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The Role of UNU Geothermal Training Programme on the Professional Man Power Build-up in China

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ABSTRACT

The Geothermal Training Programme of the United Nations University in Iceland has been operating successfully for over 41 years from 1979 to 2020. Till 2018, there will have been over 500 scientists and engineers, mostly from developing countries, trained in the programme. And the MSc and PhD programme has also been operated successfully. In 1979, 3 Chinese particitated in a short course in UNU-GTP, and In 1980, a group of Chinese fellows participated in the 6 month training programme. Till October, 2020, there will have been 92 Chinese fellows participated in the geothermal training, in which 89 of the fellows for the 6 month training, 2 fellows have got their MS degree and 1 Chinese fellow is doing her PhD in Iceland after completed the 6 month training. Beijing, Tianjin and Hebei are the areas that the most fellows come from. The Chinese fellows play very important roles in the geothermal development in the country, and many of them have become leading experts in their specialties. This greatly supported the geothermal development in the past two decades in China. The personals of UNU-GTP often come to China, and shared a lot of their expertise and know-hows in a lot of geothermal projects, such as the geothermal heating project in the Xiongan New Area. In the paper, the overall situation of the Chinese fellows will be introduced and status of a few fellows will be highlighted; the activities and come out of UNU-GTP personals in China will also be introduced. To meet the increasing needs of geothermal man power in China, some suggestions to UNU Geothermal Training Programme will also be put forward, such as starting training courses together with institutions in China.

1. INTRODUCTION

Geothermal is a kind of renewable energy that is used for power generation and various direct purposes. In China, high-temperature geothermal is only distributed in Tibet, Yunnan and Taiwan, and there are only scaled geothermal power stations in Tibet. In 2017, the total installed capacity of geothermal power generation in China has increased to 46.68MW (Tian, 2020). There are abundant low-enthalpy geothermal resources in China, distributed in most of the cities, provinces and autonomous regions, used for space heating, green house, fish farming, bathing, health spa etc. Since 1990's, space heating use has been developing fairly fast in China, especially in the big cities in the northern part of the country, such as Tianjin, Beijing and Hebei etc. On the other hand, the heating and cooling use of shallow geothermal resources by means of heat pump expanded tremendously recently. Till 2017, the installed capacity of geothermal direct use has been 239,823 MWt, and the energy use has been 384,456 TJ/a, still boasting the first place in the world (Tian, 2020). With the increasing awareness of CO2 emission control and air pollution, it is foreseen that geothermal utilization in China will continue to expand in the future. This also means that there will be greater needs for geothermal professionals in China.

Since 1979, the Geothermal Training Programme of the United Nations University (UNU-GTP) has been operating at Orkustofnun - the National Energy Authority of Iceland, with great success. The aim is to assist developing countries with significant geothermal potential to build-up groups of technical specialists that related to geothermal exploration and development. The priority is given to candidates from institutions where geothermal work is already under way. All candidates are selected by private interviews. Candidates from developing countries and most Central and Eastern European countries receive scholarship financed mostly by the Government of Iceland.

There have been 92 Chinese fellows participated in the geothermal training in Iceland, in which 89 completed the 6 month training, and 2 completed their MSc study in Iceland, and a female fellow is doing her PhD in Iceland under the framework of UNU-GTP. Of all the 92 fellows, 27 are female. Almost all the Chinese fellows returned to their geothermal post when they completed the training and MSc study, and they were very active in the geothermal exploration, utilization and management. On one hand, the UNU-GTP contributed a lot on the geothermal professional man-power build-up in China. On the other hand, it also promoted the cooperation and friendship between China and Iceland significantly.

2. OVERRALL OF CHINESE FELLOWS

In China, scaled geothermal use only started in 1970's. Hydrogeologists and petroleum geologists started the geological exploration for geothermal development. Geothermal expertise was badly needed in that time in China, regarding to the number of professionals and geothermal knowledge. The opening of UNU-GTP in Iceland in 1979 gave the Chinese professionals a good opportunity to learn advanced geothermal knowledge.

The 92 Chinese participated in the geothermal training course in Iceland are from 15 cities, provinces and autonomous regions, including Beijing (30), Tianjin (25), Hebei (12) and Tibet (5) etc. (Figure 1). In the 92 fellows, 27 of them are female, accounting for 29.3%. The Chinese fellows who participated in the training mostly specialized on reservoir engineering, chemistry of geothermal fluid, geothermal utilization and environmental studies (Table 1). Recently, geothermal utilization and environmental studies are becoming more and more popular among Chinese fellows, while reservoir engineering and chemistry of geothermal

fluid were still the very common specialties. This is because the needs for more geothermal utilization engineers and the increasing awareness of environment protection in China.

Figure 1. Number of Chinese UNU-GTP Fellows

from different cities, provinces and autonomous regions

Table 1 Specialties of Chinese fellows

Specialty	Number of fellows
Reservoir engineering	40
Chemistry of geothermal fluid	15
Geothermal utilization	16
Environmental studies	10
Borehole geology	4
Borehole geophysics	4
Drilling technology	2
Geophysical exploration	1
Total	92

In China, there is still not university education specialized in geothermal. A large part of the scientists working on geothermal are hydrogeologists, and some of them do not have knowledge of all the aspects related to geothermal. For instance, the reservoir engineers often have good understandings to the liquid movement, but often lack of knowledge about heat transportation in geothermal systems. Therefore, the UNU-GTP is a very good supplement and expansion to their geothermal knowledge. They also learn a lot of know-how from the teachers and their supervisors. For example, the computer programs LUMPFIT (Axelsson and Arason, 1992) and ICEBOX (Arason and Bjornsson, 1994) developed by Orkustofnun have been used in a lot of geothermal fields in China.

Till now, 68 of the Chinese fellows are working on geothermal and related post. And 17 fellows retired and 8 fellows changed their professions. The fellows are playing rather important roles for geothermal exploration and utilization in various part of the country. A number of the fellows have been leading geothermal experts in China.

3. FELLOWS FROM BEIJING

There have been 27 fellows from Beijing completed the 6 month geothermal training in Iceland, and 3 fellows participated in a short course in 1979. Miss Sun Caixia completed the MS study. The 5 fellows trained before 1985 have retired. Among the 25 fellows trained later than 1985, only Mr. Mu Ming (trained in 1992, is the Governor of a county in western China now) no long

work in Beijing now. Among the 24 fellows in Beijing, 18 of them work with public institutions related to geothermal, and 3 work with private companies related to geothermal, 1 in a Sino-Icelandic joint venture dedicated to geothermal (Ms. Sun Caixia), 1 work in no-geothermal post, and 1 is not contacted successfully (Table 2).

Among the 18 fellows work with geology related public institutions, 5 in the Chinese Academy of Sciences (CAS), 4 in Beijing Institute of Geo-Environment Monitoring; 3 in Beijing Institute of Geology and Mineral Resources (BIGMR), and each 1 in 6 other institutions

The fellows from Beijing made a lot of contributions to the geothermal development in Beijing, as well as other parts in China. The elder fellows from Beijing, including Mr. Xin Kuide, Ms. Huang Shangyao etc., played key roles in the founding of geothermal industry. Dr. Hu Shengbiao, maintains the geothermal heat flow database in China. After working with the International Atomic Energy Agency for a few years, Dr. Pang Zhonghe came back to his previous post in CAS in 2000, and was in charge of a number of important geothermal research and application projects. He was also the board member of the IGA for the last 2 terms, played an very important role for the communication between Chinese geothermal community and the other countries. The fellows working in Beijing Municipality are playing leading roles in the geothermal exploration, utilization, management and protection in Beijing, especially the geothermal reinjection and geothermal heat pump use for heating and cooling. They are also involved in a lot of geothermal projects in other parts of China, such as the construction of "No Smoke City" by geothermal district heating in Xiongan New Area, which is about 100 km south of Beijing, and is planned for replacing the "no capital function" of the City of Beijing.

4. FELLOWS FROM TIANJIN

Since 1983, there have been 25 Chinese fellows from Tianjin participated in the 6 month geothermal training in Iceland. Their academic backgrounds range from geology, hydrogeology, mechanical, and chemical engineering etc. They are mostly from two institutions: 18 from Tianjin Geothermal Exploration and Design Institute, the only institution responsible for the geothermal in the Municipality of Tianjin; 3 from Heat Energy Engineering College of Tianjin University; 3 from other institutions under the Municipality of Tianjin. Among the 25 fellows, 8 have retired, 14 are working on geothermal, 3 fellows moved to other countries (Table 3).

After the training in UNU-GTP, combined with practical experience in geothermal, most of the fellows from Tianjin have become geothermal specialists of various aspects. A number of them are working at reservoir engineering, chemistry of geothermal fluid and geothermal utilization etc.

Tianjin is rich with low-enthalpy geothermal, but the scaled geothermal exploration only started in 1984. Ms. Lu Run, trained in 1983, is the first UNU-GTP fellow from Tianjin, and then 5 others participated the training in 1984 and 1985. They played leading role in the geothermal exploration and utilization in Tianjin, such as the first geothermal field (Wanglanzhuang) and the second geothermal field (Shanlingzi). Mr. Zhang Baiming participated in the training in 1994, used to be the director of TGEDI, and made a lot of contributions to the geothermal utilization in Tianjin. He retired about 2 years ago, but is still working on geothermal in Tianjin, sharing his expertise in a lot of geothermal projects. Dr. Wang Kun, who used to work with TGEDI, and works with the Tianjin Bureau of Natural Resources and Real Estate Management, participated in a lot of geothermal practice in Tianjin and other part in China, especially in geothermal reinjection and numerical modelling. Mr. Chen Wanqing, Mr. Li Junfeng and others work with TGEDI are all involved in the management of TGEDI, or department leaders. The achievements of geothermal sector in Tianjin are all closely related to these fellows. Dr. Dai Chuanshan, is a professor in Tianjin University. He is one of the leading experts on numerical simulation of geothermal field, and has got a few important research achievements. Dr. Lei Haiyan, also work with Tianjin University, got her PhD in geothermal utilization in Iceland, funded and guided by UNU-GTP. She is doing well in a few research projects.

5. FELLOWS FROM HEBEI PROVINCE

There have been 12 fellows from Hebei Province，which is with the best geothermal reserve condition, completed in the UNU geothermal training. The first one was Mr. Yao Zu-jin, trained in 1980. There are 9 fellows from 2 institutes under China Geology Survey, which is responsible for most of the national level geological survey projects, including geothermal. One of these is the Institute of Hydrogeology and Environment Geology (IHEG), where 7 of the fellows came from, including Mr. Yao Zu-jin, Mr. Sun Kaiyao, Dr. Wang Guilin, Dr. Chen Zongyu, Dr. Bi Erping etc. The other institute is the Hydrogeolgy and Environment Geology Center (HEGC), where 3 fellows came from. And 2 fellows from Hebei Province are from the City of Baoding, including Dr. Wang Li and Miss Li Hongying.

Mr. Yao Zu-jin and Mr. Sun Kaiyao were two of the leading geothermal experts in China before their retirement. Dr. Wang Li, who completed the training in 1889, went to Beijing Normal University, and his job is not related to geothermal at present. Dr. Bi Erping, also moved to Beijing, and is a professor on groundwater in China Geosciences University (Beijing), and he is also involved in geothermal projects. Miss Li Hongying, used to work with the Bureau of Land Resources in the City of Baoding, has been appointed as an officer in Xiongan New Area, responsible for geothermal related affairs.

It has to be mentioned is Dr. Wang Guilin, who completed the training in 1991, and after then, he made a lot of achievements related to geothermal. As the project leader, he completed the projects of national geothermal investigation and assessment project, national shallow geothermal (by means of ground source heat pump system) investigation and potential assessment. At present, he is in charge of the geothermal project of EGS investigation in a few area with high temperature potential, and he is also in charge of the project of geothermal investigation and potential assessment for Xiongan New Area, which is planned to replace the "no capital function of the City of Beijing", and the investment of these projects is about 500 million Yuan each year. In the same time, he is also in charge of 2 national scientific research projects related to geothermal.

Table 2 The situation of UNU-GTP Fellows from Beijing.

Name	Year of training	Field of Training	Work engaged in /Institution
Zheng Chuncai	1979	Short course	Retired
Xin Kuide	1979	Short course	Retired
Huang Shangyao	1979	Short course	Retired
Tang Song-ran	1981	Drilling	Retired
Wu Liya	1984	Utilization	Retired
Pang Zhonghe	1988	Chemistry	Geothermal/prof. in CAS
Zhao Ping	1991	Chemistry	Geothermal/prof. in CAS
Wu Ming	1992	Res. Eng.	Governor of a county in western China
Hu Baigeng	1993	Res. Eng	No-geothermal
Hu Shengbiao	1994	Res. Eng	Geothermal/prof. in CAS
Pan Xiaoping	1998	Chemistry	Partly geothermal / private company
Liu Jiurong	1999	Res. Eng.	Geothermal & groundwater/Chief engineer with BIGEM
He Lijuan	1999	Res. Eng.	Geothermal /prof. in CAS
Yin Heng	2002	Utilization	Geothermal/ private company
Xu Youshi	2002	Res. Eng.	Geothermal/ private company
Zhang Yuandong	2003	Res. Eng.	Groundwater/ WRI
Xu Wei	2004	Chemistry	Geothermal/BIGE
Sun Caixia	2005	Utilization/MSc	Geothermal/ technical chief of a Sino-Icelandic joint venture
Sun Ying	2005	Res. Eng.	Geothermal & groundwater/ division leader of BIGEM
Yu Yuan	2005	Environment	Geothermal/ BIGMR
Wang Wei	2006	Chemistry	Lost contact
Yang Quanhe	2006	Res. Eng	Geophysics & geothermal/chief engineer of BIGT
Han Zheng	2008	Res. Eng	Geological information system/ BIGMR
Guo Gaoxuan	2008	Res. Eng	Geothermal & groundwater / division leader of BIGEM
Wang Shufang	2009	Res. Eng	Geothermal & groundwater/ division leader of BIGEM
Huang Jiachao	2009	Res. Eng	Geothermal / Sinopec
Pang Jumei	2010	Res. Eng	Groundwater & geothermal/CGS
Cui Yu	2011	Res. Eng	Groundwater/ BIGMR
Fu Changhong	2012	Res. Eng	Geothermal /BIG
Li Yiman	2017	Chemistry	Geothermal/ Assistant Prof. in CAS

Table 3 The situation of UNU-GTP Fellows from Tianjin

Name	Year of training	Field of Training	Work engaged in /Institution
Lu Run	1983	Res. Eng.	Retired
Li Zhi	1984	Utilization	Retired
Zhang Jinzhang	1984	Borehole geology	Retired
Lu Zhenyuan	1985	Geophysical exploration	Retired
Qi Baoxiang	1985	Borehole geology	Retired
Chen Zhenxia	1985	Borehole geology	Retired
Chen Xinming	1987	Utilization	Retired
Bai Liping	1991	Utilization	Emigrated to Australia
Dai Chuanshan	1992	Res. Eng	Geothermal / Tianjin Univ.
Dong Zhilin	1993	Res. Eng.	Emigrated to New Zealand
Li Youji	1993	Utilization	Emigrated to New Zealand
Zhang Baiming	1994	Res. Eng.	Retired, still working on geothermal
Wang Kun	1998	Res. Eng.	Geothermal /Tianjin Auth. of Natural Resources
Chen Wanqing	2001	Environment	Geothermal / TGEDI
Li Jun	2003	Res. Eng.	Geothermal / TGEDI
Li Junfeng	2004	Environment	Geothermal / TGEDI
Lei Haiyan	2004	Utilization	Geothermal/ Tianjin Univ.
Wang Liancheng	2005	Utilization	Geothermal/ TGEDI
Sheng Zhongjie	2007	Environment	Geothermal/ TGEDI
Zhang Wei	2008	Utilization	Geothermal/ Tianjin Univ.
Cao Fenglan	2008	Utilization	Geothermal/ Tianjin Univ.
Zhao Na	2010	Environment	Geothermal/ TGEDI
Li Yuanyuan	2010	Chemistry	Geothermal/ TGEDI
Ruan Chuanxia	2011	Res. Eng.	Geothermal/ TGEDI
Liu Donglin	2017	Res. Eng.	Geothermal/ TGEDI

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Table 4 The situation of UNU-GTP Fellows from Hebei Province.

Name	Year of training	Field of Training	Work engaged in /Institution
Yao Zu-jin	1980?	Res. Eng.	Retired/ IHEG
Sun Kaiyao	1981	Utilization	Retired
Wang Li	1989	Utilization	No-geothermal/ prof. of Beijing Normal Univ.
Wang Guiling	1991	Res. Eng.	Geothermal/prof. IHEG
Chen Zongyu	1995	Chemistry	Isotope geo. and geothermal/ prof. IHEG
Bi Erping	1997	Chemistry	Groundwater and geothermal/China Univ. of Geosciences
Li Hongying	2000	Environment	Geothermal/Gov. officer in Xiongan New Area
Wu Xianghui	2012	Res. Eng.	Geothermal/ HEGC
Li Shengtao	2013	Res. Eng.	Geothermal/ HEGC
Long Hui	2013	Borehole Geology	Geothermal/HEGC
Wang Wanli	2016	Res. Eng.	Geothermal/ IHEG
Xi Yufei	2018	Geophysics	Geothermal/ IHEG

6. FELLOWS FROM OTHER PARTS OF CHINA

Apart from the fellows from Beijing, Tianjin and Hebei, there have been 27 fellows from other part of the country participated in the 6 month training in Iceland. They are mostly playing important roles in the geothermal exploration, research and development in the institutions they work with. There are 4 fellows retired, 17 fellows are doing geothermal related jobs, 2 doing other geological jobs, 2 of them changed their professions, and 1 was not contacted successfully.

Mr. Sun Zhanxue, newly promoted the president of the East China University of Technology that is in Jiangxi Province, are very active in geothermal research and education. Mr. Xu Shiguang, working with the Yunnan Institute of Geological Exploration, is involved in a lot of the geothermal projects in Yunnan Province. Mr. Kan Fengxin is the leading geothermal experts in Shandong Province, and his achievements in geothermal reserve study, sandstone reservoir reinjection etc. have been well applicated in Shandong province and other parts in China. Because of the highland condition, people work in Tibet retire at 50 years old. Therefore, 3 of the 5 fellows from Tibet have retired, and there are still 2 fellows, Mr. Pingtsoe Wangyal and Mr. Fan Xiaoping working on geothermal and are playing important roles in the geothermal development in Tibet.

7. THE ACTIVITIES OF UNU-GTP IN CHINA

The contribution of UNU-GTP to the geothermal sector in China is not only the training of the fellows, but also the Icelandic expertise. The teachers of the UNU-GTP often come to China for advisory of geothermal activities.

Before the Olympics in 2008 in Beijing, Dr. Ingvar B. Fridleifsson, the former director of UNU-GTP, and a few other Icelandic experts come to Beijing a few times, helped the geothermal institutions and the government for the geothermal projects related to the Olympics constructions; Gudni Axellson, a teacher and board member of the UNU-GTP, and a few other experts, participated in the geothermal district heating projects in Lishuiqiao Area and Yanqing County in Beijing. During the carry-out of the projects, they taught the Chinese geothermal professionals geothermal practice in situ.

The first UNU-GTP workshop in Asia "Workshop for Decision Makers on Direct Heating Use of Geothermal Resources in Asia" was held in Tianjin 11-18 May 2008. High ranking decision makers from China as well as other Asian countries with geothermal heating possibilities were invited. 16 former UNU fellows from China and a few from other countries participated in the workshop. There were about 50 lectures from Iceland, China, Japan, Germany, Poland and Switzerland and the other Asian countries on the workshop, including 15 lectures by 6 UNU-GTP teachers and 18 lectures by former UNU fellows from China and other countries (Georgsson, 2010).

Table 5 The situation of UNU-GTP Fellows from other parts of China.

Name	Year of training	Place	Field of Training	Work engaged in /Institution
Zhou Xi-xiang	1980	Sichuan	Borehole geophysics	Retired
Shen Xing-wu	1981	Tibet	Utilization	Retired
Yu Heping	1987	Tibet	Utilization	Retired
Wang Liangshu	1991	Jiangsu	Borehole geophysics.	Partly geothermal/prof. of Hehai Univ.
Pingtsoe Wangyal	1992	Tibet	Chemistry	Partly geothermal/director of Tibet Geo-Environ. Monitoring
Zheng Xilai	1993	Shaanxi	Chemistry	Partly geothermal/prof. of Qingdao Univ.
Li Cheng	1994	Jiangsu	Res. Eng	No-Geothermal /prof. of Nanjing Univ.
Xu Shiguang	1995	Yunnan	Res. Eng.	Partly geothermal/Prof. of Yunnan Geo. Institute
Du Shaoping	1997	Tibet	Chemistry	Retired
Sun Zhanxue	1998	Jiangxi	Chemistry	Geothermal/prof. & president of Donghua Tech. Univ.
Du Jizhong	2000	Liaoning	Res. Eng.	Geothermal/Divs. Leader in Shenyang Geo. Center
Kang Fengxin	2000	Shandong	Res. Eng.	Geothermal/Div. leader of Shangdong Geo. Bureau
Huang Hefu	2000	Shandong	Drilling	Unclear geology
Fan Liping	2000	Yunnan	Environment	Lost contact
Huang Maochang	2001	Hainan	Environment	Partly geothermal
Zhang Zhanshi	2001	Jiangxi	Chemistry	Geothermal/ prof. of East China Tech. Univ.
Fan Xiaoping	2002	Tibet	Res. Eng.	Geothermal/Tibet Geothermal Inst.
Yin Lihe	2002	Shaanxi	Res. Eng.	Groundwater/Xian Geo. Center
Hou Haiyan	2003	Henan	Environment	No-Geothermal
Luo Heng	2004	Guangdong	Environment	Partly geothermal
Chen Gongxin	2008	Jiangxi	Chemistry	Geothermal/prof. of East China Tech. Univ.
Liu Junrong	2011	Shandong	Res. Eng.	Geothermal
Luo Chao	2014	Guangdong	Utilization	Partly geothermal
Zheng Tingting	2015	Shandong	Res. Eng.	Geothermal/PhD study in Iceland Univ.
Ren Xiaoqing	2018	Shanxi	geophysics.	Geothermal
Shi Meng	2019	Shandong	Res. Eng.	Geothermal

The Hebei Geology University in Shijiazhuang is planning to open geothermal courses. Owing to the limited experience and geothermal knowledge of the teachers, the management of the university contacted UNU-GTP, for setting up a geothermal training center in cooperation in China. Mr. Ludvik S. Georgsson, the director of UNU-GTP, made a lot of efforts on this valuable cooperation, it is believed that the geothermal training center will start in the near future.

8. CONCLUDING REMARKS

It should be mentioned that the status of all the Chinese who participated in the training may not be completely correct, because that there are so many people from so many institutions in such a big country involved in. There will have been 92 scientists and engineers from China completed the geothermal training in Iceland by October 2019, and 2 fellows completed their MSc studies. The UNU geothermal training programme in Iceland has contributed very much on the geothermal man-power build-up in China. The Chinese fellows are playing a very important role in the geothermal development in the country, and a number of the former UNU fellows have become leading experts in their specialties in deferent part of the country and several have become well known in the international geothermal community. Because of the growing needs for clean energy in China, it is predicted that geothermal utilization will expand much faster than that in the past 2 decades, and the depth of geothermal wells will be greater, and higher temperature geothermal fluid will be exploited. Therefore, there will be more needs for trained geothermal professionals in China. It is proposed that the UNU-GTP will take more fellows from China for the 6 month training, as well as MS and PhD study. It is also proposed that the UNU-GTP help Chinese institutions, for example, Hebei Geology University to open geothermal training courses.

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