

# Well Information Query Tool for Leyte Geothermal Production Field, Philippines

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## *Abstract*

*A stand-alone application program incorporating GIS to database management was developed for the Leyte Geothermal Production Field wells database. It links spatial data with tabular well information, allowing the user to query the database through a map interface. The information contained in the corporate Oracle database includes basic well data, stratigraphy, permeable zones, and intersected fault structures.*

*For visualization, a three-dimensional model of the geothermal field with the wells and the surface of Bao Volcanic Formation stratigraphic layer was also created and incorporated into the program.*

*Two 3D-model viewers were used; one featured the whole Leyte Island, while the other included only the geothermal field, itself.*

*3D modeling of the wells was done using the deviation survey data through linear referencing.*

*The program was developed using Visual Basic with MapObjects at the International Institute for Geo-Information Science and Earth Observation (ITC) in the Netherlands.*

## **1.0 Introduction**

Efficient handling of large volumes of data requires sophisticated tools such as Database Management Systems (DBMS). Aside from storing and organizing, DBMS allow quick access to stored information and provide varying levels of security to protect the integrity of the data. An organization's operation may rely heavily on its DBMS, such that inefficiencies in its system reflect the quality of the organization's overall performance.

Geographic Information System (GIS) supplements a DBMS' effectiveness. Since most information is related to actual geographic phenomena in one way or another, GIS provides the spatial framework for visualizing and manipulating these types of data. It strengthens the bond between abstract information stored in the database and its real-world relation, making it easier for the user to envisage and comprehend the message the information conveys.

Because of the powerful capabilities of the two systems, a GIS link to an existing DBMS at PNOC-EDC was conceptualized and developed. The specific objectives were to create an interface linking map representations of geothermal wells in the Leyte Geothermal Production Field (LGPF) in East-Central Philippines (Fig. 1) to tabular attributes and to provide a means for accessing information contained in these tables through interactive manipulation of the graphically displayed data.



**Figure 1.** Location of the Leyte Geothermal Production Field (LGPF). Central Philippines

Furthermore, a procedure for three-dimensional modeling of directional geothermal wells was developed using available GIS tools. The 3D well models were incorporated into digital elevation models (DEM) of the Leyte Island and LGPF. Coupled with satellite imagery and raster manipulation, a resulting three-dimensional digital representation of the LGPF was generated. This feature was included in the application program as an aid to visualization and to showcase this capability of GIS.

## 2.0 Source Data

The application program made use of both geographic (map) and tabular data. The map data was extracted from existing CAD files of LGPF, which include topographic contours, roads, rivers, and power plant locations. The CAD files were exported to shapefiles, which is the native file format for ESRI GIS modules employed as the application platform.

The tabular information used in the database were extracted from the existing Oracle<sup>™</sup> database of PNOC-EDC, consisting of basic well data, deviation survey data, permeable zones, fault intersections and stratigraphic contacts.

The same information contained in the data tables were utilized to construct the 3D well model while the topographic contour CAD files were used to generate the DEM for LGPF. A larger scale DEM covering the whole Leyte Island was generated using elevation data from the Shuttle Radar Topography Mission (SRTM). This was obtained as free download file from the Global Land Cover Facility (GLCF) website (<http://glcf.umd.edu/index.shtml>). This data has 90-meter horizontal and 1-meter

vertical resolution. Satellite imagery (Landsat TM, WRS-2, Path 113, Row 52 & 53, acquired 1992-06-29) obtained from the same site was also utilized to enhance the 3D digital model.

### 3.0 Application Development

The application program was developed in Visual Basic environment using ESRI's MapObjects 2.3 object libraries. The program is essentially an interface for the user to access information stored in the database tables. Basic map navigation functions such as zooming-in, zooming-out, and panning are provided. A locator map for quicker transition to locations not covered by the current map view was also included.

The main feature is a map area where the user can select wells of interest by interactive mouse clicking or by text-entry in corresponding dialogue boxes (Fig. 2). The interface provides the option to select wells individually or in multiples grouped by sector, as defined by the respective sector boundaries within the geothermal resource. Information about the selected wells are displayed in tabular form in listview control boxes (Fig.3). Option buttons provide the user a way of specifying the types of information that will be displayed, which include basic well parameters, permeable zones, stratigraphy, or fault intersections.



Figure 2. The query tool main interface.

DepthID	ID1	WellName	DepthMD	Remarks	Id
1360-54	23	415D	2100	Misc	125
586-881	24	415D	800-700	Misc	125
773-863	25	415D	800-900	Misc	125
1365-1454	26	415D	1450-1550	Misc	125

Number of zones: 4

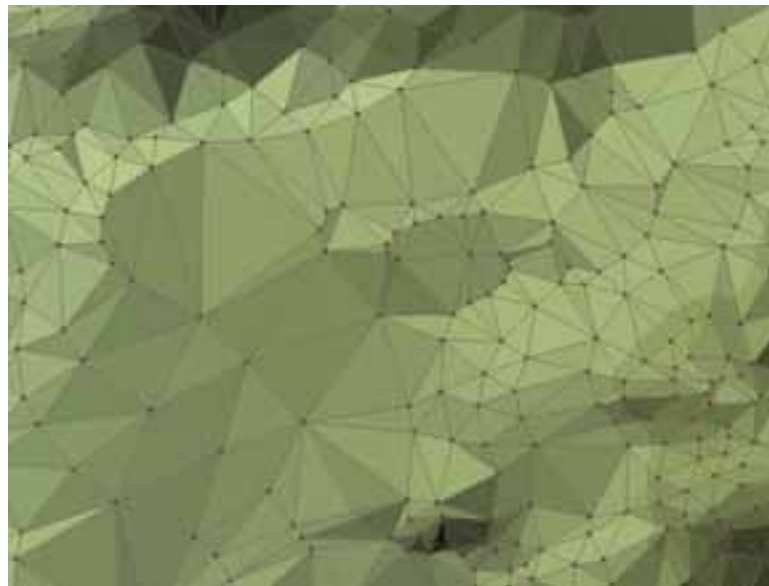
Export Close

**Figure 3.** Listview box with data in tabular form.

After displaying the required information, the user has the option to export the output table into a text-format file for further manipulation, depending on specific needs.

#### 4.0 3D Modeling

Creation of the 3D model was done in ArcInfo with the 3D Analyst tool extension. Generating a digital elevation model from CAD-type digital files is a straightforward process in ArcInfo. After converting to shapefile, a Triangular Irregular Network (TIN) surface is constructed from the topographic contours using the associated elevation values for the individual contour lines (Fig. 4). This surface can then be used to model the terrain topography or DEM.



**Figure 4.** Triangular Irregular Network (TIN) surface.

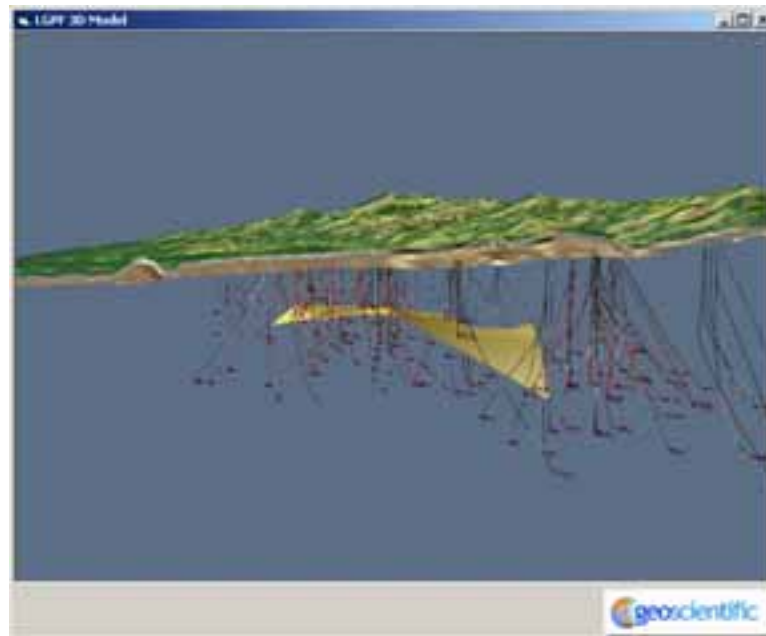
Three-dimensional modeling of geothermal wells requires more steps and an entirely different approach because instead of a surface, it deals with linear features and elements located along them. These features can assume any direction and orientation in a 3-

dimensional space. Furthermore, there are few available application tools that allow straightforward generation of 3D lines, from “XYZ” coordinates, which are the available data in this case. It was therefore part of the project to research available tools and devise a procedure for generating 3D linear features in GIS.

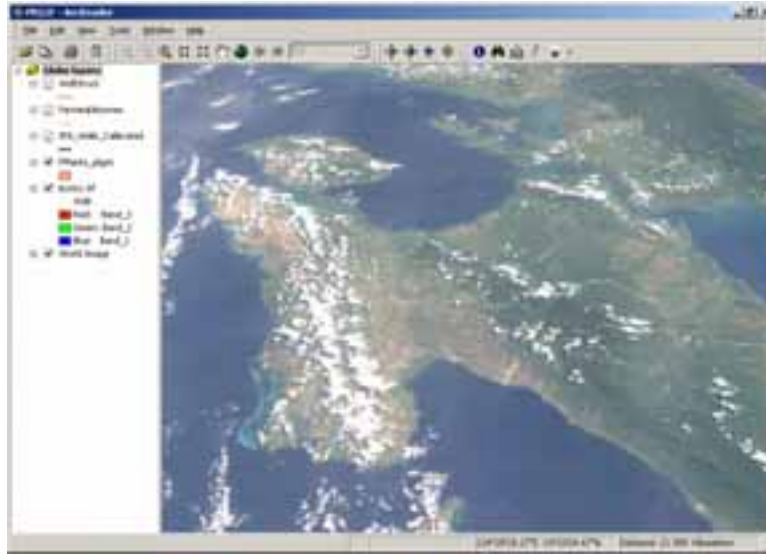
To create the 3D wells, the “XYZ” coordinates of the vertices were first extracted from the deviation survey data. These coordinates were transformed into 3D points in ArcInfo. An “out-of-the-box” tool, ET Geowizards™ was used to create 3D lines from the 3D points. This process was done for each individual well.

Linear referencing and dynamic segmentation was employed to model features such as permeable zones and fault intersections along the well. Each well was treated as a route, and the respective zones as linear events along the route. Similar procedure was followed to generate the surface model of the Bao Volcanic Formation (BVF) using the contact depths as point events along the well.

Once completed, the separate polyline features were integrated into one shapefile and incorporated in the overall model as one layer. ArcScene was used to create the model of LGPF (Fig. 5) while ArcGlobe, which is more suitable at managing large sets of 3D geographic data for visualization was used to build the 3D model of the whole Leyte Island, (Fig. 6).



**Figure 5.** ArcScene generated model of LGPF showing terrain, wells, and surface of Bao Volcanic Formation (BVF).



**Figure 6.** 3D Model of Leyte Island using SRTM elevation and satellite imagery, created in ArcGlobe™

Both models were incorporated into the Well Query program for visualization and to demonstrate the 3D visualization capability of GIS.

## 5.0 Conclusion

GIS adds more functionality to Database Management Systems. It incorporates the element of visualization to managing, analyzing, and interpreting data. Certain advances or improvements, however, need to be made in the field of 3D modeling, especially with linear features. The ArcGIS package, in particular lacks the functionality of directly creating 3D lines from “XYZ” coordinates, and there is limited availability of “out-of-the-box” utilities that allow such operation to be carried out.

Further improvements could also be incorporated in the developed query tool. Other well-related data could be included in the database, such as well chemistry and other physical data. The scope of the interface could also be broadened to include other PNOC-EDC geothermal project sites, such that it becomes an integrated interface for managing and accessing the corporate inventory of geothermal wells.

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