

Exploration of Geothermal Resources for Remote Islands of Indonesia

– For Supplying Clean Energy to Fulfill the Growing Demands for Energy in Asia –

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Background of the Project

This program, officially named “Research Cooperation Project on the Exploration of Small-scale Geothermal Resources in the Eastern Part of Indonesia” started in April 1997 and ended in March 2002. Firstly, we would like to overview the background information of the project.

The Republic of Indonesia has approximately 17,000 islands scattered in its vast territory stretching for 5,100km east to west (Fig. 1). The remarkable economic development of the country in recent years is restricted to a very few regions; Java, the most populous island that numbers 60% of the entire population (200 million), Sumatra with abundant resources and Bali, the base for tourism. The areas left behind by the economic development are the remote islands including Nusa Tenggara of eastern Indonesia.

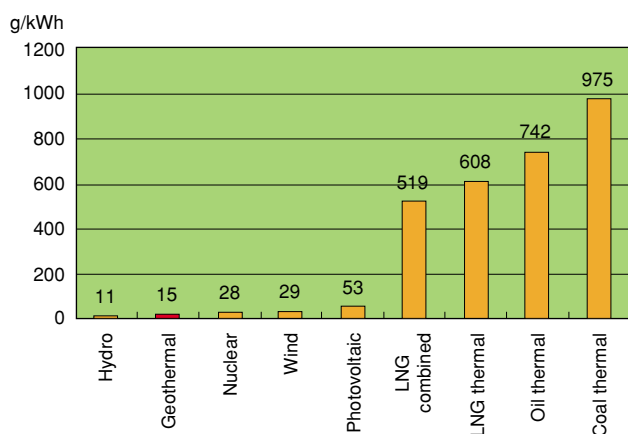
The major reason for this is attributable to the poor infrastructure of the remote islands, especially undeveloped energy supply system. With this in mind, the Indonesian government initiated the 2nd Rural Electrification Program with the aim of drastically upgrading local infrastructure as a base of industrial development in the eastern part of In-



● Fig. 1 Map of the Republic of Indonesia as an archipelago

onesia as part of the 6th five-year plan starting from 1994. As it is unrealistic to lay a submarine cable which connects these vast many islands, various sources of natural energy has been explored as dispersive power sources. However, due to the rainy and dry seasons inherent to the tropical region, there is a slim possibility for these energy sources to ensure a stable power supply throughout the year.

Meanwhile, as most of these remote islands are volcanic ones, geothermal resources are abundant. Geothermal power generation has relatively a high operating rate regardless of the seasonal weather variation, and geothermal power is one of the cleanest energies from the viewpoint of emissions of carbon dioxide (Fig. 2¹⁾). For this reason, the Indonesian government placed a higher priority on the small-scale geothermal power plant in the Rural Electrification Program, and the exploration of small-scale geothermal resources at 217 sites. This required the technologies to explore geothermal resources in a short period in the areas with insufficient geoscientific data, and the Japanese participation in technical assistance co-operation has been provided.



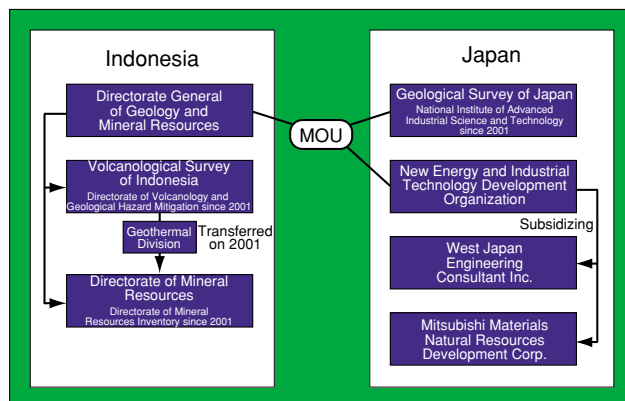
● Fig. 2 Life cycle CO₂ emissions in various power generations¹⁾

Outline of This Project

The objective of this project is to develop a geothermal exploration system that is suitable for geothermal resources of tropical remote islands in the eastern part of Indonesia and to be utilized in the development of geothermal energy in Indonesia, and consequently, to contribute to the Rural Electrification Program, one of the major projects conducted by the Indonesian government.

This project is one of the ODA major projects supported by the budget of Official Development Assistance (ODA) under jurisdiction of the International Trade Policy Bureau of the former Ministry of International Trade and Industry (MITI). The budget of Japanese participating organizations is approximately 500 million yen for the five years. 80% of the budget was allotted to New Energy and Industrial Technology Development Organization (NEDO) in charge of the actual on-site project and 20% to Geological Survey of Japan (current AIST) for "logistics", that is laboratory researches to provide scientific research background.

Figure 3 shows a cooperation regime of this project. The Memorandum of Understanding was signed by the Directorate General of Geology and Mineral Resources, NEDO and Geological Survey of Japan in Jakarta on March 26th, 1998. NEDO made an entrustment contract with West Japan Engineering Company Inc. and Mitsubishi Materials Natural Resources Development Corp. (MRC) for investigations and later, the framework was continued based on a subsidizing contract. The assigned tasks of NEDO were geothermal exploration in relatively small areas which have geothermal potential (Fig. 4), drilling of wells for survey and construction of the Indonesian Geothermal Expert Modeling System (iGEMS). AIST was responsible for the es-

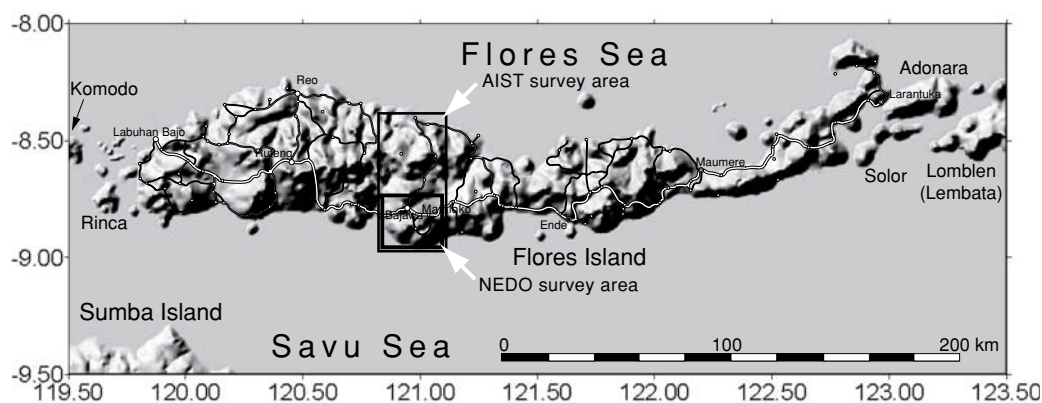


● Fig.3 Co-operation regime of the project

establishment of geothermal exploration systems, including satellite remote sensing, geological survey, geochemical survey, gravity survey, resistivity profiling and self-potential survey in more extensive areas (Fig. 4).

Although the Directorate of Mineral Resources Inventory signed the Memorandum on behalf of the Indonesian government, the organization that played the main role in the technical investigations was Volcanological Survey of Indonesia. However, as a result of the organizational reform of 2001, Volcanological Survey of Indonesia was reorganized into Volcanology and Geological Hazard Mitigation, and its Geothermal Division was transferred to the Directorate of Mineral Resources Inventory completely. The Indonesian research institutes proceeded with their own investigations and also as the host country, extended its devoted cooperation in exploration activities by Japanese organizations.

In order to develop the exploration survey system suitable for remote islands, it is necessary to select model areas. Mataloko geothermal field, located in the central Flores, was selected based on the 1997 reconnaissance survey by Geological Survey of Japan.



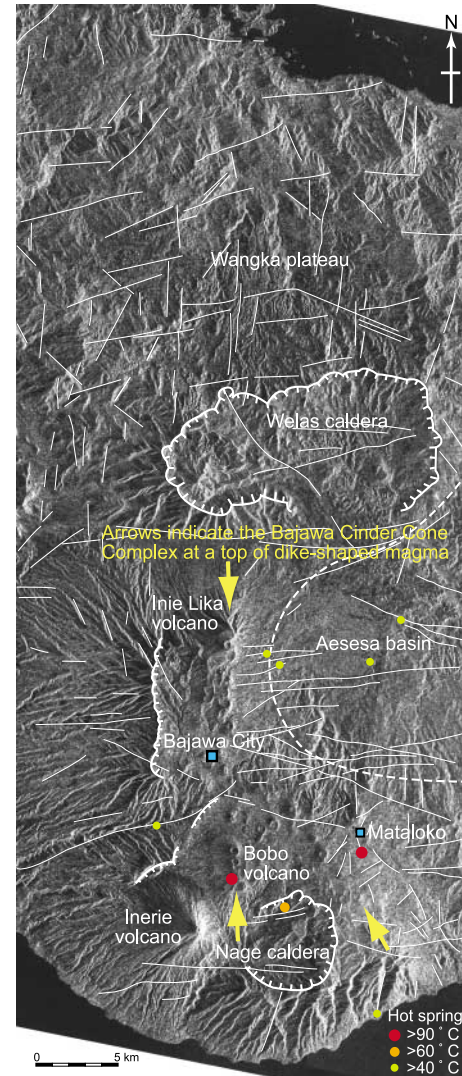
● Fig.4 Shaded-relief map of Flores Island and the survey area

Achievements in the Project

The technical details of the results of this project were compiled and released as a 348-page special number of “Bulletin of the Geological Survey of Japan²⁾” published in English by AIST. The issue features 31 articles presented by 6 organizations of the two countries. The inside stories are disclosed in the Chisitu (geological) News³⁾. More details can be obtained from these two reports. However a few key elements of the project can be represented as below.

Firstly, in reviewing the method of geothermal exploration by AIST, satellite remote sensing was utilized to the fullest extent in the areas that lack sufficient geoscientific data. In this project, the night-time infrared imagery of ASTER of Terra Satellite enabled us to directly extract the prospective geothermal areas. In addition, in cloudy tropical areas, SAR imagery of JERS-1 satellite utilizing microwave band that can penetrate the clouds provided a valuable base map (Fig. 5). This was also useful for analysis of geological conditions of the geothermal field, and the dike-shaped magma beneath Bajawa Cinder Cone Complex was identified as the important geothermal heat source of this area (Fig. 6). The key of gravity survey lies in position measurement, and the introduction of GPS (Global Positioning System) interference technique largely increased the efficiency of the survey. In the resistivity profiling, the three-dimensional inversion analysis was attempted for the first time in the geothermal field. The self-potential measurement can detect up-flow zones of a hot aquifer, so it provided useful data to select the optimum localities for drilling of exploration wells. In brief, an economical method of geothermal exploration was established under the condition of less accessible remote islands in view of the necessity of rapid exploration.

The highlight of this project was the drilling of an exploration well performed by NEDO. The drilling point was selected by piecing together all the exploration results. This means that the exploration system was to be clearly verified if the well emits steam. The flow test was performed on Jan., 20th, 2001 in the presence of several guests including two Diet members of Indonesia who flew by helicopter after the important conference in Kupang, the Governor of East Nusa Tenggara Province, the Director General of the Directorate General of Geology and Mineral Resources, the Vice-President of the Indonesian State Electricity Company, and several hundreds of local residents from neighboring villages. Due to the restricted equipment



● Fig.5 JERS-1 SAR imagery of the survey area (Copyright METI/NASDA) and geothermal features

on the remote island, it was not possible to drill the exploration well deeper than 162.35m, that is extremely shallow compared to the normal level. Although the Japanese team became bewildered by the presence of these unexpected spectators, the test was quite successful (Photograph 1). About 15 tons per hour of dry steam was discharged constantly with the valve of pit mouth fully opened. This is a remarkable volume for that drilling depth of the well, equivalent to 2.5MW by condenser-type power generation and 1.2MW by back pressure-type one. In fact, this one well could supply 2MW of electricity currently generated by small diesel power plant for Bajawa city. Furthermore, as the well produces dry steam without hot water, if back-pressure power generation method is adopted, a reduction well is not required. This drilling well has guaranteed extremely economical geothermal development in this area.

The 10-minute demonstration of a flow test was over amidst the applause of all the attendees. It can be certainly said that Japanese researchers were amongst those most relieved.

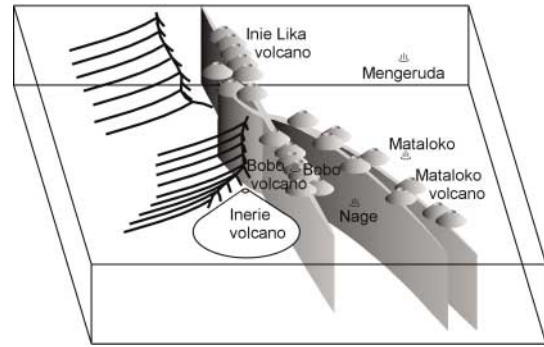
In the last fiscal year of the given ODA budget scheme, it is obligatory to hold seminars in the aid-receiving countries for the purpose of dissemination of the results. Following this rule, on February 20th, 2002, the final open seminar of this project was held at the auditorium of the Directorate General of Geology and Mineral Resources, in Bandung, Indonesia (Photograph 2). It was fortunate that the seminar was jointly held with the 4th Asian Geothermal Symposium sponsored by NEDO from February 20th to 21st and we had an audience of over 100, including ten geothermal specialists invited from other Asian countries. AIST largely contributed to this symposium, not only in terms of administration work to run the conference. In addition to the keynote speech made by the director of Geological Survey of Japan, 8 AIST researchers lectured on the technological achievements, and three chairpersons were from AIST. The outcomes of the project were introduced to not only Indonesia but also other Asian countries.

Future issues

The lofty cause of this project led a concerted effort of all the participating parties toward the realization of the goal. The successful achievements were made available to the public in a swift and comprehensive manner²⁾. These results were delivered through close co-operations with the excellent partner. The irreplaceable asset of this project is

firm friendship and unflinching trust deepened with Indonesian fellow workers. In this respect, we have a great sense of accomplishment and success.

As a matter of course, from the viewpoint of establishing infrastructure to supply clean energy, it would be ideal that Japan will take part in building a small-scale power plant in Mataloko area. Regrettably though, Indonesian State Electricity Company should not be able to construct a geothermal plant in this area without relying on outside support due to financial difficulties starting from the Asian currency crisis of 1997. The earnest wish common to the project participants is that the ultimate end of this project will be accomplished within a new project framework as represented by Clean Development Mechanism provided in the Kyoto Protocol. The project is completed, but we have a feeling that our challenge has not ended yet.



● Fig. 6 Subsurface dike model of the Bajawa Cinder Cone Complex



● Photo.1 (LEFT)
Flow test of the NEDO geothermal exploration well on January 20, 2001



● Photo.2 Participants at the final open seminar in Bandung on February 20, 2002

Relational Information
 1) Hondo, Yuki: CRIEPI News, No. 338, 4p (2002).
 2) Geological Survey of Japan: Bull. Geol. Surv. Japan, 53, No. 2/3, 61-408 (2002).
 3) Geological Survey of Japan: Chishitsu (Geological) News, No.577, 1-45 (2002).