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Development of Indonesia version Geothermal Expert Modeling System (iGEMS)

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Abstract: The iGEMS was developed as an Indonesian version of the NEDO-developed Geothermal Expert Modeling System (GEMS), which had been developed for a national project "Nationwide Geothermal Resources Exploration Project (Phase 3)" in Japan. The iGEMS was developed by improving GEMS to work on a commercially available personal computer with a minimum set of data. It enables an easy analysis, narrowing its function down to the two core functions of GEMS, which are "estimation of a 3-dimensional thermal structure that takes account of geothermal upflow" and "calculation of the geothermal resource by means of the volumetric method". The iGEMS is composed of two main programs, which are the main body of iGEMS and Surfer. The GEMS provides such main functions as analyses, generation of cross-section data, and receiving user inputs of analytic parameters and cross-section line on a simplified map displayed. Surfer is a contouring and surface mapping software to display the survey results and analyzed data in plan map or cross section on the screen. The analysis function of the system contains (1) placing heat sources, (2) calculating the conductive thermal structure, (3) calculating the activity index at each hot spring, (4) placing the discharge area, (5) calculating the activity distribution within the discharge area, (6) modifying the thermal structure taking into account the upflow and (7) calculating the geothermal resource and selecting promising areas by the volumetric method.

According to the calculation result of geothermal resource in the Bajawa geothermal area using iGEMS, 74 MW of geothermal resource per 3 km^2 (25 MW/km^2) was estimated in the Mataloko area and 92 MW per 4 km^2 (23 MW/km^2) in the Nage and Wolo Bobo areas. Indonesia is one of the world's leading geothermal power generating countries. It is expected that iGEMS will realize a smooth and easy evaluation of geothermal resources in future geothermal development projects.

1. Introduction

The Indonesia version Geothermal Expert Modeling System (iGEMS) was developed as a part of "the Research Cooperation Project on Exploration of Small-scale Geothermal Resources in the Eastern Part of Indonesia (ESSEI)" that was carried out from 1997 to 2001. The survey area for this project is the Bajawa geothermal area, in the central part of Flores Island, eastern part of Indonesia. There are many indications of the existence of geothermal resources including active volcanoes and hot springs. The purposes of the project are to develop exploration technology, which is appropriate for geothermal resources existing in the eastern part of Indonesia, apply the developed technology to the exploration of the resources, and consequently contribute to the Rural Electrification Program of the Indonesian government. The iGEMS was developed as an improved Indonesian version of the NEDO-developed Geothermal Expert Modeling System (GEMS), which had been utilized for exploration of Japan's geothermal resources by the New Energy and Industrial Technology Development Organization (NEDO). The GEMS is a computer system and supports procedures of exploratory analysis such as the construction of the geothermal concep-

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tual model and selection of promising areas by integrating the results of various surveys and analyses including geological, fluid geochemical and gravity survey (Muraoka and Narita, 1993; Narita and Todaka, 1994; Harada *et al.,* 1994).

In the ESSEI project, it was unable to apply the original GEMS to the survey results of the project area because: (1) the original GEMS depended on many specific display functions of the graphic supercomputer DN10000, which is not sold now, (2) it required many kinds of concrete data on the order of "the third national geothermal resource comprehensive survey", and it was necessary to digitize and feed all these results and (3) it is not easy to master GEMS and requires a 5- or 6-week training period because the system structure consisted of a wide range of multiple processes. On this account, iGEMS was developed as an improved system of GEMS, which permits easy analysis with a minimum set of data and works on a commercially available personal computer.

In this paper, the development of iGEMS and result of analysis of the Bajawa geothermal area by using iGEMS are reported.

2. Development of iGEMS

2.1 Summary of GEMS

The Geothermal Expert Modeling System (GEMS) was completed in the development process of the comprehensive analysis method through the national project "Nationwide Geothermal Resources Exploration Project (Phase 3)" conducted by NEDO from fiscal years 1987 to 1992. GEMS is a computer system and supports procedures of exploratory analysis such as the construction of the geothermal conceptual model and selection of promising areas by integrating the results of various surveys and analyses including geological, fluid geochemical and gravity survey. Practically all the comprehensive analysis was carried out by feeding the actual survey data into the computer at eight geothermal areas in Japan. These locations were Akitakoma, Bandai, Aso, Nasu, Tokachi, Tsurumidake, Niseko, and Hakkoda.

The scope of GEMS is recognized to select the promising area of tens of square kilometers from the survey area of hundreds of square kilometers, as GEMS is used in the general survey stage. Consequently GEMS realizes the analysis of a survey with only surface survey results area where no deep drill hole exists for geothermal exploration. The users are assumed to be geothermal engineers having general basic knowledge on the geothermal field. Actually the comprehensive analysis depends heavily on the experience and knowledge of the geothermal engineers. At the first stage on the occasion of GEMS development it was identified and organized how the engineers decided promising areas by comprehensive analysis. The GEMS was a huge system composed of up to 300,000 steps and integrated cutting edge computer technologies including artificial intelligence, computer graphics, mathematical analysis and database. Two DN10000s of Apollo USA, which were the world's fastest graphic supercomputer, were adopted for GEMS to realize the real-time rotation and zoom of 3-dimensional bird's-eye view of the geothermal conceptual model.

2.2 Basic design concept of iGEMS

Taking into account of the above-mentioned problems of GEMS, iGEMS was developed in accordance with the following principles. The comparison between GEMS and iGEMS is summarized in Table 1.

- The system works on any commercially available personal computer.
- A commercial mapping software is used to display plan maps and cross-sections.
- It is possible to realize the powerful analyses with a minimum set of data.
- It is possible to superimpose all the data that can be displayed on a map.
- Easy understandable analytic flow is adopted for the system structure.
- Operation and analyses are easy to learn and one or two days of training are enough to master ordinary analyses.
- The system is available in English so it is useful for Indonesian users.

With these principles in mind, iGEMS was developed to realize the core functions of GEMS advantages, which are "estimation of a 3-dimensional thermal structure that takes into account the geothermal upflow" and "calculation of the geothermal resource by means of the volumetric method".

Table 1 Comprarison between original GEMS and iGEMS.

	iGEMS	GEMS
Platform	Pentium PC	Graphic Supercomputer
Required data	Small	Comprehensive
Analysis Procedure	Simple(a few days)	Complex(a few weeks)
Language	English	Japanese

Table 2 Platform requirements of iGEMS.

OS	Windows 98SE or Windows 2000 or higher
CPU	Pentium 500MHz or higher
Memory	64MB or higher,128MB recommended
Hard disk	100MB of free disk space
Moniter	1024 x 768 monitor resolution or higher recommended
Software	Surfer 7.0:Contouring,gridding,and surface mapping Excel 2000:Creating data files

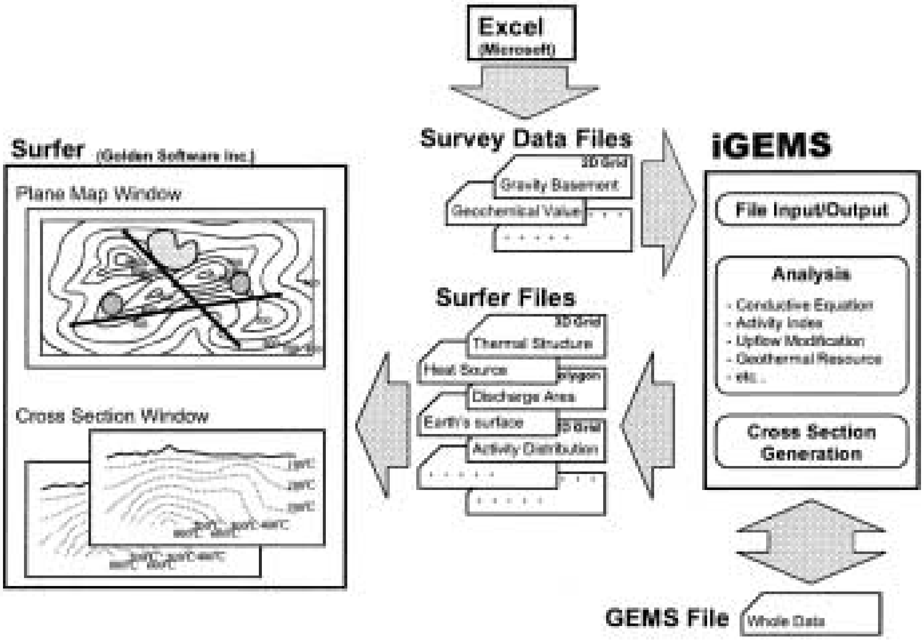

Fig. 1 System structure of iGEMS. This system is composed of two main programs, which are iGEMS and Surfer.

3. System structure

3.1 System requirement

Windows 98SE or Windows 2000 on DOS/V personal computer is employed as the platform of iGEMS as shown in Table 2. It is recommended computer equipped with more than 500 MHz of Pentium CPU performance. At least 64 MB of memory is required but 128 MB is recommended for practical use. More than 100 MB of free HD space are required for software installation and other free space for storing the survey results and analyzed data. A 1024 × 768 screen is recommended for a display monitor. In addition, a color printer is required to print out the results of analyses.

Since the system displays the survey results and analyzed data in the plan map and cross-section on the screen, Surfer 7.0 is essential. It is a mapping software provided by Golden Software and used for contour generation, gridding and mapping. The spreadsheet software Excel 2000 is recommended to prepare the initial data to be fed into iGEMS.

3.2 Programs

The iGEMS is composed of two main programs (Fig. 1), which are the main body of iGEMS and Surfer. The iGEMS provides main functions of analyses and possesses the functions to generate cross-section data. It receives user inputs of analytic parameters and displays a cross-section line on a simplified map. The analysis system of iGEMS realizes the two core functions of GEMS, which are "estimation of a 3-dimensional thermal structure that takes into account the geothermal upflow" and "calculation of the geothermal resource by means of the volumetric method". Surfer is a contouring and surface mapping software to display the survey results and analyzed data in a plan map or cross section on the screen. Surfer has various displaying functions including conversion from grid data to contour data and translation from contour data to a view of 3-dimensional face. In principle, Surfer does not create any data but operates as a dedicated displaying function.

3.3 Procedures

Before feeding survey data into iGEMS, the data should be converted into the CVS format available for iGEMS by using Excel. The survey data files are fed into iGEMS by choosing a "File" menu command on the iGEMS window. Subsequently each command in the "Analysis" menu is chosen in turn to carry out the analyses. In some cases, positional information and parameters of heat source and the discharge area are input by the user. In such cases, an input window is opened where the user inputs the data. When the analysis has been completed, "File Save" command is chosen to create and save iGEMS data file on the HD. The plan map can not be displayed on the iGEMS window but on the Surfer window, using this iGEMS data file. To display the cross-section, "Map - Cross Sectoin" command is chosen on the iGEMS window. After execution of this command, a new window displaying a simple plan map is opened to accept the user input of a cross-section line. The user can input the cross-section line on the screen by dragging it with the mouse. The cross-section line data is saved on the HD and the cross-section is displayed on the Surfer window, using this file.

4. Analysis functions

4.1 Geothermal model of iGEMS

The geothermal model of iGEMS is composed of several elements including heat source, conductive thermal structure, thermal structure, discharge area and promising areas for geothermal resource (Fig. 2). The user should specify both heat sources and discharge areas, but other elements are automatically calculated. Brief descriptions of each element are as follows.

(1) Heat source

The heat source represents a magma chamber. The shape is assumed to be a rectangular parallelepiped (Fig. 5, Fig. 7). Heat source has such attributes as central location [m, m], depth [m], age of penetration [Ma], temperature at the age penetration [℃], volume [km^3] and aspect ratio. More than one heat source can exist.

(2) Conductive thermal structure

The conductive thermal structure is obtained by solving 3-dimensional thermal conductivity equations by giving the heat flow from the heat source(s) and regional terrestrial heat flow as the boundary conditions. Conductive thermal structure is expressed as 3-dimensional grid data.

(3) Discharge area

The discharge area is an underground horizontal zone where geothermal upflow exists. The shape is assumed to be a polygon, displayed in plan and expressed in a vertex coordinate array of a 2-dimensional polygon.

(4) Thermal structure

The thermal structure is derived from the conductive thermal structure, including the convection effect of geothermal upflow. The thermal structure is expressed as 3-dimensional grid data and the unit is [℃].

(5) Promising area for geothermal resource

A promising area is where geothermal resource calculated by the volumetric method exceeds the standard value. It is a 2-dimensional area selected from a 3-dimensional area shallower than a given depth and hotter than a given temperature.

4.2 Procedure of analysis

The procedure of analysis is conducted by the following seven steps. The iGEMS mounts analytic procedures including the two core functions of original GEMS, which are "estimation of a 3-dimensional thermal structure that takes into account the geothermal upflow" and "calculation of the geothermal

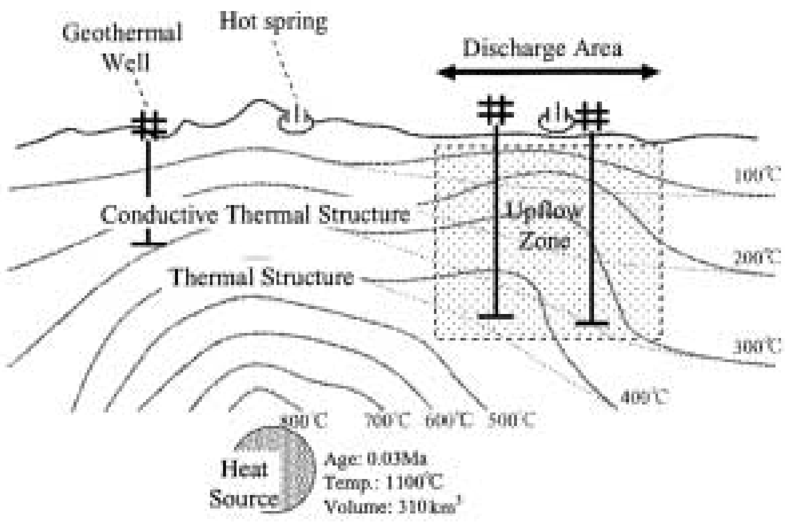

Fig. 2 Elements of geothermal model are composed of the heat source, conductive thermal structure, thermal structure and discharge area.

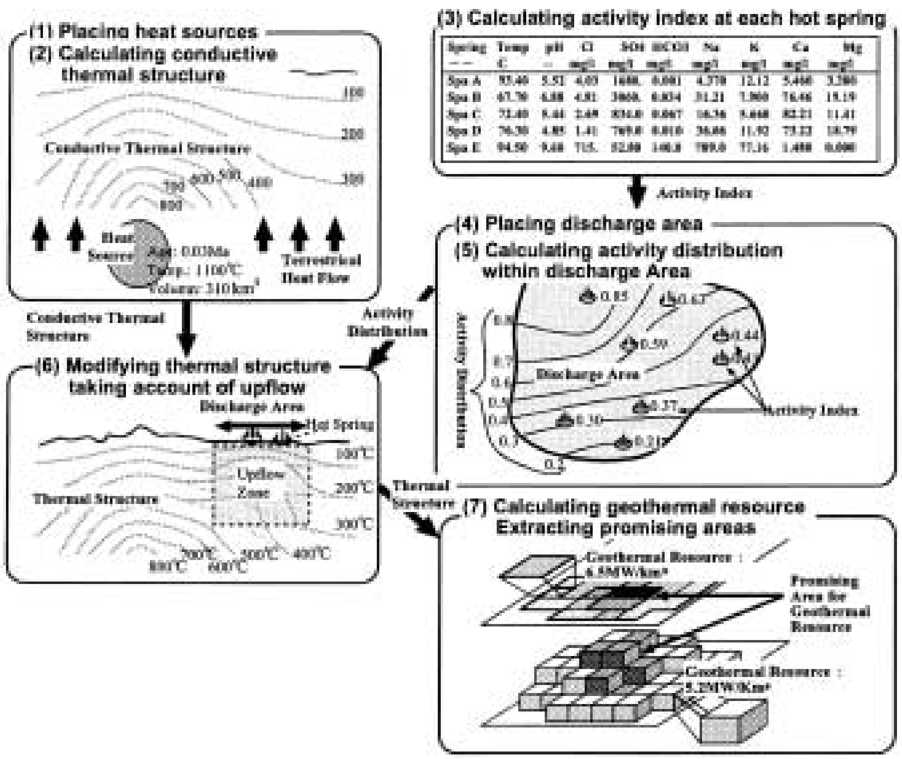

Fig. 3 Analysis flow of iGEMS. The procedure of analysis is conducted by seven steps and includes two core functions "estimation of a 3-dimesntional thermal structure that takes into account the geothermal upflow" and "calculation of the geothermal resource by means of the volumetric method".

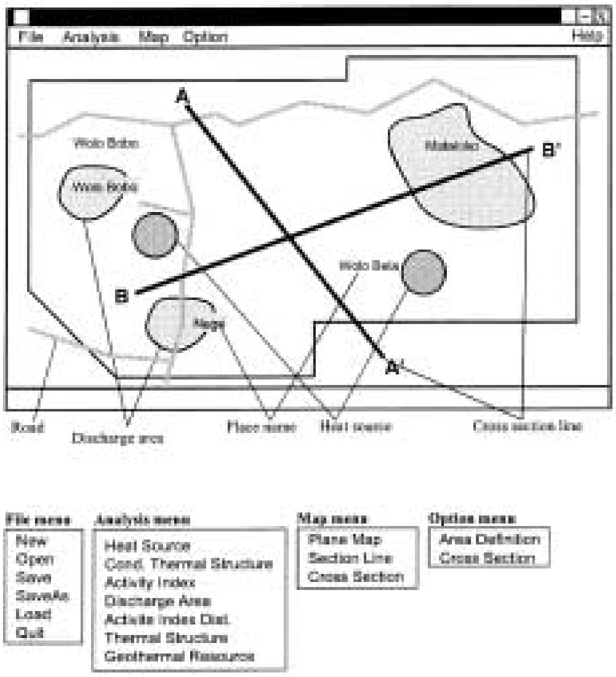

Fig. 4 The iGEMS main window.

resource by means of the volumetric method". The procedure of analysis is shown in Fig. 3 and the GEMS window in Fig. 4.

(1) Placing heat sources

Central location [X-Y coordinate], depth of the top face [m, asl], temperature [℃], age of penetration [Ma], volume [km^3] and aspect ratio of heat sources are input by the user. The shape of the heat source is assumed to be a rectangular parallelepiped squared at the top face. The length of each side is calculated from volume and aspect ratio. The user should determine the parameters of heat sources, taking the various survey results and analyzed data into consideration.

(2) Calculating conductive thermal structure

A 3-dimensional conductive thermal structure is obtained by the analytical solution of 3-dimensional thermal conductivity equations by giving the heat source parameters as mentioned in (1) and mean regional terrestrial heat flow as the boundary conditions.

(3) Calculating activity index (degree of upflow) at each hot spring

The activity index (degree of upflow) at each hot spring is calculated using five geochemical data sets such as molar concentrations of dominant negative ions (Cl, SO_4, HCO_3 and CO_3) and temperature of the spring. The calculation method of Muraoka and Tanaka (1991) was employed.

(4) Placing discharge area (upflow area)

The discharge area should be determined by the user. The user indicates the discharge area drawing quadrangle on the plan map with the mouse.

(5) Calculating activity distribution within discharge

area

Activity indices calculated in (3) are interpolated within the discharge area determined in (4), and the data is converted into 2-dimensional grid data. The value of the activity index exists only within the discharge area.

(6) Modifying thermal structure taking into account the upflow

In the area of polygonal prism within the discharge area, the external margin of modification area is the same margin of the discharge area, the conductive thermal structure calculated in (2) is modified, adjusting upward the temperature data according to the activity distribution obtained in (5).

(7) Calculating geothermal resource and selecting promising area

Using the thermal structure obtained in (6), 3-dimensional block data of thermal resources is calculated by the volumetric method. A 2-dimensional geothermal resource is calculated by vertically integrating the block data. A promising area for geothermal resources is selected, where a 2-dimensional geothermal resource exceeds the standard value.

5. Result of iGEMS analysis on the Bajawa geothermal area

5.1 Survey data of the Bajawa area

The Bajawa geothermal area is located in the central part of Flores Island of the Nusa Tenggara islands in eastern Indonesia. Many volcanoes are distributed on Flores Island. Many hydrothermal alteration zones are confirmed around the Bajawa caldera, such as Mataloko, Wolo Bobo and Nage (Fig. 5).

(1) Geology

In the Bajawa area, the stratigraphic units of volcanic rocks can be divided into five units: the older volcanic rocks (V1), Bajawa caldera volcanic rocks (Bc), volcanic products of cinder cones (C1, C2) and Inerie volcanic products (Ie) in ascending order. The V1 is distributed extensively in this area and surrounds the Mataloko area. This unit consists mainly of andesite lava, basalt lava, pyroclastic rock and lahar deposits. The Bajawa caldera is located north of Bajawa City. The Bc unit is exposed in the Bajawa caldera. This unit consists mainly of pyroclastic flow and andesite lava. The post-caldera volcanic cones (C1, C2) are distributed in the Bajawa caldera. The Ie units form Mt. Inerie. The units consist of andesite lava and pyroclastic flows. The Bajawa caldera extends 13 - 16 km east-west is distinctively observed in this area, which is surrounded by the older volcanic rocks (V1). The Bajawa caldera, which corresponds to low gravity anomaly, characterizes geological structure of this area and its margin is an observed high gradient. The Bajawa caldera has a suitable structure for providing favorable conditions for a geothermal reservoir. According to the distributions of cinder cones, hot

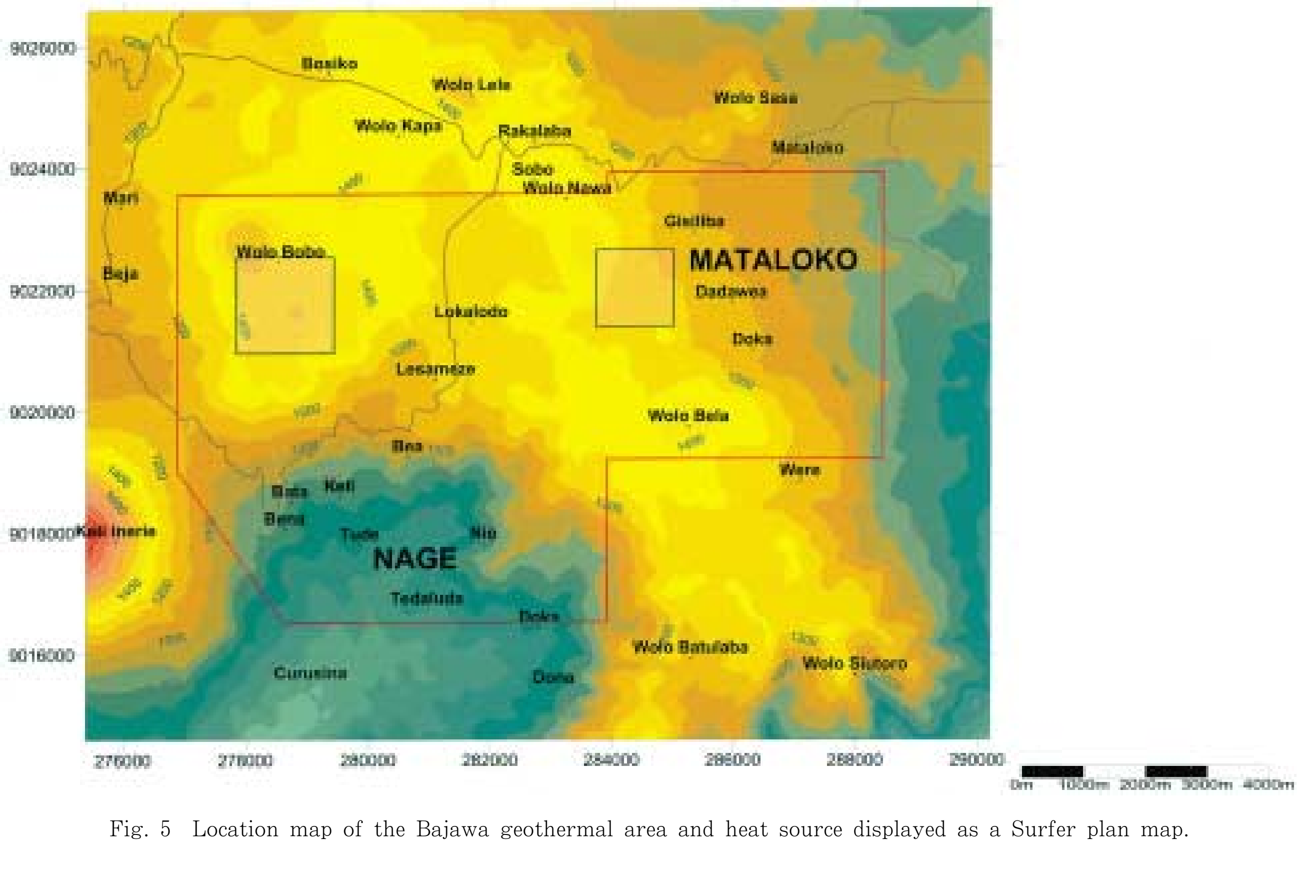

Fig. 5 Location map of the Bajawa geothermal area and heat source displayed as a Surfer plan map.

springs and fumarole, alteration zones, and gravity and resistivity discontinuities, it is considered that the fractures trending N-S, NW-SE and NE-SW are developed in the Bajawa caldera.

(2) Volcanic activity

The evolution of volcanic activity in this area can be divided into four stages: pre-Bajawa caldera volcanism, Bajawa caldera collapse, cinder cone volcanism and strato-volcano formation, which varied from andesite to basaltic volcanic activities. In the pre-Bajawa caldera volcanism stage, the older volcanic rocks (V1) erupted and the polygenetic volcano was built. It was estimated at 2.8 to 1.0 Ma. In the Bajawa caldera collapse stage, the Bajawa caldera subsided and the volcanic depression was filled by the Bajawa caldera volcanic rocks (Bc). It was estimated at 0.7 Ma. In the cinder cone volcanism stage, andesite eruptive volcanism occurred in the caldera basin and many cinder cones (C1, C2) appeared. The older cinder cone (C1) formed about 0.5 Ma and younger cone (C2) formed after 0.15 Ma. In the strato-volcano formation stage, the Inerie volcano was formed. This is the latest volcanism in this area.

(3) Alteration zone and thermal structure

The Mataloko area is located east of the Bajawa area. In the Mataloko area, the alteration zone is widely distributed along the Wae Luja River in a northwest to southeast direction extending about 1,200 meters. The alteration zone is characterized by strong argillization, where many high temperature and acidic SO_4 type hot springs are distributed.

The alteration minerals observed on the surface are kaolinite and alunite. The Mataloko area is located on the eastern edge of the Bajawa area and widely covered by the post-caldera volcanic rocks. Many cinder cones formed by post-caldera volcanism since 0.15 Ma are distributed in this area. The heat source of this geothermal system is considered to be residual magma under the young volcanic cone. At the drill hole MT-2 in the Mataloko area, steam spouting was observed and the temperature at the 175 m depth was 192 ℃, which verified the high-temperature even near the surface . The alteration of drill holes MT-1 and MT-2 are characterized by strong argillization. The argillization developed in the shallow part of both wells and progressed to form an impermeable layer, which is understood that it became the alteration cap rock (Takahashi, 1995). Wairakite is distributed about the 140 m depth in both wells and located below the strongly argillized zone. This zone indicates that geothermal fluid is high-temperature (>200 ℃) and neutral pH (Henley *et al.,* 1984). The temperature of the deep geothermal reservoir is considered to be 270 - 300 ℃ by a geochemical thermometer.

The Nage area is located in the southwest part of the Bajawa area. The alteration zone is widely distributed along the Wae Bana River and characterized by argillization and sillicification. The main alteration minerals are kaolinite, alunite and pyrophyllite. There are many high temperature, acidic SO_4 type hot springs with high Cl concentration in the alteration zone. It is considered that the hot springs are formed by magmatic gas containing HCl and SO_2. The temperature of deep geothermal fluid is estimated at 200 - 210 ℃. The heat source of this geothermal system is considered to be residual magma under the young cinder cone volcanics or high density intrusive rock assumed to exist underground by the gravity survey.

5.2 Geothermal model of iGEMS

The geothermal model of the Bajawa area was constructed and geothermal resource was also estimated using iGEMS.

(1) Heat source

The evolution of volcanic activity in this area can be divided into four stages: pre-Bajawa caldera volcanism, Bajawa caldera collapse, cinder cone volcanism and strato-volcano formation. Many cinder cones are distributed in this area. It is considered heat sources exist at Mataloko, and Nage and Wolo Bobo areas (Fig. 5). The heat source of geothermal system around the Bajawa caldera is expected to be residual magma under the young volcanic cones which erupted after 0.15 Ma.

(2) Activity index

In the Mataloko area, fumaroles and acidic SO_4 type hot springs with temperature up to 89 ℃ are distributed. In the Nage area, acidic SO_4 type with high Cl concentration hot springs with temperature up to 80 ℃ are distributed. At Wolo Bobo, one of the cinder cones north of the Nage area, fumarolic areas are observed. Tude hot springs, lying midway between Nage and Wolo Bobo, are acidic to neutral SO_4 type hot springs with temperatures between 36 ℃ and 71 ℃. The activity indices were given by the data of these hot springs. Consequently the activity index increases at both Mataloko, and Nage and Wolo Bobo areas (Fig. 6).

(3) Discharge area

The low-resistivity zone is widely distributed in the Mataloko area, and it's interpreted as an alteration caprock. As the geothermal system is covered by an alteration caprock, the low-resistivity zone in the shallow part was determined as the discharge area. In the Nage area, the area from the Wolo Bobo fumarolic area to Nage was determined as the discharge area (Fig. 6).

(4) Thermal structure

In the whole Bajawa area, the underground thermal structure is demonstrated as conduction, while it is necessary to take into account the geothermal

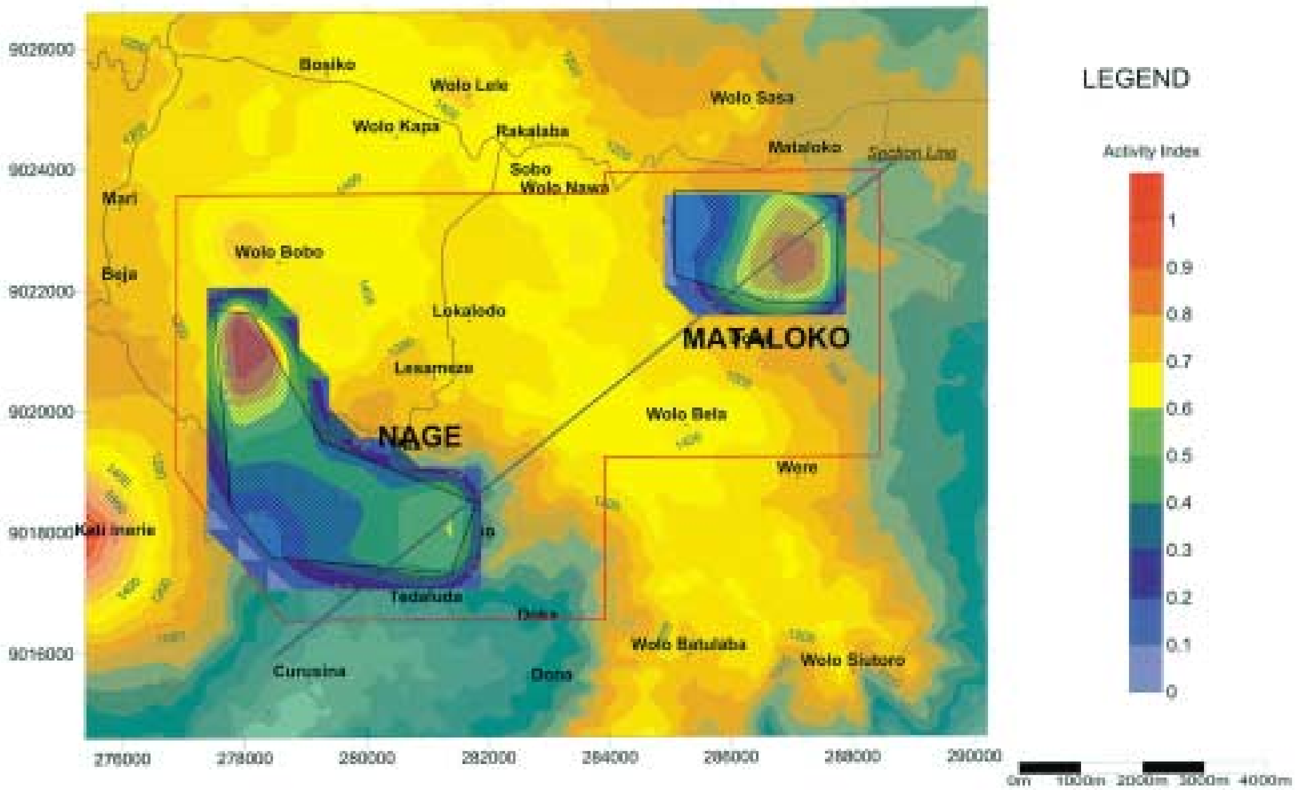

Fig. 6 Activity index and discharge area distribution displayed as a Surfer plan map.

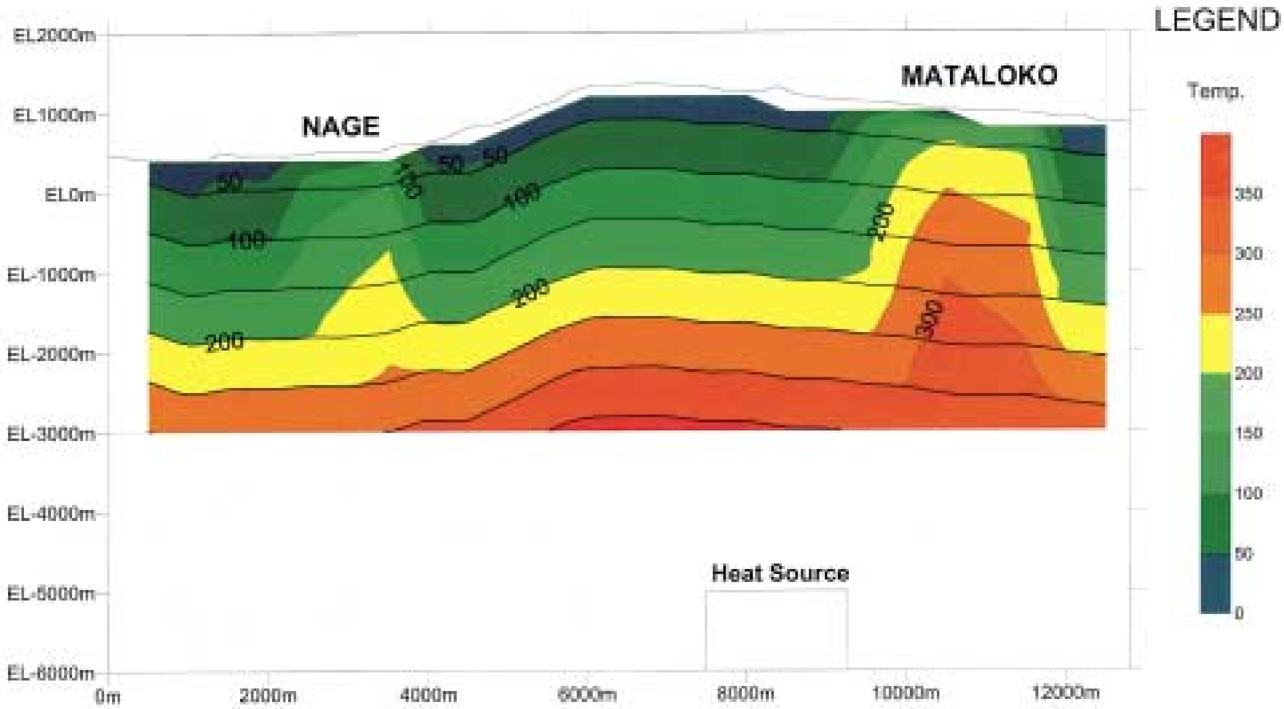

Fig. 7 Modified thermal structure displayed as a Surfer cross section.

upflow in the discharge area. Accordingly both in the Mataloko and Nage areas, the analysis of thermal structure was carried out on the condition that the high-temperature area extends up to the shallow part. In the shallow part of the Mataloko area, the temperature showed 200 ℃, and 250 to 300 ℃ at -1000 m above sea level (Fig. 7).

(5) **Geothermal resource**

The geothermal resources were calculated by segmented blocks of 500 m × 500 m × 200 m. Only if the block satisfies the following three conditions, the values of the geothermal resource were calculated

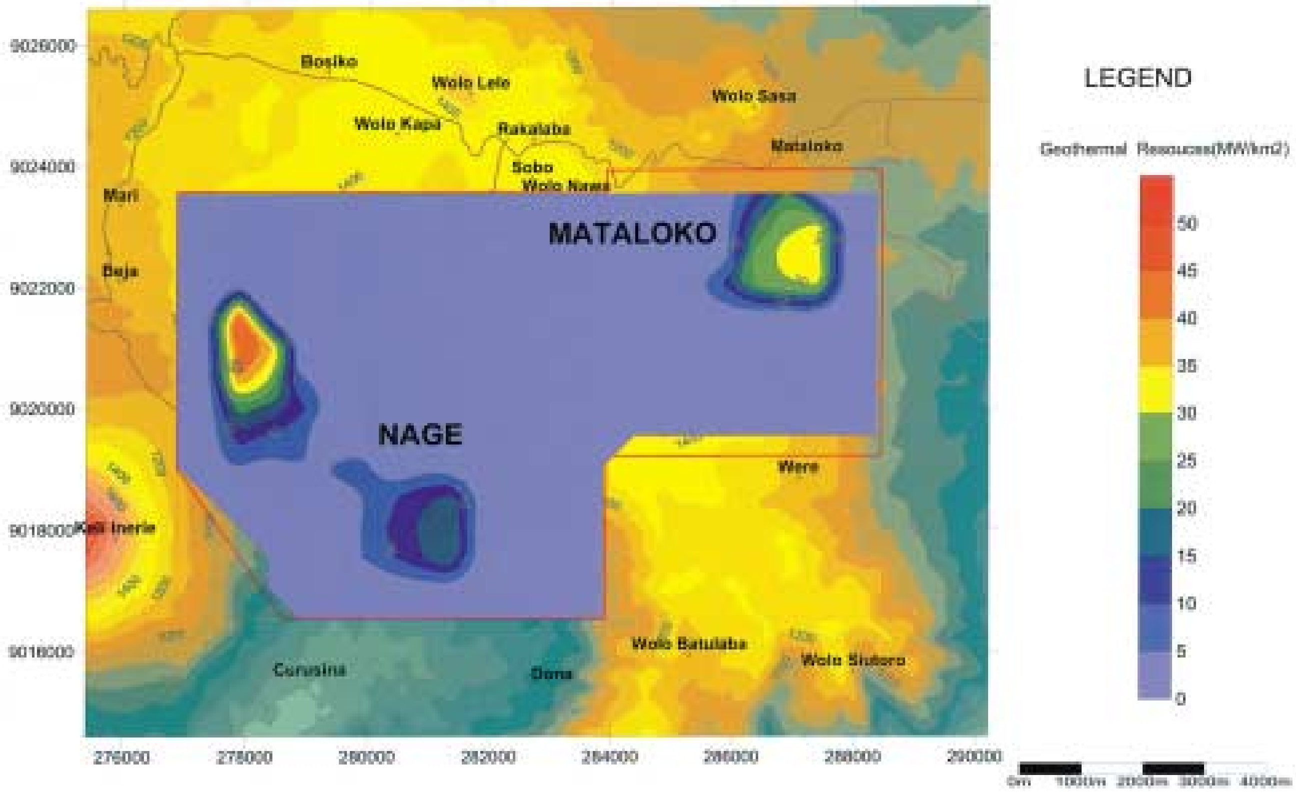

Fig. 8 The 2D geothermal resources distribution displayed as a Surfer plane map.

and summed up for the blocks:

① at a depth under 2000 m
② with temperature more than 150 ℃
③ more than 10 MW/km^2 of geothermal resource

As a result, 74 MW per 3 km^2 (25 MW/km^2) was calculated in the Mataloko area, while 92 MW per 4 km^2 (23 MW/km^2) in the Nage area (Fig. 8).

5.3 Evaluation

In the Mataloko area, geothermal upflow is generated and a high-temperature of 192 ℃ was confirmed at the 175 m depth according to the drill hole MT-2 data. The geothermal model obtained by iGEMS reproduced the thermal structure where the high-temperature extends up to near the surface by means of "estimation of a 3-dimensional thermal structure that takes into account the geothermal upflow". In the Nage area, the thermal structure obtained by iGEMS also indicates the geothermal upflow and shows a high-temperature over 200 ℃ in the deep part, although there has not been actual temperature measured of the underground. This estimated temperature approximately agrees with the result of the geochemical survey. The geothermal resources were estimated around 20 MW/km^2, which is the average resource at a general geothermal area. As a result, it is evaluated that iGEMS can provide a valid geothermal model representing the actual thermal structure.

6. Conclusion

The Indonesia version Geothermal Expert Modeling System (iGEMS) was developed as a part of "the Research Cooperation Project on Exploration of Small-scale Geothermal Resources in the Eastern Part of Indonesia". The iGEMS was developed as an improved Indonesian version of the NEDO-developed GEMS. It was designed on the premise to work on a commercially available personal computer with a minimum set of data and facilitate the analysis. The analysis system of iGEMS realizes the two core functions of GEMS, which are "estimation of a 3-dimensional thermal structure that takes into account the geothermal upflow" and "calculation of the geothermal resource by means of the volumetric method" by an easy operation. The geothermal resource of the Bajawa area, i.e. the survey area, was estimated by iGEMS. As a result, 74 MW per 3 km^2 (25 MW/km^2) was calcurated at the Mataloko area, while 92 MW per 4 km^2 (23 MW/km^2) at the Nage and Wolo Bobo area. According to the survey of drill hole MT-2, which is an exploration well in the Mataloko area drilled for this project, about 15 t/h of steam spouting was observed, and the further development of geothermal resource is expected in this area. Indonesia is one of the world's leading geothermal power generating countries. It is expected that iGEMS will realize a smooth and easy evaluation of geothermal resources in future geothermal development projects.

Acknowledgment: The iGEMS system was developed as a part of the Research Cooperation Project on Exploration of Small-scale Geothermal Resources in the Eastern Part of Indonesia. This project was carried out by NEDO as an international research cooperation project with Indonesia. The work has been realized under the leadership of NEDO, which conducted and promoted the project. We sincerely appreciate all of the effort and facilitation by everyone concerned in NEDO and its research partner, the Asia Geothermal Research Group including the leader Dr. H. Muraoka of AIST (the National Institute of Advanced Industrial Science and Technology) and all assistant researchers of DMRI and VSI.

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インドネシア版地熱資源総合解析システム（iGEMS）の開発

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要　旨

iGEMS は NEDO が日本国内の探査用に開発した地熱資源総合解析システム（GEMS）に改良を加え，インドネシア版として構築したものである．iGEMS は市販のパソコン上で最小限のデータを用いて容易に解析が可能であり，かつ GEMS の最大の特徴である「上昇流を加味した 3 次元温度分布の推定」及び「資源量算出機能」を実現できる解析システムとして構築された．iGEMS は大きく二つのプログラムから構成される．iGEMS 本体と Surfer である．iGEMS 本体は主に解析機能，断面図データの生成機能や，解析パラメータや断面線を簡単な地図上で表示しユーザに入力させる機能も持つ．Surfer は，各種の調査データや解析結果を平面図や断面図として画面に表示する表示機能である．解析機能は①熱源の設定，②伝導性温度分布の推定，③活動度指数の推定，④ディスチャージ域の設定，⑤ディスチャージ域内での活動度指数の分布，⑥上昇流動を加味した温度分布の修正，⑦容積法を用いた地熱資源量の算定からなる．

本システムを用いてバジャワ地域の資源量を算出した結果，マタロコ地域では 3 km^2 において74 MW，25 MW/km^2，ナゲ地域では 4 km^2 において，92 MW，23 MW/km^2 であった．インドネシアは世界でも有数の地熱発電国であり，本システムを使用することにより，今後の地熱開発において円滑な資源量評価が実施されると期待される．