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INTERNATIONAL DATA EXCHANGE FOR GEOTHERMAL ENERGY POWER PRODUCTION

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Summary: During the past five years great strides have been made in the development of geothermal energy resources for electrical power production. However, the same time has seen an enormous growth in publications dealing with geothermal energy, thereby raising the question of economic data handling and dissemination. An approach to this problem is the establishment of an international data exchange cooperative program with the idea to avoid unnecessary and expensive duplication of research and development effort.

Presented at the International Conference on Geological Information, April 9-12, 1978, Imperial College of Science and Technology, London, England

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Introduction

The international effort to develop and utilize geothermal energy has resulted in an enormous growth of information. However, the needed data is widely scattered, difficult to access, and largely unevaluated. Thus, an important task is to collect, evaluate and disseminate geothermal data in a timely manner, thereby avoiding unnecessary and expensive duplication of research effort.

The National Geothermal Information Resource (GRID) of the Lawrence Berkeley Laboratory is sponsored by the U.S. Department of Energy (DOE) to provide critically evaluated information for the development and utilization of geothermal energy. Included are both site specific and basic information related to resource evaluation, electrical and direct utilization, environmental aspects, and the thermodynamic and transport properties of aqueous electrolytes.

The GRID project is involved in cooperative agreements for the interchange of information with other organizations. There are currently three U.S. data centers working to implement the collection and exchange of information on geothermal energy research and production: the DOE Technical Information Center (TIC), Oak Ridge, the GEOTHERM database of the U.S. Geological Survey in Menlo Park, and the GRID project. The data systems of TIC, GEOTHERM and GRID are coordinated for data collection and dissemination, with GRID serving as a clearinghouse having access to files from all geothermal databases including both numerical and bibliographic data. GRID interfaces with DOE/TIC for bibliographic information and with GEOTHERM for certain site-dependent numerical data. Data exchange at the international

level is mainly with the Geothermal Data Bank CNUCE, Pisa, Italy via DOE.

It is not possible to discuss all facets of international data exchange for geothermal energy power production. This report is limited to the following aspects of information exchange at the international level: description of the database; data formats; the NATO-CCMS pilot study; and a section on recommendations for information exchange based on a one-year pilot study under NATO-CCMS.

Database Management

The Berkeley Data Base Management System (BDMS) is used for creating, maintaining and accessing both bibliographic and numerical data. Bibliographic records are readily retrieved from computer files using BDMS by specifying either one parameter such as the geothermal site, or a combination of parameters such as the geothermal site, the date and designated data measurement. Standards for interchange of bibliographic data are patterned after that of the International Atomic Agency's International Nuclear Information System (INIS). Utilization of the INIS format ensures compatibility with other INIS styled computer centers, thereby promoting the active interchange of data with other groups [Herr(1977)]. Data is available in the form of bibliographic compilations, numerical tables, or graphical displays disposed to paper, film or magnetic tape.

The GRID documentation system (GEODOC) contains the descriptive cataloging and indexing information for coding records. Each record contains the descriptive cataloging, abstracting, and indexing information corresponding to a single document; the information within a given record

is subdivided into data elements, some of which are indexing keys. Table I lists the definitions of typical data elements which may appear in a GEODOC record. Some data elements (e.g., author's name) can occur repeatedly within one record; an "m" in the third column of Table I indicates that such multiple occurrences are allowed. The tag used to label the data elements within a record is shown in the left hand column of Table I.

The data elements bear certain hierarchical relationships to each other; the structure is indicated in Table I by indenting the tag names of subordinate data elements and placing them after their parents. Data elements are input to the system in any order except that subordinate data elements must follow the occurrence of their parent with which they are associated.

Information Packaging and Dissemination

Information packaging is providing the data in a form that will best fit the needs of the user of the database. Output therefore takes a variety of forms. Typical information packaging for geothermal data is shown in the following table:

Information Packaging

Typical User	Data Type	Format Example
Scientist; Engineer	Basic Scientific	Correlation Equation
Data Evaluator; Program Manager	Site Dependent	Tables of Numerical Values
Engineer, Program Manager	Critical Survey	Report with Recommendations
Evaluator	Annotated Bibliography	References and Indexes

Table I. Typical GEODOC Data Elements

LBL Tag	INIS Tag	m*	n*	Data Element Definition
SC	008			document short code: unique identifier for document
TY				type of document/bibliographic levels/literary indicator
DES-CAT		m	n	delineates information for one bibliographic level
BL	009			bibliographic level indicator
PT	200			primary title (translated into English if necessary)
PS	201			primary subtitle (translated into English if necessary)
TA	620			title augmentation
L	600			language (for non-English document)
OT	230			original title (non-English) or journal/series title
OS	231			original subtitle (non-English) or journal/series subtitle
ED	250			edition
CODEN				journal CODEN
AUTHORS		m	n	delineates author - affiliation group
AU	100	m		author's name
AN	100			author note (ed., comp., eds., comps.,)
AA	100	m		author's affiliation
AC	700			affiliation code
CE	110	m		corporate entry
CC	710			corporate code
DG	111			academic degree
SPO		m		sponsor
SPC				sponsor code
SCN		m		sponsor contract number

An example of packaging is shown by comparing Figures 1 and 2. The format shown in Figure 1 is a typical output from BDMS which reflects the hierarchical structure shown in part in Table 1. We have developed a report generator which reformats the bibliographic reference in Figure 1 to a more familiar form shown in Figure 2.

NATO-CCMS Geothermal Information Exchange Pilot Study

The NATO/CCMS Information Pilot Study was established to encourage cooperative exchanges of data among participant countries. In this summary of the pilot study, the following topics are discussed: (1) objectives of the program; (2) the computerized geothermal data bases involved in the exchange program; (3) results of the CCMS phase of the program; (4) current status of geothermal data exchange with traceability to CCMS; and (5) recommendations for future work on international cooperation in information exchange.

The main goal of the program was a one-year test of linked data centers designed to facilitate the exchange of new geothermal information at the international level. Three linked principal world centers were originally suggested, as described in the Summary Record of the First Geothermal Implementation Conference [Phillips (1978)].

> Three equivalent regional information centers should be established to promote international exchange of information and data concerning the utilization of geothermal resources. Suggested locations for the centers are Italy, New Zealand, and the United States. The centers would be linked in the sense that all information generated in one center would be transmitted to the other centers and each would have a complete data file of all available information.

and

> Individual requests for specific information could be made to any of the regional centers. Each center would pro-

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RECORD 507
SC = DI PIPPO 77;
TY = R/M;
DES-CAT;
  BL = M;
  PT = HYBRID FOSSIL-GEOTHERMAL POWER PLANTS;
  AUTHORS;
    AU.1 = DI PIPPO, R.;
    AU.2 = KESTIN, J.;
    AU.3 = KHALIFA, H.E.;
    AA = BROWN UNIV., PROVIDENCE, R.I. (USA). DIV. OF ENGINEERING;
      AC = 0 947 000 US;
  SPO = ERDA;
    SCN = EY-76-S-02-0451;
  RN = CATMEC/2;
  PUB = BROWN UNIV.;
  PUP = PROVIDENCE, R.I.;
  PUD = 1977;
  COL = 41 P.;
  N = 16 FIGS., 1 TBLE., 13 REFS.;
INDEX;
  CQ = EXPLORATION/EVALUATION;
  DE.1 = TEMPERATURE MEASUREMENTS;
  DE.2 = MATHEMATICAL MODEL;
  DE.3 = THEORETICAL TREATMENTS;
  DE.4 = SITE SELECTION;
  DE.5 = POWER GENERATION;
  DE.6 = COMBINED CYCLES;
  DE.7 = TEMPERATURE DEPENDENCE;
  DE.8 = THERMAL EFFICIENCY;
  DE.9 = TABLES;
  DE.10 = DIAGRAMS;
CONTROL;
  DCSO = COPY ON FILE;
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Figure 1

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ERDA 77C
EXPLORATION/DRILLING

TITLE- OPERATIONS PLAN COSO GEOTHERMAL EXPLORATORY HOLE NO. 1 (CGEH-1).

AUTHOR- ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION.

REFERENCE- OPERATIONS PLAN COSO GEOTHERMAL EXPLORATORY HOLE NO. 1 (CGEH-1). NVO-184, ERDA NEVADA OPERATIONS OFFICE, CHINA LAKE, CALIF., 1977, 50 P..

DESCRIPTORS- CALIFORNIA; COSO HOT SPRINGS KGRA; MAPS; TABLES; DIAGRAMS; HEAT FLOW; PLANNING; DRILLING; DRILLING EQUIPMENT; HAZARDS.

506

KUNZE 74D
EXPLORATION/EVALUATION

TITLE- PROGRAM PLAN FOR FY 1974. IDAHO GEOTHERMAL R AND D PROJECT.

AUTHOR- KUNZE, J.F.;BRUGGER, R.M. [AEROJET NUCLEAR CO., IDAHO FALLS, IDAHO (JSA)].

REFERENCE- PROGRAM PLAN FOR FY 1974. IDAHO GEOTHERMAL R AND D PROJECT. ANCR-1139, AEROJET NUCLEAR CO., IDAHO FALLS, IDAHO, 1974, 71 P..

DESCRIPTORS- FAULTS; GEOLOGIC SETTING; TEMPERATURE MEASUREMENTS; POWER GENERATION; BINARY CYCLE; THEORETICAL TREATMENTS; GEOTHERMAL WELLS; DRILLING; GRAVITY SURVEYS; RESISTIVITY SURVEYS; MAGNETIC SURVEYS; AUDIOMAGNETOTELLURIC SURVEYS; IDAHO; RAFT RIVER KGRA; MAPS; DIAGRAMS.

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DI PIPPO 77
EXPLORATION/EVALUATION

TITLE- HYBRID FOSSIL-GEOTHERMAL POWER PLANTS.

Figure 2

AUTHOR- DI PIPPO, R.;KESTIN, J.;KHALIFA, H.E. (BROWN UNIV., PROVIDENCE, R.I. (USA). DIV. OF ENGINEERING).

REFERENCE- HYBRID FOSSIL-GEOTHERMAL POWER PLANTS. CATMEC/2, BROWN UNIV., PROVIDENCE, R.I., 1977, 41 P..

DESCRIPTORS- TEMPERATURE MEASUREMENTS; MATHEMATICAL MODEL; THEORETICAL TREATMENTS; SITE SELECTION; POWER GENERATION; COMBINED CYCLES; TEMPERATURE DEPENDENCE; THERMAL EFFICIENCY; TABLES;

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SDG AND E 76
EXPLORATION/EVALUATION

TITLE- GEOTHERMAL LOOP EXPERIMENTAL FACILITY. BI-MONTHLY REPORT.

AUTHOR- SAN DIEGO GAS AND ELECTRIC CO., CALIF. (USA).

REFERENCE- GEOTHERMAL LOOP EXPERIMENTAL FACILITY. BI-MONTHLY REPORT. SDG AND E, SAN DIEGO, CALIF., 1976, P. 1-1 - 8-6.

DESCRIPTORS- POWER GENERATION; TEST FACILITIES; BINARY CYCLE; CALIFORNIA; NILAND; TABLES; DIAGRAMS; PHOTOGRAPHS; DESIGN; CLIMATES; COSTS; GEOTHERMAL WELLS; PRESSURE; TEMPERATURE MEASUREMENTS.

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GEOTHERM. ENERGY MAG. 77B
EXPLORATION/EVALUATION

TITLE- GEONOMICS STARTS GEOTHERMAL PROJECT IN HONDURAS.

AUTHOR- GEOTHERMAL ENERGY MAGAZINE.

REFERENCE- GEOTHERM. ENERGY MAG., V. 5 (8), P. 17-21(1977).

DESCRIPTORS- MAPS; HONDURAS; TEMPERATURE MEASUREMENTS; POWER GENERATION; FORECASTING.

Figure 2 (continued)

vide information in appropriate tabular, graphic or computer-readable formats.

Final implementation of the information pilot study involved computerized data centers in Italy and the United States, with active participation by New Zealand in development of formats and in providing data.

In summary, the Information Exchange Pilot Study was a one-year study, using two linked regional data centers, to develop common formats and utilize computer methods for the prompt exchange and dissemination of new information and data related to geothermal energy. The information exchange depended on computer assistance to provide the most rapid, efficient and economical means of handling large quantities of data.

Implementation of the Information Exchange Program

Implementation of the program involved the following participating data centers: (1) Centro Nazionale Universitario di Calccolo Eletronica (CNUCE), Pisa, Italy; (2) The National Geothermal Information Resource (GRID), Berkeley, California, and (3) GEOTHERM, Reston, Virginia (now Menlo Park, California).

The idea was to include both bibliographic and numerical data in the exchange on a trial basis to assess the time, cost, and usefulness of the work. Objectives and data collection for the one-year pilot study included the following:

1. Bibliographic data compiled by GRID using CDC machines and the Berkeley Data Base Management System (BDMS) on the following aspects of development and use of geothermal energy, including information from other fields with relevance to geothermal

energy: (1) Subsidence; (2) Hydrogen Sulfide; (3) Geothermal Resources; and (4) Non-Electrical Applications. Indexed and annotated bibliographic listings were made available either as computer print-outs or magnetic tapes.

2. Tape of site-dependent numerical data by GEOTHERM using IBM machines and the GIPSY data management system to include the following subject areas: Geothermal Field/Area; Chemical Analysis; Geothermal Well/Drillhole.
3. Development of formats using internationally accepted standards by CNUCE, GEOTHERM and GRID.
4. Transmittal of computer tapes and other data to Pisa from Berkeley.

Conclusion

The results of the CCMS pilot study and the follow-up work demonstrate the effectiveness of the pilot study concept as applied to the exchange of geothermal information on a worldwide basis, and the advantages of computerized information systems for this kind of operation. The success of the work requires the cooperation and coordination of many agencies and laboratories in each participating nation. In the U.S., for example, the agencies involved in coordinating the project were the Department of Energy, Department of State, Environmental Protection Agency, U.S. Geological Survey, and Lawrence Berkeley Laboratory of the University of California.

Recommendations for Future Work on International Information Exchange

The primary objective of the CCMS Pilot Study on data exchange was

to create an international geothermal resource data base, a pool of information from which all countries may draw. The difficulty does not lie with designing the data system but rather with the mechanics of securing and coding the information. Most participants are eager to contribute to the file but balk at the tedious and sometimes formidable task of coding forms for the computer. This is understandable because such coding could create a drain on manpower and funds. Future work in data exchange must face the reality that responsibility for coding lies with the data center.

Recommendations for this and other future work include the following:

1. Participating countries should collect copies of data (e.g., internal reports, manually logged data) for transmittal to the designated computer centers. This is especially important for data that is not widely circulated and may be either inaccessible or difficult to obtain. This data is important for evaluation and calculation of energy parameters and should be included in the information exchange.
2. The data centers responsible for maintaining the computer tapes should fill out the input format forms. Participating countries would be required only to provide the necessary copies of reports and other data. The computer centers should therefore make provisions to add needed staff to code the information.
3. The time required to exchange or transmit material between participating countries needs to be shortened, and site visits by computer center staff with an agreed-on frequency (e.g. yearly interval)

to collect reports is required.

4. Each participating country has a different type of data need which should be provided by the data centers. The data centers, to provide for these specific requirements, may coordinate requests for information with other organizations. It is important that participating countries be provided the data they need in exchange for their reports.
5. The computer centers should contain two types of information: (a) data evaluated by the center; (b) data evaluated by others. While it is not possible to critically evaluate all data within reasonable time frames, users of the data should be aware of the sources of the information.
6. Priorities in the acquisition of data should be established. For example, given the choice between data in publications and data in unpublished files, it might be important to concentrate on the unpublished data first. Later, the more generally available data could be secured from libraries.
7. Transcribing the data on forms for computer input is the most difficult task. Three possibilities seem most reasonable.
   a. The data would be copied and sent to the data center for encoding.
   b. People would be sent to the countries to encode the information available there.
   c. Funds would be provided to the country so it may hire someone to do the encoding.

8. A system of responding to the participating countries should be organized. Such a task may include a newsletter and periodic retrievals from the file.
9. Provide computer expertise to those developing nations which currently lack such capability. Large quantities of data are handled most effectively by a computer medium (e.g., magnetic tape); it is therefore imperative that computer expertise be initiated by nations which currently lack this capability.

References

HERR, J.J., PHILLIPS, S.L., SCHWARTZ, S.R., TRIPPE, T.G., 1977, Standards for Multilateral and Worldwide Exchange of Geothermal Data, Mathematical Geology, 9:259-263.

PHILLIPS, S.L., SCHWARTZ, S.R., SWANSON, J.R., 1978, NATO-CCMS Geothermal Information Exchange Pilot Study, UCID-3995, Lawrence Berkeley Laboratory, University of California, Berkeley, CA 94720.