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# DEVELOPMENT OF DATABASE SYSTEM FOR LOST CIRCULATION AND ANALYSIS OF THE DATA

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## ABSTRACT

It is very important to reduce drilling costs because the cost of drilling the wells is approximately 50% in geothermal energy development for electric power generation. Lost Circulation (LC) is serious problem that contributes greatly to the cost of drilling and completion of the geothermal wells. LC also can be the cause of formation collapse and/or stuck drill strings as well as failure in casing cementing.

We are developing the data base system to perform data analysis system and optimum treatment of Lost Circulation. The objective of this system is to record the LC treatment procedure and result, and to analyze the data and recommend which treatment will be best for future LC occurrences. The system is developed on PC, and it has following functions.

1) Data Input(175 items)
2) Data Base(more than 4,500 LC data are recorded)
3) Data View(List, Well diagram, Well trajectory)
4) Data Search
5) Off-line Network
6) Data Analysis
7) Temperature Data
8) LC Treatment support (Expert System)

From the data analysis, 65% of LC is total loss (no circulating mud returned to the surface, however, loss severity depends on the pumped rate) in geothermal wells. Cement is used in 65% as a treatment material for total loss, and LCM is used in 30%. However, the proportion of success is about 15% with cement and about 10% with LCM.

## 1. INTRODUCTION

Approximately 50% of the costs of a typical geothermal power project are the costs of drilling and completing the wells. Given this fact, and the fact that a typical geothermal well costs two to three times that of a typical oil and gas well drilled to same depth, it is logical to seek drilling cost reduction as a way of making geothermal power more cost competitive.

Factors contributing to the relatively high cost of geothermal drilling are discussed, and potential technology improvements that could reduce those costs are identified.

Lost Circulation is the phenomenon where circulating fluid is lost to fractured or porous rock rather than returning to the surface. Lost circulation is one of most difficult events encountered during drilling and completing the well, and Lost Circulation is a costly problem in geothermal drilling due to the fact that geothermal wells are drilled through fractured volcanic rock formations, accounting for roughly 15-20% of the cost of a typical well.

To reduce the cost caused by LC, "Lost Circulation Data-Base System" is under development by NEDO/GERD. The Objective of this project is to develop a software system that is based on the LC database that enable the driller and development company to treat the lost circulation properly on site.

## 2. LOST CIRCULATION DATABASE

### 2.1 SYSTEM REQUIREMENTS

Computer requirements and the database engine for this system are listed below.
1) OS: Windows 95/98(Japanese version)
2) CPU: Pentium 90MHz or higher
3) Memory: 24MB or higher
4) Display: 640x480 dot or higher
5) Hard disk: 20MB or higher
6) Data base management system: Borlamd Database Engine (BDE)

Interface (I/O) of developed LC Data Base System is only in Japanese.

### 2.2 FUNCTION OF LC DATA BASE SYSTEM

Developed LC Data Base has the following functions.

1) Main Menu shown in Figure 1 has Data Input, Data View, Data Search, Analysis, Off-line Network and Expert system options.

2) Data-Input function shown in Figure 2 has 175 items for input such as information of drilling, formation, LC severity, treatment data and treatment result etc.

3) Data View function shown in Figure 3 to Figure 7 has List, Well diagram, Well trajectory, Details of input data and Temperature options.

4) Data Search function shown in Figure 8 can be selected from Area, Location, Well, Date, Depth, Bit Size, LC severity, Loss rate, Formation temperature, Treatment material, Treatment method, Treatment result and Number of treatments at the same depth. This function can search the data from the required key word.

5) Data Analysis function shown in Figure 9 can analyze the treatment result from the database and refer to the optimum material and method for the LC that should be used at the drilling site.

6) Off-line Network function shown in Figure 10 can export and import the data to combine the LC data in the database.

7) LC Treatment Support System shown in Figures 11 to Figure 15 infers the result from rules based on the knowledge base. The knowledge base (rules for operation support) is constructed from characterization of LC, experience of drilling engineers, properties of treatment material and laboratory test result. 338 rules in the support system could suggest the optimum treatment method or idea for characterization of LC, treatment material and treatment method.

**2.3 DISCUSSION**

From the analysis of about 4,500 LC zones encountered and the treatment data that was performed in geothermal drilling in Japan, the result of the treatment are summarized as follows.

1) The percentage of successful LC treatment from all the data is about 24%. Cement is used as a treatment material in 47% and LCM in about 35% of the cases.

2) LC treatment at deeper depth tends to become more difficult. If the well exceeds 1000m, the success rate is about 7%. This indicates that in geothermal wells at high temperature it becomes more difficult to choose the best treatment material and to identify the LC character such as loss depth, loss rate at each depth etc.

3) The percentage of total loss is about 63% in geothermal wells. This indicates that the geothermal wells drilled through the high (open) fractured formation experience a high rate of total losses. Cement is used 65% of the time as a treatment material.

**2.4 FUTURE PLANS**

This system is still under development in order to improve the functions as follows.

1) Add more LC data for better data base

2) Add new functions that should help the drilling engineer.

3) Improve the LC treatment support system that is essential to reduce the drilling cost by reducing the treatment time and materials.

4) Modify the interface (I/O) to English, if required.

**ACKNOWLEDGEMENTS**

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**REFERENCES**

Hyodo, M., Takasugi, S., and Muramatsu, S., (1992) Development of Expert System for Lost Circulation Problems. *Proc. 17$^{Th}$ Workshop on Geothermal Reservoir Engineering Stanford University*, pp147-151.

Glowka, D.A., The Role of R&D in geothermal Drilling Cost Reduction. *Geothermal Resources Council Transactions, 1997,* Vol. 21, pp405-410

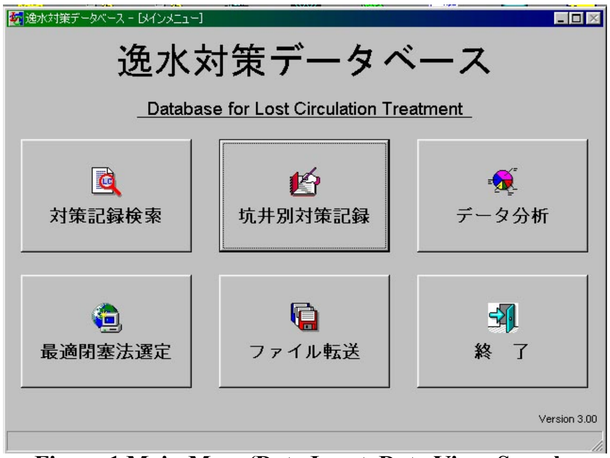



**Figure 1 Main Menu(Data Input, Data View, Search, Analysis, Off-line Network, Expert System)**

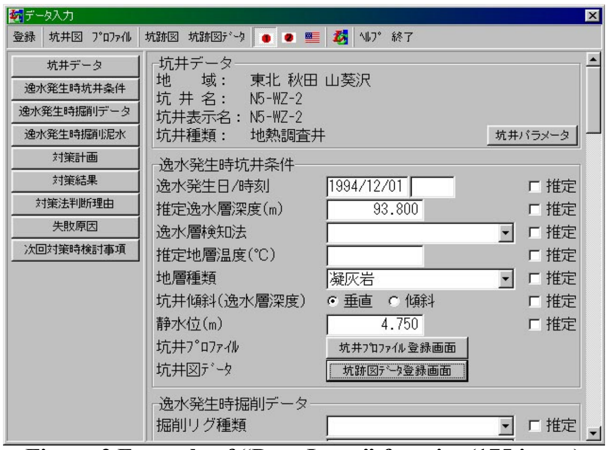



**Figure 2 Example of "Data Input" function(175 items)**


**Figure 3 Example of "Data View" function(List)**

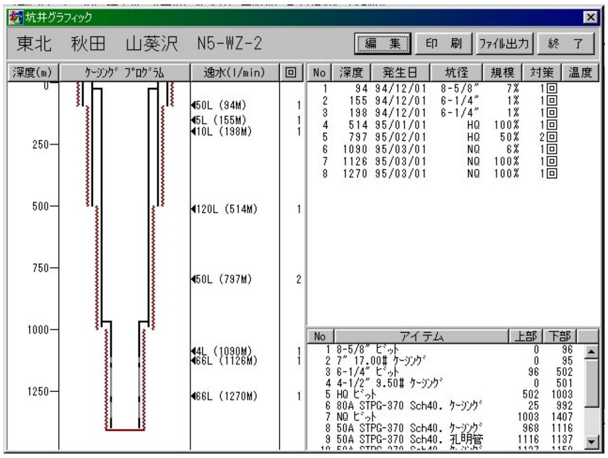



**Figure 4 Example of "Data View" function (Well Diagram )**

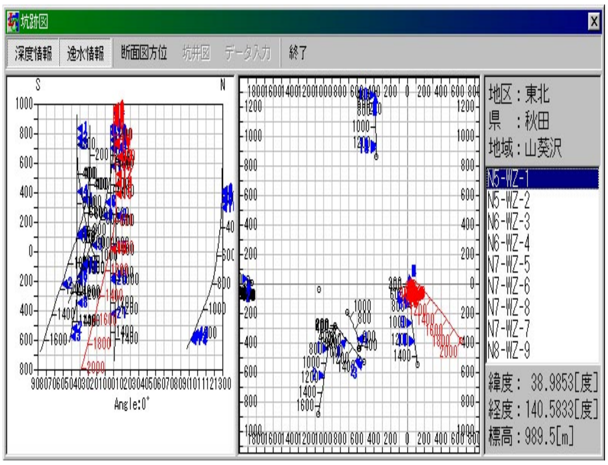



**Figure 5 Example of "Data View" function (Well Trajectory)**

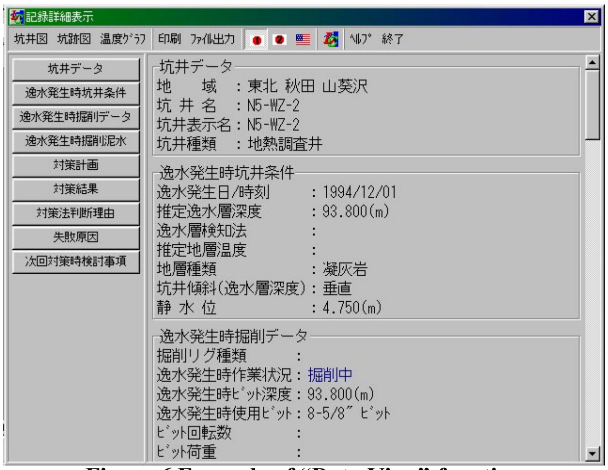



**Figure 6 Example of "Data View" function (Details of Input LC data)**

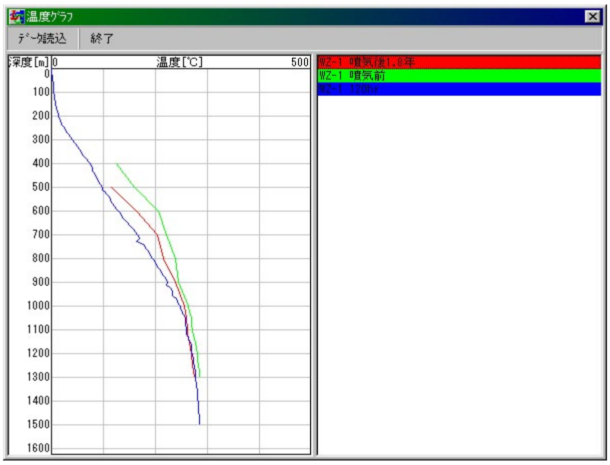



Figure 7 Example of "Data View" function (Temperature)

Figure 8 Example of "Data Search" function

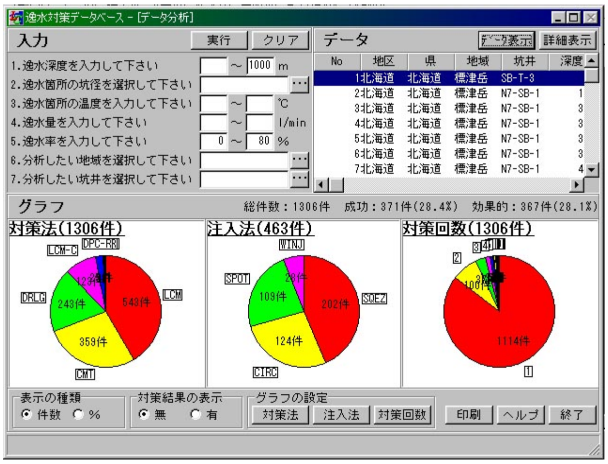


Figure 9 Example of "Data Analysis" function

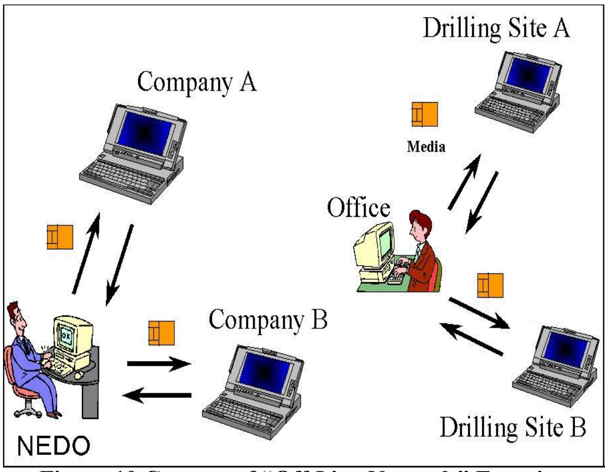
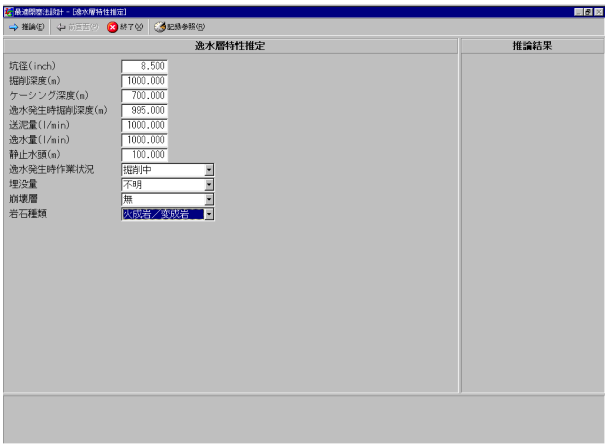


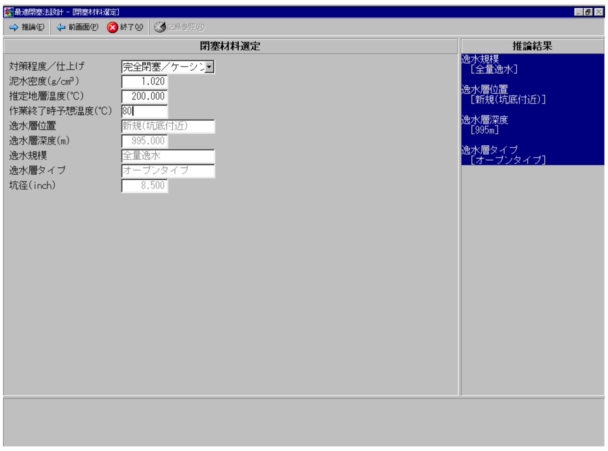

Figure 10 Concept of "Off-Line Network" Function



Input 1) Well diameter, 2) Well depth, 3) Casing depth, 4) Drilling depth at LC occurred, 5) Pump rate, 6) Loss rate, 7) Fluid level, 8) Operation at LC occurred, 9) Fill on bottom, 10) Formation collapse? and 11)Rock type

Supported output 1) Severity of LC, 2) Estimated LC zone and depth, 3) Characteristic of LC

**Figure 11 Example of "LC Treatment Support" Function (Input drilling parameter to characterize LC properties)**



Input 1) Purpose of treatment (type of completion), 2) Mud density, 3) Estimated formation temperature, 4) Estimated recover temperature at treatment

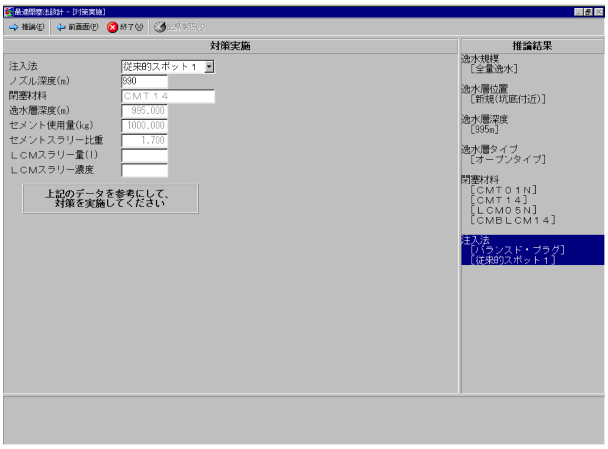
Output 1) Recommended material for LC treatment

**Figure 12 Example of "LC Treatment Support" Function (Support for treatment material)**

Input 1) Treatment material, 2) Density of cement slurry (or LCM mud), 3) Volume of cement slurry (or LCM mud), 4) Size of bit nozzle

Output 1) Recommended treatment (Injection) method, 2) Nozzle depth

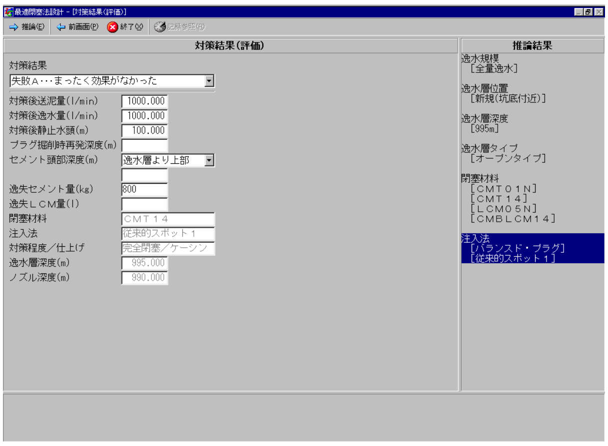
**Figure 13 Example of "LC Treatment Support" Function (Support for treatment method)**



Input 1) Treatment method, 2) Nozzle depth

Output 1) Recommended treatment (Injection) method, 2) Nozzle depth

**Figure 14 Example of "LC Treatment Support" Function (Determination of the method and Treatment)**



Input 1) Treatment result

Output 1) Recommended re-trial treatment method (if necessary)

**Figure 15 Example of "LC Treatment Support" Function (Evaluation of treatment result)**

**Table 1. Analysis results of LC treatment from Data-Base**

| Key Word | Number Of Data | Percent of Success | Percent of success with Cement (effective, Failure) | Percent of success with LCM (effective, failure) |
|---|---|---|---|---|
| No(from all data) | 4,468 | 24.2% | 13% (12%,20%) | 9% (12%,11%) |
| Depth(0 to 500m) | 3,047 | 28.8% | 16% (12%,21%) | 11% (11%,10%) |
| Depth(501 to1,000m) | 1,027 | 17.5% | 10% (12%,20%) | 7% (16%,12%) |
| Depth(more 1,001m) | 393 | 6.6% | 3% (6%,12%) | 3% (12%,13%) |
| Bit size(17-1/2") | 41 | 31.7% | 17% (2%,32%) | 12% (7%,20%) |
| Bit size(12-1/4") | 203 | 42.4% | 32% (16%,20%) | 9% (6%,4%) |
| Bit size(8-1/2") | 67 | 14.9% | 10% (33%,21%) | 4% (6%,13%) |
| Bit size(HQ) | 2,531 | 22.2% | 10% (12%,19%) | 11% (14%,13%) |
| Bit size(NQ) | 552 | 12.5% | 7% (7%,11%) | 3% (17%,10%) |
| LC severity(0 to 30%) | 829 | 26.7% | 9% (4%,6%) | 14% (12%,7%) |
| LC severity(31to 99%) | 789 | 23.2% | 9% (10%,11%) | 11% (19%,9%) |
| LC severity(100%) | 2,830 | 23.8% | 16% (14%,27%) | 7% (10%,13%) |
| Hokkaido Area | 992 | 22.3% | 5% (16%,10%) | 15% (20%,14%) |
| Honshu Area | 1,709 | 29.1% | 17% (8%,18%) | 10% (13%,9%) |
| Kyusyu Area | 1,767 | 20.6% | 14% (12%,28%) | 6% (7%,11%) |