THE IEA TASK OF DEEP GEOTHERMAL RESOURCES AN OVERVIEW OF THE TASK

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SUMMARY - The task of Deep Geothermal Resources started as a four-year collaboration program with four countries participating, New Zealand, Mexico, Australia and USA in 1997 under the IEA Geothermal Implementing Agreement. The task consists of three subtasks, A (Exploration Technology and Reservoir Engineering), B (Drilling and Logging Technology) and C (Material Evaluation Program). Japan took the lead in developing the work program and NEDO undertook tbe role as the Operating Agent (OA). The OA presents a work plan annually through the Executive Committee, and organizes task meetings, workshops and field trips for the action plan in collaboration with participants. The final results will be presented at the World Geothermal Congress (WGC2000) in Japan in 2000 and the research papers would be submitted to special volumes of international scientific journals over the next year.

1. INTRODUCTION

The IEA Geothermal Implementing Agreement (GIA) went into effect after signing up five participating countries and one organization (New Zealand, United Kingdom, United States, Switzerland, Japan and Commission of the European Communities) on March 10, 1997 at Sendai, Japan. There are three active Annexes, Annex I: Environmental Impacts of Geothermal Energy Development led by New Zealand (Operating Agent, IGNS), Annex 111: Hot Dry Rock, and Annex IV: Deep Geothermal Resources led by Japan (Operating Agent, NEDO).

The task of Deep Geothermal Resources developed as a broad international collaboration in geothermal R & D as a four-year programme and launched in March, 1997. Japan and New Zealand participated at first and subsequently Mexico, Australia and the United States joined the task in October, 1997; Italy is expected to take part in the task in the future.

2. OUTLINE OF THE TASK

The definition, object and contents of the task given in Annex IV of the GIA can be summarized as follows:

2.1 Significance and purpose of the Task

The utilization of deep geothermal resources could effectively increase the capacity of geothermal power generation. However, there are many difficulties in exploration, drilling, production and maintenance, because the reservoirs are located deep, and the expected temperatures and pressures will be high compared to shallower reservoirs.

The aim of the task is to exchange information and conduct collaborative research for the commercial development of deep geothermal resources. These activities will provide useful information to improve our understanding about deep-seated geothermal resources.

2.2 Definition of Deep Geothermal Resources

In Annex IV, 'Deep Geothermal Resources' is defined as the resource at 3,000 m and deeper. Such deep-seated geothermal resources are expected to lie underneath shallower reservoirs that have already been developed in many countries.

The New Energy and Industrial Technology Development Organization, NEDO, began a research project named 'Survey on the Deep-seated Geothermal Resources' in 1992. The aim of this project is to study the characteristics of deep geothermal environments and evaluate the possibility of utilizing deep-seated hydrothermal fluids through drilling a 3-4 km deep well. For example, at the Kakkonda field in northeast Japan, Kakkonda I (50MW) has been working since 1978 and Kakkonda II (30MW) started operation in 1996. NEDO drilled a 3.7 km deep hole (WD-1) through the shallower reservoirs and into very young Quaternary granite (Fig. 1). This project is producing fruitful results. The maximum temperature recorded was 500°C at 3,729 m depth, which is the hottest recorded temperature in a geothermal well (Uchida et al., 1997; Kamenosono et al., 1997).

2.3 Components of Task

The task of Deep Geothermal Resources includes three subtasks A, B and C which cover the research fields of deep-seated geothermal resources and development.

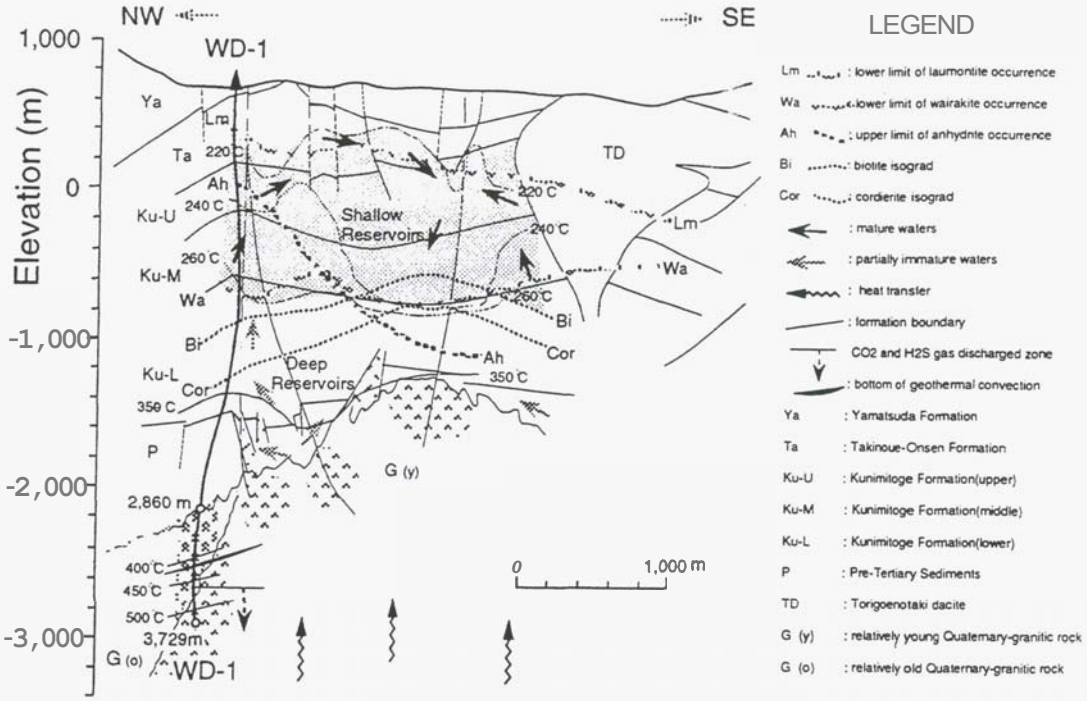


Fig.1 A conceptual model of the Kakkonda geothermal field, northern Japan (Uchida et al., *1997)*

(a) Subtask A: Exploration Technology and Reservoir Engineering. The objective of subtask A is to evaluate exploration methods and techniques used to identify deep structures in geothermal systems. This subtask contains the fields of geophysical exploration, geological and geochemical exploration, geothermal modeling and reservoir engineering.

(b) Subtask B: Drilling and Logging Technologies. The aim of subtask B is to carry out collaborative research on drilling and logging technologies necessary to develop deep geothermal resources through exchange of information on proposed research programs and development of a common data base.

(c) Subtask C: Material Evaluation Programme. The purpose of subtask C is to conduct collaborative research on material evaluation including studies on material corrosion for deep-seated and magma-ambient geothermal systems.

3. IMPLEMENTING THE TASK

3.1 Operating Agent and Task and Subtask leaders

Japan is responsible for leading the task and NEDO acts as the Operating Agent (OA). The task and subtask leaders are responsible for promoting the work plans which were approved at the 1st Executive Committee (ExCo) meeting held on March 10,1997 at Sendai, Japan.

3.2 Participants and contracting parties

The participants and their fields of interest are summarized in Table 1 (as of September 1998). Four countries, Australia, Mexico, New Zealand and Japan are taking part in the task and Italy expressed a strong interest in joining the task soon. The OA is making effort to solicit further participants.

4. ACTION PLAN FOR THE TASK ACTIVITIES

The international collaboration through the E A Implementing Agreements is classified into two categories, cost sharing and task sharing. The GIA describes the task sharing and the OA is promoting the task activities through mainly information exchange and collaboration such as meetings, workshops and the Internet among the participating countries. Yearly work plans of each subtask are presented by the subtask leaders shown in Tables 2, 3 and 4. The OA carried out the first-year program in 1997 and the results are summarized in this paper. The second-year program is now in progress; the third- and

Table 1 Participants, principal contact paersons and their interested fields

Country	Contact person	Organization	E-mail	Interested Subtask
Australia	Dr. Doone Wyborn	Australian National Univ.	dwyborn@geology.anu.edu.au	B
Mexico	Dr. Eduard R. Iglesias	IIE	iglesias@axp2.iie.org.mx	A, B
New Zealand	Dr. Bruce W. Christenson	IGNS	b.christenson@gns.cri.nz	A
	Dr. Keith A. Lichti	IRL	k.lichti@irl.cri.nz	C
	Dr. Graham J. Weir	IRL	g.weir@irl.cri.nz	A
USA	Dr. Marshall Reed	DOE	marshall.reed@ee.doe.gov	Representative for Task
	Dr. John Sass	USGS	jsass@flagmail.wr.usgs.gov	B
	Dr. John C. Rowley	Pajarito Enterprises	75033.2375@compuserve.com	B
Japan	Dr. Yasukuni Okubo	NEDO	okuboysk@nedo.go.jp	Operating Agent
	Dr. Keiji Kimbara	GSJ	kimbara@gsj.go.jp	Task leader
	Dr. Hirofumi Muraoka	GSJ	hiro@gsj.go.jp	Subtask leader (A)
	Dr. Tsunco Ishido	GSJ	g0460@gsj.go.jp	A
	Mr. Hiroshi Shigeno	GSJ	shigeno@gsj.go.jp	A
	Mr. Hideo Kobayashi	NIRE	hideo@nire.go.jp	Subtask leader (B)
	Dr. Hirokazu Karasawa	NIRE	karasawa@nire.go.jp	B
	Mr. Testuji Ohno	NIRE	ohno@nire.go.jp	B
	Mr. Norio Sanada	TNIRI	sanada@tniri.go.jp	Subtask leader (C)
	Dr. Jun Ikeuchi	TNIRI	ikeuchi@tniri.go.jp	C
	Mr. Yoshiaki Kurata	TNIRI	kurata@tniri.go.jp	C
Italy *	Dr. Giovanni Gianelli	IIRG	gianelli@iirg.pi.cnr.it	A, B
	Dr. Aldo Baldacci	ENEL	baldacci@vdtg.enel.it	A, B

* anticipate to join the Task

Table 2 Calendar of Subtask A : Exploration Technology and Reservoir Engineering (Muraoka, 1998)

	First year (1997)	Second year (1998)	Third year (1999)	Fourth year (2000)
1. Geology, Geochemistry & Geophysics	Propose a country's own model field Compose database of explorations on the model fields in a standard format			
2. Deep Well Data	Compose database of deep wells on the model field in a standard format			
3. Conceptual Model		Make a conceptual model for the model fields in a standard format		
4. Reservoir Model		Make a reservoir model for the model fields in a standard format	Comparative exploration methodology and generalization of models	
5. Integration & Summary			Deep geothermal resource assessment of each country in a standard format Strategy and recommendation of deep geothermal development	
6. Meeting (Excursions)	Signing NEDO Sympo (Japan) GRC (US/Mexico)	NZ Workshop (New Zealand)	(Italy?)	Closing WGC2000 (Japan)
7. Report				

Table 3 Calendar of Subtask B : Drilling and Logging Technology (Kobayashi, 1998)

	First year (1997)	Second year (1998)	Third year (1999)	Fourth year (2000)
1. Assess Drilling and Logging Data	Exchange information and discuss on database format	Continue to collect and store data on drilling and logging	Evaluation of drilling and logging technologies based on database	
2. Exchange R/D Activities		Exchange progress reports on proposed R/D programs	Make final reports of proposed R/D programs	
3. Integration & Future Recommendation			Evaluation of echnological, economical & environmental impact on R/D	Integration & summary
4. Meeting	NEDO Symp (Japan) GRC (US/Mexico)	NZ Workshop (New Zealand)	(Italy?)	WGC2000 (Japan)
5. Report				

Table 4 Calendar of Subtask C : Materials Evaluation Program (Sanada, 1998)

	First year (1997)	Second year (1998)	Third year(1999)	Fourth year (2000)
1. Database	Fluid chemistry Materials and their failures			
2. Corrosion Model		Chemistry and meterials-environment Corrosion model for aggressive environment		
3. Materials Selection			Materials selection guidelines	
4. Meeting	NEDO Sympo (Japan) GRC (US/Mexico)	NZ Workshop (New Zealand)	(Italy?)	WGC2000 (Japan)
5. Report				

fourth-year programs will be described briefly in this paper.

5. TASK ACTIVITIES IN 1997

The OA organized task meetings as well as workshops in March and October in order to exchange information among the participants.

5.1 Task meetings

The first task meeting was held in March 12, 1997, Sendai, Japan. 28 geothermal experts from 7 countries, Italy, Japan, Mexico, New Zealand, the Philippines, Switzerland and USA attended the meeting. The meeting was held as a side-meeting of the NEDO International Geothermal Symposium and was opened to the public in order to welcome further participants. The major aims were to discuss the four-year work plan as well as the detailed work programme for 1997.

The OA held the second task meeting in October 14, 1997, San Francisco, USA. There were twenty participants from 5 countries, Italy, Japan, Mexico, New Zealand and USA. The meeting was planned as a side-meeting at the GRC 1997 Annual Meeting. The main subjects of the meeting were to report and discuss the task progress in 1997, work programme for 1998 and present the status of participating countries.

5.2 Workshops

The technical session on the 'Deep Geothermal Resources' was held at the NEDO International Geothermal Symposium, March 12, 1997, Sendai Japan. Sixteen papers were submitted to this session from seven countries, Italy, New Zealand, USA, the Philippines, Mexico, Japan and the United Kingdom.

The OA also organized a technical session on the 'IEA Contributions to Geothermal Development' at the GRC 1997 Annual Meeting, October 14, 1997, San Francisco, USA. Nine topics were presented from four countries, Italy, Mexico, New Zealand, Switzerland and Japan.

5.3 Field trip to geothermal fields

The OA planned a field trip to the Salton Sea, USA and Cerro Prieto, Mexico in order to collect and exchange information about the present status of deep geothermal development in both fields. The field trip was carried out on October 17 to 20 after the GRC 1997 Annual Meeting. Ten experts from three countries, New Zealand, Italy and Japan, participated in the trip. The trip was very successful in providing infomation and improving our understanding about deep geothermal resources.

5.4 Construction of an Internet Database

The Geothermal Implementing Agreement states the construction of an international database to be accessed by the participants through the Internet in Annex IV. The OA prepared and distributed a questionnaire to fourteen representatives from six countries in order to assess their ideas on the database and the presentation and content of well data. As a result of the questionnaire, the OA concluded that it is premature to develop a full-scale database because of the difficulty with data availability. Instead the OA decided to collect the deep geothermal data from published papers in conjunction with participants and report them on the Internet. The web site (http://www.ieageo.or.jp) will provide a useful tool for information exchange among the participants.

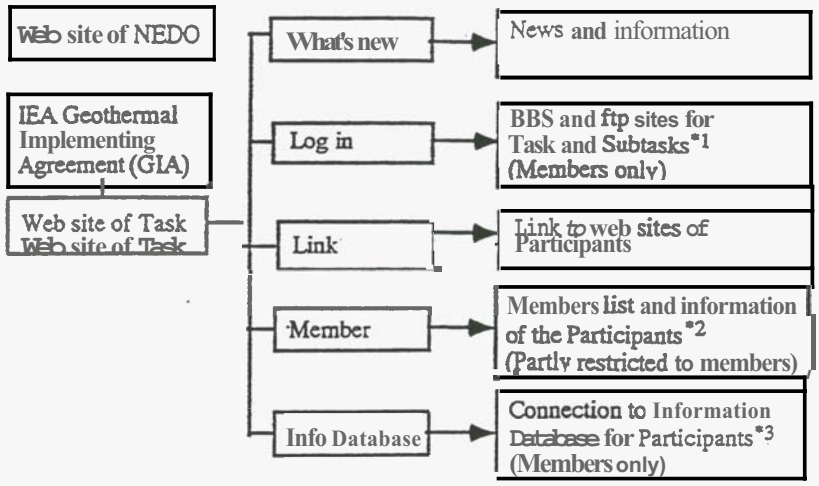
The web site of the task can be also accessed from the NEDO web site (http://www.nedo.go.jp). The top page of the web site shows 'What's new', 'Log in', 'Link, 'Member' and 'Info Database' (Fig. 2).

(1) 'What's new' gives the latest news and information related task activities. (2) 'Log in' is a page to access to BBS (Bulletin board system for the task members) and ftp (File transfer protocol) sites for the subtasks A, B and C. (3) 'Link' is connected to the web sites of each participant. (4) 'Member ' provides the member lists and related information of the participants. (5) 'Info Database' is hooked on to the information database for each subtask. The country reports to be given by the participants and progress reports of NEDO related projects are also available in the web site.

'What's new' and 'Link' are opened to the public, but 'Log in' and some parts of 'Member' and 'Info Database' are restricted to the participants. The OA gives a password which is required for access to information through the secretariat (Mr. T. Nakao, e-mail: nakao@gerd.co.jp) under the permission of task and subtask leaders.

5.5 Report to ExCo meeting on the task progress

The OA is reponsible for preparing the detailed work programme and reporting the progress together with the results to the ExCo meeting in consultation with the participants in each year. The OA has reported them to the 1st and 2nd ExCo meetings held on March 10 in Sendai, Japan and on November 10 in Wairakei, New Zealand, respectively.



*1 BBS/ftp sites can be accessed by the participants
*2 Phone number and related individual information are available to the participants only
*3 Task and Subtask leaders provide the right to access to the pages and data

Fig. 2 A Web site of the IEA Task of Deep Geothermal Resources (@ttp.Jlwww.icagco.or.jp/)

6. WORK PROGRAMME IN 1998

6.1 General activities

General activities in 1998 will be summarized as follows:

(a) The OA opened the web site of task (http://www.ieageo.or.jp) in April 1998.

(b) The OA continues to invite countries to participate and collect data related to deep geothermal resources in close cooperation with the existing participants.

(c) The OA organized a task meeting and technical session at the 20th New Zealand Geothermal Workshop to be held in Auckland in November together with a trip to the geothermal fields in New Zealand after the Workshop. About twenty papers were submitted to the Workshop from New Zealand, Mexico and Japan.

(d) The OA reported the task progress and work programme for 1999 to the 3rd ExCo held in Washington, USA on September 18, 1998 and published an annual report for 1998.

6.2 Activities in each subtask

The work plans of each subtask shall be developed in detail by the subtask leaders in conjunction with their colleagues.

(a) Subtask A. Collaboration of the subtask A will be centered on the Internet communications, task meetings and field excursions. Specifically, subtask A will continue to make the database related to information on deep geothermal fields, deep geothermal explorations and deep geothermal drill holes which will be collected as a by-product through major research products and field excursions. In parallel, subtask A will start making a conceptual model of deep geothermal resources.

(b) Subtask B. Subtask B will continue to collect and store data in the technical fields on drilling and well logging. The progress reports on individual proposed R&D programme will be exchanged among the participants.

(c) Subtask C. Subtask C involves collecting the data on fluid chemistry, materials and their failures. Information exchange and development of the database will continue by taking advantage of the web site. Subtask C will involve advancing a corrosion model for high-temperature and two-phase flow environments.

7. FUTURE WORK PROGRAM

7.1 Work program in 1999

To accelerate the task-collaboration in 1999, each subtask will be required to make greater efforts to promote the task activities toward its final goal.

The OA will continue to organize a task meeting together with a workshop in 1999. The OA envisages to hold an IEA-related workshop in Italy in cooperation with the related organizations such as ENEL or IIRG subject to their consent and participation in the task. THE OA also continues to maintain the WWW system to support the task activities.

(a) Work plan for subtask A:
Comparative modeling.
Continue to collect information on deep geothermal environments, deep geothermal explorations and deep geothermal drill holes.
- Summarize the data collected as a spread-sheet type table and supply them through the Internet.

(b) Work plan for subtask B:
- Evaluate drilling and logging technologies based on the data collected and stored.
- Make draft report of 5 proposed programmes.
- Evaluate technological, economical and environmental impacts on the drilling and logging R/D items for future recommendation.

(c) Work plan for subtask C:
- Develop databases of deep and acidic fluid chemistry from published papers
- Develop corrosion models for materials in inflows and continue to make corrosion models in deep and acidic fluids

Continue to compile references of the literature concerned with chemistry and materials performance

7.2 Work program in 2000

The task of Deep Geothermal Resources initiated as a four-year international collaboration programme in 1997 and it is scheduled to terminate in the year of 2000. As a result of the activities, The OA will present the recommendation for technical and economical development of deep geothermal development. The OA will organize a special session at WGC 2000 in Japan in 2000 and the results of task activities will be presented by the participants. The OA expects that the final results could be submitted to one or more special volumes of international scientific journals over the next year.

8. ACKNOWLEDGMENTS

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