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SATREPS: Geothermal Collaborative Research With Kenya

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ABSTRACT

SATREPS is a Japanese government program that promotes international joint research, and is an acronym standing for Science and Technology Research Partnership for Sustainable Development. Japan Science and Technology Agency and Japan International Cooperation Agency are jointly in charge of research themes about "Environment/Energy", into which the research themes about geothermal energy are classified. In FY2019, "Comprehensive Solutions for Optimum Development of Geothermal Systems in East African Rift Valley (Partner Country: Kenya)" proposed by Kyushu University was adopted as a 5-year project from FY2020. Research institutions of this research project in Japan are Kyushu University and other two universities and one company, and those in Kenya are Jomo Kenyatta University of Agriculture and Technology and one university and two companies. This research project targets to obtain four outputs, i) High resolution geothermal reservoir models of Olkaria and Menengai geothermal areas are developed, ii) Silica scale formation mechanism in highly alkaline hot water environment is understood and countermeasures are examined, iii) A scenario for enhancement of social acceptance by the expansion of cascade use of geothermal energy is proposed, and iv) Human resources in geothermal development and research of the counterpart institutions in Kenya are cultivated. Unfortunately, this project was brought to a standstill caused by the COVID-19 pandemic in FY2020 both in Japan and Kenya. Although the influence of COVID-19 pandemic still remained in FY2021, we resumed some field researches in Kenya. And the project period was extended for one year. Results are being obtained for four outputs.

1 INTRODUCTION

SATREPS is a Japanese government program that promotes international joint research, and is an acronym standing for Science and Technology Research Partnership for Sustainable Development. The program is structured as a collaboration among the Japan Science and Technology Agency (JST) and the Japan Agency for Medical Research and Development (AMED), which provides competitive research funds for science and technology projects, and JICA, which provides development assistance (ODA). Based on the needs of developing countries, the program aims to address global issues and lead to research outcomes of practical benefit to both local and global society.

There are five research fields in SATREPS.

1. Environment/Energy (Global-scale Environmental Issues)
2. Environment/Energy (Low Carbon Society/Energy)
3. Bioresources
4. Disaster Prevention and Mitigation
5. Infectious Diseases Control

Currently, the research fields from Nos. 1 to 4 are handled jointly by JST and JICA, and AMED and JICA are involved with the research field No. 5.

The countries covered by SATREPS are the ODA ‘Technical Cooperation Projects’ receiving countries. The duration of a project is from 3 to 5 years and the total project budget in a 5-year case is approximately 500,000,000 JPY.

2 SATREPS PROJECTS ON GEOTHERMAL RESEARCH

Research themes about geothermal energy are classified into the field of "Environment/Energy (Low Carbon Society/Energy)", and there have been 2 research projects before the proposal of Kyushu University was adopted. One was “Utilize Renewable Geothermal Energy for a Low-carbon Society” by Kyoto University with Indonesia (Project period: FY2015-FY2019), and another was “Thermoluminescence Techniques in Geothermal

Exploration and Integrated Evaluation System of Geothermal Reservoir" by Tohoku University with El Salvador (Project period: FY2018-FY2023).

The proposal for the SATREPS project "Comprehensive Solutions for Optimum Development of Geothermal Systems in East African Rift Valley" by Kyushu University with Kenya was adopted in FY2019 in the research field of 'Environment/Energy (Low Carbon Society/Energy)'. The duration of the research was 5 years from FY2020. Due to the length of the official project name, the project was given the nickname LENGO (Leading an Enhanced Notable Geothermal Optimization). The word "lengo" in Swahili means "aim", "target" or "goal".

3 SATREPS PROJECT OF KYUSHU UNIVERSITY

Research institutions of LENGO project in Japan are Kyushu University, Institute of Science Tokyo, The University of Tokyo and West Japan Engineering Consultants, Inc. (West JEC), and those in Kenya are Jomo Kenyatta University of Agriculture and Technology (JKUAT), The University of Nairobi (UoN), Kenya Electricity Generation Company Ltd. (KenGen) and Geothermal Development Company Ltd. (GDC) (Figure 1).

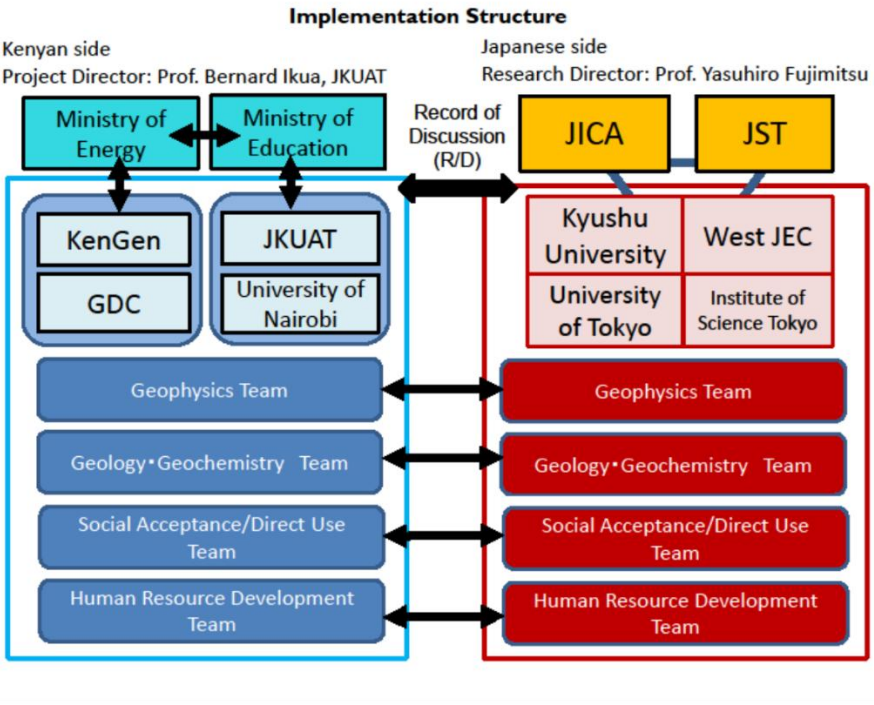


Figure 1. Implementation structure of LENGO Project.

LENGO project targets to obtain four outputs. Those are, i) High resolution geothermal reservoir models of Olkaria and Menengai geothermal areas are developed (Output 1), ii) Silica scale formation mechanism in highly alkaline hot water environment is understood and countermeasures are examined (Output 2), iii) A scenario for enhancement of social acceptance by the expansion of cascade use of geothermal energy is proposed (Output 3), and iv) Human resources in geothermal development and research of the counterpart institutions in Kenya are cultivated (Output 4). Unfortunately, this research project was brought to a standstill caused by the COVID-19 pandemic. Especially, the project activities in FY2020 almost suspended both in Japan and Kenya. Although the COVID-19 situation in the world was not good in FY2021, we resumed some field researches in Olkaria and Menengai geothermal areas (Figure 2) by Kenyan researchers and acceptance of the counterpart researchers as the graduate students of Kyushu University or the participants of JICA International Training Course "Intensive Training for Geotherm Resource Engineers" conducted by Kyushu University. Since the start of FY2022, overseas travel from Japan to Kenya has been permitted, and LENGO project has begun moving forward in earnest. And considering the one-year hiatus in activities due to the COVID-19 pandemic, this project period was extended by one year (the final year is FY2025).

4 PROGRESS OF LENGO PROJECT

LENGO project has not yet been completed, but the implementation status of each output at this point is briefly described below.

4.1 Output 1

The summary of Output 1's achievements to date is as follows.

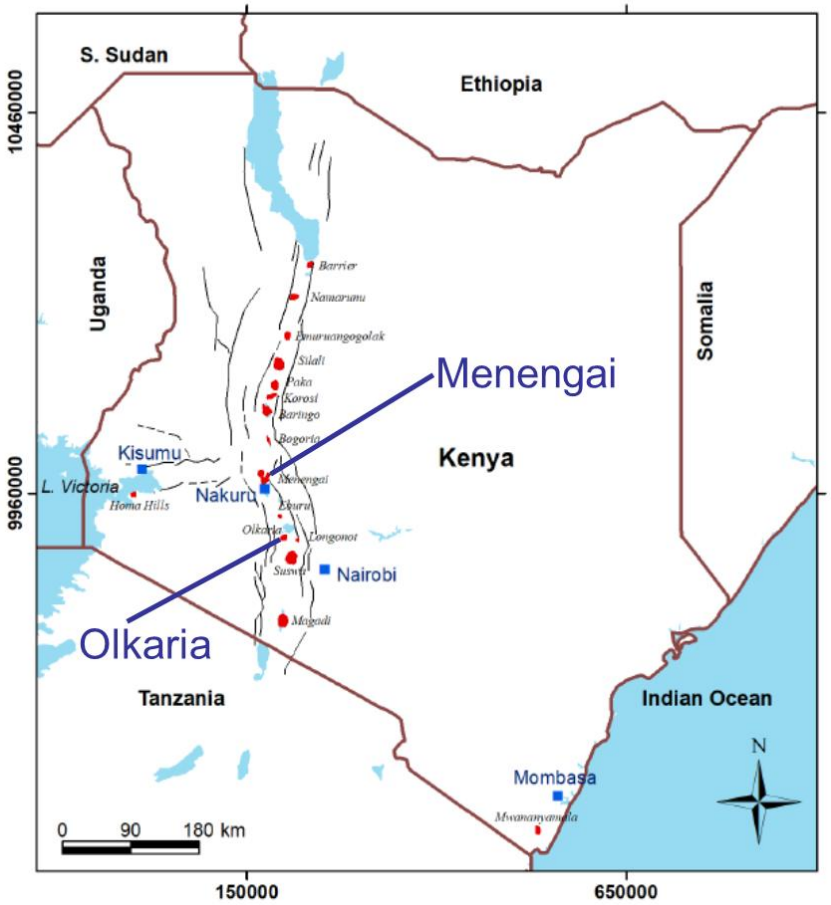


Figure 2. Geothermal areas in Kenya and the target fields of LENGO project. (Kanda, 2019)

- An implementation structure has been established enabling researchers from each counterpart organization to collaborate and proactively conduct seismic and gravity surveys.
- In addition to the data acquisition techniques for the above geophysical surveys, we also transferred the data analysis techniques through technical training conducted in Japan.
- We are integrating existing conceptual models to create numerical models of geothermal reservoirs in the Menengai and Olkaria areas.
- Seismic and gravity surveys in the Menengai and Olkaria areas are almost complete, and are expected to contribute to the refinement of geothermal reservoir models (Figure 3).

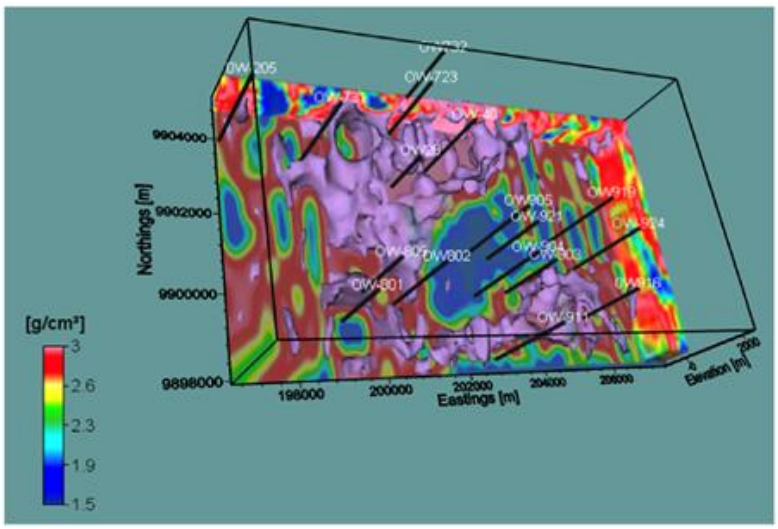


Figure 3. 3D density structure of the Olkaria geothermal reservoir by gravity surveys with vertically drilled wells. (Omollo and Nishijima, 2023a)

Due to insufficient seismic data, the understanding of fluid flow paths may be inadequate. Therefore, continuous data acquisition is required even after the project concludes.

Due to the remaining research period and equipment issues, the on-site MT surveys within the project are discontinued and changed to reanalyzing existing data. And temperature estimation using machine learning could not be performed due to transfer of the responsible researcher. These are promising topics for post-project research.

4.2 Output 2

The summary of Output 2's achievements to date is as follows.

- Through hydrothermal property testing and metal plate immersion experiments at the Olkaria and Menengai geothermal power plants, we implemented technology transfer leading to the development of silica scale prevention measures.
- Through technical training in Japan, we implemented the transfer of various geochemical analysis techniques.
- Laboratory experiments were conducted to analyze the behavior of silica in fluoride-containing alkaline hot water characteristic of the rift valley. The effects of fluoride and Al-F complexes on scale formation were investigated, and countermeasures were proposed (Figure 4).
- We constructed a new geochemical thermometer and estimated the approximate age of the water cycle for geothermal reservoir management.
- By implementing the above activities through collaborative works among all organizations, a framework has been established enabling mutual collaboration and the future international joint research.



Figure 4. Scale inhibitor evaluation test.

The design of geothermal power plants and parameters such as gas-liquid ratios vary significantly. Therefore, scale control measures, including a review of the plant's operational systems, are necessary based on the estimated scale formation mechanism. However, even with the current system, there are areas where sufficient countermeasures using inhibitors can be implemented.

4.3 Output 3

The summary of Output 3's achievements to date is as follows.

- A field survey was conducted among residents living near the Olkaria geothermal power plants.
- Group interviews with young people and women in the vicinity of the Olkaria geothermal power plants were conducted.
- A workshop on geothermal cascade utilization was held with local chamber of commerce.
- Initial surveys for geothermal heat utilization using GIS was conducted.
- Numerical analysis was performed (Figure 5) and a cascade geothermal utilization scenario was proposed.

In the research field of social acceptability surveys, conducting effective research was initially difficult due to a lack of collaboration history between partner universities and companies in the host country, insufficient investment in survey equipment, and complex factors including the COVID-19 pandemic.

During this period, we held repeated discussions with JKUAT faculty members, conducted field visits, and deepened their understanding of geothermal development and community acceptance. We then formulated a research survey plan that leveraged their expertise and, with UoN's cooperation, were able to conduct the survey in Olkaria. Following the survey, corporate interest has grown, and we are now engaged in discussions regarding data analysis. This survey has enabled researchers from JKUAT and UoN to establish connections with both local community and corporate stakeholders.

Research on cascade utilization was initially advanced primarily at Kyushu University. Through the workshop with GDC and local industry, it was confirmed that JKUAT faculty would lead research efforts, including analysis of heat demand data from industry and exergy analysis related to heat utilization. The findings from JKUAT and industry surveys suggest that the geothermal utilization project could potentially lead not only to geothermal energy use but also to the next-generation industrialization of the region through the industrial park concept.

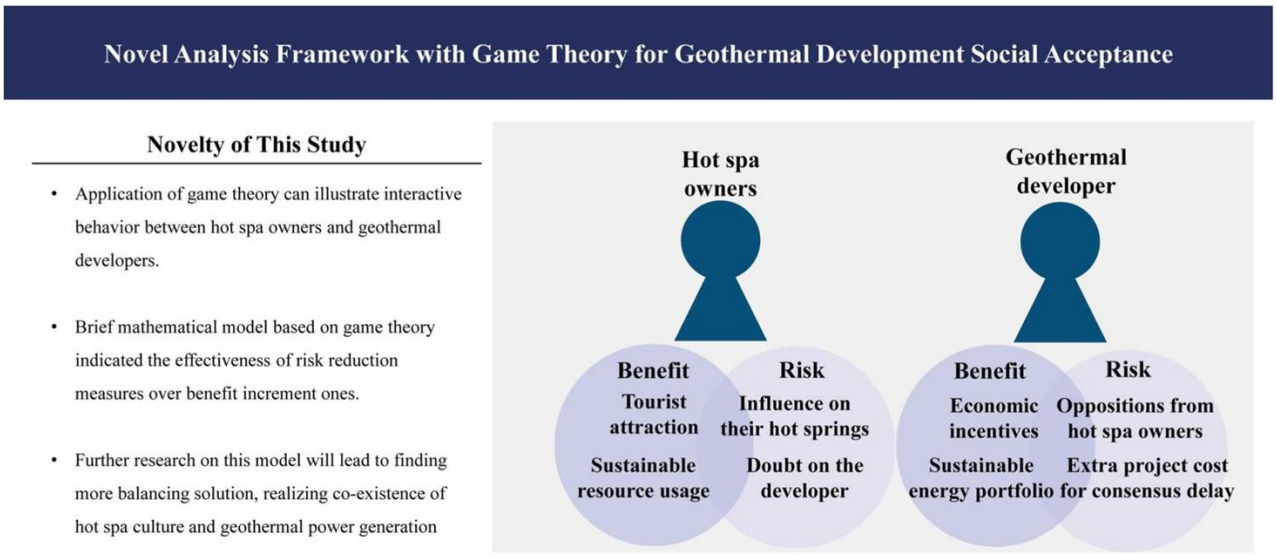


Figure 5. Graphical abstract of a game theory analysis of geothermal development consensus building. (Shinozaki et al., 2025)

4.4 Output 4

The summary of Output 4's achievements to date is as follows.

- Kenyan researchers were accepted as graduate students of Kyushu University (Table 1) or participants in the JICA International Training Course "Geothermal Resource Engineers."
- We hosted Kenyan researchers to provide training on the operation and analysis methods for equipment to be introduced to Kenyan institutions.
- In March 2023 and March 2025, the geothermal short course was conducted at JKUAT for students from JKUAT and UoN (Figure 6).
- The International Symposium on Earth Science and Technology is held annually at Ito Campus of Kyushu University to raise awareness of the SATREPS and LENGO projects among individuals outside the project participants.

Table 1. Number of degree recipients in LENGO project.

Fiscal Year	PhD	Master
2021	0	JKUAT 1, KenGen 1
2022	JKUAT 2, KenGen 1	0
2023	GDC 1	0

2024	KenGen 1	GDC 1
Currently Enrolled	JKUAT 2	UoN 1



Figure 6. Geothermal Short Course in 2025 at JKUAT.

5 PUBLICATION OF RESEARCH FINDINGS

Although many activities were affected by the COVID-19 pandemic, we conducted field surveys in Olkaria and Menengai in Kenya. And some research results have been published in the journals and proceedings of the conferences by FY2022. Only papers co-authored by Japan and Kenya are included here.

With regard to Output 1, Omollo et al. (2021, 2022) and Omollo and Nishijima (2022, 2023a) concluded the geophysical explorations (magnetotelluric method and gravity survey) in the Olkaria geothermal field, and Omollo and Nishijima (2023b) showed that microgravity temporal changes in the Olkaria geothermal field are associated with regular reservoir field operation. And Bett and Fujimitsu (2021, 2022, 2023) indicated the conceptual and numerical models of the geothermal system in the Olkaria East and Southeast area. In addition to them, Mutonga and Fujimitsu (2021, 2022, 2023, 2024) showed the results of a borehole image analysis and a geochemical analysis of a fluid sample from a well in Menengai geothermal field.

As for Output 2, Wanyonyi et al. (2022) provided the characterization of amorphous silica scales at the separators of the power plant in the Olkaria geothermal field. And Wanyonyi et al. (2023) showed that Well OW-35 scale composed of a mixture of amorphous Al-rich opal-A and crystalline quartz, suggesting that Al may participate in the formation of the silica scale. Wanyonyi et al. (2024) conducted some experiments on the precipitation behavior of silicic acid and Aluminum in geothermal water at the Olkaria geothermal field. Auko et al. (2024, 2025) indicated geochemical characteristics of the siliceous scale deposits precipitated from geothermal waters on the bypass silencers at the Menengai geothermal field.

And about Output 3, Ngethe and Jalilinasrabady (2020a, 2020b, 2021a, 2021b, 2022a, 2022b, 2023) presented some scenarios for direct use of the hot waters in some geothermal systems in the East African Rift Valley.

6 CONCLUSIONS

In FY2019, the SATREPS project proposed by Kyushu University was adopted as a 5-year project from FY2020. However, this research project was brought to a standstill caused by the COVID-19 pandemic. Especially, the project activities in FY2020 almost suspended both in Japan and Kenya. Although the COVID-19 situation in the world was not good in FY2021, we resumed some field researches in Olkaria and Menengai geothermal areas and published some research results. And acceptance of the counterpart researchers as the graduate students of Kyushu University or the participants of JICA International Training Course "Intensive Training for Geotherm

Resource Engineers" conducted by Kyushu University was also restarted. And the project period was extended for one year (to 2025). Results are being obtained for four outputs.

Acknowledgements

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