelandic Training Program in Beijing, China.

The covid-19 pandemic has affected GTP operations in recent years, as already mentioned. The pandemic has accelerated GTP's experimentation with online training, with 4 such activities organized up to late 2022. It is expected that online training will become yet another pillar of GTP training activities, complementing other modes of training and expanding GTP's audience.

5. BENEFITS OF GTP'S ACTIVITIES

The benefit of GTP's capacity building is clearly manifested by the progress of individual fellows, many of whom having become leading experts in their home countries, by advances in geothermal development in many supported countries as well by appraisals of the programme performed (see more details in Ómarsdóttir et al., 2023).

Figure 3: The 2022 group of GTP six-month fellows on a fieldtrip in Eyjafjördur in the north of Iceland.

Usually, support and development cooperation are evaluated objectively in terms of numbers. In energy related matters this can e.g. be in terms of megawatts or number of power plants. As a case in point for GTP one can take Kenya as an excellent example, where

installed geothermal electricity generation capacity increased from 594 MW_e in 2015 to 865 MW_e in 2020 (Omenda et al., 2021), mostly through power plant installation in the Greater Olkaria Geothermal Area by KenGen. GTP has actually provided six-month training for 146 fellows from Kenya during the last four decades, the majority of which has come from KenGen.

Such numerical evidence does not grasp the full success, reach and results of the training. A subjective approach is needed in addition to capture these. The trainees who obtain a fellowship to come to Iceland, gain access to the Icelandic geothermal sector and local experts, many of whom are world leaders in their field with a vast experience from Iceland's long history of utilizing geothermal resources. But equally as important they also gain access to each other as they are themselves experts in their fields, with experience they can share with both other fellows and teachers. The training, therefore, provides a unique venue where this interactive knowledge sharing for geothermal experts from all around the world is made possible.

The resulting international hub of experts is one of the fundamentals for the success of the training in Iceland. During their time in the training, the fellows get a chance to step out from their own environment and habits and expand their horizon to get a different point of view both professionally and on a personal level. Iceland being one of the leading countries in geothermal research and utilization gives the fellows a chance to experience with their own eyes what geothermal can do and how it matters.

Furthermore, in a world rushing to reach the UN SDGs and in times of conflict, it has rarely been more important to build bridges between countries and continents and to focus on increased cooperation in energy security as well as endorse tolerance towards the fellow man. Examples from the training in Iceland have shown the fellows who share their time and space working towards a common goal generally create understanding of each other across religion, culture, and race leading to less prejudiced individuals who many then advocate for more tolerance in their own country upon their return.

As a UN affiliated graduate, after sharing half a year with people from all around the world, expanding their professional network and making international, intercultural, and interracial friendship bonds, they are expected to have acquired certain leadership capabilities and qualities such as good communication skills, diplomacy, respect for others, and as good leaders, have courage and experience to back up their decisions which is what the GTP aims to instill and achieve with its training in Iceland. Experience through the decades of training has also shown that many fellows have become great leaders of geothermal development in their home countries which further supports how successful the training really is.

GTP's activities clearly contribute to some of the UN SDG's. In particular, Goal 7: "Ensure access to affordable, reliable, sustainable and modern energy for all" and Goal 13: "Take urgent action to combat climate change and its impacts". Then, its activities contribute indirectly to other goals like Goal 1: "End poverty in all its forms everywhere", Goal 3: "Ensure healthy lives and promote well-being for all at all ages", Goal 8: "Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all" and Goal 11: "Make cities and human settlements inclusive, safe, resilient, and sustainable".

Gender equality and gender issues are a key element in Icelandic foreign policy and gender equality has always been the focus of GTP, and thus it also supports UN Sustainable Development Goal 5: "Achieve gender equality and empower all women and girls". Through the four decades of six-month training at GTP in Iceland, about 25% of the fellows have been women. Yet, the ratio is improving and actually came close to 50% in 2021. Overall, nearly 23% of the MSc- and PhD-students that have graduated are women. Energy related research and development is still quite male-dominated, not least in the developing part of the world, but GTP actively promotes gender equality through a gender balanced candidate selection and by cooperating with our sister GRÓ programme GEST. GTP will continue to increase the share of women selected for training and MSc/PhD-studies, with the ultimate goal of reaching gender equality in all our activities.

6. CONCLUSIONS

The Icelandic government and GRÓ aim to strengthen the four GRÓ programmes, including GTP, in coming years. This is clearly reflected in GRÓ's Theory of change and Strategic priorities 2022-2027 (see https://www.grocentre.is/gro/media/publications). In the case of GTP the following points can be emphasized:

- Continued emphasis on six-month training, as the need is not diminishing.
- New countries should be added to GTP's roster, with emphasis on non-volcanic resources and direct utilization. Central Asia, various island nations, South America, and Africa, can be named as examples of global regions.
- MSc- and PhD-scholarships have proven to provide valuable additional support for a selected part of the fellow-group and beneficiary countries.
- Increased emphasis should be placed on short courses on location, e.g. Asia in addition to Africa and Latin-America.
- Increased support for local and regional training centres, akin to the El Salvador Diploma Course – e.g. in E-Africa, China, etc. Participation in the running of the Diploma Course has strengthened GTP's status in the Spanish speaking world.
- Short courses tailored to meet specific needs of various customers will continue to be important.
- Online training activity has tremendous potential, ranging from simple few-hour courses based on lectures and discussions to more intricate, longer-term training.
- Increased emphasis will be placed on using former fellows as lecturers and advisors.
- Increased cooperation with UNESCO, other international entities (e.g. World Bank), private sector, etc.

Notwithstanding rapid growth in recent times, geothermal utilization is at present minor compared to utilization of solar- and wind power. Yet the potential of the Earth's geothermal resources is enormous, both compared with its utilization today, and the future energy-needs of mankind. Geothermal resources are also extremely variable in nature. They have the potential of contributing a lot more to the future energy needs of mankind than the present utilization, as well as being renewable and mostly environmentally benign. They can also, if properly managed, be utilized in a sustainable manner. Rapid growth in geothermal utilization, akin to that

of the last two decades, is certainly expected, but radically increased utilization awaits various technological advances, such as in research methods, deep drilling and in utilization technology. It's also important to keep in mind that geothermal resources are in fact best suited for direct use applications, since they consist of thermal energy, and the potential for such uses is vast as they can be based on resources of lower grade than those suitable for electricity generation. Thus, geothermal resources can contribute even more to what is expected to be an ever-intensifying battle against global warming and climate change by replacing fossil-fuel-based energy production.

Comprehensive training and capacity enhancement are prerequisites for a greatly increased role of geothermal energy in the future. The training activities ongoing in the World today, which are on a small scale albeit highly significant, must be greatly enhanced reaching more beneficiaries (governments, institutes, companies, and individuals). This can be partly done by making geothermal training part of mainstream university education as well as by strengthening existing programs and setting up new ones. In line with what has already been mentioned above, greater emphasis also needs to be placed on resources other than volcanic as well as on direct geothermal utilization.

REFERENCES

Georgsson, L.S., Haraldsson, I.G., and Ómarsdóttir, M.: UNU Geothermal Training Programme in Iceland: Sharing geothermal knowledge with developing countries for 41 years. *Proceedings World Geothermal Congress 2020+1*, Reykjavík, Iceland (2021).

Haraldsson, I.G., Axelsson, G., Ómarsdóttir, M., and Hardardóttir, V.: GRÓ Geothermal Training Programme in Iceland – Training activities abroad. *Proceedings World Geothermal Congress 2023*, Beijing, China (2023).

Haraldsson, I.G, Georgsson, L.S., and Ómarsdóttir, M: United Nations University Geothermal Training Programme in Iceland: Training Activities Abroad. *Proceedings World Geothermal Congress 2020+1*, Reykjavík, Iceland (2021).

Omenda, P., Mangi, P., Ofwona, C., Mwangi, M.: Country Update Report for Kenya 2015-2019. *Proceedings World Geothermal Congress 2020+1*, Reykjavík, Iceland (2021).

Ómarsdóttir, M., Axelsson, G., Haraldsson, I.G., and Hardardóttir, V.: Successes and challenges of Geothermal Training: Behind the Scenes Insight into the UNU/GRÓ Geothermal Training Programme. *Proceedings World Geothermal Congress 2023*, Beijing, China (2023).

Newson, J., and Green, R.M.: Geothermal training courses around the world. *J. Geotherm. Res. Soc. Japan*, **41**, No. 3 (2019), 91-99.