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Geothermal Education Program in El Salvador Through SATREPS Project

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ABSTRACT

Geothermal power generation in El Salvador started in the '70s, with over 40 years of history. Nowadays, El Salvador has been promoting the introduction of renewable energy. Actually, one-quarter of domestic generated electricity comes from geothermal plants, which plays a crucial role in energy demand. However, the civil war, which started in 1979 and ended in 1992, had seriously damaged human resources. It is urgent to recover human resources in the country.

University of El Salvador (UES) is one of the key players for human resource development. Geology is the foundation for promoting geothermal development, but unfortunately, there is no school for education/research specializing in geology/mineralogy/geothermal exploration at UES. This is one of the challenges to aim for the above-mentioned geothermal exploration and development.

Tohoku University-centered group in Japan (Iwate University, National Institute of Advanced Industrial Science and Technology, Geothermal Engineering Co., Ltd), UES, and LaGeo (national company) have agreed to launch a cooperative research project. The SATREPS project, Thermoluminescence Techniques in Geothermal Exploration and Integrated Evaluation System of Geothermal Reservoir. Through this project, we are making efforts to develop human resources.

1. INTRODUCTION

El Salvador in Central America is located in the Pacific Rim volcanic zone, Ring of Fire, and is a country with earthquakes and volcanoes. Geothermal exploration and development have been active in the country since around 1960s. Ahuachapán geothermal power plant, the country's first geothermal power plant, began its commercial operation in 1975. After that, two units were added, and the power plant capacity reached 95 MW. Also, the Berlín Geothermal Power Plant started commercial operation in 1992. The unit has expanded to 109.4 MW (including binary power generation), and the total capacity is 204.4 MW. The power generated by these geothermal power stations covers about one-fourth of the domestic demand. So, it can be said that geothermal energy is an essential resource for the country. (http://www.lageo.com.sv/)

However, the country's civil war from around 1979 to 1992 caused the university's functions to stop, and a large number of human resources had flowed out to foreign countries.

At present, there is no university in the country with a department that specializes in geology, mineralogy, and geothermal exploration. And there are not so many human resources who lead those research.

Entering the 2000s, LaGeo and UES have created an opportunity to develop human resources for geothermal development. They held workshops, seminars, and diploma courses for geothermal exploration and development with the support of the United Nations University-Geothermal Training Program, Italian Cooperation, and other institutions (De Velis and Montalvo, 2011; De Velis, 2014; Georgsson et al. (2015)). And now, it is becoming a center for developing engineers in Central and South America. With such a background, it is expected to create a new base of learning and research in the country.

Tohoku University started an international joint research project in 2018 with University of El Salvador (UES) and LaGeo in the framework of SATREPS. One of the goals of the project is to contribute to human resource development through research activities. In this paper, we will focus on human resource development and introduce the contents and the progress so far.

2. OUTLINE OF SATREPS PROJECT

SATREPS (Science and Technology Research Partnership for Sustainable Development) is an international science and technology cooperation program promoted by the Japanese government JICA (Japan International Cooperation Agency), and the Japan Science and Technology Agency (JST) are providing support.

Tohoku University, UES, and LaGeo have set up a research subject called SATREPS "Thermoluminescence Techniques in Geothermal Exploration and Integrated Evaluation System of Geothermal Reservoir." And we agreed to conduct research activities for exploration and evaluation of geothermal resources in the country, the provision of analytical instruments necessary for research, and human resource development, and the project started in 2018.
(https://www.jst.go.jp/global/english/kadai/h2903_elsalvador.html)

Thermoluminescence of quartz (TL) is a phenomenon that occurs in storing radiation energy in the crystal. Since the amount of light emission changes according to the annealing in the past, the area with high geothermal potential can be known by comparing the relative light emission intensity (Tsuchiya et al., 1994, 2000, 2015; Nambu et al., 1996; Saito et al., 2017).

This project's research theme is to contribute to the exploration of geothermal resources in the country. We will construct a system to evaluate the geothermal potential in an integrated manner by combining the various exploration data, including thermoluminescence intensity. Ultimately, we aim to contribute to the prevention of global warming by boosting geothermal power development in the country and increasing the amount of electricity generated by renewable energy and the resulting reduction in fossil fuel consumption.

Tohoku University is leading this project. Iwate University (IU), the Fukushima Renewable Energy Research Institute, Institute of Advanced Industrial Science and Technology (FREA), and Geothermal Engineering Co., Ltd. (Geo-E) support for mainly human resource development.

3. HUMAN RESOURCE DEVELOPMENT IN THIS PROJECT

Geothermal education in El Salvador started with training for internal engineers started by LaGeo since 2002. In 2006, workshops and short courses began with the support of the United Nations University. And “Diploma Course in Geothermal Energy” has started at University of El Salvador with the support of Italian Cooperation and other institutions in 2010. Since then, geothermal education activities have been carried out actively (De Velis and Montalvo, 2011; De Velis, 2014; Georgsson et al. (2015)). Based on these achievements, We all hope that the research institute or department that specializes in teaching and researching geothermal energy will be established.

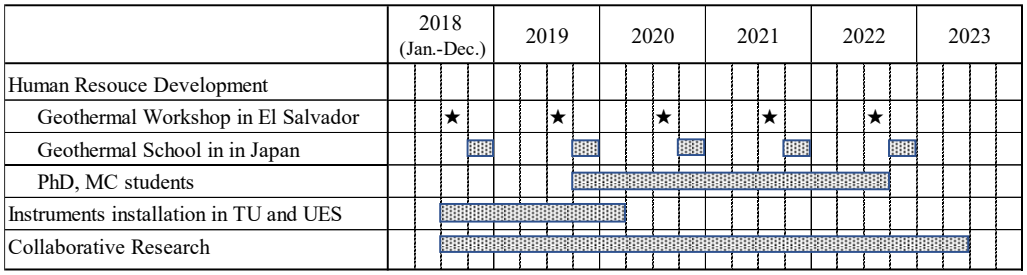
SATREPS project way is different from those mentioned above. From the viewpoint of universities, we emphasize primary education, including geology and mineralogy. Besides, through research activities, we aim to increase the number of professionals in UES.

We have three types of programs for human resource development.

Geothermal workshop in El Salvador (4-5 days) /Geothermal school in Japan (3 months (2 months in 2018)) /Acceptance of doctoral and master's course students at Tohoku University.

Table 1 shows the five years schedule (original).

Table 1: SATREPS Project Schedule (original)*



*Due to the pandemic of COVID-19, 2020 Workshop and School were cancelled and the schedule after 2021 will be reviewed.

3.1 Geothermal workshop in El Salvador

This workshop is held in August at El Salvador University on a short schedule of four to five days. The contents of the workshop implemented in 2019 are as shown in Table 2. The lecturers are from Tohoku University, FREA, and Geo-E. And the topics are geology, geothermal energy, the evolution of volcano, geothermal fluid flow, and essential matters on exploration, and social acceptance for development. Also, the lectures are in English. However, an interpreter for Spanish is provided to support the understanding of the participants.

The target audience for this workshop is El Salvador's university students, university teachers, engineers, engineers of LaGeo. There were 32 participants in 2018 and 31 in 2019 (Figure1).

Table 2: Contents of Workshop August 22nd~27th,2019

Day1	Geothermal Exploration (including Introduction to GeoFluid Science)
Day2	Subduction System / Supercritical Geothermal Fluid and Water-Rock Interaction / Supercritical Geothermal Reservoir / Thermoluminescence Geothermal Exploration
Day3	Field Trip
Day4	Heat and Fluid Transfer / Introduction to Reservoir Stimulation / Geochemistry of Geothermal Development
Day5	Thermal Prospection of Geothermal Reservoir by using TL and Sustainable of Geothermal Reservoir Forecasting



Figure1: Geothermal Workshop (a) Lecture in UES (2019), (b) Rock sampling in the field (2018 Field Trip)

3.2 Geothermal school in Japan

The school runs in Japan from September (from October of 2018) to December (November of 2018). It is held on Tohoku University in Sendai, Iwate University (IU, Morioka City, Iwate Prefecture), AIST Fukushima Renewable Energy Research Institute (FREA, Koriyama City, Fukushima Prefecture), Geothermal Engineering Co., Ltd. Head Office (Geo-E), Takizawa City, Iwate Prefecture) as a training site.

The school had five participants in 2018, six in 2019. In 2018, there were 4 participants from UES and one from LaGeo. Participants in the school ranged from the twenties to the fifties and were mainly teachers (technicians).

The learning contents of each field are as shown in Table 3. Figure 2 (photos) shows lectures and training in Geothermal School in 2018.

Table 3: The Contents of Geothermal School in Japan, 2018 and 2019

Contents	Instructor	2018 (Basic)		2019 (Advanced) Group A		Group B		Group C	
			day		day		day		day
General Topic	Tohoku Univ.								
Geothermal Energy (development) in Japan		✔	0.5	✔	0.5	✔	0.5	✔	0.5
Risk Management for Geothermal Energy		✔		✔		✔		✔	
Geology/Mineralogy/Geochemistry	Iwate Univ. Tohoku Univ. Geo-E								
Fundamentals of Geology									
History of the earth /Minerals /Rocks		✔							
Geological Survey (Lecture and field work)									
Geomorphological features		✔		✔		✔		✔	
Observation of outcrops		✔		✔		✔		✔	
Observation of drilled cores		✔							
Orientation of beds and faults /Rock sampling		✔		✔		✔		✔	
Geological mapping			5.5	✔	15.5	✔	15.5	✔	11.0
Volcano				✔		✔		✔	
Fractures									
Rock deformation /Faults and veins /Stereographic projection		✔		✔		✔		✔	
Geothermal Energy									
Geothermal structure		✔							
Thermoluminescence geothermal exploration		✔		✔		✔		✔	
Geochemistry /Chemical equibrium		✔		✔		✔			
Practical Training in Geothermal Field (Power Plant)	Geo-E		n/a		3.0		3.0		n/a
Fluid sampling				✔		✔			
Practical Training in Laboratory	Tohoku Univ. Geo-E								
Sample preparation (cutting, grinding for XRD/XRF, glass bead)		✔		✔		✔		✔	
Thin section making /Polarizing microscope observation		✔		✔				✔	
X-Ray Diffraction analysis (XRD)		✔		✔					
X-Ray Fluorescence analysis (XRF)				✔		✔			
Chemical analysis by ICP-OES		✔	16.0		16.5	✔	16.0		9.5
Geothermal fluids(gas, hotwater) chemical analysis (Silica,CO_2, H_2S, NCG)						✔			
Fluid inclusion observation and homonization temperature measurement						✔			
Thermoluminescence Measurement		✔		✔				✔	
QGIS Utilization		✔						✔	
Basics of Geophysical Exploration and Reservoir Simulation	Fukushima Renewable Energy Institute, AIST (FREA) Tohoku Univ.								
Current Status of Geothermal Development in Japan		✔							
Micro Earthquake Monitoring / Micro Earthquake Monitoring for Geothermal Reservoir		✔							
Geophysical Exploration Technology for Geothermal Reservoir Simulation by MT and Gravity Survey		✔	5.0		n/a		n/a		14.0
Field Practice Geophysical Exploration Technology for Geothermal Reservoir Simulation Model Construction		✔							
MT Exploration and Gravity Exploration		✔							
Geothermal Reservoir Simulation		✔						✔	
Academic Conference		✔	5.0	✔	3.0	✔	3.0	✔	3.0
Field Trip (Geothermal Power Plants, Geothermal fields, etc.)	Tohoku Univ. FREA,Geo-E	✔	4.0	✔	4.0	✔	4.0	✔	4.0
Total			36.0		42.5		42.0		42.0

* Group A: Geology/Mineralogy/TL field * Group B: Geochemistry field * Group C: Geophysical exploration/ Reservoir simulation field



Figure 2: Geothermal School 2018

(a) Fracture observation, (b) XRD training, (c) Core observation, (d) Lecture (rock property)

This school is based on the premise that the same trainee participates twice. In the first year, all attend the same lecture and practice. The contents include geology and mineralogy, fieldwork, analysis of collected samples, rock properties, geothermal exploration, reservoir simulation, etc. However, due to time constraints, all items remain essential matters.

In the second year (2019), we divided the school into three-course (geology, mineralogy, thermoluminescence field, geochemical field, physical exploration, reservoir simulation field). Each participant can choose the desired course, based on the training results of the first year and each trainee's specialty,

In each field, we will prepare specialized contents more than the previous year. However, we plan to emphasize practical training as much as possible, including the handling of instruments and software used in research.

3.3 Acceptance of doctoral and master's course students at Tohoku University

Since October 2019, Graduate School of Environmental Studies, Tohoku University accepts the researchers from UES as Ph.D. and Master's degree students. And they are researching the theme related to our project. This project shoulders all of their tuition fees.

These two students have been given research themes related to the project. Through this research, they will be able to acquire knowledge and skills in geology, mineralogy, learnings for geothermal exploration, and development. We expect they will play as leaders in the future in UES and LaGeo.

Acceptance of two more students to this master course is planned for 2020 as well.

4. STANDARDIZATION AND UTILIZATION OF ANALYTICAL INSTRUMENTS

Analytical instruments in recent years have been automated, and analysis is becoming simple with the manual. However, to obtain correct results for any analysis, sufficient training is required, including sample treatment. The school will provide not only analytical methods but also enough training opportunities for handling instruments and samples.

In this project, we planned to install the necessary analytical instruments in UES and use them for on-site analysis. These devices are expected to be fully utilized in UES after this project.

The school students have training with the same instruments on TU. Therefore, they will be able to confirm the skill and techniques they acquired in Japan.

In this research, we can also compare the analytical results of the samples. And there is another advantage that it is easy for a specialized teacher to give instructions even if an unknown point or problem occurs with these devices in El Salvador. We think this is important to get the instruments to be used for a long time

5. CONCLUSION

The effective use of geothermal energy is recognized as one of the keywords of global warming countermeasures all over the world. This project goal is the exploration and evaluation of geothermal resources in El Salvador. It is a central theme to expand further and promote geothermal power generation. The effective utilization of this energy will not only contribute to the increase in the amount of electricity generated by renewable energy but also the improvement of the country's economy. However, we need human resources to develop. This project will be one step.

We hope to be able to foster human resources and contribute to the creation of an environment where renewable energy and geothermal energy resources can be used more effectively.

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LaGeo website http://www.lageo.com.sv/

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