King Fahad University of Petroleum and Minerals

City and Regional Planning Department

CRP 514: Introduction to GIS

Term 122

(GIS in Oil Exploration)

By

Mohammed Elhibir Mohammed

ID # g201206180

Course Instructor

Dr. Baqer Al-Ramadan

May. 18, 2013

1-Abstract:

GIS is a powerful tool has been more common by Oil Companies which would enable each operating company to implement and build GIS applications around a common user interface and functional model.

Exploration departments are having Multidisciplinary teams, looking for discovering more Petroleum resources and to be successful at the competition in the oil industry.

The primary uses for GIS technology within Exploration are in providing users with simple access to corporate attribute data via a uniform map-based interface, thereby enabling them to carry out data quality control, spatial analysis, and mapping.

GIS is used to evaluate the best promising areas and its potential.

Analysis of satellite imagery, surface geology studies, digital aerial photomosaic, seismic surveys, subsurface geology, well location, cross section interpretation and images, and existing infrastructures information.

GIS can be used to overlay, display, manipulate, and analyze the data and determine its potential.

GIS technology is used to the daily needs of objects in petroleum industry such as wells, facilities, pipelines, leases, environmental concerns.

These papers illustrate how the implementation of GIS, in combination with the development of homogenous corporate databases, is leading to an Improvement in data quality, in wider use of common datasets, and better decision-making.

The primary objective of this development was the provision of a low cost alternative to photogrammetric mapping in support of seismic acquisition surveys and it helps in seismic line design, processing and seismic interpretation. (Barbara. S, et al 2011)

2-Literature review:

GIS applications are being more common in oil exploration such as

A- Saudi Arabian Company (Aramco):

GIS is used in Saudi Aramco for more than decade to address the challenges in oil industry.

These data also contains data on reserves, surface topography, seismic surveys, well locations satellite & aerial imagery, and existing infrastructure information and the ability to manage all these data. (Imtiaz et al, 2005)

B-PETRONAS: Oil and Gas exploration in Ethiopia.

Integrated geological maps had been developed using various data types such as topographical map, Digital Elevation Model, lithology, strike and dips, folds and faults, satellite images, cultural data, leads and prospects map to identify the best prospect to find oil and gas. (Zukhairi, et al 2008)

C-Shell: Global rollout, integration of all kinds of data, 3D designing, On Demand access**.**

D-ExxonMobil: Mapping Geological marker, Data integration, Service station location.

E-Chevron: Pipeline manager.

F-BP (British Petroleum): workflow management, pipeline routing, 3D design.

G-Petrobras: Transnational pipeline, new construction.

H-Elpaso: Continental infrastructures, pipeline surveillances, data modeling.

These case studies are from OMAN by PDO Company and from Gulf of Mexico by Mobil oil, Philips and Shell Companies.

These papers deal with different categories such as well data and representing these well as

1-point features and separate these well according to the Type of well (oil, gas or water), Total depth, drilled depth, drilling year, drilling company, type of hydrocarbon gas or oil, producing formation, cumulative production, well classification.

2-Line feature includes Seismic 2D-3D surveys, political borders, pipeline, concession area, and well trajectory (horizontal or vertical)

3-Polygon features includes prospects and leads identification, Oil and Gas accumulations, producing fields, and seismic interpretation.

3-Introduction:

There are many definitions of GIS, but one which is commonly used is: “a system for capturing, storing, checking, manipulating, analysing and displaying data which are spatially referenced to the Earth.” (Maguire et al., 1991).

The GIS would enable each operating company to implement and build GIS applications around a common user interface and functional model.

GIS is more importantly an integrating technology. The integration of information generated by Specialist processing software stored in a corporate database results in a map showing the location of licenses, prospects, wells, seismic surveys and reservoir interpretations.

Where a GIS differs from other digital mapping applications is in the need for structured topological data (point, line, and polygon) for any map layers where spatial analysis is required.

Most industrial GIS handle both vector and raster data and provide tools to carry out analysis using either. Remote sensing image data is an example of raster data, dealing with a discrete space having units as squares or pixels, and data values assigned to each pixel representing spectral reflectance.

The primary uses for GIS technology within Exploration are in providing users with simple access to corporate attribute data via a uniform map-based interface, thereby enabling them to carry out data quality control, spatial analysis, and mapping. (Richard , 2010)

This paper discusses the implementation approaches; various techniques used, and describe the benefits of GIS to the oil business.

The paper will also illustrate how the implementation of GIS is leading to an improvement in data quality, in wider use of common datasets, and better decision-making.

4-Populating the GIS:

The first step in implementing GIS was to start defining and populating the map layers, which were organized into logical themes, There were 13 themes: Topography, Wells, Seismic, Fields, Geology, Oilfield Infrastructure, Exploration Prospects, Safety Environment, Administrative Boundaries, Geophysics, Production, Images and Map Indexes.

Providing the user with the visualization of data in a map-based view, significant data improvements and the data became shared amongst a large number of users provided an incentive for the data owner to ensure data quality.

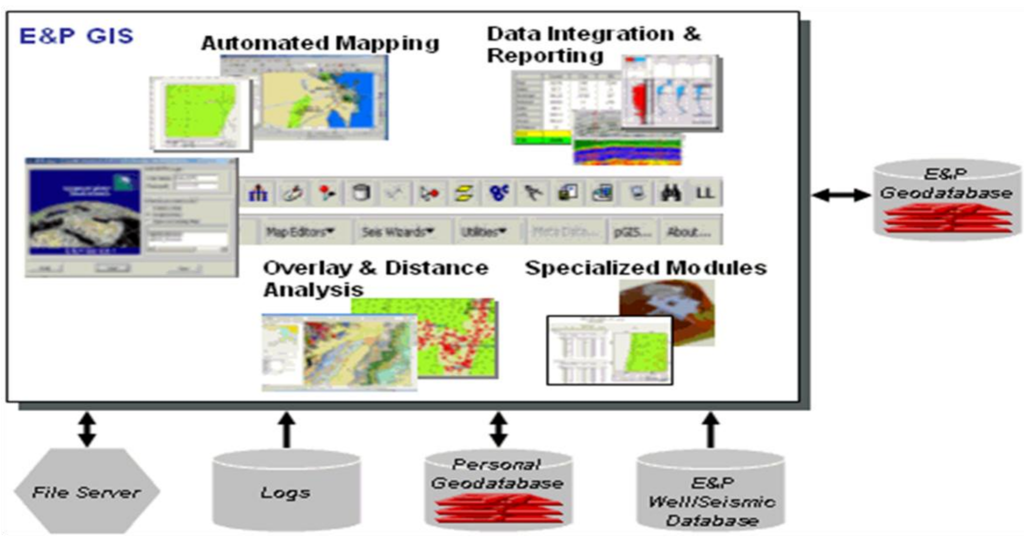

Figure (1) Populating the Geographical Information System

The use of company-wide common keys (tags) is essential (for example standard seismic line names or well names).

5-APPLICATIONS AND TOOLS DEVELOPED:

Initially development of GIS applications concentrated on 3 data types: prospects, wells and seismic, of which by far the main benefits have been realized from management and clean-up of the prospect portfolio using the GIS and a Shell Group Oracle database. The application allows the external attributed data to be fully integrated into the GIS so that it appears as part of one homogeneous system

6-Gulf of Oman case study:

Location of the study area figure (2) (Kevin et al, 2003)

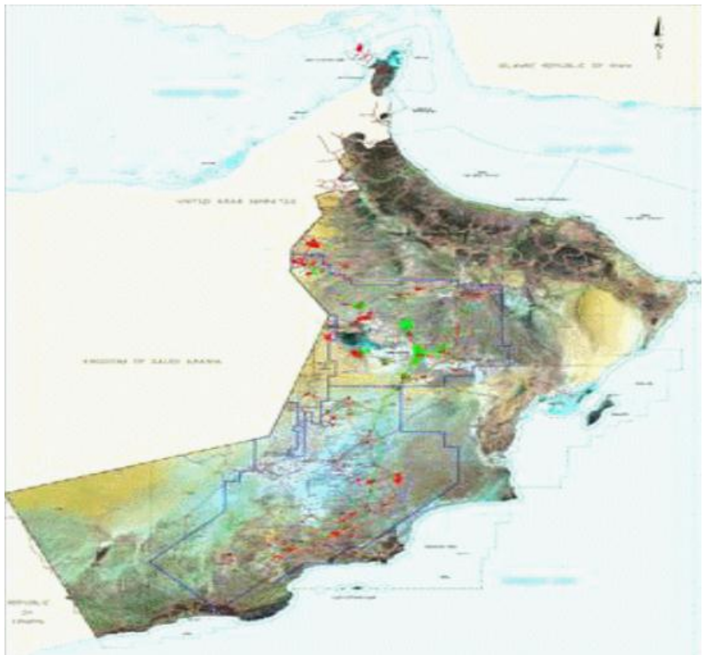

Figure (2) PDO concession area

7-Prospects:

Prospects have been imported in two ways:

(1) As point features linked directly to tables within SPACE/DB providing general attributes as well as volumes and risks.

(2) As polygon features layered according to prospect type and stratigraphic objective. Figures (3, 4) Other GIS layers were provided to support the application, such as geological features Figure (5), play domains, team and 'prospect champion' boundaries, as well as wells and seismic. A simple spatial query, for example, would select all seismic lines intersecting the prospect and report these to the user, perhaps for checking that all lines were available to an interpretation project. Figure (6, 7)

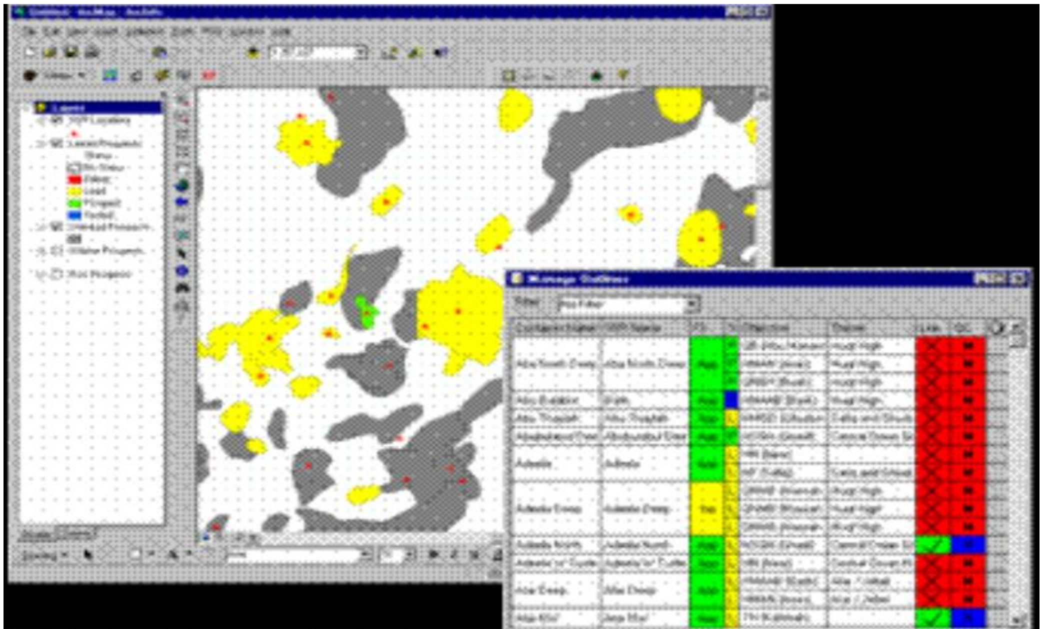

Figure 8: Filter tool within prospect module.

Figure (3) Define leads and prospects

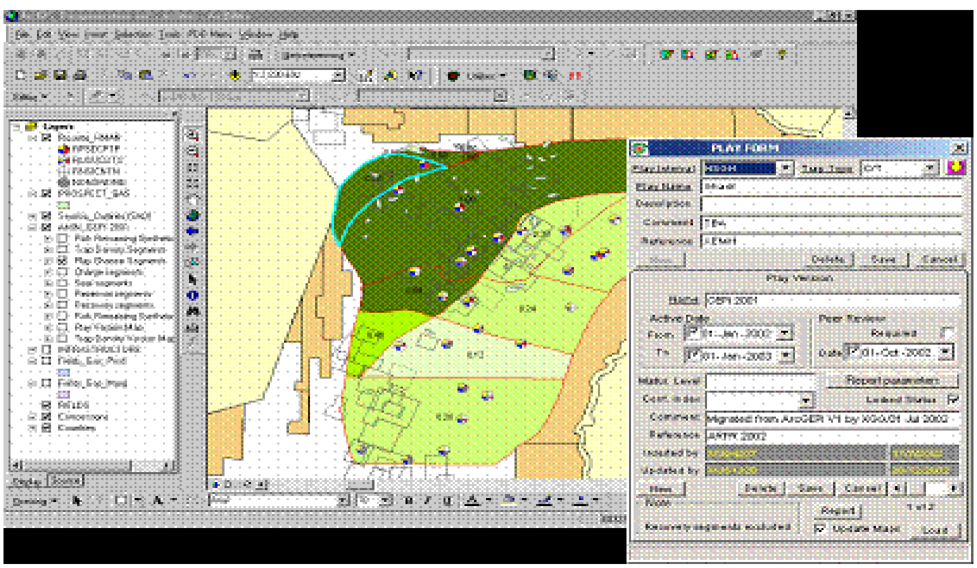

Figure (4) Play Analysis System within ArcGIS.

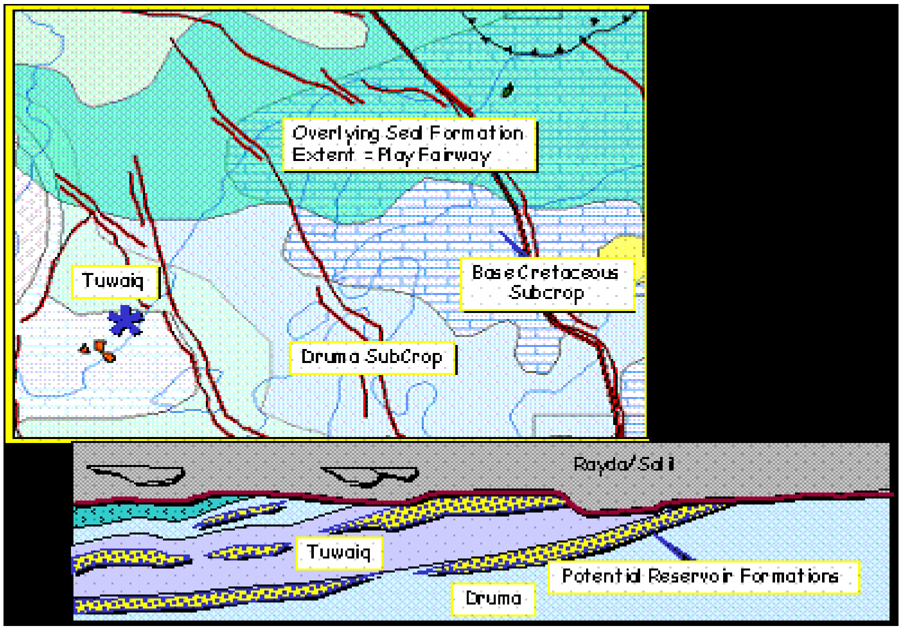

Figure (5) Play Fairway Mapping. Cross section illustrates formation structure.

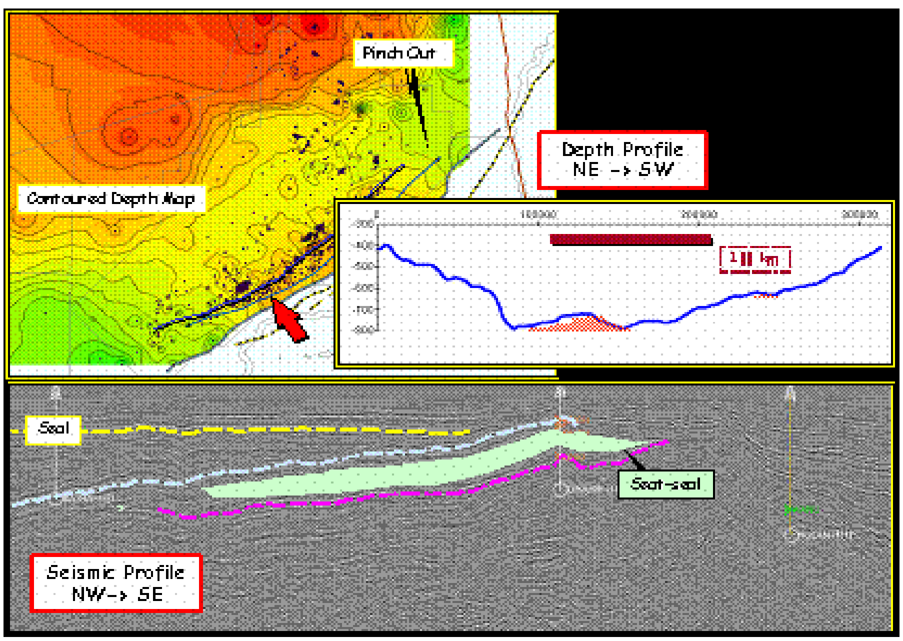

Figure (6) Mapping and analysis of trapping configurations.

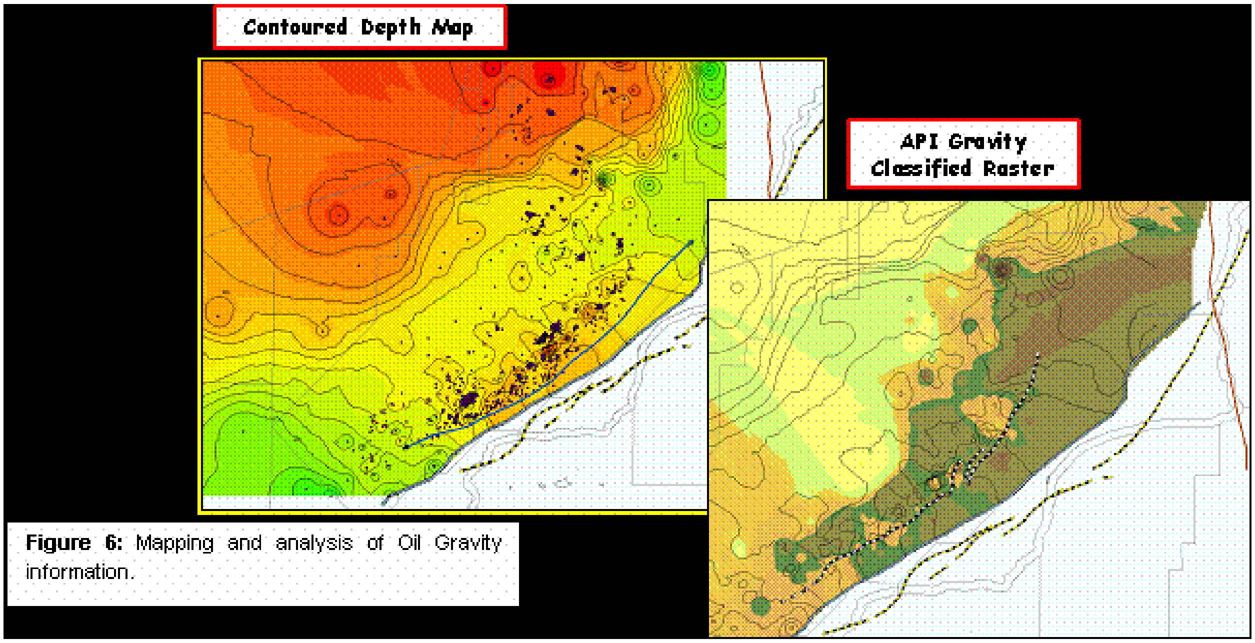

Figure (7) mapping and analysis of oil gravity information

8-Wells:

Wells were imported as point feature maps in different layers according to well type (exploration, development, water, etc.) linked to a corporate well database. In addition a 2-D vector map of well trajectories was provided, which when combined with surface infrastructure layers, can be used for well planning purposes (Figure 8).

The means to query, select and report wells according to subsurface horizons penetrated allows the user to locate well attributes according to horizons of interest. Also, tools are provided to export well tops and travel times in a format suitable for import to gridding/contouring systems. Attribute data available linked to GIS layers includes lithostratigraphy, well tops, biozones, biostratigraphy, sidewall samples, and cores.

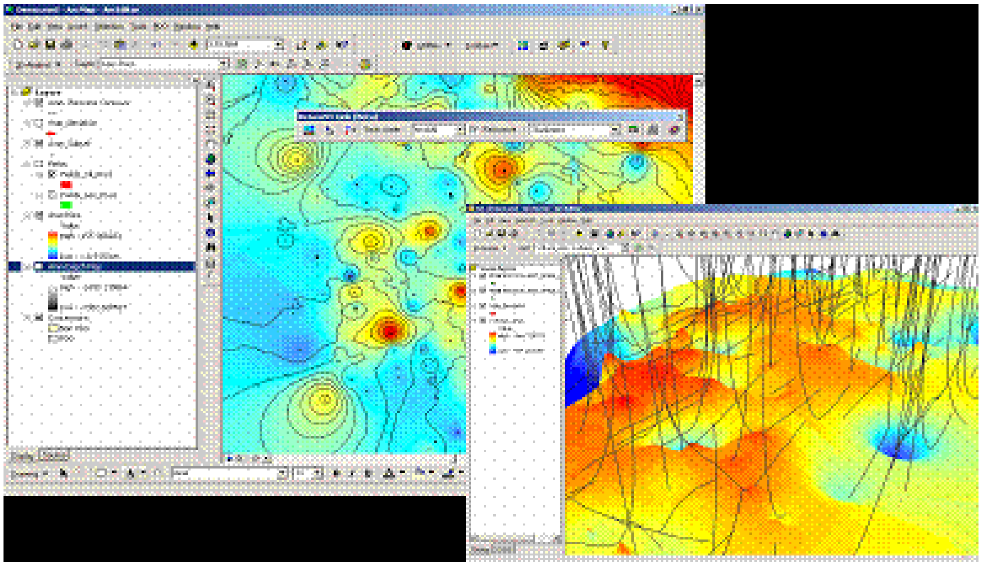

Figure (8) Well Database Module (ArcMap) and a 3D view of well track combined with stratigraphic depth map.

9-Seismic:

Seismic layers provided include 2-D seismic and 3-D survey outlines linked to a database and providing access to historical seismic survey coordinate data and attributes. A future enhancement is a link to a corporate seismic interpretation database allowing users to call up and display archived interpretations (including 3-D visualisation) and to export these into TIS projects (Figure 9).

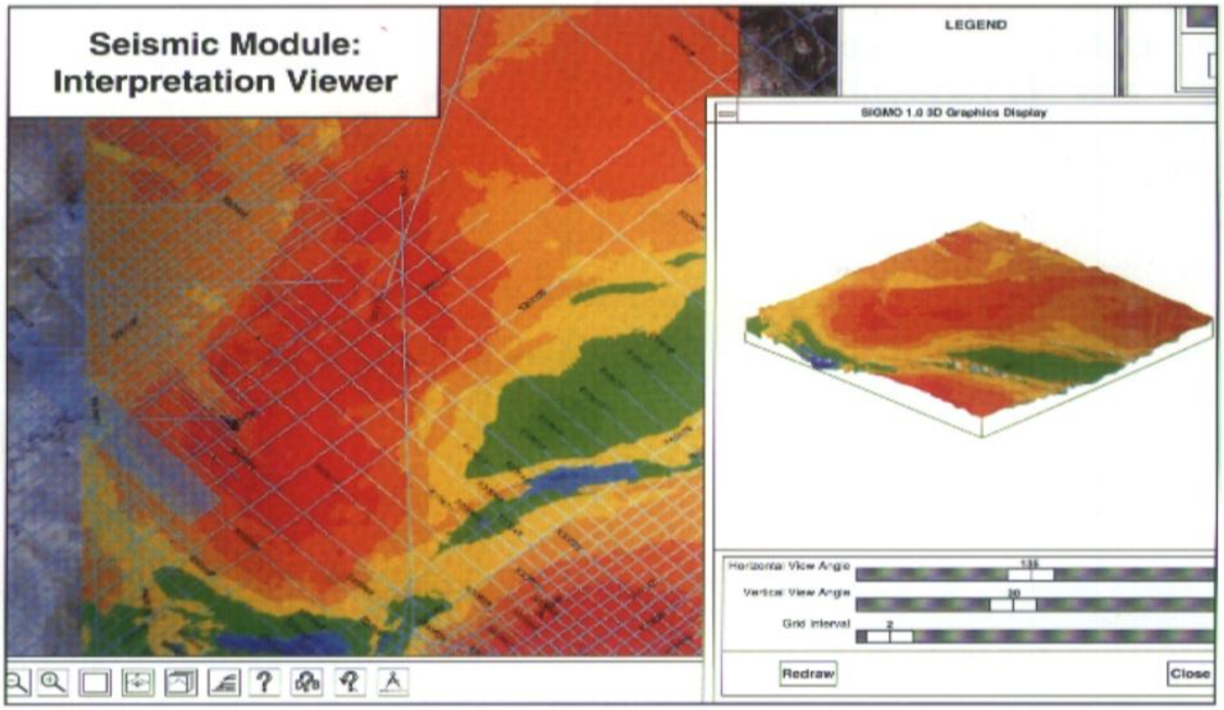

Figure (9) GIS seismic module showing a subsurface mapped horizon with 3-D graphics display

In addition a seismic planning application was built, providing users with map layers showing current and future 2-D and 3-D survey areas linked to attributes such as survey date, crew, acquisition method etc. (Figure 10).

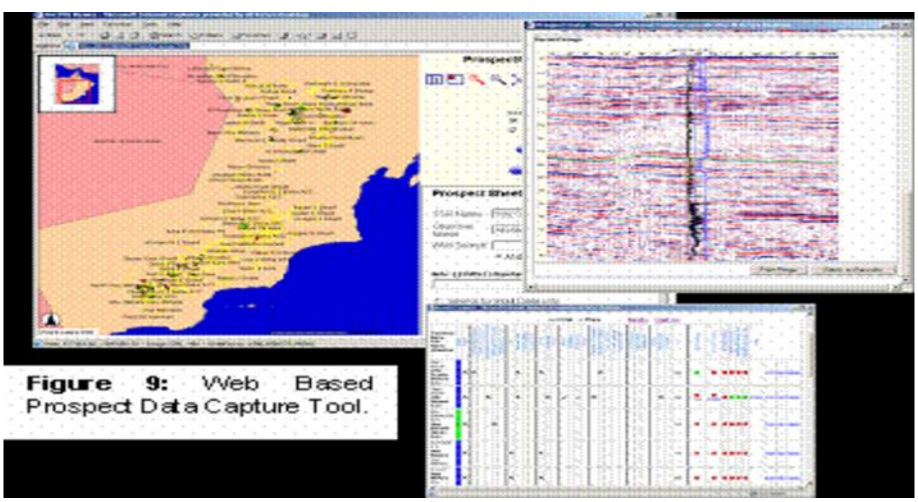

Figure (10) Web base prospect data capture tool

Other layers available to support seismic planning include military areas, topography and survey

Control stations, which are used as the basis for establishing local survey height and position control.

Managers can investigate cost benefits and set programme priorities by extracting summed prospectivity within the seismic prospect areas.

10-Gulf of Mexico case study:

The second case study was established in Gulf of Mexico by Different Petroleum Company such as Shell, Exxon Mobil, and Philips. (Barrell, K. A., 2000)

Well data: was interpreted as a point feature as figure (10, 1)

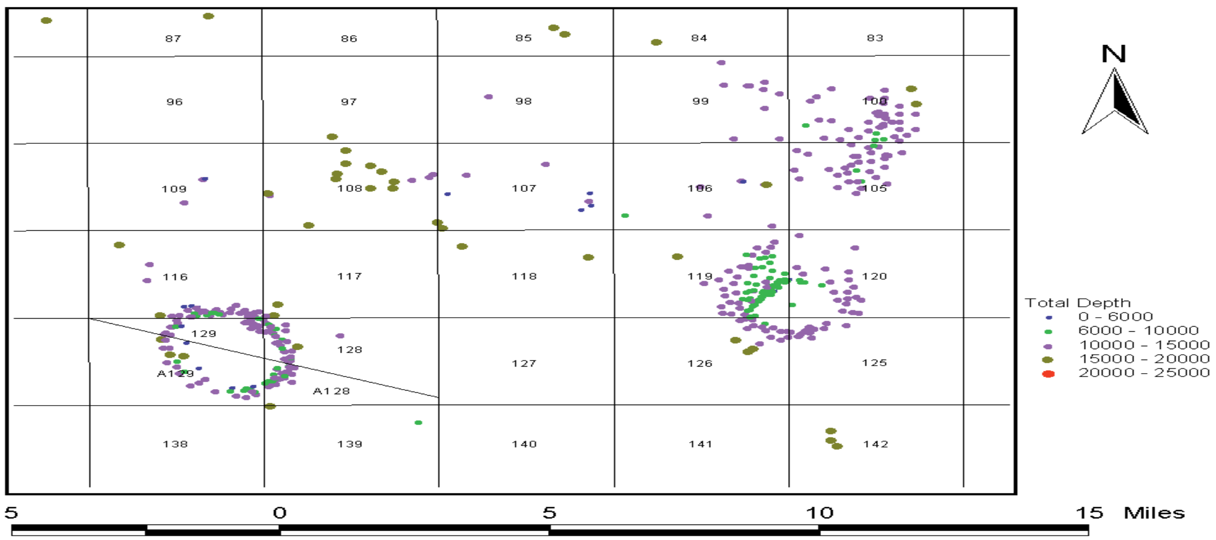

Figure (10, 1) Sorting Wells according to the Total Depth

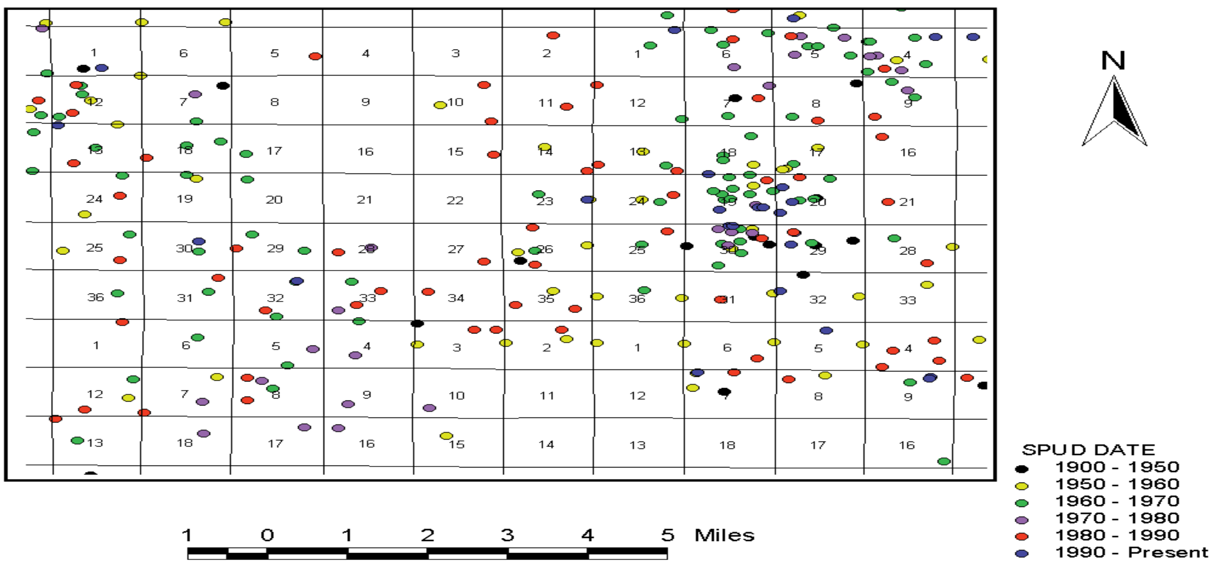

Figure (10, 2) Sorting Well according to the Spud Date

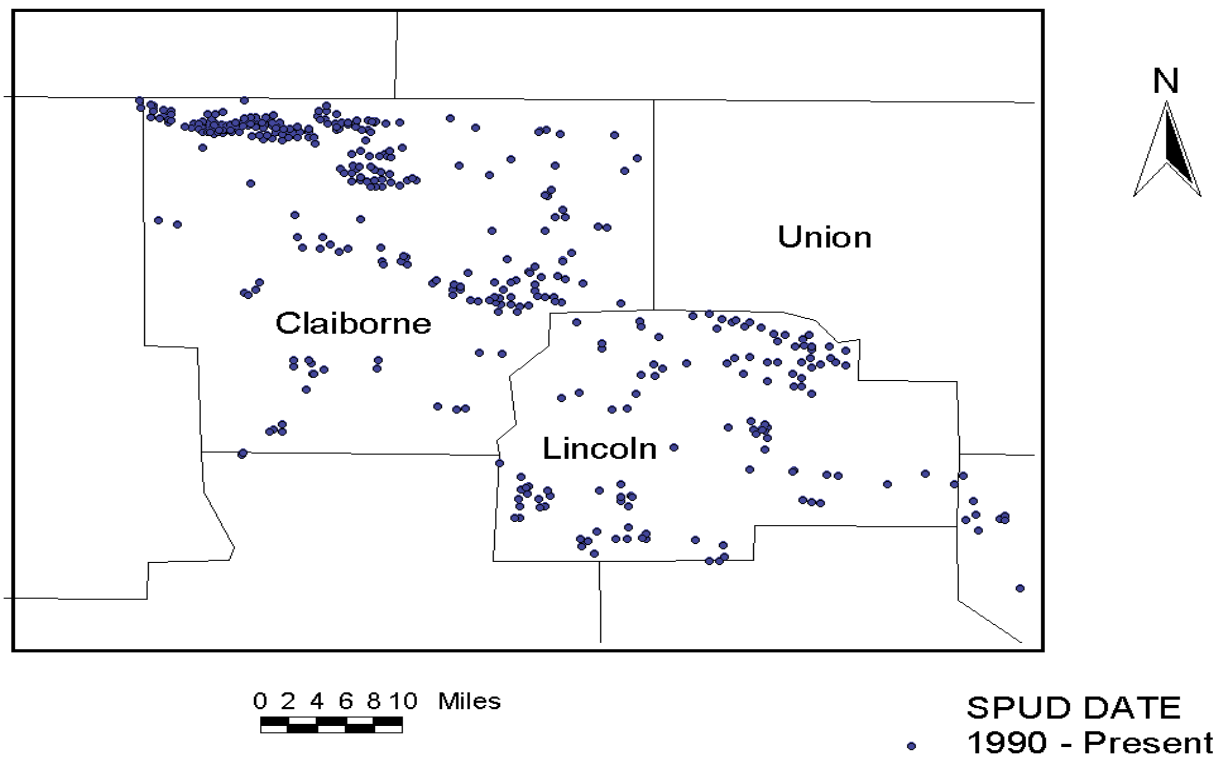

Figure (10, 3) Sorting Well according to the Spud Date from 1990 to present

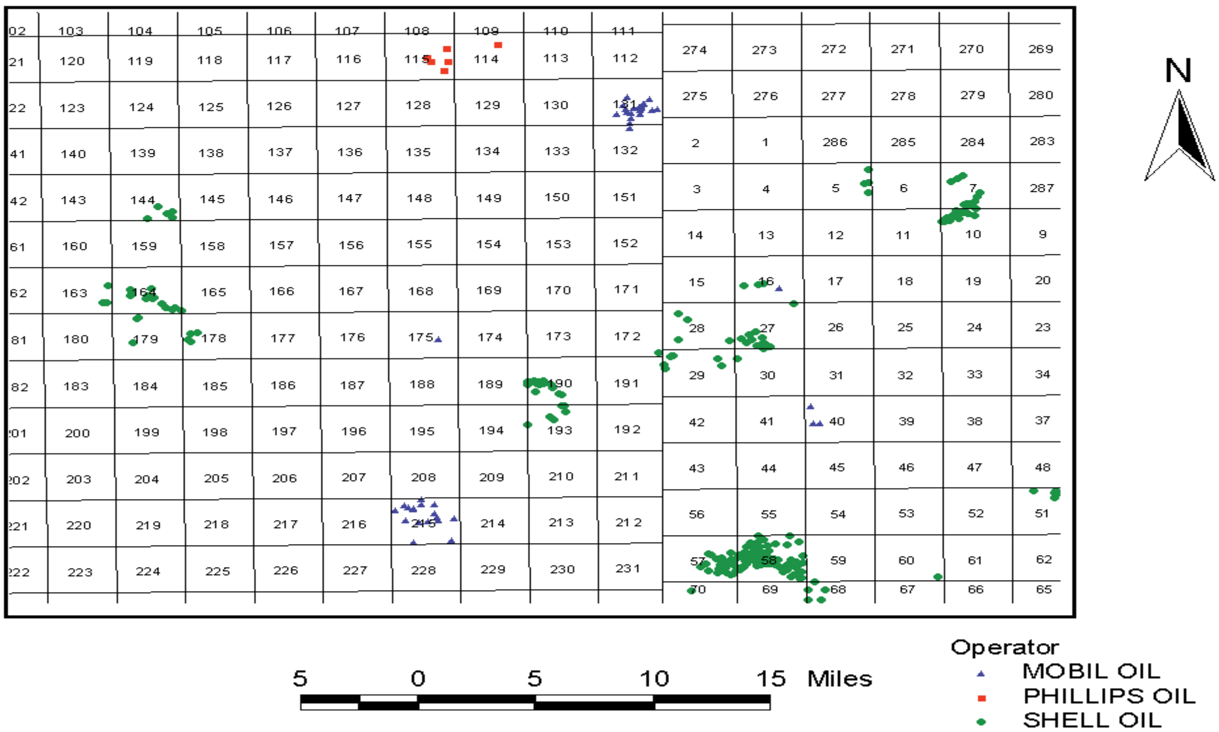

Figure (10, 4) Sorting Well according to the Operating Company

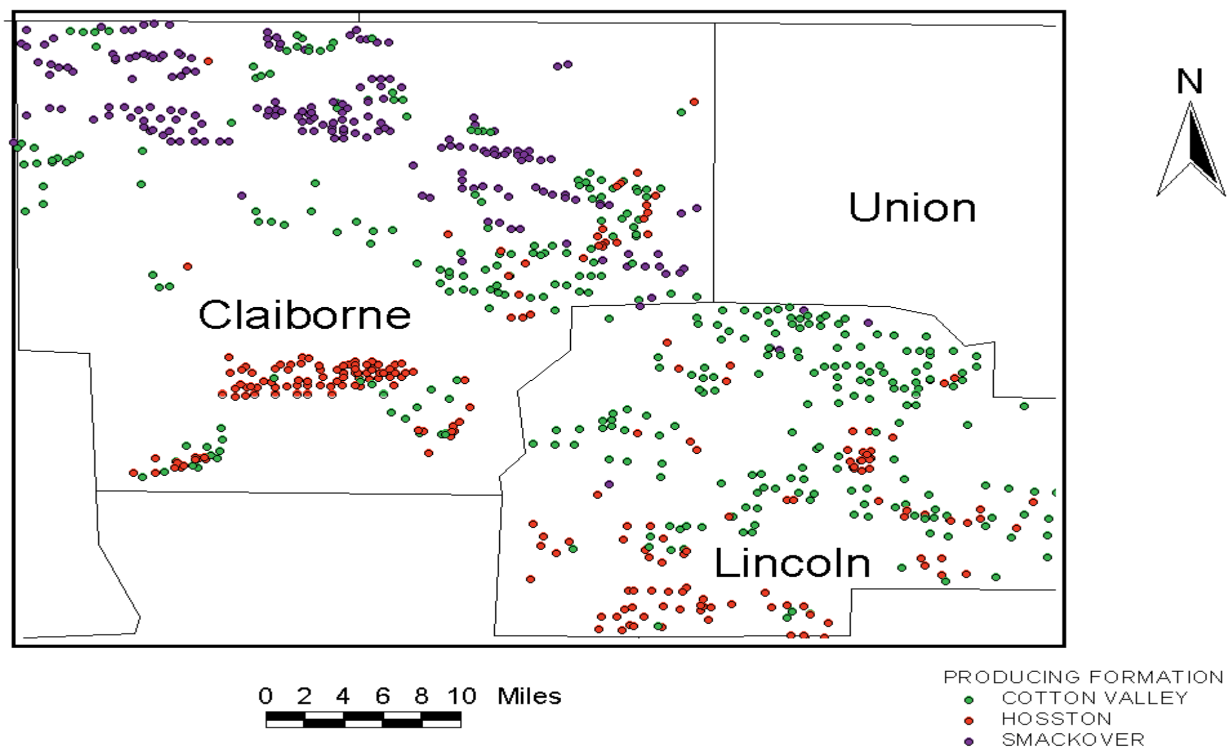

Figure (10, 5) Sorting Wells according to the Producing Formations

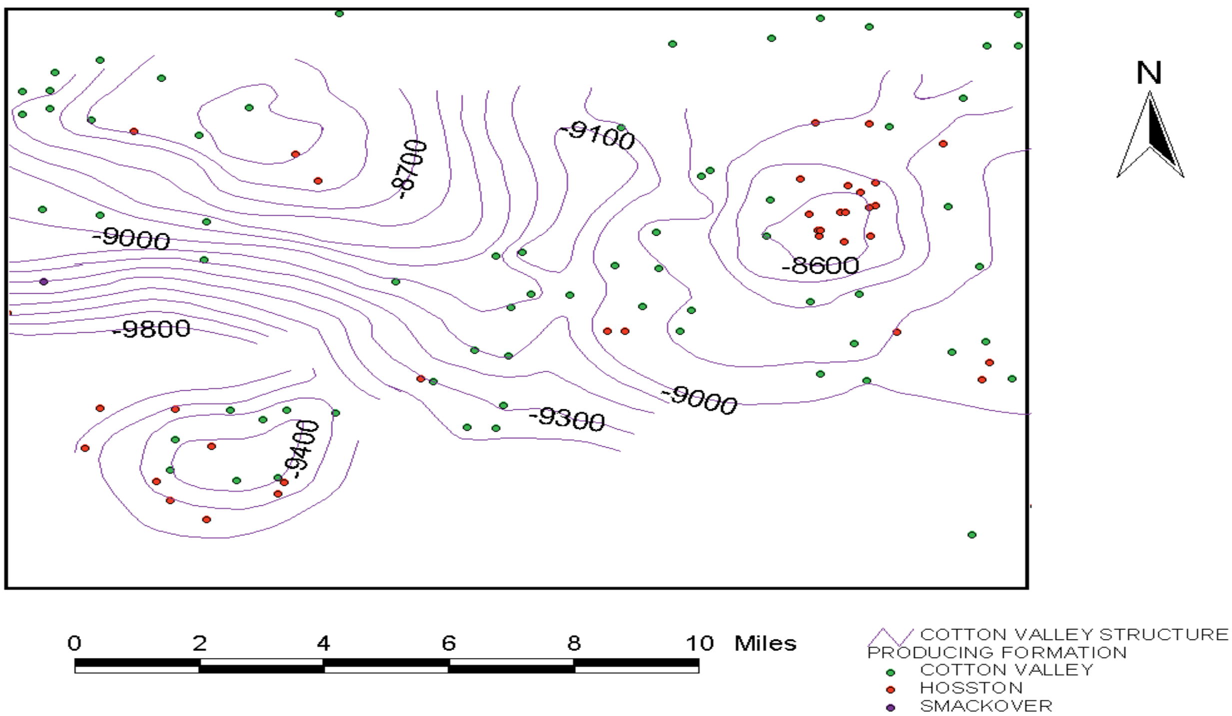

Figure (10, 6) Contouring lines of the Producing formations

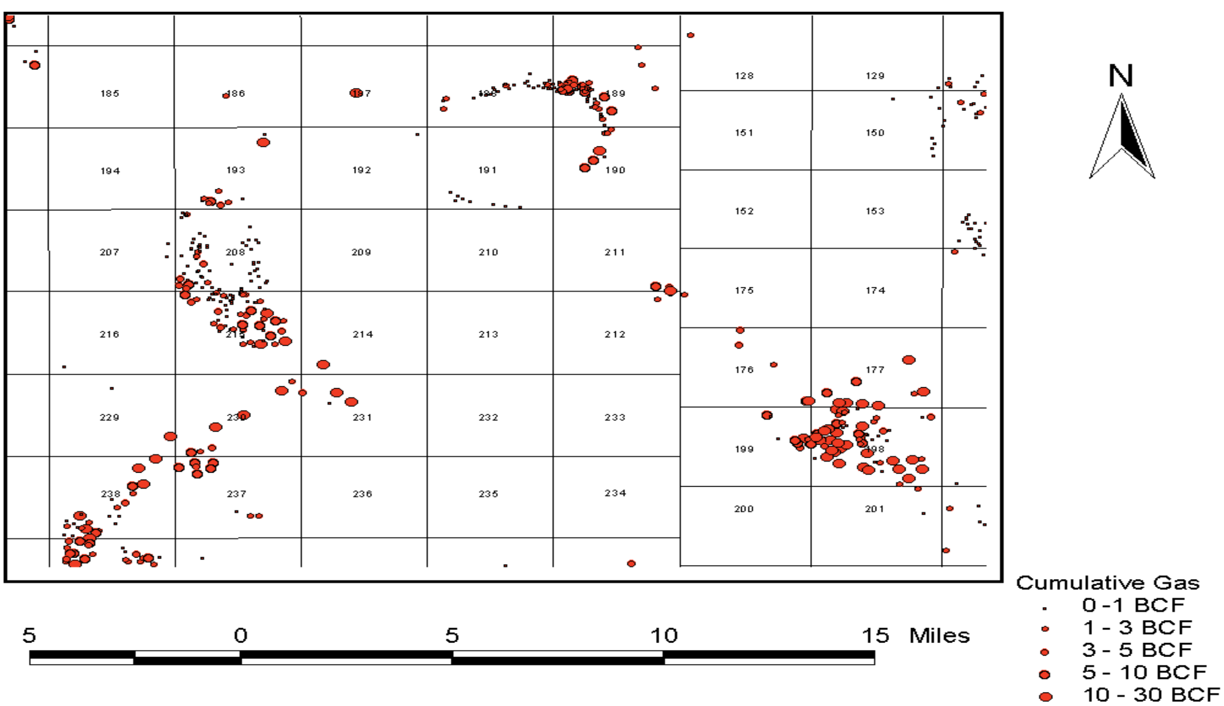

Figure (10, 7) The Gas production in the fields

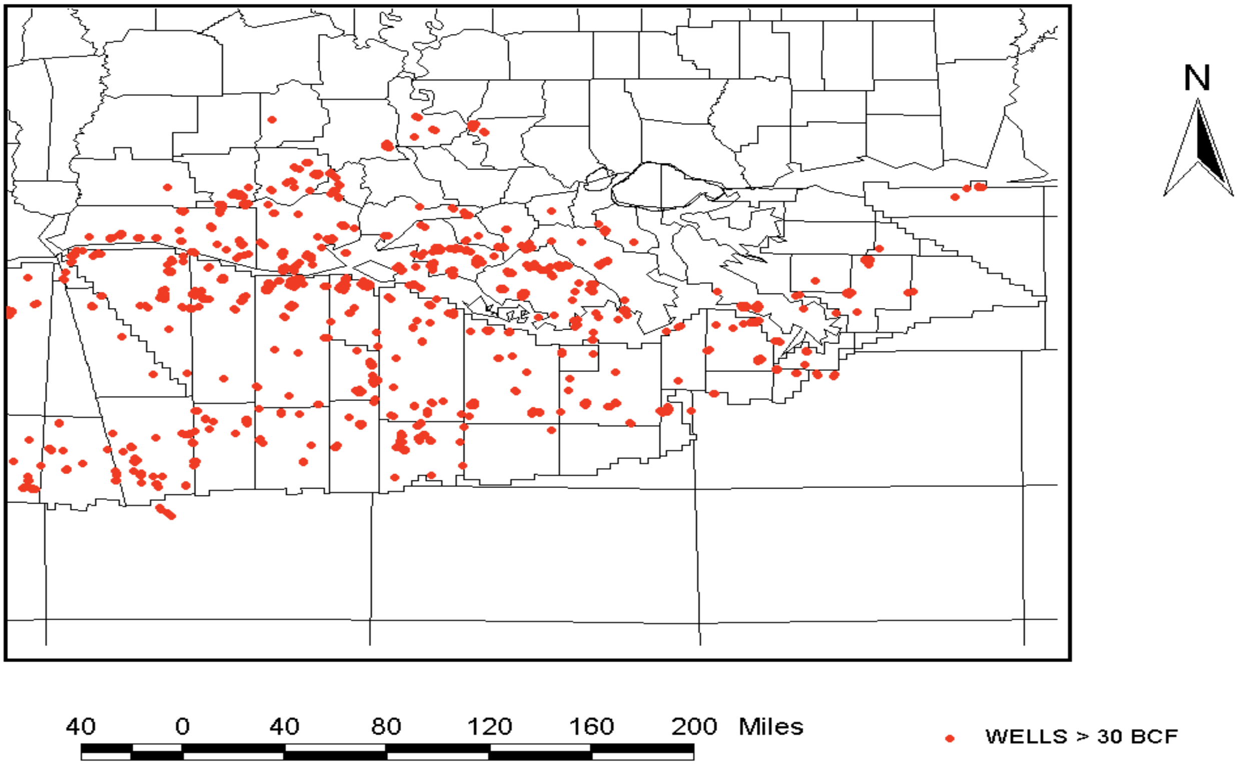

Figure (10, 8) Sorting Fields with >30 BCF production

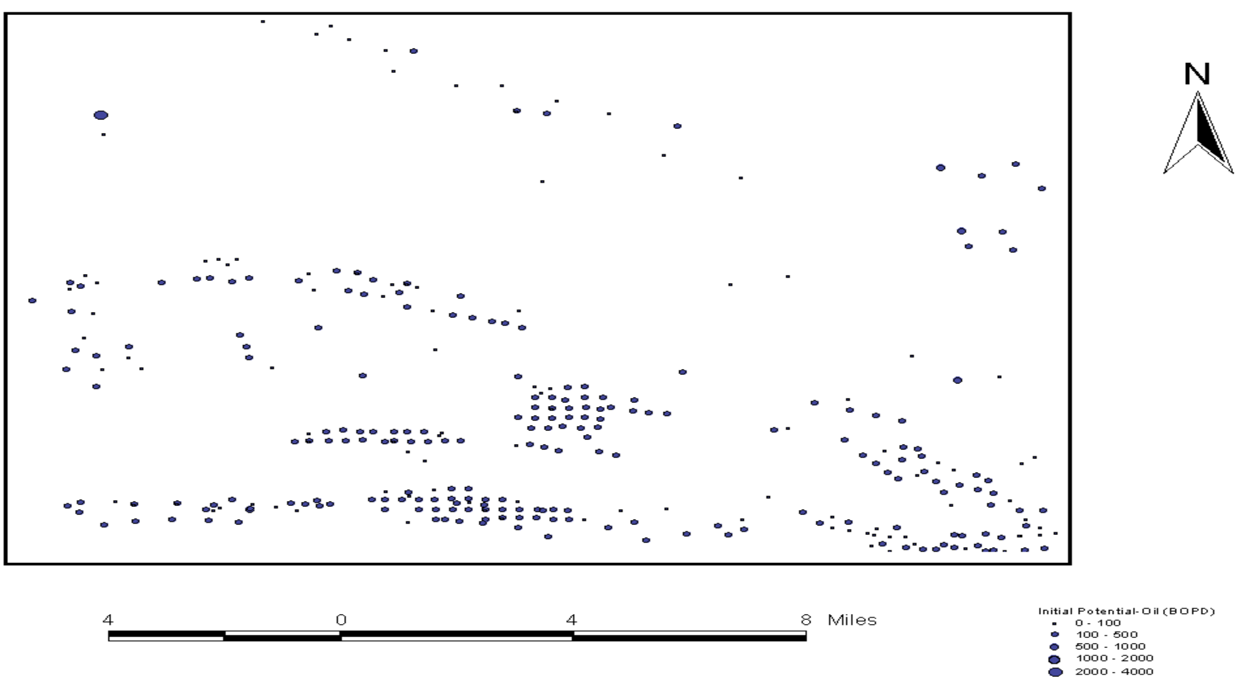

Figure (10, 9) Sorting wells with the Oil production

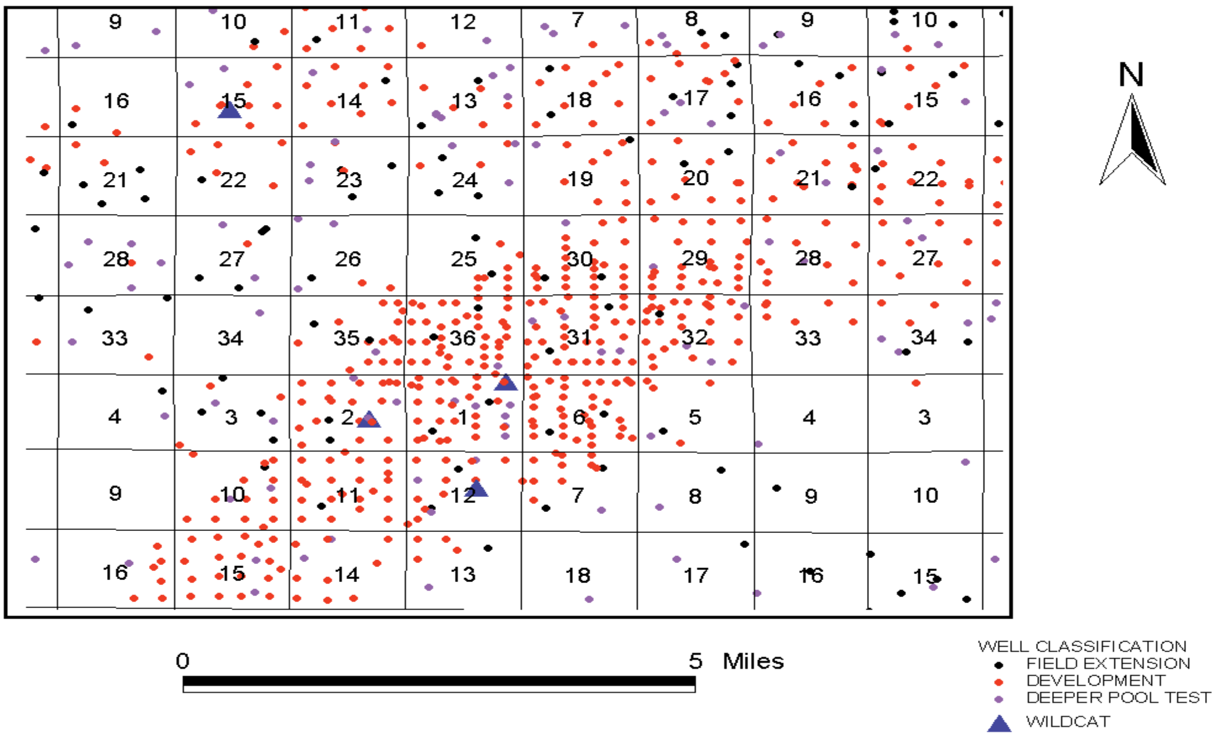

Figure (10, 10) Sorting Wells according to the Drilling purposes

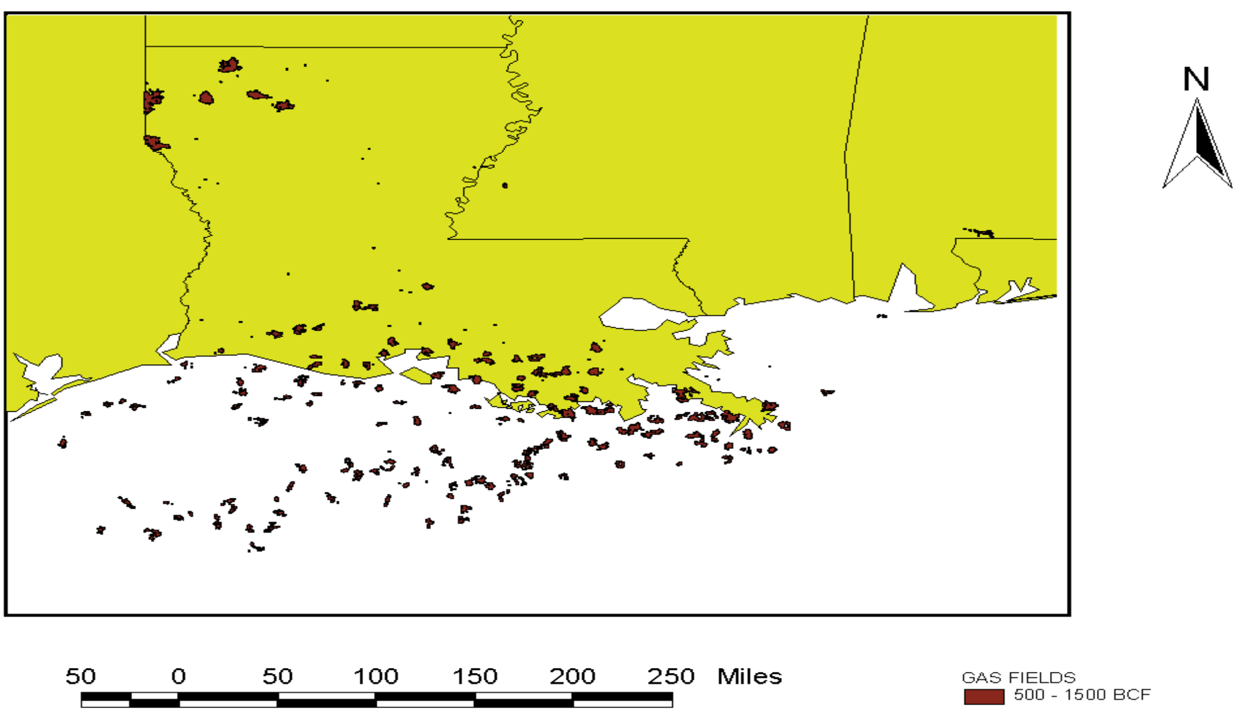

Figure (10, 11) Gas Fields with production between 500-1500 BCF

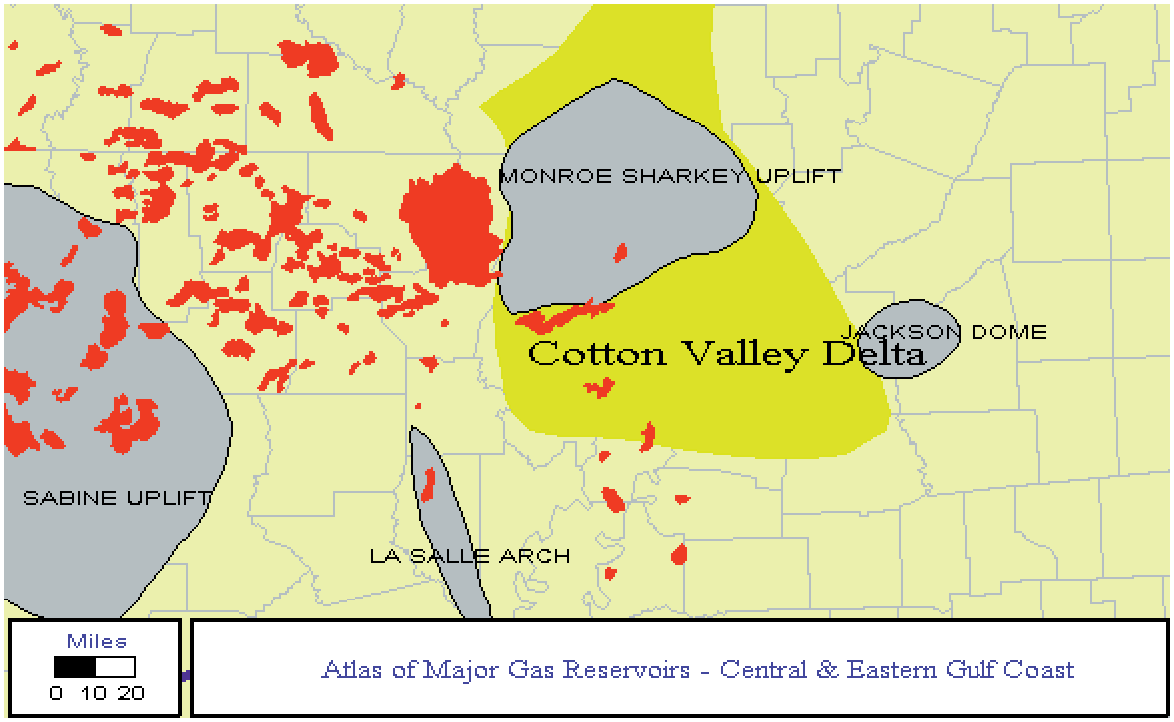

Figure (10, 12) Major Gas Reservoirs

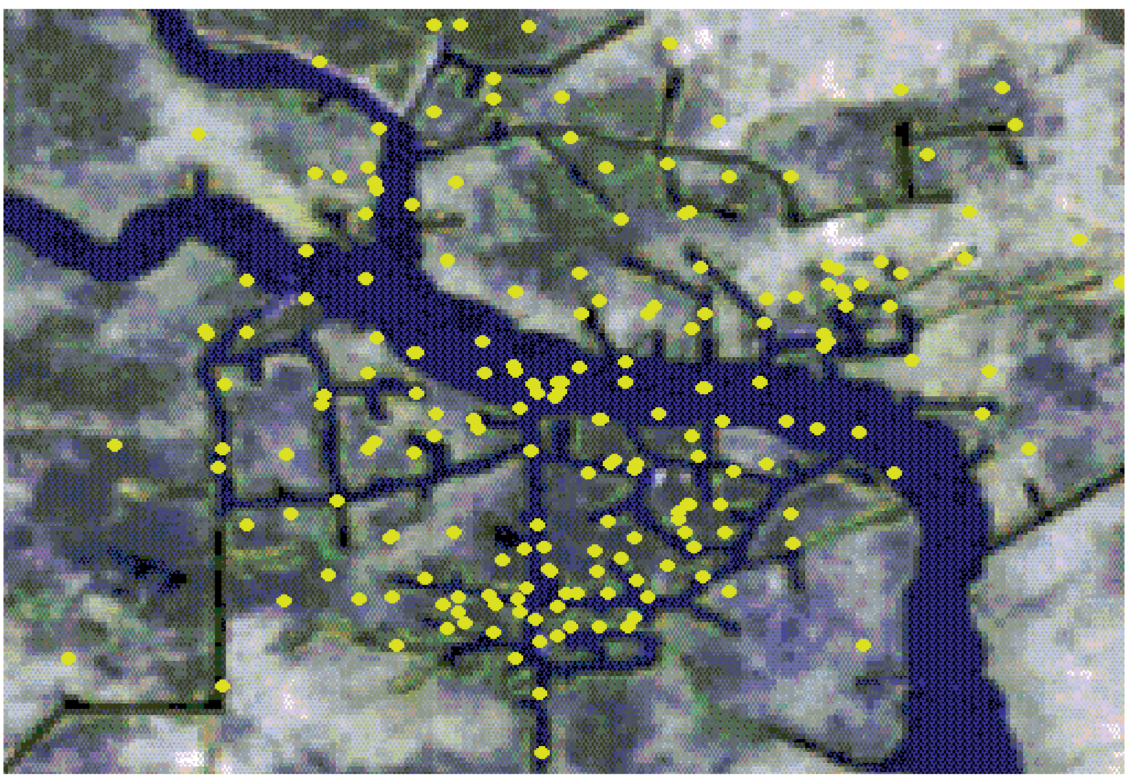

Figure (10, 13) LandSat image of Southern Louisiana base map and superimposed wells

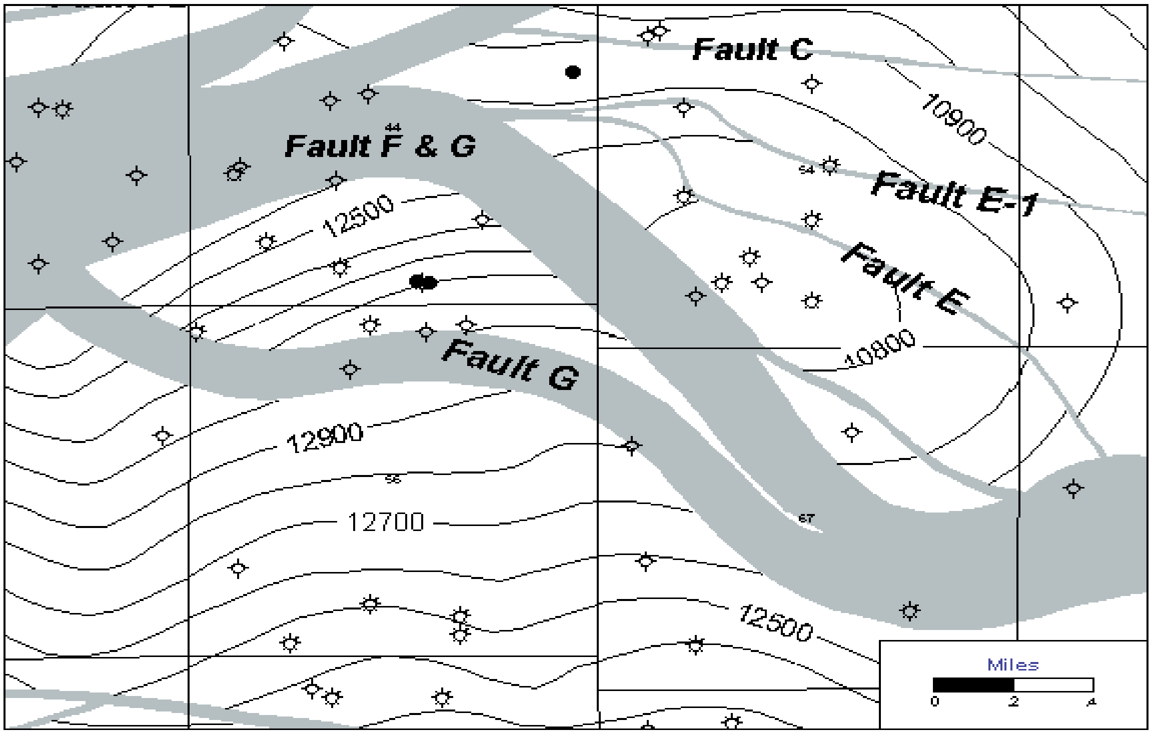

Figure (10, 14) Oligocene Camerina Sand structure map in Southern Louisiana

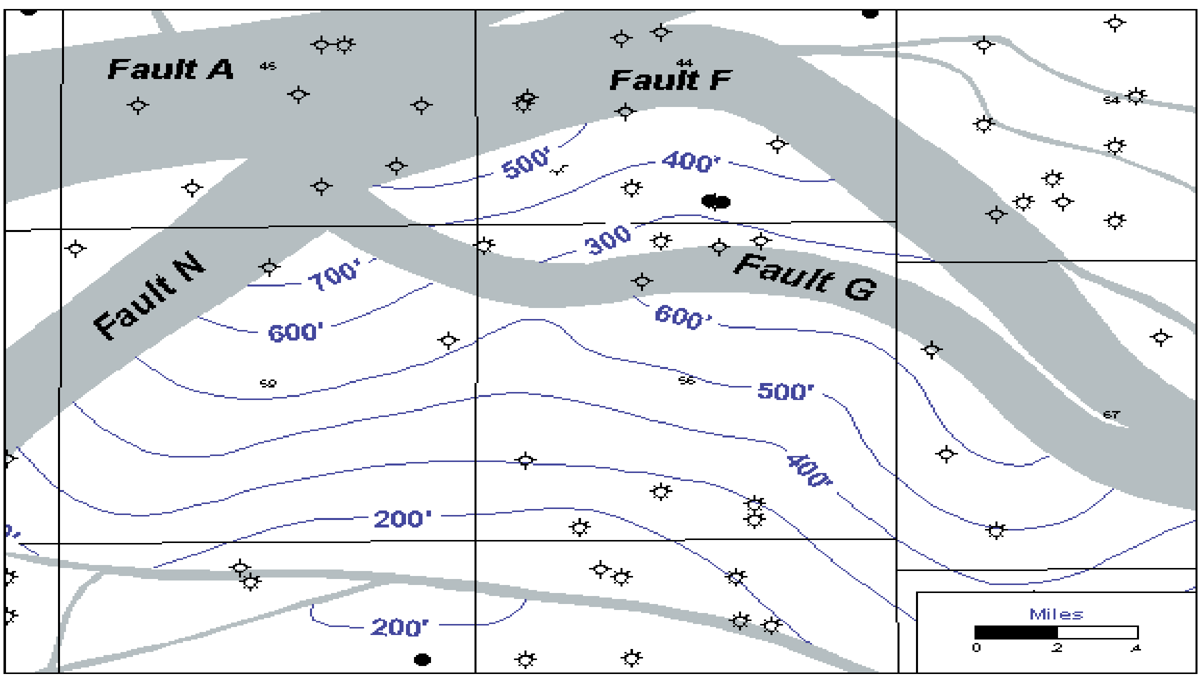

Figure (10, 15) Oligocene Camerina sand, isopach map southern Louisiana

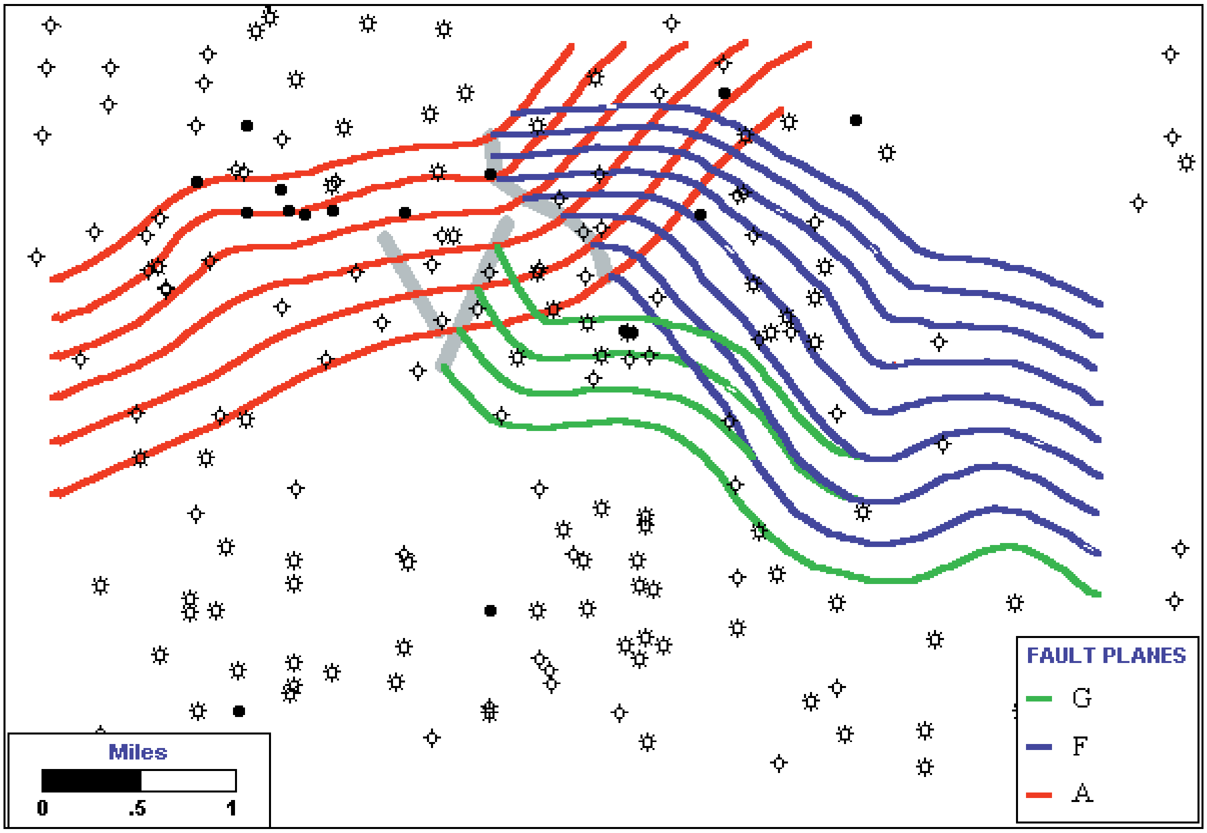

Figure (10, 16) Map of fault planes classified by fault name of Southern Louisiana

11. INTERFACES WITH OTHER MAP-BASED APPLICATIONS

The current role of GIS amongst these applications is to provide user-friendly means for all Explorationists to visualize their data on their desktop, make spatial or attribute-based selections, do simple spatial analysis, make working maps, and report results or export data to other applications for further analysis. Final, cartographic quality maps remain in the domain of the drawing office using its Map Management and the challenge for data managers is to ensure the availability, currency and efficient maintenance of data in the two environments (GIS and Micro station).

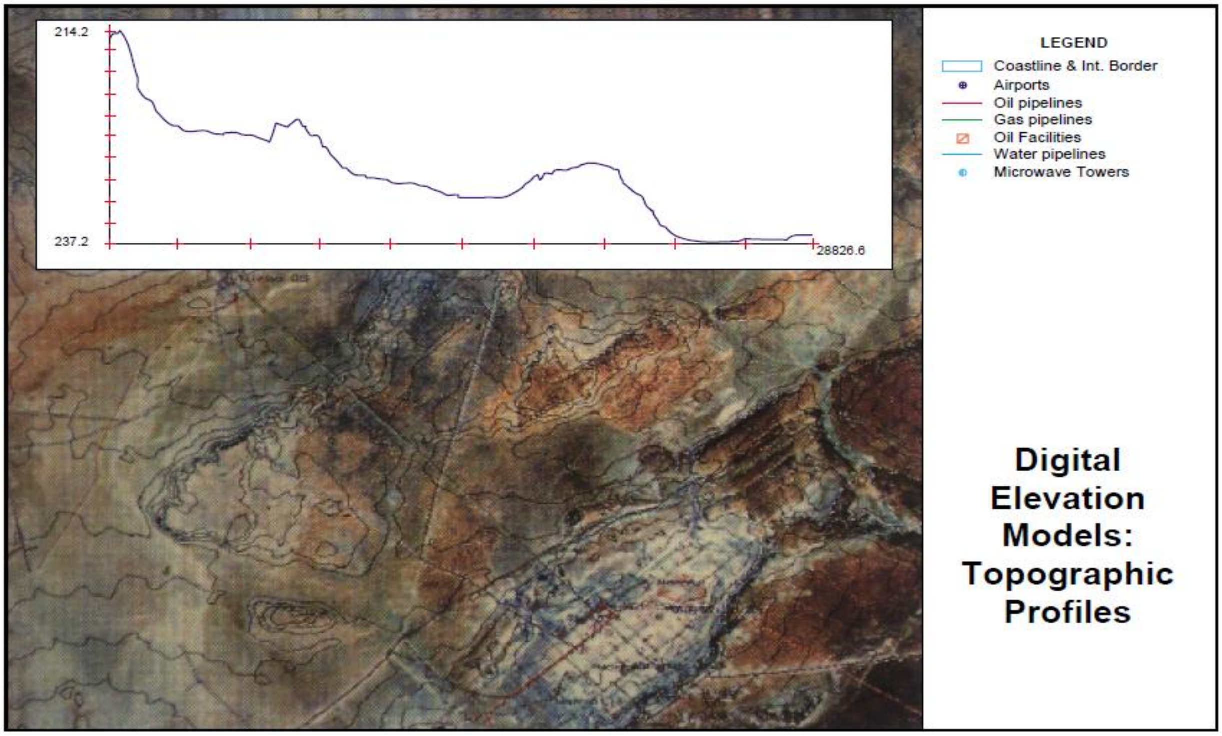

Figure (11) GIS raster data, Landsat TM image overlain with contoured DTM and interpolated topographic profile

12. BENEFITS AND SOME EXAMPLES

To date GIS has been used to support a wide variety of applications and already some significant benefits have been realized. Whilst it has made some routine jobs easier and therefore saved interpreters and technical assistants' valuable time.

Its main benefits however are in the areas of:

- Data visualization through a common user-friendly map interface,

- User friendly access to corporate data (data sharing) in a straightforward, reliable and timely way,

- investigating data relationships through the spatial component,

- improving data quality,

- enforcing data management and standards

- integrate with specialist software systems.

It has played a major role in cleaning up the prospect inventory and supporting management in preparing and optimising the exploration drilling programme.

Interpreters also report major time savings (days/per project) in locating well and seismic data.

13. New applications are frequently arising, for example:

GIS is used extensively to support decision-making in analyzing prospectively, investment history (wells, seismic, infrastructure) within target relinquishment.

- Extracting road distances and drive times for the road network to support new journey management safety imitative.

- Reporting sensitivities for new well locations or seismic prospects.

- Prepare elevation profiles using an underlying digital terrain model.

GIS technology is still rather immature and requires specialist expertise to operate, develop and maintain.

14. CONCLUSIONS AND FUTURE DEVELOPMENTS

The successful implementation of GIS technology has provided users with access to valuable core information via a uniform map based interface. Visualization of various exploration data such as wells, seismic and prospects, in a map-based view led to significant improvements to the spatial definition of these data, and has led to the enforcement of data standards.

GIS is seen as a significant aid to efficient management of prospect portfolios and optimization of drilling programs.

The evolution of GIS will continue in the short and medium term, in order to satisfy both new exploration requirements and to develop new applications. (Richard W., 2011)

The development of new applications in support of non-exploration activities are expected to include pipeline and flow line facility management, general asset management, and emergency response.

15-Acknowledgement:

First of all thanks for God help that allowed me to conclude this term paper. Thanks and gratitude to my instructor Dr. Baqer AL Ramadan for his guidance, supervision, unlimited help through the course of Introduction to GIS. I also would like to express my thanks to my colleagues and KFUPM.

References:

Barbara S., Esri W., 2011. Subsurface Modeling of Directional Well Bores at Fidelity Exploration & Production Company. ESRI conference Fall, 2011.

Barrell, K. A., 2000. GIS: The exploration and exploitation tool, in T. C. Coburn and J. M. Yarus, eds., Geographic information systems in petroleum exploration and development: AAPG Computer Applications in Geology, No. 4, p. 237–248.

Imtiaz A, Dimitris K, Wessam H., Hamad M. Well Placement Optimization Using GIS, 2005. 25th Annual ESRI International User Conference (San Diego).

Kevin M., Roland M, Safia M., 2003. ArcGIS in the Oil and Gas Exploration Workflow. 23rd Annual ESRI International User Conference. (San Diego, July 2003)

Maguire D.J., M.F. Goodchild and D.W. Rhind 1991. Geographical Information Systems. Volumes 1 and 2. Longman Scientific and Technical, Essex, UK. Vol. 1, 530 p. Vol. 2, 326 p.

Naylor, M.A. and Spring, L.Y. 2001. Exploration Strategy Development and Performance Management: a Portfolio-based Approach. GeoArabia, v. 6, no. 4.

Richard W., 2011. Inventory Directed by Congress Assesses Restrictions to Oil and Gas Exploration: ESRI 2009, 2010.

Zukhairi M, Ruszaidi B., 2008. Oil and Gas Exploration in Ethiopia using GIS.

And some other references from ESRI (GIS for Petroleum, ESRI. February, 2007)