

Contribution of UNU/GTP training to geothermal development in China

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Abstract

The Geothermal Training Programme of the United Nations University (UNU/GTP) in Iceland has been operating successfully for 25 years since 1979, financed mostly by the Icelandic Government. There have been 300 scientists and engineers, mostly from developing countries with significant geothermal potential, trained in the Programme to date. In 1980, the first Chinese Fellows participated in the Geothermal Training Programme. Since then, 54 Chinese Fellows, from 14 provinces, cities and autonomous regions, have completed the six month specialized geothermal training in Iceland, accounting for 18% of all the Fellows. Beijing and Tianjin are the areas with the most Fellows (14 each). The Chinese UNU Fellows are playing a very important role in geothermal development in the country. Many of them have become leading experts in their specialties in different parts of the country, and several of them have become well known in the international geothermal community. The UNU/GTP has given great support to China's geothermal development in the past 25 years. At the same time, the UNU/GTP has significantly promoted the friendship between China and Iceland.

Keywords: United Nations University, Geothermal Training Programme, China, Beijing, Tianjin, geothermal utilization.

1 Introduction

Geothermal energy is a renewable and environmentally friendly energy source that is used for power generation and various direct uses. As of 2002, 22 countries are using geothermal for power production, with 8,000 MWe installed capacity, and 50 TWh electricity production annually. There have been 58 countries making direct use of geothermal, with 15,200 MWt installed capacity, and 53 TWh energy used annually (Lund, 2002).

In China, high-enthalpy geothermal energy only occurs in Tibet, Yunnan Province and Taiwan. The current installed electricity generation capacity is 32 MWe, thereof 88% of the national total in Tibet in 2002. 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 spas etc. Since the 1990s, space heating using geothermal has been developing fairly fast in China, especially in the big cities in the northern part of the country, such as Tianjin, Beijing and Xi'an. With the increasing awareness of environmental protection, it can be foreseen that geothermal utilization in China will continue to expand in the future (Liu, 2002).

The UNU/GTP in Iceland has played a very important role in the history of China's geothermal development. In 1980, the first group of Chinese Fellows participated in the Geothermal Training Programme. Since then, 54 Chinese Fellows, from 14 provinces, cities and autonomous regions, have completed the six month specialized geothermal training in Iceland, accounting for 18% of all the Fellows. The Chinese Fellows have played a very important role in geothermal development in the

country. In this paper, the history of the cooperation between China and the UNU/GTP will be reviewed, and the activities of the Chinese UNU Fellows in various parts of the country will be presented.

2 UNU/GTP and Chinese Fellows

Since 1979, the UNU/GTP has been operated 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 or strengthen groups of technical specialists that cover most aspects of 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 scholarships (covering tuition fees, per diem and international travel) financed by the Government of Iceland (80%), and the United Nations University (20%). Upon completion of their training, the participants receive a UNU certificate (Fridleifsson, 2002).

In 1979, two senior geothermal specialists from China came to Iceland on a three-week study tour as UNU Special Fellows, Dr. Xin Kui and Prof. Huang Shangyao. Dr. Xin Kui, who was chief geologist and an important officer in the Ministry of Geology and Mineral Resources, did a lot in the promotion of geothermal development in China. Although retired now, he still cares for China's geothermal development and the UNU/GTP. Prof. Huang Shangyao, was a senior scientist at the Chinese Academy of Geological Sciences. She has officially retired, but is still very active in geothermal research. She has a wealth of academic achievements, including the Map of Hot Springs in China. In January 1980, the first two UNU Fellows were selected by interviews in Beijing for the six month specialized courses. These were Dr. Yao Zujin from the Institute of Hydrogeology and Engineering Geology of the Chinese Academy of Geosciences in Hebei province, and Prof. Zhou Xixiang from the Applied Geophysics Department of Chengdu University of Technology.

A total of 54 UNU Fellows from China have completed the six month geothermal training courses during 1980-2003. They have come from 14 cities, provinces and autonomous regions: Beijing (14), Tianjin (14), Tibet (5), Fujian (1), Hebei (6), Henan (1), Hainan (1), Jiangsu (2), Jiangxi (2), Liaoning (1), Shandong (2), Shaanxi (2), Sichuan (1), and Yunnan (2). Figure 1 shows the number of Chinese UNU/GTP Fellows from the different cities and provinces (modified from Fridleifsson, 2002).

The 54 scientists and engineers from China have completed the following specialized courses: borehole geology 3, geophysical exploration 1, borehole geophysics 2, reservoir engineering 20, chemistry of geothermal fluid 11, environmental studies 5, geothermal utilization 10, and drilling technology 2. The predominance of participants in the courses on reservoir engineering, chemistry and geothermal utilization, reflects that Icelandic expertise has been regarded particularly valuable in those fields, to the geothermal development in China.

In China, there is still no university programme specializing in geothermal energy. A large number of the scientists working on geothermal energy 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 understanding of the liquid movement, but often lack 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 (NEA) have been used in a lot of geothermal fields in China, especially in the areas of Beijing and Tianjin.



Figure 1: Number of Chinese UNU/GTP Fellows from different cities and provinces (modified from Fridleifsson, 2002).

Before China's opening up to the outside world in the 1980s, there were not many people who were able to speak English or any other foreign languages. This made it difficult for the Chinese geothermal community to communicate with international geothermal institutions. The geothermal training in Iceland has much improved the English ability of the Chinese Fellows, and they are becoming more and more active in international geothermal cooperation. The UNU/GTP has supported China's geothermal development greatly in the past 25 years. At the same time, the UNU/GTP has significantly promoted the friendship between China and Iceland.

Although some Fellows from China are no longer working on geothermal (a few Fellows of the early years have retired, some others have changed their profession), more than 30 of the Chinese Fellows are still working in the field, and some are playing important roles in various parts of the country. A few of the Fellows have become leading geothermal experts in China, such as Prof. Zhao Ping at the Institute of Geology and Geophysics of the Chinese Academy of Sciences, Mr. Zhang Baiming at the Tianjin Institute of Geothermal Exploration and Development, and Mr. Pan Xiaoping at the Beijing Institute of Geological Engineering.

3 Fellows from Tianjin

Since 1980, 14 Chinese Fellows from Tianjin have completed the UNU/GTP six month courses. Their academic backgrounds include geology, hydrogeology, mechanical, and chemical engineering (Table 1). Among the 14 Fellows, 7 are from Tianjin Geothermal Exploration and Development Institute (TGEDI). Most of the Fellows have played important roles in geothermal development in Tianjin, which is the leading geothermal district heating region in China.

Table 1: The background and current roles of UNU/GTP Fellows in Tianjin.

Name	Year of training	Academic background	Field of Training	Work engaged in /current position
Sun Kayaو	1981	Mechanical engineering	Geothermal Utilization	Senior engineer at Tianjin Gas Company and later Tianjin ACE. Retired.
Lu Run	1983	Hydrogeology	Reservoir Engineering	Senior engineer of Reservoir Engineering Division in TGEDI. Retired.
Li Zhi	1984	Mechanical engineering	Geothermal Utilization	Senior engineer at Tianjin Gas Company.
Lu Zhenyuan	1985	Geology	Borehole Geology	Senior engineer of Borehole Geology Division in TGEDI. Retired.
Qi Baoxiang	1985	Hydrogeology	Geothermal Utilization	Senior engineer of Development and Utilization Division in TGEDI. Retired.
Chen Zhenxia	1985	Geology	Geology	Senior engineer of Borehole Geology Division in TGEDI. Retired.
Bai Liping	1991	Chemistry	Geochemistry	Thermal fluid chemistry, scale inhibition. Recently emigrated to Australia.
Dai Chuanshan	1992	Thermal Physics	Geothermal Utilization	Geothermal designing / vice professor in Tianjin University
Dong Zhilin	1993	Hydrogeology	Reservoir Engineering	Reservoir engineering/coordinator of geothermal development in Tanggu geothermal field.
Li Youji	1993	Mechanical Engineer	Geothermal Utilization	Senior engineer at the Tanggu Geothermal Office. Emigrated to New Zealand.
Zhang Baiming	1994	Hydrogeology	Reservoir Engineering	Director Tianjin Geothermal Exploration and Development Institute (TGEDI).
Wang Kun	1998	Mathematics and Reservoir Engineering	Reservoir Engineering	Reservoir engineering, Geochemistry/geothermal Management Dept. in Bureau of City Planning and Land Resource.
Cheng Wanqing	2001	Hydrogeology	Environmental Studies	Reservoir engineering, geochemistry. Deputy head of Geothermal Geological Dept. of TGEDI.
Li Jun	2003	Hydrogeology	Reservoir Engineering	Reservoir engineering, geochemistry / engineer in TGEDI (current Fellow)

After the training in UNU/GTP, combined with practical experience in geothermal, most of the Fellows have become geothermal specialists. A number of them are working in reservoir engineering, especially the numerical modelling of geothermal systems. In addition, quite a few are working in chemistry of geothermal fluids.

Ms. Lu Run, trained in 1983, was the first UNU/GTP Fellow from Tianjin (TGEDI) to study reservoir engineering, and three of her colleagues joined the training in 1985. They brought back many new concepts and technologies from the training courses, and shared their knowledge and experience with their colleagues. Wanglanzhuang geothermal field is the first geothermal field explored and developed in Tianjin. Ms. Lu Run was the chief engineer of the exploration project. The second geothermal field (Shanlingzi geothermal field) was explored under the guidance of Ms. Chen Zhenxia (1985 Fellow). Best use was made of the knowledge learned from UNU/GTP, and this greatly brought forward the reservoir engineering study of the geothermal fields.

Mr. Zhang Baiming (1994 Fellow) is the director of Tianjin Geothermal Exploration and Development Institute (TGEDI). The major tasks achieved by TGEDI are geothermal resources exploration and evaluation of new fields, such as the coastal region (including Tanggu, Hangu and Dagang), Wuqing County and the deep basement reservoir in Tianjin urban area, etc. They have also drilled many geothermal wells and undertaken various jobs on geothermal utilization, such as space heating,

swimming pools and agricultural use etc. As of 2002, TGEDI has drilled 50 geothermal wells in the area of Tianjin. TGEDI also fulfilled a lot of consulting services to many real estate projects related to geothermal development. With this experience, TGEDI is marketing its expertise in the northeastern and western regions in China, such as Inner Mongolia, Heilongjiang and Gansu Province.

In the 1990s, more and more UNU Fellows have been involved in the geothermal exploration and development in Tianjin. For many years, Mr. Dong Zhilin (1993 Fellow) has been in charge of the geothermal utilization development in Tanggu. After completing the resource evaluation of Wuqing geothermal field and deep basement reservoir around the urban area in Tianjin, Ms. Wang Kun (1998 Fellow) left TGEDI and joined the Geothermal Management Division of Tianjin in 2001. She is responsible for the approval of the well drilling and geothermal development programme, and is also the technical coordinator of the geothermal users in Tianjin. Presently, she is mainly working on the reinjection tests in porous medium reservoirs and compiling the 2003-2005 Geothermal Plan in Tianjin. Mr. Chen Wanqing (2001 Fellow), the deputy head of the geothermal geological department of TGEDI, is involved in several geothermal exploration and development projects related to reservoir engineering, geochemistry, and environmental studies.

In recent years, extensive research has been done on the geothermal utilization, reinjection, reservoir engineering and information systems of geothermal monitoring /management in Tianjin. But some problems are still awaiting further investigation. The UNU/GTP Fellows from Tianjin will certainly continue to use what they learn in Iceland to solve these problems.

4 Fellows from Beijing

Fourteen Fellows from Beijing have completed the six month courses at the UNU/GTP, including eight from the central level institutions related to geothermal, and four from institutes under the Beijing Bureau of Geological and Mineral Exploration. At present, most of the Fellows from Beijing are still working on geothermal exploration and development.

4.1 Fellows from the central level institutions

Eight of the Fellows from Beijing have come from central level institutions and governmental agencies, such as the Ministry of Geology and Mineral Resources (2), and the Institute of Geology and Geophysics of the Chinese Academy of Sciences (6). Most of them have made important contributions to geothermal development in China. Prof. Tang Songran (1981 Fellow) is the President of the Institute of Exploration Engineering, China University of Geosciences. Dr. Pang Zhonghe (1988 Fellow) is now a technical officer at the International Atomic Energy Agency. His work is often related to geothermal and he cares much about the geothermal development in China. Prof. Zhao Ping (1991 Fellow), Dr. Hu Shengbiao (1994 Fellow), Dr. He Lijuan (1999 Fellow) and Mr. Zhang Yuandong (2003 Fellow) are all working at the Institute of Geology and Geophysics under the Chinese Academy of Sciences. Prof. Zhao Ping is well known in the geothermal community in China for his research on geothermal in Tibet and other parts of China. Dr. Hu Shengbiao and Dr. He Lijuan have also done a lot in geothermal research in various parts of China.

4.2 Fellows from the municipality of Beijing

Beijing is rich with low-enthalpy geothermal resources distributed in the sedimentary basins, and areas identified with geothermal potential extend over 2,000 km², including the urban geothermal field and Xiaotangshan geothermal field. The 38-89°C geothermal water is used for space heating, fish farming, greenhouses, swimming pools, health spas, and recreation. Beijing will host the 2008 Summer Olympic Games, and geothermal water will be used in the Olympic facilities for space heating and bathing. It has been planned that 10 geothermal wells will be drilled for the Olympic geothermal project, including 3 reinjection wells.

In the early days of the UNU/GTP, two engineers from the Beijing Public Utility Bureau were trained in Iceland (Mr. Shen Xingwu in 1981, and Mrs. Wu Liya in 1984). At present, two institutes, Beijing Institute of Geological Engineering (BIGE) and Beijing Institute of Geotechnology (BIG), are the most active in geothermal exploration and development. They will be responsible for the Olympic geothermal project. Four UNU Fellows from Beijing Municipality are working at these two institutes: Mr. Pan Xiaoping (1998 Fellow), and Dr. Liu Jiurong (1999 Fellow) are from BIGE; and Mr. Yin Heng (2002 Fellow), and Mr. Xu Youshi (2002 Fellow) are from BIG. They are all key technical personnel of the institutes. These Fellows are also quite active in international exchanges related to geothermal. In 2002, Beijing held the *2002 International Symposium on Geothermal at the 2008 Olympics* in Beijing. Mr. Pan Xiaoping and Dr. Liu Jiurong were the key organizers of the symposium, and Dr. Liu Jiurong compiled the proceedings of the symposium as the chief editor.

With the fast development of geothermal utilization in Beijing, more and more trained geothermal experts will be needed in the city. It is hoped that the UNU/GTP will select more young geothermal scientists and engineers for the training course.

5 Fellows from other areas

Apart from the Fellows from Beijing and Tianjin, 26 Fellows from other parts of the country have completed the six month courses at the UNU/GTP. Six have come from Hebei province, five from Tibet, but one or two from other provinces. Most of them play important roles in geothermal exploration, research, and development in the institutions where they work. Owing to a lack of complete information for all of the Fellows, only a few of them who are well known in the geothermal community of China will be briefly mentioned below.

Prof. Sun Zhanxue (1998 Fellow), professor and vice president of the East China Institute of Technology in Jiangxi Province, is very active in geothermal research and education. Mr. Xu Shiguang (1995 Fellow), the chief engineer of the Yunnan Institute of Geological Exploration, is involved in many geothermal projects in Yunnan Province, such as the one in the famous Tengchong geothermal field. Mr. Wang Guiling (1991 Fellow) who works at the Institute of Hydrogeology and Engineering Geology of the Chinese Academy of Geosciences in Hebei, has been very active in reservoir modelling and is presently involved in the modelling of the geothermal field in Xi'an. The first of four UNU Fellows from this institute (in Hebei), trained in Iceland in 1980, was the well known geochemist Dr. Yao Zujin, who has now retired.

6 Recommendations

Although 54 scientists and engineers from China have completed the six month geothermal training courses in Iceland, it is recommended that more Chinese Fellows be selected for the UNU/GTP, considering the vast territory and large population of the country, as well as the expanding needs of geothermal exploration and development.

In the selection of the Fellows, English ability should be considered at a higher standard, because some Chinese Fellows in the past have had difficulties in understanding the lectures given in the training courses.

It is recommended that UNU/GTP cooperate with a university in China, to give some Chinese Fellows the opportunity for formal postgraduate research and education with an advanced academic degree. It is certain that most of the supervisors of UNU/GTP are capable of giving extended lectures and instructions to postgraduate students.

7 Conclusions

There have been 300 scientists and engineers, mostly from developing countries with significant geothermal potential, trained in the UNU/GTP in Iceland including the year 2003. In 1980, the first Chinese Fellows participated in the Training Programme. Since then, 54 Chinese Fellows, from 14 provinces, cities and autonomous regions, have completed the six month specialized geothermal training in Iceland, accounting for 18% of all the Fellows. The Chinese Fellows are playing a very important role in the geothermal development in the country. Many of the former UNU Fellows have become leading experts in their specialities in different parts of the country, and several have become well known in the international geothermal community. The UNU/GTP has been greatly supporting China's geothermal development in the past 25 years. At the same time, the UNU/GTP has significantly promoted the friendship between China and Iceland. It is recommended that the UNU/GTP will take more Fellows from China, and cooperate with a university in China for postgraduate research and education.

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