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The role of fellows of Geothermal Training Programme in Iceland in the geothermal sector in China

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ABSTRACT

The Geothermal Training Programme in Iceland has been running for 44 years, running under the umbrella of United Unions University (UNU)from 1979 to 2019, and transferred to be under UNESCO (UNESCO-GRO) in 2019. The training programme includes 6-month training on various specialties of geothermal knowledge and MS study. The fellows are from developing countries with geothermal potential,。 There have been 91 Chinese fellows participated in the 6-month training and 2 of them completed their MS study. The fellows have been the most important technical professionals in various geothermal related institutions in China, and made remarkable contributions to the geothermal exploration, utilization, research and education, management and so on. The paper is to summarize the present status and the geothermal related contributions of the Chinese follows, and some proposals also to be put forward.

1. INTRODUCTION

Geothermal energy is a kind of renewable and environmental friendly energy source that is used for power generation and various direct purposes. In China, high-enthalpy geothermal energy only occurs in Tibet, Yunnan and Taiwan, and electricity generation is only in Tibet at present. There are abundant low-enthalpy geothermal resources in China, distributed in most of the cities, provinces and autonomous regions, used for space heating, greenhouses, fish farming, bathing, health spa etc. Since the 1990's, space heating using geothermal fluid has been developing fairly fast in China, especially the big cities in northern China, such as Tianjin, Beijing and Xi'an. In the meantime, the shallow geothermal use by means of heat pump systems has also been growing fast, not only in northern part, but also in southern part of the country, meeting the needs of both heating and cooling. With the enforcement of ecological civilization construction, the "carbon peak" and "carbon neutrality" strategy in the country, it can be foreseen that geothermal utilization in China will continue to expand in the future.

Geothermal education and training of geothermal professionals is very important for the progress of the industry. But there is not any university giving systematic geothermal teaching for undergraduates, and there are only a few universities and research institutions with geothermal education for postgraduate students. Therefore, the Geothermal Training Programme in Iceland is very important for Chinese geothermal industry, which gives university graduates engaged in geothermal work intensive on-the-job training in their chosen fields of specialization. From 1979-2022, 766 scientists and engineers from 65 countries have completed the annual 6-month training. They have come from countries in Africa (39%), Asia (34%), Latin America (16%), Central and Eastern Europe (10%), and Oceania (1%). Among these have been 190 women (25%). GRÓ GTP also offers Fellows that complete the 6-Month Training the possibility to pursue a higher academic degree and extend their studies to MSc, or PhD degrees in geothermal sciences or engineering in cooperation with the University of Iceland or Reykjavik University (GRÓ GTP, 2023).

In 1979, a group of 3 geological scientists visited the Geothermal Training Programme for a short period of time. Since1980, Chinese fellows started to participate in the 6-month training course.So far, 91 Chinese fellows have completed the six- month specialized geothermal training in Iceland, accounting for 11.9% of the total number of fellows.

The Chinese fellows were mostly trained in reservoir engineering (RE), chemistry of geothermal fluid (CGF), geothermal utilization (GU), environmental studies (ES), and some of them were trained in borehole geology (BG), borehole geophysics (BG), drilling technology (DT) and geophysical exploration (GE). And the fellows are mostly from Beijing (30), Tianjin (25), Hebei (12), and also from Shandong (5), Tibet (5), Shaanxi (4), Jiangxi (3), Jiangsu (2), Yunnan (2), Guangdong (2), Liaoning (1), Henan (1) and Hainan (1). Among the 91 fellows, 26 are female, accounting for 28.6%.

The Geothermal Training Programme in Iceland played a very important role for the development of geothermal survey, assessment and utilization in China, by taking a large number of Chinese fellows. The fellows had been playing key roles in different periods of geothermal development. Presently, the fellows before 1988 have all retired, and some of the fellows later than 1988 have also retired, and there are still over 60 fellows at work.

In the paper, present situation and the achievement of the Chinese fellows will be presented according to the present institutions that the fellows work with, rather than the province where the fellows were trained, and the focus will be on the fellows after 1988, because the fellows before 1988 have been reviewedin detail in previous paper (Liu, 2020）, and the remarkable contribution of some fellows to the geothermal development in China will be manifested.

2. THE FELLOWS IN CENTRAL LEVEL INSTITUTIONS

There are a large number of the Chinese fellows working with central level institutions, including the Chinese Academy of Sciences (CAS), China Geology Survey (CGS) and Sinopec Star Co. Ltd. There are also 2 fellow working with other central level institutions

（Dr. Zhang Yuandong working with the Ministry of Water, and Dr. Tian Jiao working with the Institute of Earthquake Forecasting, China Earthquake Administration）.

2.1 Chinese Academy of Sciences

There are five fellows working in two institutes of CAS, the Institute of Geology and Geophysics (IGG) and Institute of Tibetan Plateau Research (ITPR) (Table 1), all of them are engaged in geothermal research and geothermal related activities.

Table 1: List of Fellows Working at CAS

Institution	Name	Year of training	Trained specialty	Geothermal job?
IGG	Dr. Pang Zhonghe	1988	CGF	yes
	Dr. Hu Shengbiao	1994	RE	yes
	Dr. He Lijuan	1999	RE	yes
	Dr. Li Yiman	2017	CGF	yes
ITPR	Dr. Zhao Ping	1991	CGF	yes

Dr. Pang Zhonghe is the director of Sino-German Geothermal Center, and is also the director of Geothermal Committee of China Geophysical Society. He worked for IAEA for more than 20 years, presided on global projects on Hydrology and Geothermal Applications in Nuclear Science and Technology. In the past 10 years, he was in charged of a number of geothermal projects, and got important achievements, such as the heat accumulation theory of large karst geothermal reservoir that is successfully applied in geothermal projects in Xiong'an New Area. He was the member of Board of IGA for 2 terms, leading the geothermal cooperation between China and the world, and played a key role in China's bidding for host of the 2023 World Geothermal Congress. He has published more than 200 papers with more than 4500 international citations and presided on 6 technical standards related to geothermal.

Dr. Zhao Ping made a lot of contributions to the geothermal research in Tibet. He worked with IGG for a rather long time, and was the vice director of IGG for several years. In 2013, he was appointed as the vice director of ITPR. He is very good at chemistry and isotope of geothermal fluids research. He has jointly published five academic monographs and more than 40 technical papers. One of his representative paper is "Limited understanding on thrusting of India below Tibet: $^{3}He/^{4}He$ analysis of thermal springs locates the mantle suture in continental collision (in PNAS, 2022)". He is now the chief scientist of a national scientific project " Clean Energy Status and Perspective Evaluation" that is involved in the Second Tibetan Plateau Scientific Exploration and Research Program".

Dr. Hu Shengbiao is mainly occupied by research of terrestrial heat flow measurement, lithospheric thermal structure, geothermal resource evaluation, thermal history recovery of oil and gas basins, cooling and uplift rate of orogenic belts and low temperature chronology. He is a member of the International Heat Flow Committee and the International Low Temperature Thermochronology Committee. He completed the newest territorial heat flow map in China. He completed more than 30 geothermal projects, and the simulation system for oil and gas basin thermal history recovery he developed is widely used in geothermal sector in China. He published more than 100 papers and won important scientific prizes.

Dr. He Lijuan also works on studies of terrestrial heat flow, basin thermal history, and numerical simulation of lithospheric tectono-thermal evolution. She is a member of the International Heat Flow Committee and general secretary of the Geothermal Committee of the Chinese Geophysical Society. Based on numerical modeling, she explained the significance of pacific plate subduction on destruction of North China Craton from geothermal perspective. She proposed a lithospheic tectono-thermal evolution model for mutil-stage extensional basins, and revealed the shallow tectono-thermal response of lithospheric extension evolution quantitatively.

2.2 China Geology survey

2.2.1 Institute of Hydrogology and Environmental Geology (IHEG)

IHEG is in the City of Shijiazhuang, Hebei Province, and is an institute under CGS, mainly responsible for hydrogeology, environmental geology and geothermal geology projects funded by CGS. There are 3 fellows working with IHEG presently (Table 2), engaged in a number of geothermal projects of geological investigation and scientific research. Recently, CGS takes geothermal as one of the most important fields of geological survey, for supporting the clean energy strategies of the country.

Table 2: List of Fellows Working at CHEG

Institution	Name	Year of training	Trained specialty	Geothermal job?
IHEG	Dr. Wang Guiling	1991	RE	Yes
	Miss Wang Wanli	2016	RE	Yes
	Miss Xi Yufei	2018	GE	Yes

Dr. Wang Guiling is the director of Geothermal Exploration and Utilization Research Department of IHEG, and is also the leading scientist on geothermal for CGS, responsible for geothermal projects planning, implementation, technical guidance and so on. In recent years, his team completed the national shallow geothermal resources assessment, national mid-deep geothermal resources assessment, and completed the geothermal exploration and resources assessment for the Xiong'an New Area, participated in the pioneering development of hot dry rock resources in the Gonghe Basin, Qinghai Province. He also presided over 30 scientific research projects, published over 200 papers and 11 monographs. He was awarded “National Labor Medal”, “Special government allowances by the State Council” and so on, and he is also a foreign academician of Russian Academy of Natural Sciences.

2.2.1 The Center of Hydrogology and Environmental Geology (CHEG)

There are 3 fellows working with CHEG (Table 3), which is an institution under CGS, responsible for hydrogeology, environmental geology and geothermal exploration and research. After completed the geothermal training and returned from Iceland, they become the most important geothermal scientists of the institution.

Table 3: List of Fellows Working at CHEG

Institution	Name	Year of training	Trained specialty	Geothermal job?
CHEG	Dr. Li Shengtao	2013	RE	Yes
	Miss Long Hui	2013	BG	Yes
	Mr. Liu Donglin	2017	RE	Yes

Mr. Li Shengtao has been the leader for a team with about 30 geothermal professionals for a few years, and his team has completed more than 10 geothermal projects, including geothermal exploration in Xiongxian, Xiong'an New Area, geothermal exploration around Dongli, Tianjin. At present, his team is undertaking a large-scale geothermal project, that is the hot dry rock exploration in East China.

Mr. Liu Donglin worked in Tianjin before 2019, on geothermal resources monitoring, reinjection, resource assessment. He joined CHEG in 2019 and started working together with Mr. Li Shengtao, and become a key member for geothermal exploration and research projects in CHEG.

2.2.3 The Others Fellows in CGS

There area a few fellows working with other institutions under CGS, including Dr. Chen Zhongyu , Dr. Pang Jumei and Dr. Yin Lihe, working with the Command Center of Natural Resource Comprehensive Survey (CCNRCS), and Mr. Du Jizhong, working with Shenyang Geology Survey Center (SGSC) (Table 4).

Table 4: List of Fellows Working at Other Institutions under CGS

Institution	Name	Year of training	Trained specialty	Geothermal job?
CCNRCS	Dr. Chen Zhongyu	1995	CGF	Partly
	Dr. Yin Lihe	2002	RE	No
	Dr. Pang Jumei	2010	RE	Yes
SGSC	Mr. Du Jizhong	2001	BG	Partly

Dr. Chen Zongyu had long been working with IHEG, until he was appointed as the director of Groundwater Division in the headquarters of CCNRCS in 2020. His research was mostly related to the application of isotope technique on groundwater and geothermal systems, and got outstanding achievements. He has been responsible for a large number of projects of the National Natural Science Foundation, and has co-authored six monographs and published about 100 papers.

Dr. Yin Lihe worked in the Xi’an Geology Survey Center for a long time until he was appointed the director of the Urumqi Center under CCNRCS. He is good at hydrogeology in drought areas, especially the relationship of groundwater and ecology. Because of his remarkable achievements, he was taken into the Leading Scientists Plan by the Ministry of Natural Resources.

Mr. Du Jizhong is the leading scientist for hydrogeology and geothermal in SGSC, which is one of the six regional center of CGS, and responsible for the project management and implementation for Northeast China. He is familiar with geothermal in Northeast China, and with rich achievements.

2.3 Fellows in Sinopec Star Co. Ltd and related joint venture

The business of Sinopec Star Co. Ltd focuses on new energy, and geothermal is the most important. It has completed a few large scale space heating projects using geothermal, such as the “no-smoke city” in Xiongxian. Sinopec Star Co. Ltd has become the leading enterprise of geothermal sector in China. There are 4 fellows working with Sinopec Star Co. Ltd or a joint venture related, that is Green Energy Geothermal (GEG), including Miss Sun Caixia, Mr. Huan Jiachao Miss Zhao Na (works with Tianjin Branch of GEG) and Mr. Ren Xiaoqing (works with Xi’an Branch of GEG) (Table 5).

Table 5: List of Fellows Working at Sinopec Star Co. Ltd

Institution	Name	Year of training	Trained specialty	Geothermal job?
GEG	Miss Sun Caixia	2005	GU	Yes
	Miss Zhao Na	2010	ES	Yes
	Mr. Ren Xiaoqing	2018	DT	Yes
Sinopec Star Co.	Mr. Huang Jiachao	2009	RE	Yes

Miss Sun Caixia has been the technical chief of Green Energy Geothermal that is a joint venture between Sinopec Star Co. Ltd and a Icelandic company, since she completed her training in Iceland. Green Energy Geothermal has successfully set up and run the space heating projects in Xiongxian and Xianyang etc., demonstrating the sustainable use of geothermal resources, through reinjection of the used tail water back into the geothermal reservoir and the rational management. Miss Sun is closely involved in these geothermal projects.

Mr. Huang Jiachao did his MS study in the Geothermal Training Programme in Iceland, after the 6-month training. He worked on the geothermal space heating project in Xiongxian, Hebei Province, and made big contribution on the construction of "no smoke city". At present, he is the director of a dipartment in the New Energy Institute in the headquarter of Sinopec Star Co. Ltd, responsible for geothermal projects. He was closely involved in the application of WGC 2023, and is an important member of the Organization Committee of WGC 2023.

3. THE FELLOWS IN PROVINCIAL LEVEL INSTITUTIONS

3.1 The fellows in the City of Beijing

Beijing, the capital of China, has abundant low-enthalpy geothermal resources, which are mainly used for space heating and recreation, and it is in the leading place in China about the shallow geothermal use by means of heat pump systems. There are 12 fellows working for 5 institutions, in which 3 in Beijing Institute of Geology and Mineral Survey (BIGMS), 4 in Beijing Institute of Geo-Environment Monitoring (BIGEM), 2 in Beijing Institute of Engineering Geology (BIEG), 1 in Beijing Institute of Geothermal development (BIGD), and 2 fellows in Beijing Huaqing Geothermal Development Group Co. Ltd (BHGD) (Table 6).

Table 6: List of Fellows Working at Institutions in the Municipality of Beijing

Institution	Name	Year of training	Trained specialty	Geothermal job?
BIGMS	Miss Cui Yu	2011	RE	Partly
	Miss Yu Yuan	2005	GC	Yes
	Mr. Han Zheng	2008	RE	Partly
BIGEM	Dr. Liu Jiurong	1999	RE	Partly
	Dr. Sun Ying	2005	RE	Partly
	Dr. Wang Shufang	2009	RE	Partly
	Dr. Guo Gaoxuan	2008	RE	Partly
BIEG	Mr. Yang Quanhe	2006	RE	Partly
	Mr. Xu Wei	2004	RE	Yes
BIGD	Mr. Fu Changhong	2012	RE	Yes
BHGD	Mr. Yin Heng	2003	GU	Yes
	Mr. Xu Youshi	2003	RE	Yes

Miss Yu Yuan did a lot in GHP use in Beijing and other parts in China, such as the GHP system for the New Office Building Area for the Government of Beijing in Tongzhou, which is with a heating and cooling service floor area of about 400 million m^2. She is also the General Secretary of the Geothermal Committee of China Mining Association, which is an important no-governmental institution related to geothermal.

Dr. Liu Jiurong is the Chief Engineer for BIGEM. He was in charge of over 30 geothermal projects, related to geothermal well designing, drilling and completion, geothermal reinjection, resources assessment, regional geothermal planning and so on. He applied the reinjection knowledge learned during the geothermal training in Iceland in Beijing and Xiongxian, Hebei Province, promoted geothermal reinjection in China remarkably. He participated in the compilation of a few technical standards related to geothermal exploration, resource assessment, hot spring water quality and so on. He was awarded "Special government allowances" by the State Council, and is selected as the Leading Talent for groundwater and geothermal by the Ministry of Natural Resources.

Dr. Wang Shufang, is the director of Groundwater Monitoring department, and he is also good at borehole geology, reinjection, resources assessment and numerical modeling of geothermal systems. He supervised a great number of geothermal well projects in

Beijing and Xiongxian, Hebei Province, completed the reinjection experiment and numerical model for Xiongxian, greatly supported the rational management of geothermal resources.

Mr. Xu Wei is the director of Geothermal department in BIEG, and he is in charge of the geothermal system monitoring in Beijing, which has been in operation for over 50 years, played an important role for the sustainable management of geothermal resources in Beijing.

3.2 The fellows in the City of Tianjin

The geothermal in Tianjin is stored in both karst and sandstone sediments, and is with great geothermal potential and the use for space heating is in the first place in China. There are 8 fellows working in 5 institutions of the Municipality of Tianjin presently (Table 7), including 2 in Tianjin Bureau of Planning and Natural Resources (TBPNR), 1 in No.2 Institute of Tianjin Geological Exploration (No.2 ITGE), 1 in Tianjin Geological and Mineral Testing Center (TGMTC), 3 in Tianjin Geothermal Exploration & Development Designing Institute (TGEDDI) and 1 in Tianjin Institute of Surveying and Mapping Co.ltd (TISMC).

Table 7: List of Fellows Working at Institutions of the Municipality of Tianjin

Institution	Name	Year of training	Trained specialty	Geothermal job?
TBPNR	Miss Wang Kun	1998	RE	Yes
	Mr. Li Ljun	2003	RE	Yes
No.2 ITGE	Mr. Cheng Wanqing	2001	EE	Yes
TGMTC	Li Ljunfeng	2004	CGL	No
TGEDDI	Mr. Wang Liancheng	2005	GU	Yes
	Miss Li Yuanyuan	2010	GC	Yes
	Miss Ruan Chuanxia	2011	RE	Yes
TISMC4	Mr. Sheng Zhongjie	2006	ES	No

Most of the fellows in Tianjin were taken when they work with TGEDDI, a institute dedicated to geothermal in Tianjin. Miss Wang Kun worked with TGEDDI before 2007, and is well known for her achievements in geothermal reinjection, modeling of geothermal reservoir in the geothermal community in China. She completed a number of geothermal research projects in Tianjin, made big contributions in the sustainable use of geothermal resources in Tianjin as well as in China. Because of her achievements, she was invited to give guest lectures in 2008 in the Geothermal Training Programme.

Miss Ruan Chuanxia is the director of the Geothermal Exploration Department of TGEDDI. Her hard-working is known among the Chinese fellows and the geothermal community in China, because that she had awarded 2 projects by China Natural Sciences Foundation. She also is in charge of a lot of geothermal projects in Tianjin and other part in China, such as the geothermal resources assessment projects for two important areas in the Xiong'an New Area.

3.3 The fellows in Shandong Province

Shandong is a province with great needs and potential for geothermal, and the government pays a lot of attention on geothermal exploration, utilization and scientific research. There are 3 fellows working with Shandong Provincial Bureau of Geology and Mineral Resources (SDGM) and its subordinate institutions (Table 8).

Table 8: List of Fellows Working at Shandong Province

Institution	Name	Year of training	Trained specialty	Geothermal job?
SDGM	Dr. Kang Fengxin	2000	RE	Yes
	Miss Zheng Tingting	2015	RE	Yes
	Mr. Shi Meng	2019	RE	Yes

Dr. Kang Fengxin is the director of the Department of Environmental and Geothermal Geology, Shandong Provincial Bureau of Geology and Mineral Resources (SDGM) and the director of Shandong Provincial Research Center for Groundwater and Geothermal Resources. He is the visiting professor at a few universities. His research focuses on geothermal energy and groundwater resources. He has been in charge of scientific projects funded by National Natural Science Foundation of China and other institutions. He has established geothermal accumulation mechanisms, prospecting models of various geothermal fields in China. He put forward a dynamic calculation method for sustainable yields of geothermal resources with balanced exploitation and reinjection. His scientific contribution includes more than 90 articles and technical book publications, 14 national and provincial industry standards and 23 patents and computer software copyrights. As the geothermal project leader, he has won four First Prizes and 8 Second Prizes of Science and Technology Progress, awarded by Shandong Provincial People's Government and Ministry of Natural Resources of the People's Republic of China.

Miss Zheng Tingting has worked with SDGM on geothermal, and is currently doing her Ph.D. study in Earth Sciences at the University of Iceland on a fellowship from the GRÓ Geothermal Training Programme. She served as a technical paper reviewer for World Geothermal Congress (WGC) 2020+1 in Reykjavik, and a member of the technical committee of WGC2023 in Beijing. She is an active member of the Women in Geothermal (WING), as a female expert working in the geothermal community while pursuing her study.

3.4 The fellows in Tibet Autonomous Region

Tibet is rich with high temperature geothermal, and is the only place with geothermal power generation at present. There were 5 fellows from Tibet who have completed the six months geothermal training in Iceland, and 3 of them are still active in geothermal related activities (Table 9), including Mr. Pingtsoe Wangyal who is the director of the Tibet Institute of Geo-Environmental Monitoring (TIGEM), Mr. Du Shaoping and Mr. Fan Xiaoping who worked with Geothermal Geological Brigade of Tibet (GGBT) before retired in 2015.

Table 9: List of Fellows Working for Tibet Autonomous Region

Institution	Name	Year of training	Trained specialty	Geothermal job?
TIGEM	Mr. PingtsoeWangyaL	1992	CTF	partly
GGBT	Mr. Du shaoping	1997	CTF	partly
GGBT	Mr. Fan Xiaoping	2002	RE	partly

Mr. Du Shaoping is working with a private company on geothermal projects in Tibet at present although officially retired. And Mr. Fan Xiaoping was employed by a private energy company in 2016 and worked in geothermal fields in western Sichuan and Tibet. Also he participated in the compilation of the geothermal sections of “the Chinese Annals of Mineral Geology- Tibet volume” and the geothermal sections of “Overview of Energy Research in China” in 2018. He is the main author of “the Research Report on Geothermal Energy Development in Tibet Autonomous Region” in the year 2019 – 2020.

3.5 Fellows working in others provinces

There are some fellows working with institutions of a few other provinces, such as Dr. Xu Shiguang in Yunnan Geology Exploration Co. Ltd (Group) (YGEC), Miss Li Hongying in the Xiong'an New Area, Hebei Province(XANA), Mr. Huang Maochang in Hainan Province, and Miss Hou Haiyan in Henan Province, Mr. Luo Heng in Guangdong Province (Table 10).

Table 10: List of Fellows Working at institutions of other provinces

Institution	Name	Year of training	Trained specialty	Geothermal job?
YGEC	Dr. Xu Shiguang	1995	RE	Partly
XANA	Miss Li Hongying	2000	ES	Yes
Unknown	Mr. Huang Maochang	2001	ES	No
Unknown	Miss Hou Haiyan	2003	ES	No
Unknown	Mr. Luo Heng	2004	ES	No

Yunnan is a province rich with high and low temperature geothermal, and the utilization is mainly on health spa and recreation etc. Dr. Xu Shiguang is the Chief Engineer of YGEC, and he is working on geological disaster, groundwater and geothermal. He completed the projects about geothermal geological exploration around Kunming, Yunnan, the study of Rehai geothermal system and so on. He published a few books about geothermal systems, greatly supported geothermal development and management in Yunnan.

In 2017, China announced plans to establish Xiong’an New Area, located about 100 kilometers southwest of Beijing, and it is a strategy that will have lasting importance for the millennium to come and a significant national event. There is great geothermal potential in XANA, stored both in karst reservoir, and sandstone reservoir. The geothermal use for space heating in Xionxian that is one of the three counties of XANA, had extremely good effects. Miss Li Hongying had been in charge of the geothermal management in XANA since the start in 2017. Because of proper planning and management, the geothermal use in XANA has been in a sustainable manor. She is active in the publication of the clean and renewable feature of geothermal energy.

4. THE FELLOWS IN UNIVERSITIES

Some fellows were recruited from Tianjin University and East China University of Technology (ECUT), and there are also some fellows who transferred to universities. The situation and contributions of the Chinese fellows in universities will be introduced below.

4.1 The fellows in Tianjin University

There are 3 fellows still working in Tianjin University (Table 11).

Table 11: List of Fellows Working at Tianjin University

Institution	Name	Year of training	Trained specialty	Geothermal job?
TU	Dr. Dai Chuanshan	1992	RE	YES
	Dr. Lei Haiyan	2004	GU	YES
	Dr. Zhang Wei	2008	GU	YES

Dr. Dai Chuanshan is the head of Geothermal Center in Tianjin University, and his research interests include geothermal utilization, reservoir modelling, heat and mass transfer in porous media; multiphase flow heat transfer, enhanced heat transfer, etc. He has been responsible for more than 10 National-level projects, published two geothermal monographs, as well as more than 40 high-level Journal papers. Recently Dai's research team independently developed a numerical simulation software for geothermal development and utilization using Lattice Boltzmann method, and established the first open-loop geothermal single well system in Hebei, China. Currently Dai is undertaking two National-level projects: (1) In-situ forced circulation heat transfer technology for hot dry rock. (2) High-efficiency heat extraction technique for deep open-loop geothermal single well.

Dr. Lei Haiyan did her post-doc research at ISOR in 2011 after the 6-months training. She was a visiting scholar at Malardalen University in Sweden in 2017 and has been a post-doc at Lawrence Berkeley National Laboratory (LBNL) from 2018 to 2020. She was an Adjunct Professor at Reykjavik University. She has been responsible for 5 National-level research projects, published two geothermal monographs and more than 40 high-level Journal papers, and has obtained 5 national patents.

4.2 China University of Technology (East China)

There are three fellows working for China University of Technology (East China) (ECUT), Dr. Zhanxue Sun, Dr. Zhanshi Zhang and Dr. Gongxin Chen. (Table 12).

Table 12: List of Fellows Working at ECUT

Institution	Name	Year of training	Trained specialty	Geothermal job?
ECUT	Dr. Zhanxue Sun	1998	CGF	Yes
	Dr. Zhanshi Zhang	2001	CGF	Partly
	Dr. Gongxin Chen	2008	CGF	Partly

Dr. Zhanxue Sun has been the president of ECUT since 2019. He has been working on chemistry of groundwater and geothermal systems for almost 40 years. He is good at water-rock interactions and gas geochemistry of geothermal systems, radioactive heat-production. In recent years, he mainly engaged in hot dry rock research in SE-China, by means of hydrogeochemical and isotopic geochemistry of thermal waters as well as other approach. He has published more than 30 research papers and 6 books related to the geothermal water.

4.3 Fellows in other universities

There are a few other fellows working the a few other universities, including Dr. Wang Li in Beijing Normal University (BNU), Dr. Wang Liangshu in Nanjing University (NU), Dr. Zheng Xilai in Ocean University of China (OUC), Dr. Bi Erping in China University of Geosciences (Beijing)(CUGB), Dr. Liu Junrong in China University of Petroleum (East China) (CUP), Miss Cao Fenglan in Tianjing Medical University (TMU) and Dr. Luo Chao in Houzhou University (HU) (Table 13). Most of them transferred from research institutions to universities.

Table 13: List of Fellows Working at Other Universities

Institution	Name	Year of training	Trained specialty	Geothermal job?
BNU	Dr. Wang Li	1989	GU	No
NU	Dr. Wang Liangshu	1991	RE	No
OUC	Dr. Zheng Xilai	1993	CTF	No
CUGB	Dr. Bi Erping	1997	CTF	Partly
UPC	Dr. Liu Junrong	2011	RE	Yes
TMU	Miss Cao Fenglan	2008	GU	yes
HC	Dr. Luo Chao	2014	GU	Yes

Dr. Liu Junrong is a professor at the School of Petroleum Engineering, UPC (East China). His teaching and research specialty is in intelligent oil field, downhole fiber optic monitoring and oilfield geothermal development and utilization. Since 2017, he has been in charge of five geothermal-related research projects. He has published more than 40 articles and books, six of which are on geothermal. He has authorized 11 geothermal-related invention patents.

Dr. Lou Chao participated in the training courses when he worked at the Guangzhou Institute of Energy Conservation, CAS and now he became an associate professor of Thermal Power Engineering in Huizhou University. His current research area includes geothermal power generation, geothermal cascade utilization, heat pump and building energy efficiency etc. He has published more than 20 papers in international journals.

5. ACTIVITIES OF THE GTP IN CHINA

The Geothermal Training Programme in Iceland not only trains fellows from China, but also in involved in other activities in China, such as lectures, consultation, training courses and cooperation on geothermal education and geothermal projects.

GTP employees, such as Dr. Ingvar Fridleifsson, Mr. Ludvic Georgsson and Dr. Gudni Axelsson, and the teachers often come to China and give lectures. They also conduct geothermal technical consultation in China, such as Dr. Gudni Axelsson and other teachers from Iceland stayed in Beijing for a long time for geothermal projects for 2008 Olympics in Beijing. Dr. Gudni Axelsson also gave a short geothermal course in Shandong in 2018.

In 2008, GTP organized the Workshop for Decision Makers on Direct Heating Use of Geothermal Resources in Asia, tegether with Tianjin Bureau of Land Resources and Real Estate Management (TBLRREM) and Tianjin Bureau of Geology and Mineral Exploration and Development (TBGMED) in Tianjin. Representatives from China and a few other Asian Countries participated in the workshop. The Icelandic and Chinese experiences and technique were shared in depth, and resulted in great improvements to geothermal space heating in China and other Asian countries (Fridleifsson, 2008).

In 2019, a Sino-Icelandic Geothermal Training course was launched in Beijing, China, and made a prime example of using Iceland's advanced geothermal utilization technology to successfully enhance the capacities building of geothermal experts in developing countries. This 4-week training is held in China for the first time, received positive responses from the trainees.

6. CONCLUDING REMARKS

The GTP in Iceland has taken 91 fellows from China for the 6-month geothermal training since 1980, and the fellows become the most important geothermal professionals and a few of them are playing leading roles in different aspects and different regions. Other activities of GTP in China, such as short courses and lectures, also have very positive effects on promoting the geothermal sector in China. The GTP also promoted the friendship between China and Iceland.

There will be more and more needs for geothermal professionals, and needs for international cooperation on geothermal in China, because that there is not proper geothermal education capacity in China. It is recommended that the UNSCO-GRO recruit more fellows from China and continue to offer short-term geothermal courses in China. In addition, It is suggested that UNSCO-GRO help certain university in China to offer geothermal courses for undergraduate .

The Compilation of this paper is really a big task due to the difficulties of collecting the information about the Chinese fellows from so many institutions and places. Unfortunately, the authors were unable to contact several fellows in Henan, Guangdong and Hainan Provinces, and some information may not be completely correct. The authors welcome any corrections.

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