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Twenty Five Years of Geothermal Training in Iceland

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ABSTRACT

The Government of Iceland and the United Nations University (UNU) decided in 1978 to establish the UNU Geothermal Training Programme (UNU-GTP). Orkustofnun (the National Energy Authority of Iceland) became the host institution of the UNU-GTP. Specialized training is offered in geological exploration, borehole geology, geophysical exploration, borehole geophysics, reservoir engineering, chemistry of thermal fluids, environmental studies, geothermal utilization, and drilling technology. The aim is to assist developing countries and Central and Eastern European countries with significant geothermal potential to build up groups of specialists that cover most aspects of geothermal exploration and sustainable development. The trademark of the UNU-GTP is to give university graduates engaged in geothermal work intensive on-the-job training in their chosen fields of specialization. The trainees work side by side with geothermal professionals in Iceland. The training is tailor-made for the individual and the needs of his institution/country. All participants are selected by private interviews during site visits to the countries concerned where UNU-GTP representatives visit geothermal fields, research institutions and energy utilities. Participants are selected for training in the specialized fields that are considered most relevant to promote geothermal development in the respective country. The candidates must have a university degree in science or engineering, a minimum of one year practical experience in geothermal work, speak English fluently, have a permanent position at a public energy company/utility, research institution, or university, and be under 40 years. During 1979-2003, 300 scientists and engineers from 39 countries have completed the annual six month courses. Of these, 43% have come from countries in Asia, 25% from Africa, 15% from Latin America, and 17% from Central and Eastern Europe. Over 80 have received shorter training. In 2000, MSc programme was started in cooperation with the University of Iceland. In many countries in Africa, Asia, Central America and Central and Eastern Europe, UNU-GTP graduates are among the leading specialists in geothermal research and development. They have been very successful, and have contributed significantly to energy development in their parts of the world.

1. INTRODUCTION

The Geothermal Training Programme of the United Nations University (UNU-GTP) was established in Iceland in 1978 when Orkustofnun (the National Energy Authority) became an Associated Institution of the UNU (United Nations University, 1979; Fridleifsson, 2003). Since 1979, a group of professional scientists and engineers from the developing and transitional countries have come to Iceland every spring to spend six months in highly specialized studies, research, and on-the-job training in geothermal science and engineering. All of them are university graduates with practical experience in geothermal work and permanent positions at energy agencies/utilities, research organizations or universities in their home countries.

Since the foundation of the UNU-GTP, 300 scientists and engineers from 39 countries have completed the annual six month specialized courses offered. Of these, 43% have come from countries in Asia, 25% from Africa, 15% from Latin America, and 17% from Central and Eastern European (CEE) countries. The largest groups have come from China (54), Kenya (33), Philippines (29), El Salvador (20), Ethiopia (20), Poland (14), Indonesia (12), Costa Rica (11), and Iran (10). In all, there have been 46 women (15%). In many countries, UNU-GTP graduates are among the leading specialists in geothermal research and development. They have also been very active internationally, as exemplified at the World Geothermal Congress in Japan in 2000, where 61 UNU Fellows from 24 countries attended and presented papers. Among these were 14 women.

The UNU-GTP has, through the years, kept in good contact with the other three international geothermal schools which were established in Italy (Pisa in 1970), Japan (Kyushu in 1970), and New Zealand (Auckland in 1978). Unfortunately, the Pisa school has not held its annual course since 1993 due to drastic cuts in government financing, but has occasionally held short courses (1-3 weeks) in developing countries. The International Group Training Course at Kyushu University was closed in 2001 and the Diploma course at Auckland University in 2003 also due to withdrawal of government financing. Auckland University will, however, continue admitting students to MSc and PhD studies in geothermal as a part of its regular activities. Kyushu University started a new doctoral course (with Japanese Government Scholarships) entitled "International Special Course of Environmental Systems Engineering" in 2002.

The UNU-GTP is thus at present the only international graduate school offering specialized training in all the main fields of geothermal science and engineering. MSc studies are also offered at the Faculty of Science and the Faculty of Engineering of the University of Iceland in cooperation with the UNU-GTP.

2. INSTITUTIONAL ENVIRONMENT AND ORGANIZATION

The UNU-GTP (www.os.is/unugtp/) is operated at Orkustofnun – the National Energy Authority (NEA), which has been an Associated Institution of the UNU since 1978. The NEA is a government agency under the Ministry of Industry and Commerce. Its main responsibilities have been to advise the Government of Iceland on energy issues and related topics, and to carry out energy research and

provide consulting services relating to energy development and utilization. NEA has an excellent library specializing in energy research and development (in particular geothermal and hydropower), with some 12,000 titles, and subscriptions to 140 journals. The turnover of the NEA in 2002 was 12 million USD. In 2002, NEA published 80 research reports, and 100 scientific papers and abstracts by staff members were published in refereed journals and conference proceedings. UNU funds are, of course, not used for NEA research. The UNU Fellows, however, have full access to the research facilities and the multidisciplinary research environment of the NEA, which for over three decades has been one of the leading geothermal energy research institutions in the world.

Until 2003, the NEA was divided into four independent units: the Energy Management Division (energy resources, statistics and analyses), the UNU Geothermal Training Programme (UNU-GTP), the Geoscience Division, and the Hydrological Service Division. NEA had a staff of about 110, whereof 77% were university graduates. Most of the teaching and research supervision of the UNU-GTP has through the years been conducted by geothermal specialists of the Geoscience Division.

In 2003, as a result of changes in the energy legislation in Iceland, the Geoscience Division was separated from the NEA and a new government owned company established with the name Islenskar Orkurannsoknir (ISOR). The English name is ISOR Iceland GeoSurvey. The principal tasks of ISOR are: to conduct research under contract on potential energy resources, their nature and possible utilization; to invent, develop, and adapt methods and equipment to study the country's energy resources; to teach and supervise research students attending the UNU-GTP; and to market the expertise of Iceland GeoSurvey internationally (www.isor.is). It is expected that about 20% of the annual turnover of ISOR will come from government contracts and the remainder from contracts with various energy companies, utilities and municipalities. This is similar to the operations of the Geoscience Division in recent years.

Of the 52 staff members of ISOR, 45 have university degrees, and 16 of these have PhD qualifications. The disciplines are represented as follows: 16 geologists, 15 geophysicists, 6 chemists, 4 engineers, 2 geographers, and 2 administrators. ISOR has a chemical laboratory, geophysical laboratory, petrological laboratory, and three logging trucks for geothermal wells. The new company continues working on the same premises and with the same staff as the Geoscience Division. The UNU-GTP is on the same floor of the building. It is expected that the integration of the UNU Fellows with the specialists and the research atmosphere of ISOR will continue as in previous years.

The UNU-GTP also has a close cooperation with the University of Iceland (UI). Staff members of the Faculty of Science and the Faculty of Engineering have been amongst the key lecturers and supervisors of the UNU Fellows in some subjects throughout the 25 years of operations of the UNU-GTP. The UNU Fellows have full rights and privileges to use the facilities of the UI as registered students. In May 2000, a cooperation agreement was signed between the UNU-GTP and the UI on MSc studies in geothermal science and engineering. This is designed for UNU Fellows who have already completed the traditional six month courses at the UNU-GTP, which constitute 25% of the MSc programme.

The UNU-GTP has three permanent staff members (employed by NEA), but lecturers and support staff are hired from NEA, the UI, and other agencies/companies. Every year, about 50 staff members of these institutions render services to the UNU-GTP under specific contracts. This allows the flexibility required to provide highly specialized training in the nine fields of specialization offered.

The UNU-GTP is academically governed by a Studies Board, which is composed of experts (from ISOR and UI) responsible for each of the specialized courses. The UNU-GTP director is the chairman of the Studies Board. In addition to the eight specialized courses offered from 1979, a course in Environmental Studies has been operated since 1997. The present members of the Studies Board are Dr. Ingvar B. Fridleifsson (chairman), Dr. Kristjan Saemundsson (Geological Exploration), Dr. Hjalti Franzson (Borehole Geology), Dr. Knutur Arnason (Geophysical Exploration), Dr. Benedikt Steingrimsson (Borehole Geophysics), Dr. Gudni Axelsson (Reservoir Engineering), Dr. Halldor Armannsson (Environmental Studies), and Mr. Sverrir Thorhallsson (Drilling Technology) from ISOR; Prof. Stefan Arnorsson (Chemistry of Thermal Fluids), and Prof. Pall Valdimarsson (Geothermal Utilization) from UI.

Dr. Ingvar B. Fridleifsson has been the director of the UNU-GTP from the beginning except for one training season in 1981 when Dr. Hjalti Franzson served as director, and three training seasons in 1986-1988 when Dr. Jon Steinar Gudmundsson served as director. Mr. Ludvik S. Georgsson has been the deputy-director since 1990. Mrs. Gudrun Bjarnadottir has been the administrative assistant since 1996.

3. SPECIALIZED TRAINING

The approximate time schedule of the six month specialized courses is shown in Table 1. All participants attend an introductory lecture course (5 weeks, three lectures per day) which aims to provide background knowledge on most aspects of geothermal energy resources and technology, and to generate an appreciation for the interrelationship between the various disciplines necessary in geothermal projects from the initial exploration to the stages of implementation and utilization. Participants have to take two written tests during the introductory lecture course. The lecture course is followed by lectures and practical training in the respective specialized fields (7 weeks), and the execution of a research project (12 weeks) which is concluded with an extensive research project report. Excursions are also arranged to the main geothermal fields under exploration and utilization in Iceland. Seminars are held and case histories studied on each of the fields.

The main emphasis of the training is to provide the participants with sufficient understanding and practical experience to permit the independent execution of projects within a selected discipline in their home countries. Nine specialized lines of training are offered. Each participant is meant to follow only one line of training, but within each line there is a considerable flexibility.

The following lines of specialized training are offered. A more detailed description can be found on the home page of the UNU-GTP (www.os.is/unugtp/):

- **Geological exploration** offers practical training in basic geological and geothermal mapping, which is commonly the first step in the geothermal exploration of an area. Participants should have a degree in

geology.

- **Borehole geology** gives training in making geological logs, analyses of drill cuttings and cores. The identification of alteration minerals (microscope and x-ray diffraction) and the interpretation of the alteration mineralogy forms an integral part of the course. Participants should have a degree in geology.
- **Geophysical exploration** is practical training in conducting geophysical surveys of geothermal areas and/or interpretation of such data. Emphasis is on the application of computers in the interpretation. Participants should have a degree in physics, geophysics or engineering.
- **Borehole geophysics** covers the essentials of geophysical measurements in boreholes used for geothermal investigations, with an emphasis on temperature and pressure measurements. Participants should have a degree in physics, geophysics or engineering.
- **Reservoir engineering** covers the methodology needed to obtain information on the hydrological characteristics of geothermal reservoirs and to forecast the long term response of the reservoirs to exploitation. Participants should have a degree in engineering, physics, geophysics, mathematics or hydrogeology.
- **Environmental studies** cover environmental impact assessments (EIA), laws and policies, the planning and execution of EIA projects and environmental auditing. Scientific methods suitable for environmental monitoring are assessed and biological impact, pollution and occupational safety considered. Participants should have a degree in science or engineering.
- **Chemistry of thermal fluids** gives an insight into the role of thermal fluid chemistry in geothermal exploration and exploitation, including sampling, analysis of major constituents and the interpretation of results. Participants should have a degree in chemistry, geochemistry or chemical engineering.
- **Geothermal utilization** deals with the civil, mechanical and chemical engineering aspects of geothermal fluids in pipes, equipment and plants. The feasibility of projects and environmental factors are also considered. Participants should have a degree in engineering.
- **Drilling technology** provides engineers with the information and on-site training necessary to prepare them for the work of drilling engineers or supervisors. The course deals with the selection of drilling equipment, well design and casing programs, cementing techniques, and the cleaning and repairs of production wells. Participants should have a degree in engineering.

Computers have played an ever increasing role in the training. All participants receive training in using PC-computers for word processing, interpretation of data as well as in using the Internet. Each of them is provided with a personal PC during their training in Iceland. They have also access to the Orkustofnun central computer system if necessary for their project work. Most trainees have now access to PC-computers at home, and they can take their CDs home and continue the work there. Thus there has been a considerable transfer of computer technology from Iceland to geothermal institutions in the developing countries.

A significant part of the practical training is done in connection with the research projects of the Fellows. In many cases, the participants bring with them data from geothermal projects in their home countries, but sometimes the research projects are integrated with geothermal exploration or utilization projects that are in progress in Iceland at the time of training. The project topic is always selected with respect to the conditions of the home country of the participant. All the project reports are published by the UNU-GTP. Since 1994, the reports have been published in the annual book "Geothermal Training in Iceland" (edited by Ludvik. S. Georgsson), which has an international publishing code (ISBN 9979). Copies can be obtained upon request. The books are mailed regularly to former UNU Fellows, universities and leading geothermal research and development institutions in over 40 countries. The titles of the research reports from 1979-2003 are listed in the home page of the UNU-GTP (www.os.is/unugtp/). Abstracts of reports since 1988 and the complete reports since 2002 are also available on the home page.

On many occasions, UNU Fellows from a given country (e.g. Costa Rica, El Salvador, Kenya, the Philippines) conduct over several years multidisciplinary research (geology, geophysics, chemistry, reservoir engineering, environmental impact studies) on data from the same area in their home countries under supervision of Icelandic specialists. All of the countries mentioned above obtain 10-22% of their electricity from geothermal steam. In 2003, 16 of the 20 research projects dealt with geothermal areas in the home countries of the Fellows.

Table 2 lists the countries of origin of the participants who have completed the six month training during 1979-2003, and their specialized courses. Figure 1 shows the same on a world map. The largest groups have come from China (54), Kenya (33), Philippines (29), El Salvador (20), Ethiopia (20), Poland (14), Indonesia (12), Costa Rica (11), and Iran (10).

Regular contact is held with former UNU Fellows by sending them the UNU-GTP yearbook and an annual newsletter. The majority of the Fellows keep in contact with the UNU-GTP and each other through correspondence. This has become much easier lately as over 200 former UNU Fellows (out of 300 graduates) are listed in the e-mail directory of the UNU-GTP. An updated directory is sent out twice per year to all alumni of the Programme.

4. MSC PROGRAMME

Since 2000, a few former UNU Fellows have been admitted to a MSc programme in geothermal science and engineering in cooperation with the University of Iceland. Many of our trainees have already completed their MSc or PhD degrees when they come to Iceland, but several excellent students who have only BSc degrees have made requests to come again to Iceland for a higher academic degree. Their six months in the UNU-GTP fulfil 25% of their MSc programme credit requirements. The first UNU Fellow (UF) to attend the MSc programme in geothermal engineering was Mr. Muthafar Emeish from Jordan (UF 1999). He graduated with MSc in 2001.

The aim of establishing the MSc programme in cooperation with the UI was to go a step further in assisting selected countries in building up their specialist groups. Kenya was given a priority in the beginning. Two scientists from Kenya started their MSc studies in January 2001 and graduated in 2002. One of them (UF 1996) conducted research on the reservoir engineering aspects of the Olkaria geothermal field in Kenya, the other (UF 2000) wrote his

MSc thesis on the chemistry of the same field. Two more Kenyans commenced their MSc studies in 2002 and graduated in 2004. One of them (UF 2001) worked on the environmental aspects and the other (UF 1995) on the geology and alteration mineralogy of the Olkaria field. Kenya is the leading country in geothermal research and development in Africa. Most of the geothermal specialists in the country have been trained in Iceland. With the advanced training of the MSc students, the UNU-GTP is assisting Kenya in bringing geothermal research to a still higher level. It is hoped that, in the future, Kenya will be in a position to assist neighbouring countries by training some of their scientists and engineers. At present, Kenya obtains about 9% of its electricity from geothermal energy. The government plans to increase this figure to 20-25%. The UNU-GTP will support this aim.

In 2003, an environmental scientist from Iran (UF 1999) and a mechanical engineer from Mongolia (UF 2001) started their MSc studies, and an environmental scientist from Uganda in 2004 (UF 1993).

5. TEACHING MATERIAL

Most of the teaching is done by tutorials and practical work where the teacher works with two or three trainees and use is made of available textbooks and articles in journals as appropriate. In some instances, however, a special effort has been required to compile text material and manuals as teaching material for the training. Most of this work has been done by the regular teachers of the UNU-GTP, who are mostly staff members of NEA/ISOR and UI. Some texts have also been written by visiting scholars from other countries. Some of the teaching material has been published in reports, which are listed on the UNU-GTP home page. A few of the teaching texts are already into their second and third editions. UNU Fellows have in many cases used teaching material from the UNU-GTP to train colleagues in their own institutions. The teaching material has also been used by teachers of the UNU-GTP when giving courses in various parts of the world.

One guest lecturer with an international reputation is invited every year as a UNU Visiting Lecturer to give a lecture series and to lead discussions with the trainees. The UNU Visiting Lecturers have stayed from one week to two months in Reykjavik. Table 3 lists the UNU Visiting Lecturers. Many of the lectures of the UNU Visiting Lecturers have been published and are listed by author in the reference list on the UNU-GTP webpage (www/os.is/unugtp/). Some of these have served as important teaching material.

The international conference organized by the Geothermal Association of Iceland to celebrate the 25th anniversary of the UNU-GTP (www.jardhitafelag.is/igc/nytt) was preceded by a three day international course on the Sustainable Use and Operating Policy for Geothermal Resources which was organized by the UNU-GTP and the Geothermal Association of Iceland in cooperation with the International Summer School in Skopje in Macedonia and the International Geothermal Association. There were over 60 participants from 18 countries. The lecturers came from Germany, Iceland, Macedonia, Philippines, Romania, Switzerland, and the USA. The fifteen lectures presented at the course were published in a book of 250 pages in the UNU-GTP publication series (Fridleifsson and Gunnarsson, 2003), and can be obtained on the UNU-GTP web page (www.os.is/unugtp/). Copies of the publications of the UNU-GTP are available on request.

6. SELECTION OF PARTICIPANTS AND SITE VISITS

Candidates for participation in the specialized training must have a university degree in science or engineering, a minimum of one year practical experience in geothermal work, speak English fluently, be under 40 years in age, and have a permanent position dealing with geothermal energy at a public energy company/utility, research institution, or university in their home country.

Much care is taken in selecting the participants. Site visits are conducted by representatives of the UNU-GTP to the countries requesting training. The potential role of geothermal energy within the energy plans of the respective country is assessed, and an evaluation made of the institutional capacities in the field of geothermal research and utilization. Based on this, the training needs of the country are assessed and recipient institutions selected. The directors of the selected institutions are invited to nominate candidates for training in the specialized fields that are considered most relevant to promote geothermal development in the respective country. All qualified candidates are interviewed personally. Training starts in late April and ends in late October each year. Nominations (including the curriculum vitae of the candidates) must be received in Reykjavik before 1st September each year for participation in training starting the following year.

Participants from developing countries and most CEE countries (not EU members) normally receive scholarships financed by the Government of Iceland and the UNU that cover international travel, tuition fees and per diem in Iceland. The participants therefore do not need other funds for their training. The UNDP and the International Atomic Energy Agency (IAEA) have also financed fellowships for several trainees through the years. With the entrance of some of the CEE countries into the European Union (EU) in 2004, the new member countries previously eligible for UN Fellowships (Estonia, Latvia, Lithuania, Poland, and Slovakia) are not eligible for UN Fellowships any more (Fridleifsson and Georgsson, 2004). Qualified participants from industrialized countries (including EU countries) can be accepted for UNU-GTP training on condition that they obtain similar scholarships from their own countries or international funds.

The site visits have played a very significant part in the work and in the success of the UNU-GTP. Since 1979, an average of 5-6 site visits has been conducted annually to countries requesting training, or a total of 138 visits. The site visits have been divided between the continents as follows: Africa (19%), Asia (38%), Central America (22%), and Europe (21%). The highest number of visits has been to China (15), Kenya (10), Philippines (9), El Salvador (8), Costa Rica (8), and Ethiopia (6). The visits have been made by the permanent staff of the UNU-GTP (66%), members of the Studies Board (22%), and other geothermal specialists (12%), mostly from NEA. The UNU-GTP director or the deputy-director normally undertake the first site visit to a given country. In addition to visiting geothermal fields, research institutions, and interviewing candidates, the UNU-GTP representatives commonly participate in local or national/regional geothermal energy conferences/seminars, and in some cases give lectures or lecture series at selected institutions and universities. Indeed, many site visits are planned to coincide with regional conferences and seminars. In some cases, members of the Studies Board and other specialists from the NEA (now ISOR) spend a few extra days in a given country/continent to make site visits for the UNU-GTP

when they are travelling to conferences or on consultancy missions. In this way, the travel cost can be shared. In connection with the site visits, meetings are held with the UNU-GTP alumni in each country/region as practicable.

The site visits are extremely valuable for the quality of the training. The private interviews with candidates are aimed to secure the quality of the selected Fellows. During the 25 years of the UNU-GTP, only seven UNU Fellows (out of 307) have been unable to complete the six months of training, mostly for medical reasons. The visits to institutions and geothermal fields aim to tailor the training to the needs of the country and the institutions from which the candidates come. The site visits have, without doubt, contributed very significantly to the successful transfer of technology from Iceland to the recipient countries. A wealth of information and practical experience has been gathered and shared between the various countries participating in the UNU-GTP activities. The site visits have contributed significantly to make the UNU-GTP an international centre of learning.

7. BUILDING OF SPECIALIST GROUPS AND EVALUATION

The aim of the UNU-GTP is to concentrate its training efforts to assist in building up groups of specialists in the geothermal departments of selected countries with significant geothermal potential. Priority for training is given to candidates from carefully selected institutions from developing and CEE countries where geothermal exploration and development is already under way. The limiting factor is, in some cases, the availability of sufficiently qualified staff in the recipient institutions. The fact that participants must speak English fluently has, for example, hampered participation from certain parts of the world such as Latin America.

Figure 2 shows the number of Fellows completing the six month specialized training per year during 1979-2003. The number of Fellows has gradually increased, mostly controlled by available financing. There have always been waiting lists of qualified candidates. In the last few years, there have been 16-20 Fellows graduating per year.

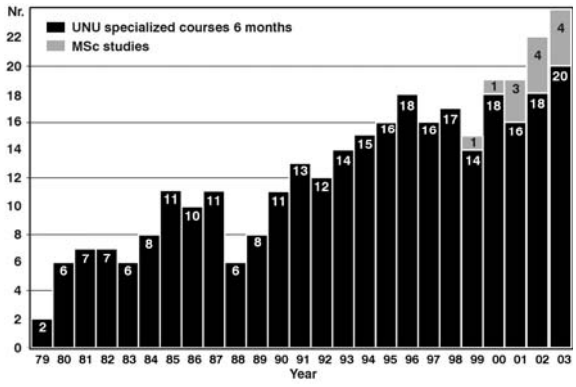

Figure 2: Number of Fellows completing six month courses and studying for a MSc 1979-2003.

The UNU-GTP has two times been evaluated as a part of the UNU system. In 1996, a detailed account was given within an assessment report on UNU training and fellowship activities (United Nations University, 1996). In 1998, a brief description was given within a report on the 20-year review and evaluation of the UNU (United Nations University, 1998). Both evaluations were very favourable to the UNU-GTP.

Internal assessment of the training has, in the past, mainly taken the form of interviews with former trainees and their directors during site visits. Meetings are also arranged in connection with international geothermal conferences. Changes have been made in the detailed contents of some of the specialized courses, based on the feedback from the trainees and their institutions. In 2002, a special evaluation was made of the Introductory lecture course (see Table 1). A member of the Studies Board (Dr. Knutur Arnason, senior geophysicist of ISOR) sat through most of the lectures of the five week course. He wrote a report with recommendations on the overall balance of the course, and made specific recommendations on improving lectures in the different subjects. During the training, questionnaires (anonymous answers) are also used to obtain the opinion of the Fellows on the content of the lectures and the performance of the lecturers.

In preparation for the International Geothermal Conference IGC-2003, held to celebrate the 25th anniversary of the UNU-GTP, former UNU Fellows were asked to write papers on the contribution of UNU-GTP training to geothermal development in Africa, Asia (without China), Central America, Central and Eastern Europe, and China (Mwangi, 2003; Benito and Reyes, 2003; Barrios, 2003; Kepinska, 2003; Zhao et al., 2003, respectively). These papers give valuable assessments on the UNU-GTP from the point of view of the respective regions. The papers can be obtained on the UNU-GTP webpage.

Generally speaking, the effort to have the training tailor-made to the abilities of the individual and the needs of the recipient country/institution, seems to have been very successful. The number of fully qualified applicants each year is normally much greater than the number of scholarships available. All the participants are selected after private interviews by UNU-GTP staff, and on the recommendation of the recipient institutions. It is, therefore, not surprising that many of the former trainees have become the leading specialists in their countries in their given fields. Our records indicate that about 80% of all our trainees have continued working in the geothermal sector for five years or more after training. A number of the Fellows from the first years of training have gone into retirement.

8. INTERNATIONAL COOPERATION

One of the roles of the UNU-GTP, according to the Agreement on the Status of Association with the UNU, is to "develop and maintain communication among developing countries and arrange, as necessary and appropriate, conferences, seminars, workshops and panels which would further the dissemination and application of practical knowledge" in geothermal energy. This has been fulfilled partly by direct cooperation with the UNU-GTP alumni and their institutions, and partly through active participation in international geothermal conferences, workshops, and seminars. The UNU-GTP has contributed to the organization of many international meetings such as the 1985 International Symposium on Geothermal Energy (US Geothermal Resources Council, Hawaii 1985); UN Workshop on the Development and Exploitation of Geothermal Energy in Developing Countries (with UN/DTCD in Reykjavik 1986); the World Geothermal Congress 1995 (International Geothermal Association, Italy 1995); and the World Geothermal Congress 2000 (International Geothermal Association, Japan 2000).

Former UNU Fellows have also been active with their colleagues in some countries in arranging regional and

international conferences/workshops such as the annual PNOC-EDC Geothermal Conference in the Philippines; the European Summer School on Direct Applications of Geothermal Energy (sponsored by the European Commission and the International Geothermal Association, at Oradea University, Romania 2001); the International Scientific Conference on Geothermal Energy in Underground Mines (Poland in 2001); the 2002 International Symposium on Geothermal at the 2008 Olympics in Beijing; and the KenGen Geothermal Conference in Kenya 2002, which was expanded in 2003 under the title 2003 Eastern Africa Market Acceleration Conference. The UNU-GTP has been very active within the International Geothermal Association (IGA), with the director serving as Chairman of the European Branch of IGA 1992-1995, and as IGA President 1995-1998. Many former UNU Fellows are active members in the respective national geothermal associations (which are affiliated with the IGA) and three (from Ethiopia, Kenya, Poland and Romania) are on the present Board of Directors of IGA.

The most memorable participation of UNU Fellows in the international arena was the World Geothermal Congress 2000 in Japan. There were about 1,250 participants (plus over 100 accompanying members) from 61 countries. The proceedings of the Congress (published on CD-ROM as well as in hardcopy) included 670 technical papers. These were presented in oral and poster sessions. Fellows trained at the UNU-GTP in Iceland during 1979-1999 were authors or co-authors of 85 technical papers at the Congress. Out of the total of 227 Fellows who had completed the six month courses in Iceland, 61 from 24 countries attended the Congress and presented papers. Among these were 14 women. The former Fellows came from Bulgaria (4), China (14), Costa Rica (2), Egypt (1), El Salvador (2), Ethiopia (3), Guatemala (1), Indonesia (3), Iran (3), Jordan (1), Kenya (5), Lithuania (1), Macedonia (1), Mexico (1), Nepal (1), Pakistan (1), Philippines (6), Poland (2), Romania (4), Serbia (1), Slovakia (1), Tunisia (1), Turkey (1), and Uganda (1). Many of them presented the country papers for their respective countries and were, in some cases, the only representatives of their countries. The Fellows presented a total of 41 papers orally and 44 posters. They made a very significant contribution to the Congress, and their participation has certainly strengthened the position of their respective institutions/countries in international geothermal cooperation.

A reunion was held for UNU Fellows, members of the Studies Board and teachers/instructors of the UNU-GTP, as well as for several UNU Visiting Lecturers who have taught at the UNU-GTP through the years (see Figure 3). It was a great occasion where former classmates met who were trained in Iceland as much as twenty years ago, and who presently are among the leaders of geothermal development in their respective countries. A similar reunion was held at the World Geothermal Congress 1995 in Florence (Italy) where 35 former Fellows (out of 161 graduates) attended and presented papers

Through the years, the director of the UNU-GTP has frequently been asked to represent geothermal energy in international working groups and at conferences, as the UNU-GTP is the most active UN centre dealing with geothermal energy at present. Two recent examples can be mentioned: An invitation to be the lead author of the chapter on geothermal energy of the World Energy Assessment Report (WEA, 2000) prepared by UNDP, UN-DESA, and the World Energy Council (WEC), as an input to the session on energy and sustainable development of the UN Commission on Sustainable Development in April 2001, at the UN in New York; and an invitation to give a paper on geothermal energy opportunities in Africa to the Twenty-first Session of the Governing Council of UNEP and the Second Global Ministerial Environment Forum in Kenya, in February 2001. The director was furthermore invited by the organizers of the International Conference for Renewable Energies (Bonn, June 2004) to describe the UNU-GTP and its capacity building of professionals from developing countries in a Plenary Session entitled “Best-Practice Examples and Success Stories”.

9. FINANCES

The activities of the UNU-GTP are mainly funded (80-90%) by the Government of Iceland, but the UNU also contributes a certain amount annually towards fellowships. International agencies (e.g. UNDP and IAEA) have also financed fellowships for several trainees through the years in connection with their geothermal projects. These have both been for six months and shorter periods of time. Fellowships awarded by UNU/Iceland have been restricted to six months training and MSc studies. Over 80 people have come for short training and study visits (2 weeks to 4 months) during 1979-2003, in addition to the 300 who have completed the six months training and the 8 MSc students.

A second UNU training programme, the UNU Fisheries Training Programme (UNU-FTP, www.unuftp.is), was established in Iceland in 1998. The training methods and mode of selection of participants is based on the experience of the UNU-GTP. Five specialized courses are offered: Fisheries Policy and Planning; Marine Resources, Assessment and Monitoring; Fishing Technology and Fleet Operations, Fish Handling, Processing and Quality Management; and Management of Fisheries Companies and Marketing. Eighty four professionals from 20 countries have graduated from the UNU-FTP during 1989-2004. Over 40 UNU Fellows from developing and transitional countries come annually to Iceland for specialized training at the UNU-GTP and UNU-FTP.

The Government of Iceland contributes a higher amount annually to the UNU than any other UN institution. It is no coincidence that the two UNU programmes, UNU-GTP and UNU-FTP, are hosted in Iceland. Both of these topics are of national importance, since some 60% of the export earnings of Iceland come from fish products, and over 50% of the total primary energy is provided by geothermal energy. Some 72% of the total primary energy of Iceland is provided by renewables (geothermal and hydropower). Oil (imported) is almost exclusively used for the transport sector (cars, ships, airplanes). The technically highly developed and sustainable use of the fisheries resources and the renewable energy resources have been instrumental in bringing Iceland from the category of developing countries in the 1960s, to the ranks of the ten countries with the highest BNP/capita since the 1980s. Iceland is prepared to share its experience with the developing and transitional countries through effective transfer of technology on the sustainable use of natural resources.

10. UNU-GTP PLANS FOR 2005-2008

The core activity will continue to be specialized six month training with about 20 Fellows annually. Through the years, there has been a steady flow of requests from all over the world for the six month training, and it has been possible only to meet a portion of the requests. New countries will be added, but care will be taken not to spread the efforts too thin. After 25 years of operations, experience strongly

suggests that to make technology transfer successful and sustainable, it is necessary to build up a group of at least ten geothermal specialists in a given country. The present MSc programme with the University of Iceland is expected to expand from 5 to 10 MSc students per year.

New activities will involve short courses in Africa (Kenya, Ethiopia, Uganda) under the REEEP initiative (established after the Johannesburg Summit in 2002). The first course is expected to be held in Kenya in 2005 in collaboration with Kenya Electricity Generating Co. and the UNEP/GEF African Rift Geothermal project (ARGEO) with participants from Kenya and neighbouring countries with geothermal resources. The teaching will be in the hands of former UNU Fellows in Kenya and the regular teachers of the UNU-GTP. Funding is partly secured from the Government of Iceland, but co-financing will be sought with energy utilities in the region as well as international development agencies.

The Government of Iceland made a further commitment at the International Conference for Renewable Energies (in Bonn, June 2004) to provide the core funding for short specialized courses in geothermal development conducted in selected countries in Africa, Asia, and Central America. The courses will be set up by the UNU-GTP in cooperation with the energy agencies/utilities and earth science institutions responsible for the exploration, development and operation of geothermal energy power stations and utilities in the respective countries. The teaching will be in the hands of UNU-GTP graduates in the respective countries/regions and the regular teachers of the UNU-GTP. The time plans for the first courses in Asia and Central America have tentatively been set for 2006-2008. Longer term goals of the United Nations University and the UNU-GTP are to assist in the establishment of formal training centres with former UNU Fellows as main teachers in e.g. China, El Salvador, Kenya, and Philippines.

The UNU-GTP would also be prepared to assist in the establishment of an international geothermal training centre(s) focusing on the needs of the CEE countries. The core funding for such a centre would, however, most logically come from the EU. The teaching material prepared for the regular operations of the UNU-GTP together with the material prepared for the short courses in Africa, Asia, and Central America, could be adapted and shared with such international geothermal training centres in the CEE countries under a cooperation agreement.

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Table 1: Approximate time schedule for the six month specialized courses at UNU-GTP

UNU GEOTHERMAL TRAINING PROGRAMME IN ICELAND

Week	Geological Exploration	Borehole Geology	Geophysical Exploration	Borehole Geophysics	Reservoir Engineering	Environmental Studies	Chemistry of Thermal Fluids	Geothermal Utilization	Drilling Technology
1 2 3 4 5	Lecture course on all main aspects of geothermal energy exploration and utilization, practicals and short field excursions								
6 7 8 9 10	Field geology Maps and photos Structure analysis Hydrogeology	Drilling Petrological logging Alteration Mineralogy	Resistivity methods Thermal methods Magnetics Gravity	Course on well logging and reservoir engineering including: Logging and well testing practises Reservoir physics Reservoir simulation Tracer tests Computer programs		EIA Project planning Chemistry Physics Biology Monitoring Revegetation Health and safety	Sampling of fluids and gas Scaling and corrosion Analytical methods Thermodynamics Geothermometers	Heat transfer and fluid flow Control systems	Drilling equipment Drilling procedures Well design Safety Management Rig operations
11 12			Excursion to the main geothermal fields of Iceland						
13 14	Field work in deeply eroded strata	Aquifers Modelling	Data processing techniques	Logging methods Data evaluation	Responses to exploitation	Gas dispersion and abatement	Water rock interaction	Design of plants and systems	Cementing Completion
15 16 17 18 19 20 21 22 23 24 25 26	Project and report	Project and report	Project and report	Project and report	Project and report	Project and report	Project and report	Project and report	Project and report

Table 2: Number of Fellows per country completing the six month specialized courses 1979-2003

Country	Geolog. Explorat.	Borehole Geology	Geophys. Explorat.	Borehole Geophys.	Reservoir engineer.	Chem. of therm.fluids	Environm. studies	Geothermal utilization	Drilling technolo.	Tot.
Algeria	1					1		1		**3**
Bulgaria				1	2	2				**5**
Burundi	1									**1**
China		3	1	2	20	11	5	10	2	**54**
Costa Rica	2	2	2		2	1	1	1		**11**
Djibouti		1								**1**
Egypt		1			1	1				**3**
El Salvador	1	1	2	2	4	4	2	1	3	**20**
Eritrea			1							**1**
Ethiopia		3	3	1	4	3		4	2	**20**
Georgia								1		**1**
Greece			1					2		**3**
Guatemala		1			1	1				**3**
Honduras		1	1							**2**
Indonesia		3	3	2	3			1		**12**
Iran	1	3	1	1	1		1	2		**10**
Jordan				1	1	1		1		**4**
Kenya	1	4	7		5	6	5	1	4	**33**
Latvia								1		**1**
Lithuania					1			1		**2**
Macedonia						1				**1**
Mexico	1		1		2					**4**
Mongolia						1		3		**4**
Nepal						1		1		**2**
Nicaragua					3	1				**4**
Pakistan	1	1			1	1				**4**
Philippines		3	5	4	9	5		3		**29**
Poland				2	5	1		6		**14**
Romania						1		4		**5**
Russia					2	2				**4**
Serbia				1	1	1				**3**
Slovakia				1	1					**2**
Tanzania	1									**1**
Thailand		1		2		1		1		**5**
Tunisia					1			5		**6**
Turkey		1			1	3	1	3		**9**
Uganda	2	1	1			2				**6**
Ukraine					2					**2**
Vietnam	1		1		1	1			1	**5**
Total	**13**	**30**	**30**	**20**	**74**	**53**	**15**	**53**	**12**	**300**

Table 3: UNU Visiting Lecturers 1979-2003.

1979	Donald E. White	USA		1992	Patrick Muffler	USA
1980	Christopher Armstead	UK		1993	Zosimo F. Sarmiento (UNU Fellow 1980)	Philippines
1981	Derek H. Freeston	New Zealand		1994	Ladislaus Rybach	Switzerland
1982	Stanley H. Ward	USA		1995	Gudmundur Bodvarsson	USA
1983	Patrick Browne	New Zealand		1996	John Lund	USA
1984	Enrico Barbier	Italy		1997	Toshihiro Uchida	Japan
1985	Bernardo Tolentino	Philippines		1998	Agnes Reyes (UNU Fellow 1979)	Philippines/ New Zealand
1986	Russel James	New Zealand		1999	Mike Wright	USA
1987	Robert Harrison	UK		2000	Trevor Hunt	New Zealand
1988	Robert O. Fournier	USA		2001	Hilel Legmann	Israel
1989	Peter Ottlik	Hungary		2002	Karsten Pruess	USA
1990	Andre Menjoz	France		2003	Beata Kepinska (UNU Fellow 1994)	Poland
1991	Wang Ji-yang	P.R. China				

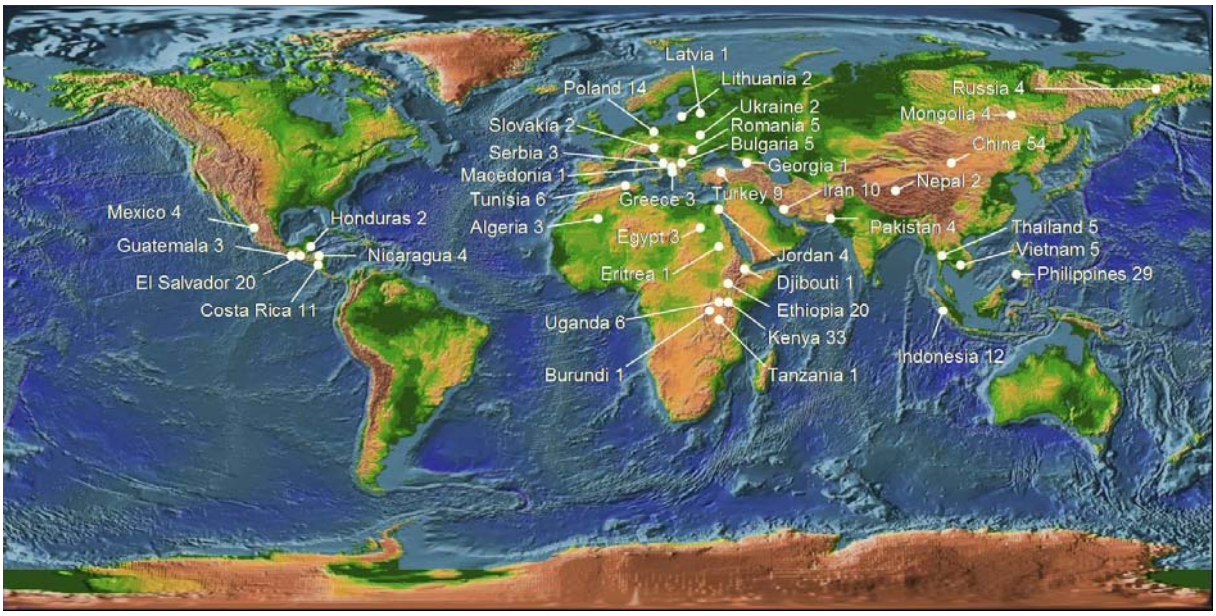

Figure 1: Fellows completing the six month courses at the UNU-GTP in Iceland 1979-2003

Figure 3: Fellows trained at the UNU-GTP in Iceland during 1979-1999 were authors or co-authors of 85 technical papers at the World Geothermal Congress 2000 in Japan. Out of a total of 227 Fellows who had completed the six month courses in Iceland, 61 from 24 countries attended the Congress and presented papers. The photo shows the Fellows with the UNU Rector, the director, and a few instructors of the UNU/GTP.