GD MANAGER, AN INTEGRATED GEOTHERMAL DATA MANAGEMENT SYSTEM

E. B. Anderson and G. N. H. Ussher
Geothermal Energy New Zealand Limited, Auckland

SUMMARY - As the geothermal industry matures, geothermal data management is likely to trend away from the individualistic approach that has often been common until now, towards corporate oriented strategies. As geothermal resources progress into later stages of development, operators will need to increasingly ensure a thorough and orderly accumulation of their data which is essential for regular reassessment of their resource. A corporate approach to geothermal data will enable geothermal organisations to focus on data quality and to develop long term data management practices to protect their data and accumulated investment in staff expertise. The GDManager integrated geothermal database system developed by Geothermal Energy New Zealand Limited is presented as an implementation of modem data management and presentation tools which can flexibly meet such corporate geothermal data management goals. There is potential for the industry to consider the possibilities for some standardisation of geothermal data management methods.

1. INTRODUCTION

Geothermal resources are developed primarily to produce energy. However, an important and often underrated intermediate product is the scientific data collected during the exploration and development of these resources. This data is essential for the efficient development and management of a resource. During geothermal exploration and development, each successive stage is more expensive than the last (Figure 1).

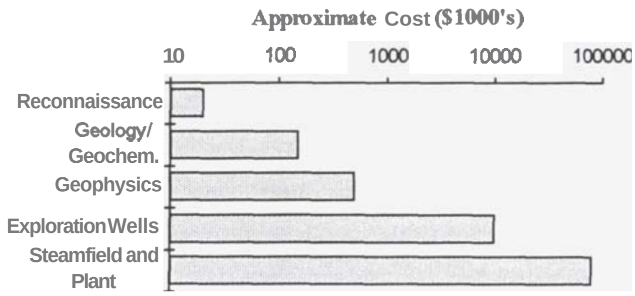

Figure 1: Trend of costs through a geothermal development.

The integration of all data, possibly into a conceptual resource model, is essential for providing a sound base on which to base economic decisions throughout the development. The conceptual model of the resource will be improved at each stage but many aspects of the resource may remain unknown because the characteristics of a geothermal reservoir are difficult to observe. We can only collect reservoir information through indirect exploration techniques, drilling and production. The geothermal reservoir has more gross features than its oilfield equivalent and generally lies in a more chaotic geological environment. The thermodynamic properties of water/steam conspire to complicate the investigation of permeability structures and reservoir fluid characteristics.

To overcome these difficulties, requires the integration and interpretation of all available data. All the geosciences have to work together. New surveys may need integrating with older data of a similar type. Production data and reservoir conditions are monitored for change over time. This integration is an essential element of geothermal science and is a strategic part of the 'detective' work necessary for understanding the resource. Computer systems have long been seen as potentially very important tools in geothermal science but the orderly implementation of such systems in a geothermal organisation is a major task.

2. THE INDIVIDUAL VERSUS THE 'SYSTEM'

In geothermal science, computers were initially used mainly for specialised calculations and modelling specific data sets. Much of the software for these purposes was written by individual scientists to meet their own specialised requirements. More recently, the data storage and graphical presentation capabilities of computers have become increasingly important. The proliferation of inexpensive personal computers and interactive software such as spreadsheets and graphing packages has enabled scientists to perform calculations and present data in the many ways that suits their needs. The resulting computing systems are however, often very closely associated with individual scientists and in most geothermal organisations there has developed a multitude of different software units used for geothermal data management.

The challenge for geothermal organisations lies in balancing the ingenuity, initiative and individualism of its staff with corporate objectives for achieving outputs to a high standard which meet long term objectives.

The geothermal industry is young and still comparatively small and new techniques are regularly developed through the effort of individual experts. As such, the industry presents a small, very specialised and difficult market to prospective software developers. The geothermal industry's more mature cousin - petroleum exploration - has available a good range of commercially developed software utilising (almost) standardised methods for analysis and presentation of data. For decades, oil exploration companies have developed corporate approaches to data management with a strong focus on the collection and interpretation of the data and information which they recognise as their primary product.

As geothermal technology matures and as an increasing number of geothermal fields progress through the more expensive stages of development, scientific emphasis within many organisations can be expected to shift away from the development of techniques towards application of existing knowledge to the essential task of managing and interpreting accumulated data. In the field of scientific data management, this will mean some reduction in the level of individualism that has often dominated in the past.

People and their skills can be transient within an organisation so the challenge for Management is to maintain continuity and steadily develop the knowledge base of the enterprise. The adoption of a corporate strategy to data management, implemented in appropriate software systems, can be an effective way of retaining and maximising the benefit from the organisation's investment in acquired data and knowledge.

A suitable data system should be flexible and adaptive to new techniques, but should be well structured and not excessively dependent on the skills of individual staff. It should be possible to integrate the skills of staff to modify the system but this should be done in a rigorous manner. The system should hold all scientific and measurement data and simplify the mundane work of data entry and presentation. It should also make this data available to specialist interpretation programs used by the organisation.

Data must be secure and able to be accumulated in an orderly way for regular interpretation or modelling. Basic tools should be provided for the presentation of data in ways that technical staff can directly utilise or interpret.

3. THE GDMANAGER CONCEPT

GDManager is a generalised and integrated geothermal data management system developed by Geothermal Energy New Zealand Limited (GENZL) over the past 6 years. The primary objective of it's design has been the support of GENZL's scientific consultancy service to clients who are developing a range of geothermal resources. Advising clients over a period of twenty years, GENZL saw the need for formalising long term data management strategies. The traditional series of surveys, well reports, measurement reports and regular production reports interspersed with occasional resource reviews and feasibility studies needed to be augmented by systems for the orderly accumulation and presentation of data.

Every geothermal resource under production needs regular assessment of performance and any proposal for expansion requires a thorough reassessment of the resource size and capacity. It is at these times that the need for a well structured database is felt the most. All data from a range of sources needs to be collated, remodelled, replotted (on consistent graph and map formats, at similar scales) and reinterpreted into an updated conceptual model.

This was the concept for GDManager. A database system for storing and presenting all data normally collected during the life of a geothermal development.

It should provide:

- a properly structured database that records the space-time location of measurements as well as grouping data by 'tests' or other artefacts of the measurement process - simultaneously modelling the resource and the way we conceptualise the measurement systems we use.
- data entry, editing and consistency checking tools. Clear identification of all data as to where, when and how it was collected so that it doesn't get 'lost' in the system
- flexible query and data selection tools to choose data for analysis, reporting and graphical presentation
- high quality graphics and contouring facilities that are simple to use and modify. A wide range of graphical presentation for each data type. Data should be able to be viewed in every imaginable way and with a range of groupings
- standard data calculations and the ability to incorporate special modelling packages
- user customization of all graphs, reports and other features
- capabilities for new datasets to be added to the system as required and the system should have an overall orderly structure

The GDManager system has been developed with the objective of meeting these goals. It has been made available for sale to other geothermal organisations and as such is the first commercially marketed computer system for specifically managing geothermal data. The implementation of the GDManager system is presented here to provide an example of how an integrated system such as this can provide substantial advantages to an organisation.

4. THE GDMANAGER IMPLEMENTATION

GDManager has undergone several major revisions during its life. The system has always aimed to meet the concept objectives as described above, but the implementation has progressed significantly from that described by Bamett et *al* (1987).

4.1 Database Structure

GDManager is a fully relational database system using data normalisation techniques as described previously (Barnett et *al*., 1987). The system has been constructed using PARADOX which is a MSDOS-PC based database system licensed from Borland International Inc.

The database structures have been designed to provide maximum flexibility by collating all data of a similar type together while at the same time referencing the data in a variety of ways. This allows the data to be viewed by the user in the form that they are used to (and expect) but also enabling a much wider range of data interaction.

For example, the reservoir engineering module allows for downhole temperature 'runs' to be entered as a single test but the information about the test (who did it, when, where, using which instruments) is stored in one table, while the actual measurements are bundled into another table which holds all subsurface temperature and pressure measurement data. Individual runs can still be edited and viewed as a unit but each individual downhole measurement point is also clearly identified with time and location information so that data can be viewed as changing with time or compared to data from other wells. Figure 2 demonstrates this idea with a presentation of a series of typical well heating profiles and a separate view of a subset of the same data at a particular level.

Well designed database systems strongly contrast with systems based on spreadsheets or graphical packages where data is usually stored in separate files for each well or test. With data scattered across many files in spreadsheet systems, the data is difficult to find and it is difficult or impossible to correlate or integrate data from the different files.

The management of wells is another important feature of the GDManager system. Wells are a major source of data and require special treatment in a geothermal database. Details about any well's location, depth, and deviation must be entered before any data can be entered for it. This well information is then available for the modules that need to reference wells (Reservoir, Chemistry, Geology, Production). Well deviation information is used for calculating vertical depth, elevation and actual northing/easting of downhole data. Data from separate wells are easily compared, for example, by plotting downhole temperature against elevation. These simple facilities do so much of the mundane calculative work that would otherwise be very time consuming and would tend to restrict how data is compared across a resource. The calculations are also completed in more detail enabling more accurate resolution of

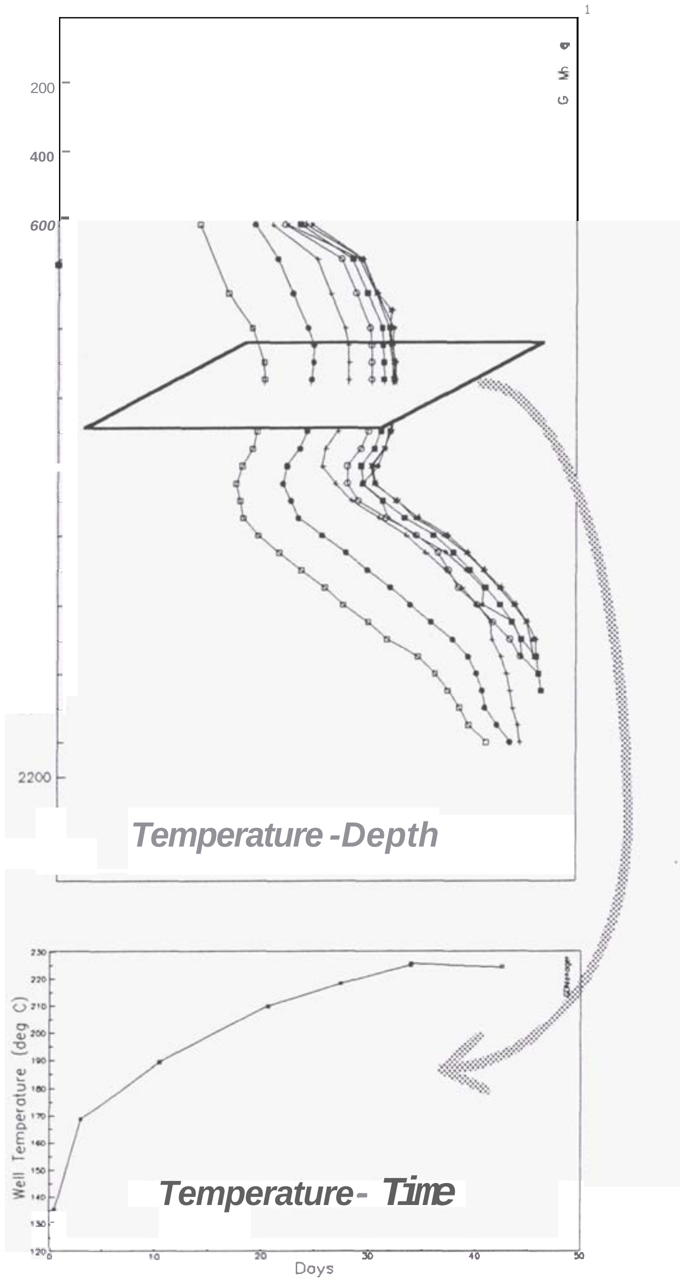

Figure 2: The structured GDManager database allows data to be viewed in a variety of ways. In the upper graph data is presented as a series of downhole temperature runs. In the lower graph a subset of the same data (at a specific depth) is viewed to show how it has changed with time.

4.2 Data Entry and Caretaking Facilities

The well organised data structure provides for storage of complete information about entered data. A standard suite of data entry, editing, renaming, browsing and deleting routines has been designed to suit the range of data types collected in geothermal science. Provision is made for specialised calculations within the data entry systems. Logical associations between different data tables are maintained and checked as appropriate. When accessing data, lists of existing data can always be called up to choose from, or search criteria can be defined to locate data by key fields. Data comment fields are shown to ensure that the correct data is chosen.

During the last year, GDManager has been extended to include local area network compatibility. This enables several workers to simultaneously access the same database and provides the ideal environment for a scientific and reservoir engineering team who are responsible for a geothermal resource. Data is centrally coordinated, avoiding duplication and enabling a greater degree of interpretative integration.

4.3 Data Search and Selection Tools

The structured database design ensures that all data is properly identified as to the type of measurement or test and where and when it was collected. Generally the primary identifiers of data are a mix of location name (such as a sample site or well), the type of sample or test, and the date and time of collection or measurement. Data can be chosen individually or using a variety of general selection criteria that can be applied to the primary identifiers. In the Chemistry module, the selection tools have been extended to enable the definition of named groups of data which provides for the arbitrary grouping of data for presentation purposes if required by the scientist.

4.4 Graphics and Contouring

The GDManager system provides a smooth interface between the database and the commercially available graphics packages GRAPHER and SURFER copyright of Golden Software Inc. (USA). The data is chosen using the various selection tools, optionally special calculations are performed, and the data is transferred to the graphics package and applied to a predefined presentation format suitable for that data type. Simplified interfaces are provided to the graphics packages so that a suitable graphic can be produced even by novice users but full modification of formats is accessible to advanced users. X-Y graph types and contouring facilities are provided for all modules.

The graphical presentation of data in suitable formats is generally one of the most time consuming but important aspects of the geothermal data interpretation process. The system aims to provide a full range of graph types, often including some preprocessing calculations, leaving the scientist free to undertake interpretative evaluation rather than spend excessive time on tedious data preparation.

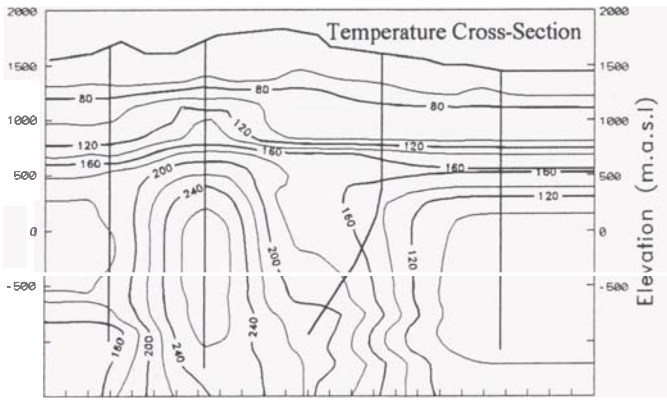

Figure 3: Reservoir Engineering contouring:- example of a temperature cross-section.

The Reservoir engineering module, for example, provides a large number of general graph types for plotting data against depth or elevation, or with time from minutes to years. It also provide specialist graph types such as Homer, MDH, P^2 Homer, log-log and logP^2-log which would otherwise involve tedious calculations. Curve fitting facilities are provided within the graphics package. Contouring of temperature and pressure data can be made in plan view or as cross-sections. Examples are shown in Figures 3 and 4.

The Chemistry module enables calculation of any ratios and the plotting of any constituent or calculated

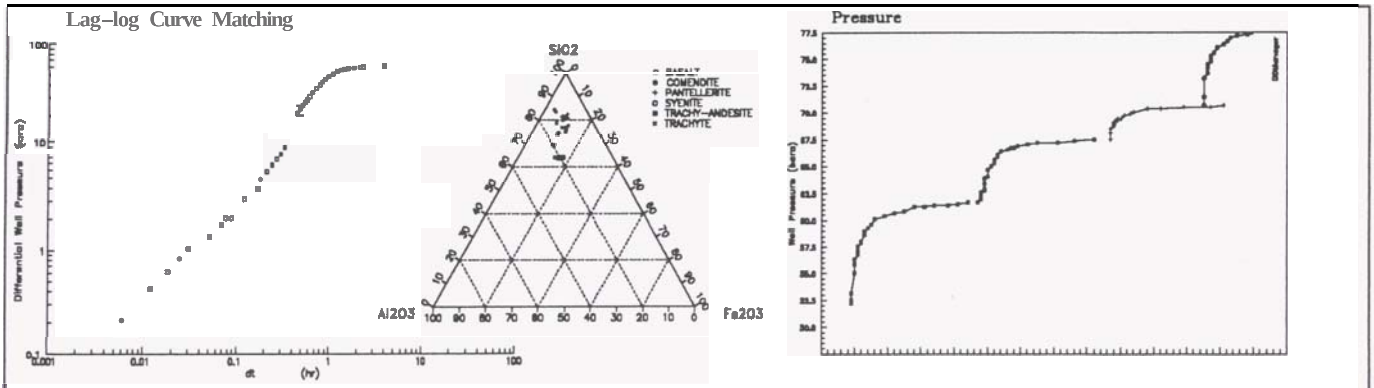

Figure 4. Some examples of the possible standard X-Y plot formats.

item against any other. A range of (otherwise difficult) ternary plots are provided within the Chemistry and Geology-rock chemistry modules.

For most graphics, data can be grouped in a variety of ways to suit the various presentations. In Chemistry, data can be grouped (plotted with common symbols) on the basis of the sample site name, the type of sample site, the type of sample or the year of collection.

The tight integration between database and graphics packages ensures that all data is fully labeled on the graphics and data is correctly located on maps. As new data is collected, graphs or contour maps can be quickly regenerated to incorporate the new information. These features ensure that data retains its full value through being always identifiable and able to be augmented by newer measurements.

4.5 Calculations and Modelling

Specialised calculations are easily accommodated into GDManager. All standard data entry, editing, graphing and export routines can call calculation routines specific for the current data type. For example the Chemistry module performs a wide range of calculations and data checking when data is added or edited: geothermometers and ion balances are calculated, gas concentrations are normalised and collection pressures have consistency checking performed. In the resistivity Soundings module, resistivities are calculated from raw field data and special edited data sets can be created for later modelling.

The resistivity Soundings module also incorporates an interactive graphical modelling program which is passed measured data from the database and returns calculated models to the database system. A similar system is adopted for MT 1D modelling and can be applied to a wide range of similar problems.

This inclusion of modelling and specialised calculations is seen to be an increasingly important aspect of the GDManager system. The data is kept in the main database where standard routines are available for entry and general storage utilities. Standard selection routines are used to pull out desired data for modelling and models or results can be returned to the database. This system ensures that any effort or expense put into developing special modelling packages is retained because they are always accessible from GDManager. Too often special programs are designed to run stand-alone and are not as widely used as they should because they have obscure or no data storage facilities and workers are unsure of how to run them or even where they are to be found on the computer systems. This allows the formalising of any special modelling packages developed to meet the special requirements of the enterprise.

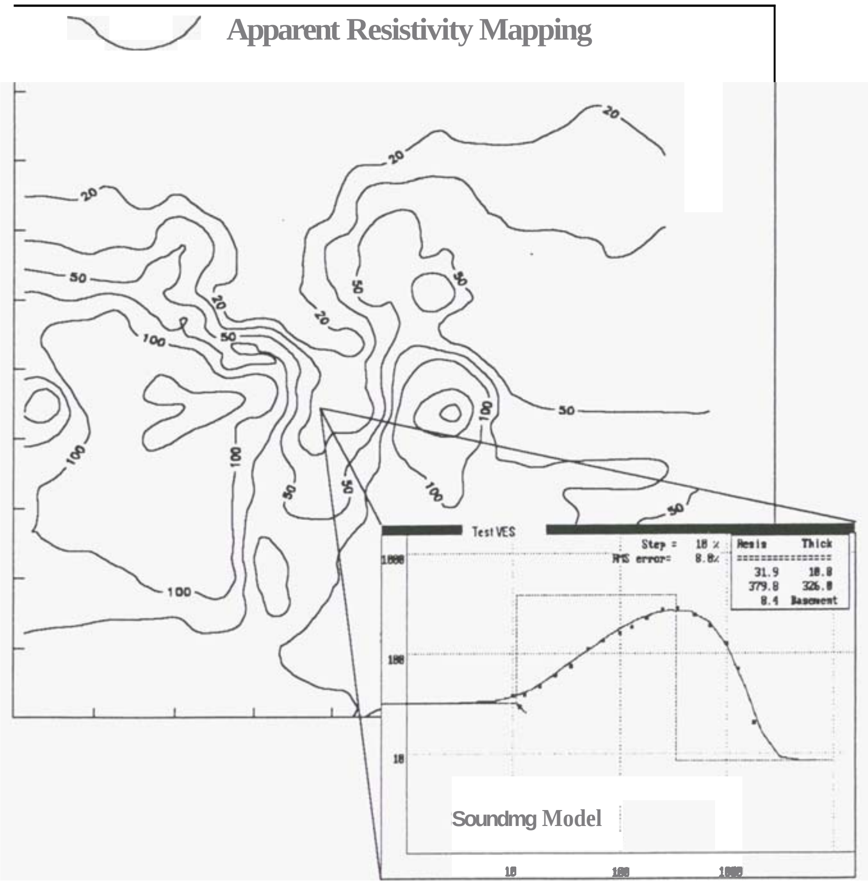

Figure 5: Special programs such as interactive graphical VES resistivity modelling can utilise data directly from the database, providing a high level of integration and multiple views of the data. Shown above is also an example of output from the standard GDManager contouring facilities.

Figure 5 shows an example of a modelling package that is integrated as part of the GDManager system.

4.6 User Customisation

To meet the requirements of different organisations, individuals and geothermal fields, it is often necessary to modify the style of graphical and printed outputs from the database system. GDManager has standard routines included in the graphical and reporting facilities for completely modifying output formats. Such changes can be made for individual output sessions or saved permanently to the system for future use. This flexibility is essential if professionals are expected to conform to (and tolerate) use of a common data management system. They will often require modifications to suit changes of interpretative methods and these can be easily implemented.

Another form of flexibility and customisation has recently been added to GDManager in the form of providing for dynamic measurement unit conversions and the renaming of the fields within the database. Units conversions enables the entry of data in an unlimited range of units (the user can define their own unit conversions). The data is actually stored in standard SI units but is converted to the chosen units on entry and exit from the database. This not only allows for international versatility but is also a practical approach to situations where a variety of equipment is employed on any one site. The current unit symbols are shown on data entry forms and reports, avoiding any confusion.

The ability to rename the presented label of any of the database fields enables the system to be customised to suit an organisation's naming conventions, as well as allowing the users to perform a considerable amount of translation into other languages. This can be particularly useful in ensuring that lesser skilled data entry staff correctly use the system.

4.7 System Expansion

GDManager is constructed as a series of modules for managing each of the main geothermal scientific disciplines. Each module utilises a common range of program routines for data entry, editing, graphing, reporting etc. These standard routines are integrated with data forms, report layouts, graphic formats or calculation routines specific for the particular data type. Menus are developed to provide easy access to the routines.

A specific application generation tool has been developed by GENZL for the interactive development of GDManager menus for new data sets. This tool allows the developer to integrate the separately built objects required for each menu task with the standard routines in an orderly way. All menu objects and actions are themselves stored in a database so that the developer can locate and identify the role of any object in the system and perform regular maintenance duties. If standard routines are upgraded, the entire menu system can be rebuilt in minutes.

This structured approach to the system design enables the addition of new data sets to be accomplished very economically. Such work involves the design of data tables, entry forms, graphic objects, reports and any special calculations, followed by integration using the application development tool.

5. CONCLUSIONS

If a corporate or organisational approach to geothermal data management is adopted, there are a number of benefits that can be achieved without necessarily sacrificing flexibility and individuality. The GDManager system has undergone considerable change from it's original implementation and this reflects the effort necessary to develop a fully flexible system that can meet these requirements. Many of the changes made to GDManager result from requests from clients who have differing requirements from those originally imagined by the developers. In this way the system is expanding in versatility and capability.

Any organisation can benefit from formalising their data systems, however the time involved in fully analysing their data structures and building systems from scratch can be deceptively great. Such analysis is a worthwhile endeavour but can become a large consumer of staff effort. Systems like GDManager are likely to become more common as the industry follows the worldwide trend to 'outsourcing' more of the technology it requires rather than developing systems in-house.

The industry must soon begin to consider whether there is value in standardisation of the storage, presentation and transfer of geothermal data. Certainly, large exploration companies already face these issues with the transfer of data between offices and in transferring expertise among their scientific teams. As environmental, resource usage and resource allocation issues become increasingly important there may be value for the industry in general to investigate the use of data management standards such as those being implemented in GDManager.

6. REFERENCE

Barnett, P.R., Farrell, R.B., Paterson, A.R. and Ussher, G.N. (1987). GDManager: A development in the management, interpretation and representation of geothermal field data. Proceedings of 9th NZ Geothermal Workshop, University of Auckland Geothermal Institute, p9-15.