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TITLE: PREPARATION OF NORTHERN MID-CONTINENT PETROLEUM ATLAS

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FOREWORD

ABSTRACT

Report covers the third year of the Digital Petroleum Atlas (DPA) Project. The DPA is a long-term effort to develop a new methodology for efficient and timely access to the latest petroleum data and technology for the domestic oil and gas industry, research organizations and local governmental units. The DPA is a new approach to generating and publishing petroleum reservoir, field, play and basin studies. Atlas products are available anywhere in the world using a standard point-and-click world-wide-web interface (http://www.kgs.ukans.edu/DPA/dpaHome.html). In order to provide efficient transfer of the technology for client-defined solutions, all information and technology in the DPA can be accessed, manipulated and downloaded. The DPA design provides a dynamic product that is constantly evolving through new information structures, the latest research results, and incorporation of additional data. The user has complete and flexible access to both the interpretative products and the underlying reservoir and well data. The DPA has significantly altered the relationship between research results, data access, the transfer of technology, and our relationship with our clients.

The third year of the project concentrated on development of integration of relational databases into the DPA.   The result is that previously completed products, such as field and basin studies, are automatically updated with the latest production and well data. Linking to relational databases also permits efficient construction of larger scale studies.

Over the last year content of the DPA has increased with two additional field studies (Chase-Silica and McKinney fields), comprehensive regional maps on all major oil and gas producing horizons and several new county scale maps.

The DPA Project continues to provide improved access to a "published" product and ongoing technology transfer activity. The DPA remains widely used by oil and gas producers and other groups interested in natural resources.

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EXECUTIVE SUMMARY

The Digital Petroleum Atlas (DPA) Project is in the third year of a long-term effort to develop a new methodology to provide efficient and timely access to the latest petroleum data and technology for the domestic oil and gas industry, public sector research organizations and local governmental units. The DPA provides real-time access through the Internet using widely available tools such as World-Wide-Web browsers. The latest technologies and information are "published" electronically when individual project components are completed removing the lag and expense of transferring technology using traditional paper publication. Active links, graphical user interfaces and database search mechanisms of the DPA provide a product with which the operator can interact in ways that are impossible in the paper publication. Contained in the DPA are forms of publication that can only be displayed in an electronic environment (for example, relational searches based on geologic and engineering criteria). Improvement in data and technology access for the domestic petroleum industry represents one of the best and cost-effective options that is available for mitigating the continued decline in domestic production.

Year 3 of the project concentrated on improved integration of relational databases that permit automatic updating of all DPA products (e.g., latest production and well data for field studies). Pages containing production data are generated through query of the most currently available data. In this aspect the DPA is a constantly and automatically updated product that will remain current well beyond the duration of the project.

Additional fields have been added to the DPA, including Chase-Silica. Chase-Silica is an older field in Rice, Barton and Stanford counties, producing primarily from the Arbuckle. This field is a first attempt at using online relational databases to both construct maps and provide access to data from an extremely large field (> 5,000 wells). McKinney Field (Chester, Marmaton, and Morrow) in Meade County was also added to the DPA. Field studies generated in previous years of the project remain, and have been enhanced with updated data and additional maps. These fields include Arroyo Field (Morrowan), Stanton County; Big Bow Field (St. Louis), Grant and Stanton counties; and Gentzler Field (Morrowan), Stevens County; Amazon Ditch and Terry fields (Lansing-Kansas City, Mississippian and Morrowan), Finney County; and Schaben Field (Mississippian) Ness County. Eight counties now contain detailed maps on multiple horizons. Regional maps at the statewide scale cover all the major oil and gas producing intervals. Methodologies developed in year three of the DPA Project provide improved access to a continuously "published" product and ongoing technology transfer activity.

Usage statistics and unsolicited feedback show that oil and gas producers are using the DPA on a regular basis to develop prospects, evaluate properties and provide regional background to ongoing and potential projects. In addition, public sector agencies, such as the Kansas Corporation Commission, use the data and results available in the Digital Petroleum Atlas.

INTRODUCTION

THE NEED FOR A DIGITAL PETROLEUM ATLAS

The United States obtained 85 percent of its energy from fossil fuels in 1995, nearly 40 percent from oil alone (of which half was imported), and 24 percent from natural gas (President's Committee of Advisors on Science and Technology, 1997). U.S. fossil fuel dependence, like that of the rest of the world, will decline only slowly in the future. It has been estimated that fossil fuels will provide two-thirds of all world energy needs in 2030 and half or more in 2100 (EIA, 1997). U.S. oil imports, according to the "reference" forecast of the Department of Energy, would grow from 9 million barrels per day in 1995 to 14 million barrels per day in 2015 and continue to increase for some time thereafter. The Digital Petroleum Atlas program addresses many of the issues of insuring a secure U.S. oil and gas supply as outlined by the report of the President's Committee of Advisors on Science and Technology (1997).

The US and the Northern Mid-continent have large remaining oil and particularly gas resources in numerous reservoirs. A higher percentage of original oil and gas in place can be produced if old and new data and knowledge are made available to operators. Basic data and innovative developments in technology need to be directly accessible to assist operators in day-to-day decisions. The Kansas Geological Survey continues to work with the U. S. Department of Energy and oil and gas producers to create a Digital Petroleum Atlas (DPA) to meet these information needs. The DPA is unique in that it provides independent operators on-line digital and hard copy information, digital data bases, new cutting-edge scientific study of typical fields of the region and purposeful technology transfer. The atlas also provides to independent operators an evaluation of the technologies that are best suited for additional oil and gas recovery. Information is available when and where operators need it (literally on the operator's desk).

During the past few years, the United States economy has performed beyond most expectations. A shrinking budget deficit, low interest rates, a stable macroeconomic environment, expanding international trade with fewer barriers, and effective private sector management are all credited with playing a role in this healthy economic performance. Many observers believe advances in information technology (IT), driven by the growth of the Internet, have also contributed to creating this healthier-than-expected economy. In recent testimony to Congress, Federal Reserve Board Chairman Alan Greenspan noted, "...our nation has been experiencing a higher growth rate of productivity—output per hour—worked in recent years. The dramatic improvements in computing power and communication and information technology appear to have been a major force behind this beneficial trend." The Digital Petroleum Atlas is one attempt to bring these advances in information technology to the independent oil and gas operator.

The DPA will provide a tool to enhance Kansas oil and gas production. The demonstration of the digital petroleum atlas will also enable similar projects to be instituted in other petroleum producing areas, so that a geographically broad on-line digital database will be available to domestic operators. The ultimate goal is a national digital petroleum atlas.

Short of conducting a full-scale reservoir analysis of each producing field, an efficient and effective method of communicating key information to operators is by example. For each reservoir type in a producing region, a thoroughly studied and documented analog can illustrate geologic and engineering procedures that are likely to be most successful in increasing ultimate recovery. An analog example provides operators with sufficient information

and procedures to study producing fields, and increase production and ultimate recovery by modifying and applying proven methods. One way to accomplish the goal of disseminating information by analog is to provide a digital on-line geological and engineering based, state-of-the-art, petroleum atlas that contains not only historical data and descriptions, but technologically advanced syntheses and analyses of "why reservoirs produce" and "how ultimate production may be increased." This is a national need. A digital petroleum atlas is an efficient and effective vehicle to provide access to legacy databases and innovative knowledge that can be used by the operator.

The traditional role of technical publication is to formalize and record scientific and technical results in time, and to transfer technology to potential users (Kerkhof, 1994). The published petroleum atlas is a time-honored approach to illustrating by analog the latest petroleum exploration and development knowledge and application (e.g., Powers, 1929; Galloway, et al., 1983; Bebout, et al., 1993,). Similar proprietary compilations are common at major petroleum companies. The underlying goals of these petroleum atlases have been to:

- Synthesize information on major reservoirs, fields, plays and basins;
- Assist in efficient exploration and development by increasing technical knowledge of trapping, discovery and production of oil and gas;
- Serve as analogs for reservoirs, fields and plays similar to those described; and
- Provide an overview and introduction to the various petroleum basins described.

The traditional published atlas is a time consuming and expensive process that results in static paper product. Typically, products and data are limited by space and cost considerations to summary information at the field or reservoir level. For each play, field or reservoir only a relatively small number of author-selected maps, cross-sections, charts and other summary data are included. Typically, the paper atlas does not provide access to well and lease data or to intermediate research products (such as digital geographic and geologic components of maps, interpreted and uninterpreted subsurface data, well test analyses, thin section images, and other traditionally unpublished material). Without access to the data and intermediate products, modifying and updating a published field study to fit a user-defined application or new scientific idea is a difficult and time consuming process.

Today, traditional channels of scientific and technical communication represented by the petroleum atlas are being challenged by the shear volume of publication, the increased unit costs, the relatively decreased resources of academic and industrial library systems, and the rapidity of technical change (Okerson,1992). In addition, the growth of networks, storage servers, printers, and software that make up the Internet are rapidly changing the world from one in which research organizations, publishers and libraries control the printing, distribution, and archiving to a world in which individuals can rapidly and cheaply "publish", provide access and modify scientific results on-line. These changes offer significant challenges and opportunities both to public and private sector participants and to the traditions of technical publication (Denning and Rous, 1995).

KANSAS PETROLEUM ATLAS

The Kansas Digital Petroleum Atlas (DPA) is an on-line publication available on the Internet anywhere in the world using a standard point-and-click world-wide-web interface (Figure 1).

The Uniform resource locator (URL) is http://www.kgs.ukans.edu/DPA/dpaHome.html. The DPA consists of studies at reservoir, field, play and basin scales. The DPA is a dynamic, evolving product with new structure, research results, and data appearing almost daily. Through complete and flexible user access to technology, interpretative products, and underlying geologic and petroleum data, the DPA alters the relationship between interpretative result and data, between technology generation and application. At the present time, the Digital Petroleum Atlas currently contains over 6,000 static web pages covering 8 counties, 7 fields and two regions of Kansas. "Static" pages are actual HTML text files on the DPA web server showing information to visitors. Most of DPA pages are very similar--that is, a template can be made and multiple pages extracted from that template. For example, for a set of county geology pages (Figure 2), the only differences are the names of the files, the window titles, and the two figures (i.e., map and stratigraphic chart). The navigation is adjusted for each page (assigning a "Previous" page and assigning a "Next" page). As a result, a new set of geologic maps, core photos, etc., for a new play or field can be integrated into the DPA efficiently as a new set of static web pages. In addition, web access is provided to programs that can query relational database systems containing production, well and electric log data. The pages cover Kansas's oil and gas plays at scales from the regional through the single well sample. It also consists of a navigational architecture that permits accessing the DPA information by a number of methods.

USAGE OF THE PROTOTYPE DIGITAL PETROLEUM ATLAS

Since the Digital Petroleum Atlas is an electronic publication, on-line access was provided to the public soon after project inception (January 1996). Use of the DPA products was almost immediate and has grown steadily over the last three plus years (Figure 3). This near real-time transfer of technology and information to the client is one advantage clearly demonstrated by the DPA.

The pages that comprise the DPA make up the bulk of the web site for the Petroleum Research Section (PRS) of the Kansas Geological Survey. Usage statistics show that access to these pages has grown to over 50,000 access "hits" per month (Figure 3). In measuring access "hits" on the PRS site, all access to graphics is removed. This eliminates the multiple counting of access hits that result from multiple figures (buttons, bars, arrows, etc.) on a single web page. In addition, all access from the Kansas Geological Survey subdomain (kgs.ukans.edu) is removed. This measurement protocol produces a consistent and conservative measure of external usage. Current usage statistics are collected daily and weekly and are available on the Petroleum Research Section of the Kansas Geological Survey web site (http://www.kgs.ukans.edu/usage/past_stats.html).

Each month a detailed usage report is generated for the oil and gas portion of the Kansas Geological Survey web site. The latest report for April 1999 (http://www.kgs.ukans.edu/usage/1999/apr_wt/default.htm) provides rough quantitative measures for the Digital Petroleum Atlas. In April, the pages of the Digital Petroleum ranked among the most requested pages (Figure 4). Other highly requested pages on the Petroleum Research web server are portals that provide general access to the Digital Petroleum Atlas and other oil and gas information. After the user enters the Digital Petroleum Atlas Home Page or DPA-Kansas Page they split off in any number of directions. The Digital Petroleum Atlas HomePage was also the number 3 most popular entry page and the number 5 most popular exit page. This is interpreted to mean that the DPA is bookmarked and users jump directly to it. The April statistics also show that the Petroleum Research Web Site and the Digital Petroleum Atlas appealed primarily to companies (.com domain with 72.54% of total hits and 3904 separate sessions last month) and networks (.net domain with 20.02% of total hits and 1279 separate). The .net domain is interpreted as representing the very small independent and consultant who uses a local or national Internet access provider. Statistics for April 1999 measure the most accessed directories on the Petroleum Research web server. The DPA is the most accessed directory with over a third of the total hits for the site (Figure 5).

Other measures of the impact of the Kansas Digital Petroleum Atlas are unsolicited comments and success stories received by users. A selection of comments and a success story are provided in Appendix A.

Kansas Home
Searches
Regional Maps
Oil & Gas Plays

Kansas Digital Petroleum Atlas

Links to Kansas Oil and Gas fields analyzed in the DPA.

Map linked to fields and counties Only counties colored in ▮ have been added to the atlas at this time. Clicking on the other counties will take you to annual oil and gas production files (those colored in ▨ include oil and gas field maps). Counties colored in ▨ have had no oil or gas production.

Figure 1. Interactive map of Kansas Digital Petroleum Atlas (DPA) showing counties that contain fields and plays that have been added to the DPA. Regional maps on key horizons are available for all highlighted counties. Counties not added to the DPA have oil and gas field maps and links to annual field production. During year three, county-scale maps were added covering Meade and Rice counties, and access to current production and well data was automated.

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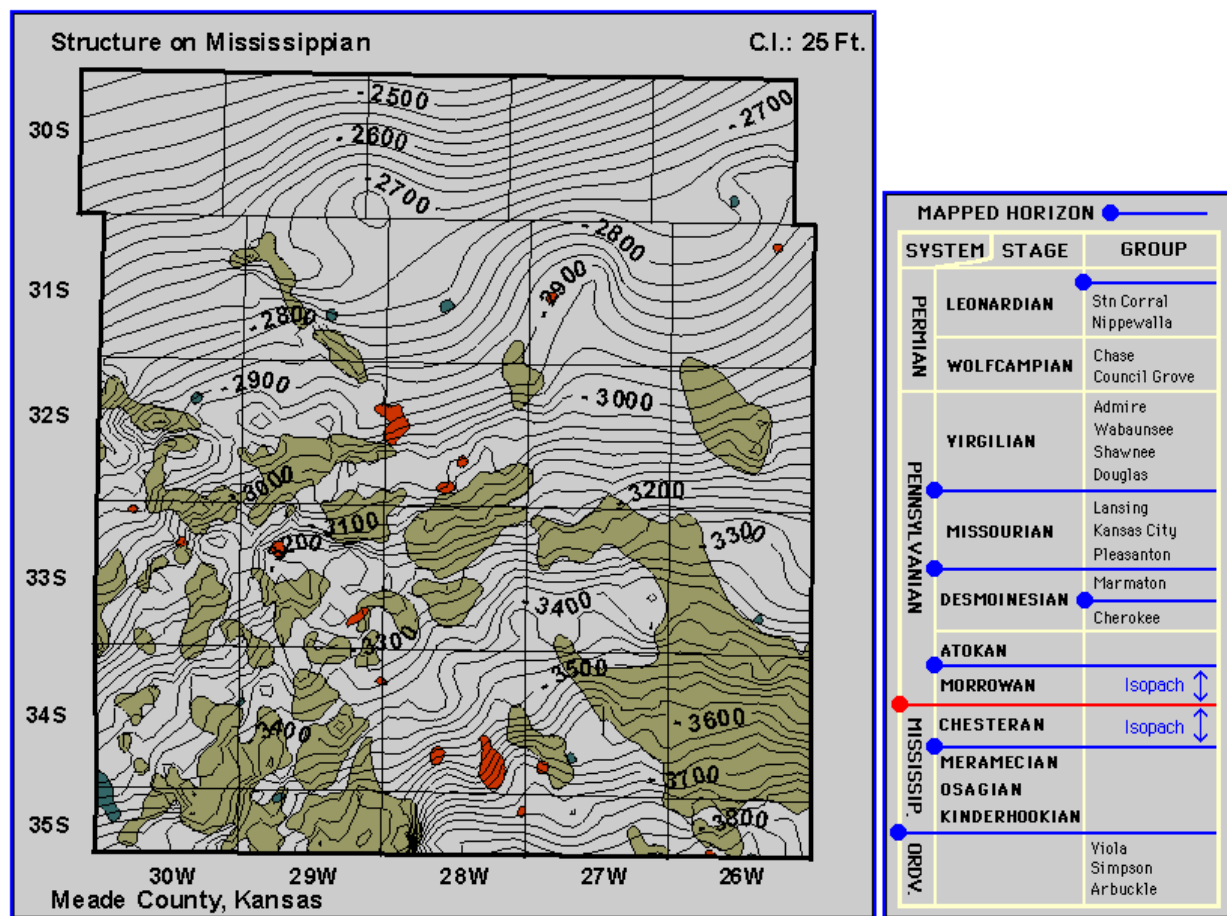
Figure 2. Meade County, a sample county page added to the Digital Petroleum Atlas in year 3. County page shows structure on top of Chestereran and contains a field study. Page shows typical navigation buttons and page layout. Map and stratigraphic column are interactive and linked to other county-scale maps and selected field studies. (http://www.kgs.ukans.edu/DPA/County/klm/meade.html).
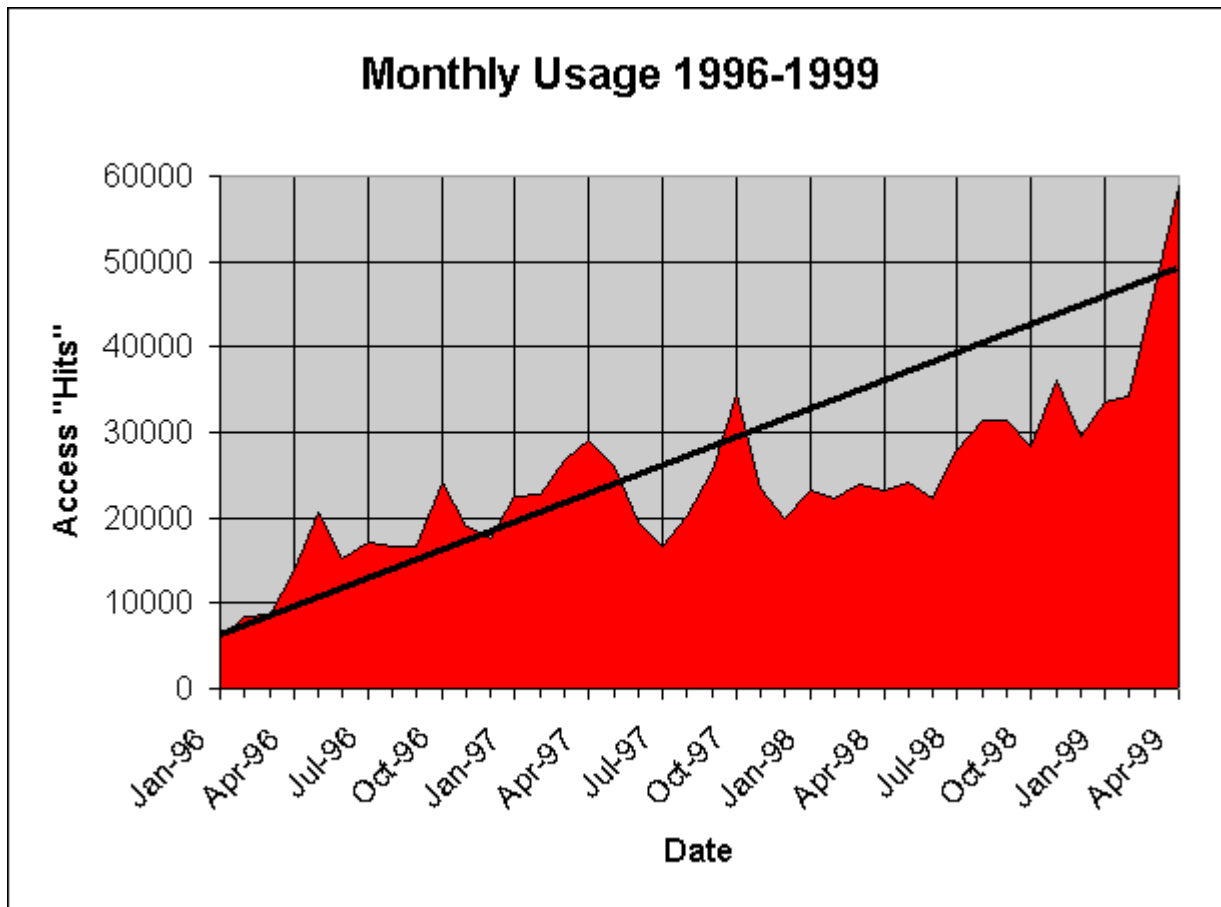
Figure 3. Monthly usage statistics measure separate pages viewed from the Petroleum Research server. Miscellaneous graphics and access from Kansas Geological Survey computers are removed prior to analysis. Current usage statistics are collected daily and are available on the Petroleum Research Section of the Kansas Geological Survey web site (http://www.kgs.ukans.edu/usage/past_stats.html).

Most Requested Pages				
Pages	Views	% of Total Views	User Sessions	Avg. Time
1	**KGS--Oil and Gas Info** *http://www.kgs.ukans.edu/PRS/petroIndex.html*	771	2.55%	703	00:02:28
2	**Digital Petroleum Atlas Home** *http://www.kgs.ukans.edu/DPA/dpaHome.html*	412	1.36%	390	00:01:04
3	**Northern Mid Continent PTTC Home Page** *http://www.kgs.ukans.edu/ERC/pttcHome.html*	393	1.3%	361	00:01:43
4	**DPA--Kansas** *http://www.kgs.ukans.edu/DPA/dpaKansas.html*	337	1.11%	316	00:01:38
5	**KGS--Oil and Gas Production** *http://www.kgs.ukans.edu/PRS/petro/interactive.html*	313	1.03%	296	00:02:21
6	**KGS Data and Search Page** *http://www.kgs.ukans.edu/DB/*	298	0.98%	282	00:04:15
7	**KGS - Search the Web Site** *http://www.kgs.ukans.edu/Excite/*	214	0.7%	192	00:00:46
8	**ERC Homepage** *http://www.kgs.ukans.edu/ERC/*	196	0.64%	191	00:02:21
9	**DPA--Site Map** *http://www.kgs.ukans.edu/DPA/dpaMap.html*	173	0.57%	166	00:02:00
10	**Digital Petroleum Atlas--Well Search--T-R** *http://www.kgs.ukans.edu/DPA/Forms/TW-R.html*	164	0.54%	156	00:02:36
	Sub Total For the Page Views Above	**3271**	**10.83%**	**N/A**	**N/A**
	Total For the Log File	**30199**	**100%**	**N/A**	**N/A**

Figure 4. Statistics measuring most requested pages viewed from the Petroleum Research web server in April 1999. Pages that were part of the Digital Petroleum Atlas were among the most requested pages (positions 2, 4, 6, 9,10). Other highly requested pages on the Petroleum Research web server are portals (positions 1, 3, 8) that provide general access to the Digital Petroleum Atlas and other oil and gas information. Complete report for April 1999 is available online at http://www.kgs.ukans.edu/usage/1999/apr_wt/default.htm.

Most Accessed Directories					
Path to Directory	Hits	% of Total Hits	Non Cached %	Non Cached K Xferred	User Sessions
http://www.kgs.ukans.edu/DPA	10814	34.47%	96.78%	44,889K	2538
http://www.kgs.ukans.edu/PRS	9662	30.8%	94.52%	119,328K	3112
http://www.kgs.ukans.edu/Hydro	3207	10.22%	99.71%	1,309K	136
http://www.kgs.ukans.edu/ERC	3173	10.11%	93.44%	18,233K	1616
http://www.kgs.ukans.edu/KCC	1560	4.97%	97.56%	6,353K	746
http://www.kgs.ukans.edu/cgi-bin	634	2.02%	100%	6,135K	258
http://www.kgs.ukans.edu/midcont99	482	1.53%	90.45%	2,357K	152
http://www.kgs.ukans.edu/DB	298	0.95%	87.91%	1,418K	282
http://www.kgs.ukans.edu/Hugoton	279	0.88%	78.85%	1,387K	47
http://www.kgs.ukans.edu/Excite	215	0.68%	85.58%	263K	192
http://www.kgs.ukans.edu/Conferences	213	0.67%	99.06%	734K	117
http://www.kgs.ukans.edu/Director	205	0.65%	94.63%	638K	146
http://www.kgs.ukans.edu/software	110	0.35%	100%	0K	79
http://www.kgs.ukans.edu/WellLogs	104	0.33%	98.07%	4,896K	30
http://www.kgs.ukans.edu/Class2	100	0.31%	100%	377K	72
http://www.kgs.ukans.edu/	92	0.29%	97.82%	98K	86
http://www.kgs.ukans.edu/usage	86	0.27%	100%	0K	38
http://www.kgs.ukans.edu/DMT97	69	0.21%	100%	136K	57
http://www.kgs.ukans.edu/Excite2	37	0.11%	94.59%	87K	35
http://www.kgs.ukans.edu/Maps	10	0.03%	100%	5K	7

Figure 5. Statistics for April 1999 measure the most accessed directories on the Petroleum Research web server.   The DPA is the most accessed directory with over a third of the total hits for the site. Complete report for April 1999 is available online at http://www.kgs.ukans.edu/usage/1999/apr_wt/default.htm.

YEAR 3: RESULTS AND DISCUSSION

WEB STRUCTURE

A goal of the Digital Petroleum Atlas (DPA) was to provide users flexible access to the original data and intermediate steps of the study. Results of field studies are fed immediately into the databases. The flexibility of the Web provides access to the data that went into the study at the same time as the results.

To support these technical goals, a design was created for the web site. Several models were drawn up, but the goals were very simple:

1. Display information assembled
2. Allow user to choose path and goals
3. Don't let user get lost.
4. Allow for efficient updating

As the DPA was constructed, there were two obvious "paths" through the digital data. The user could move geographically through several scales of data:

$$Play \rightarrow Basin \rightarrow County \rightarrow Field \rightarrow Well$$

At each geographic scale, the user would be presented with choices and answers.

a. For this county, which field would you like to see?
b. What is the structure of the Morrow in the basin?
c. For this Field, which well are you interested in?
d. For which Play is this field an analog?

As an alternative the DPA could be structured around topical areas. For the DPA the topical areas were broken into following categories:

| Regional | General | Geology |
| Geophysics | Reservoir | Wells |

For each field, basin and county, information was structured in terms of both geographic scale and topical area. These two general structural styles of information (pages based on geographical scale and pages based on topical area) result in a grid system. However, in practice this structure becomes rapidly unmanageable. While it would be nice to simultaneously compare the geologic maps of three or four fields (isopach or structure), it is not possible and not desirable to have links from each geology page to every other geology page. As a result, for the DPA we emphasized movement among geographic scales, and worked to maximize the visitor's ability to move from County to Field to Well. Movement between topical areas is limited to within the selected geographic scale (e.g., figures 1, 2).

IMPROVED DATABASE MANAGEMENT

At the present time, the Digital Petroleum Atlas currently contains over 6,000 static web pages covering 8 counties, 7 fields and two regions of Kansas. "Static" pages are actual HTML text files on the DPA web server showing information to visitors. Most of DPA pages are very similar--that is, a template can be made and multiple pages extracted from that template. For example, for a set of county geology pages (Figure 2), the only differences are the names of the files, the window titles, and the two figures (i.e., map and stratigraphic chart). The navigation is adjusted for each page (assigning a "Previous" page and assigning a "Next" page). As a result, a new set of geologic maps, core photos, etc., for a new play or field can be integrated into the DPA efficiently as a new set of static web pages.

However, the method of creating static web pages has two problems. The first problem is maintenance of pages containing variable data. Data such as oil and gas production changes monthly, and the pages must be updated periodically. With more and more fields added, the work of creating all the new pages and updating all the previously created pages can take up all available time. The second problem is one of scale. For any small field (25-100 wells), it is easy to create pages for each well and attach scanned well completion forms, digital well logs, and other information. But with larger fields, such as the Chase-Silica field with 10,378 wells, assembling the data is in itself a major task and pages can not be created by hand. By creating pages with a relational data base management system (e.g., Oracle), whatever data is available can be displayed to the visitor. New production data is available immediately. Plus, the database can create lists of wells for the user based on location information, and pages for the wells can be created only if the user wants to see detailed information.

Creating pages for smaller fields

The first field added to the DPA was Arroyo, a field with 36 wells needing web pages. These pages were created by hand and links were made from the field map and the web pages (Figure 6). After the well pages were created, pages for completion forms, production, petrophysical analysis, etc. were created as needed and attached by hand to the well pages. Updating the production pages would take only a few hours of student time.

Big Bow was handled the same way, but Gentzler and Schaben fields added a new challenge. While the number of wells in Gentzler and Schaben fields was reasonable, the geographic scale of these new fields meant that the visitor could not select an individual well of interest because the well spots were too small to resolve on the user's screen. For fields with a larger geographic area, clicking on the main map brings up a map with more detail on the particular quarter of interest (Figure 7).

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Figure 6. Sample field map from the DPA for a small field (Arroyo Field, Stanton, County). Because of the small size of the field and small number of wells the field map was easily linked to the well pages using ImageMap HTML command. Page is available online at http://www.kgs.ukans.edu/DPA/Arroyo/arroyoMain.html.
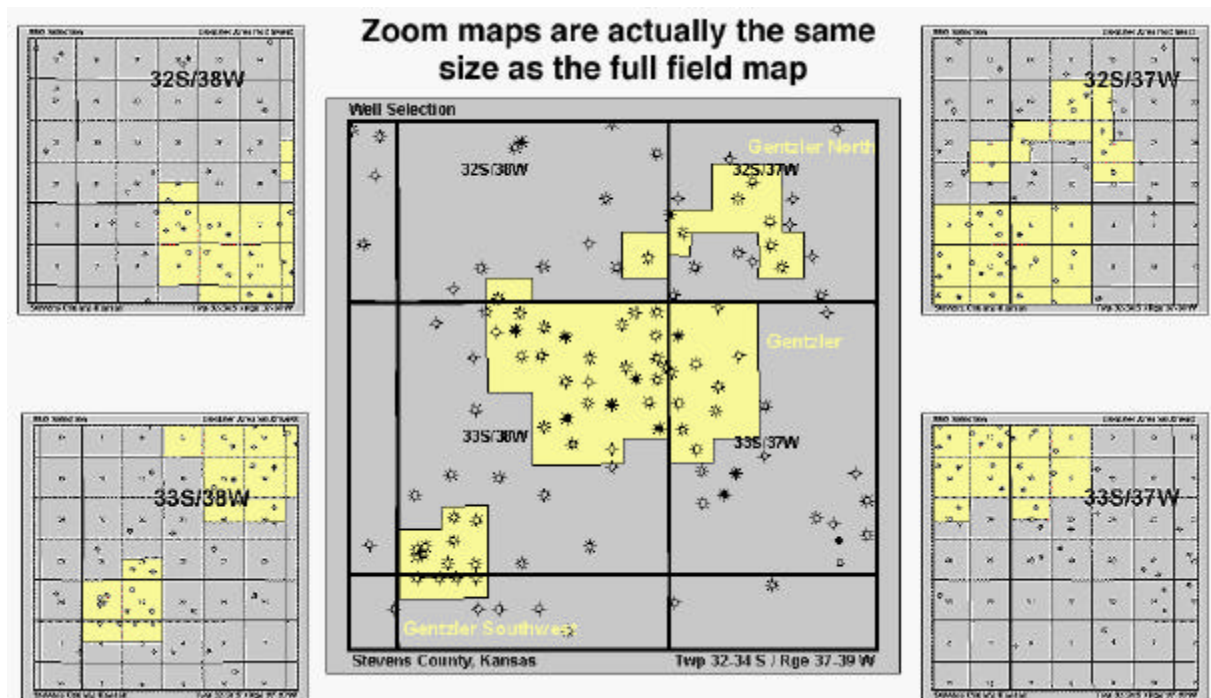

Figure 7. Zoom maps allow user to select from larger number of wells across a larger geographic area. Large map shows only selected wells. Field map is available online at http://www.kgs.ukans.edu/DPA/Gentzler/gentzlerMain.html.

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Creating Pages for Very Large Fields

For Chase-Silica Field (Rice County), simple zooming does not allow a clear picture of all wells without creating several levels of zoom. In addition, the resulting maps and individual well pages would require the creation and maintenance of 10,378 additional web pages. The map of Chase-Silica Field covers eight townships (288 square miles). At this scale it is impossible to resolve and select all wells, and only currently producing well are shown. Clicking on selected parts of the field scale map accesses eight pages, created at the township scale to show the detailed well spots (Figure 9).   Discussion of the ImageMap command of HTML is provided under a later section (Linking maps with HTML).

The township scale maps of Chase-Silica Field are also active maps that use the ImageMap command of HTML (Figure 9). However, clicking on an individual section does not access a web page, but generates a query to several relational database tables. The result returned to the user is a web page that contains an annotated list of all wells for which production and geologic data is available (Figure 10). Clicking on the "Well_ID", normally the API number, generates additional queries for detailed well, wireline log and production data and returns a web page to the user (Figure 11).

The web pages at Chase-Silica Field are not static. They are generated as requested by the user and contain the latest geologic, production and other data loaded into the various relational databases. Using relational databases significantly improves the efficiency of undertaking and maintaining large-scale field studies. The thousands of potential web pages are reduced to small number of programs operating on a manageable number of relational data tables. Updates to the various data tables are immediately accessible to the user. Procedures for constructing and providing web access to relational database tables are discussed in a later section.
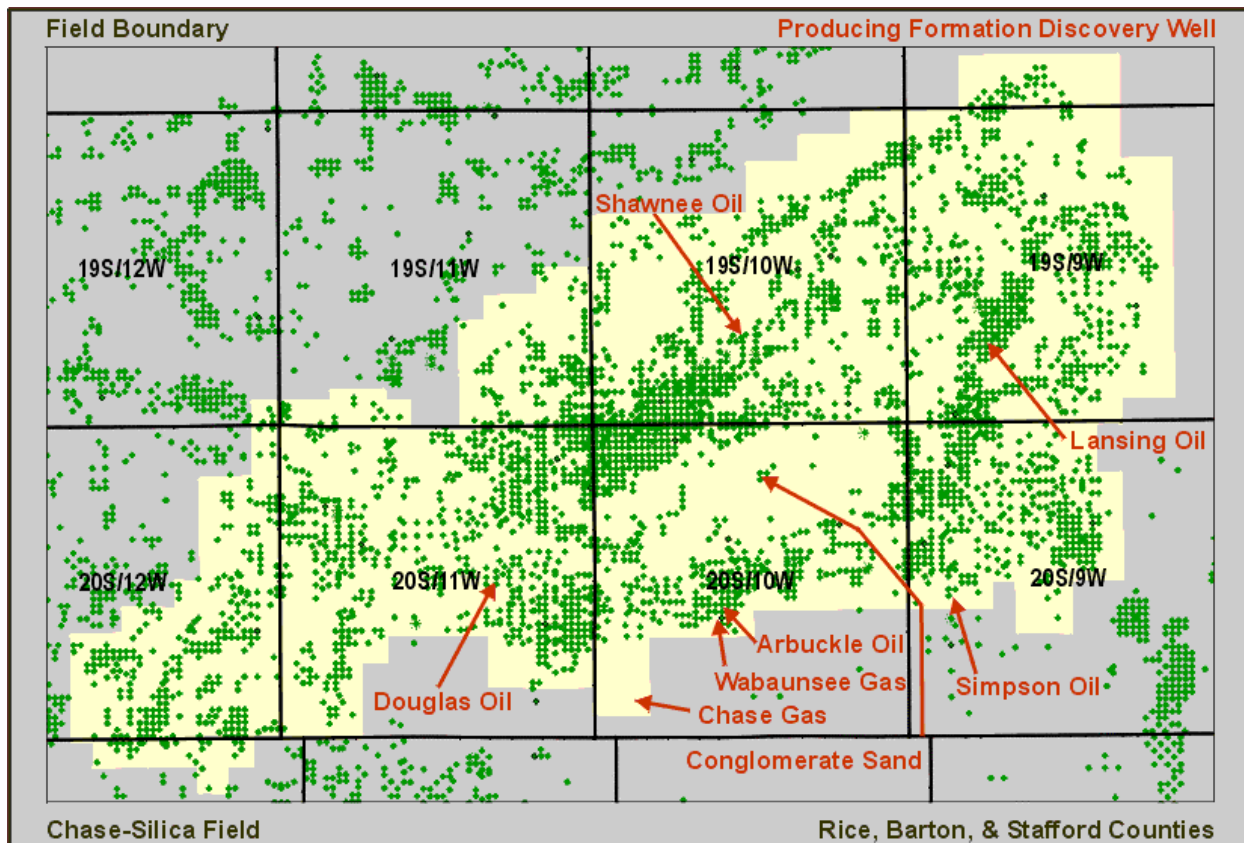
Figure 8. Clicking on any township-range block brings up a more detailed figure of the wells in that block (Figure 9). Page is available online at http://www.kgs.ukans.edu/DPA/Chase/Wells/chaseWell1.html.
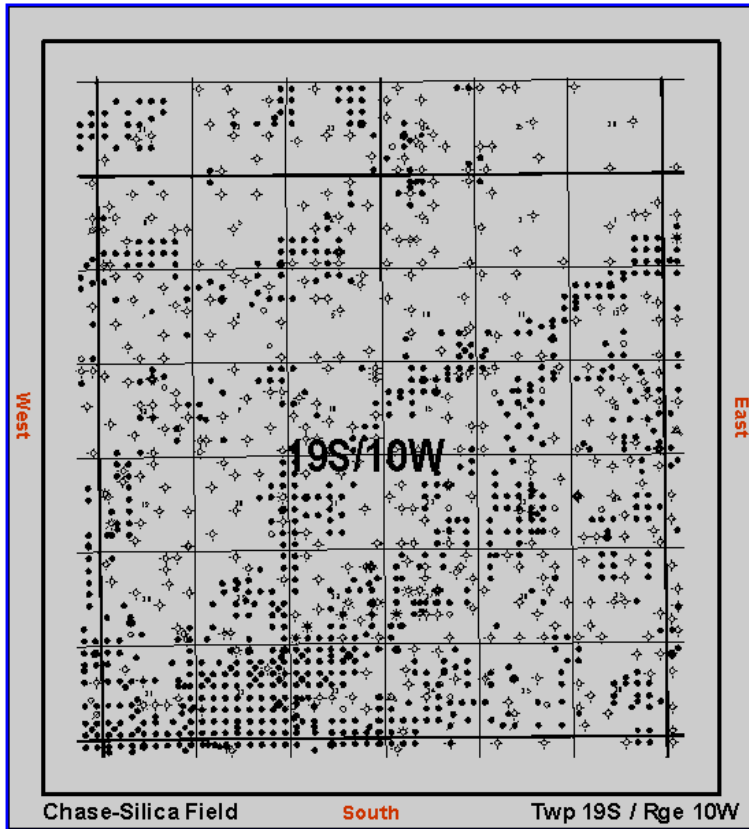
Figure 9. Township-range block showing a more detailed picture of the wells. Clicking on any section generates a query to the database and creates a list of the wells in that section (Figure 10). Page is available online at http://www.kgs.ukans.edu/DPA/Chase/Wells/19S10W.html.

Figure 10. A portion of well list generated by clicking on section to generate query to database. Clicking on individual well generates another query to generate detailed well report from well and production databases (Figure 11). Query is in the form of http://magellan.kgs.ukans.edu/abyss/public/dpa.chase.mainTRS?twn=19&rge=10&sct=32.

Chase Field--Well Information

Well_ID: 15159014780000
Operator: Brougher Oil
Well: Birzer Owwo 1
Location: Twp. 19S, Rge. 10W, Sec. 32
Footage: 01980FNL 00660FWL

Production Data

[View Table]
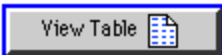
ACO-1 and Driller's Logs
No forms have been scanned for this well.

Well History Data

```
API #: 15159014780000
Field: CHASE-SILICA        Operator: BROUGHER OIL
Spud date: 23-APR-82       Comp. Date: 30-SEP-82

State API: 15  County API:  159  Latitude: 38.35665  Longitude: -98.4
Meridian: 6  Township: 19S    Range: 10W    Section: 32
Location: 01980FNL 00660FWL

Datum and Elevation: KB 1805      Total Depth: 3304
Formation @ total depth: ANH
Status: OIL      Well class.: DEVELOPMENT

Formation        Depth        Subsea    Comments

*HEEB            2862
HEEB             2869
*TORNTO          2887
*BL              2987
BL               2991
*LANS            3005
LANS             3018
*OARB            3286
OARB             3295

IP Formation: LANS
IP Oil (Barrels): 15  IP Gas (MCF):  IP Water (Barrels)250
```
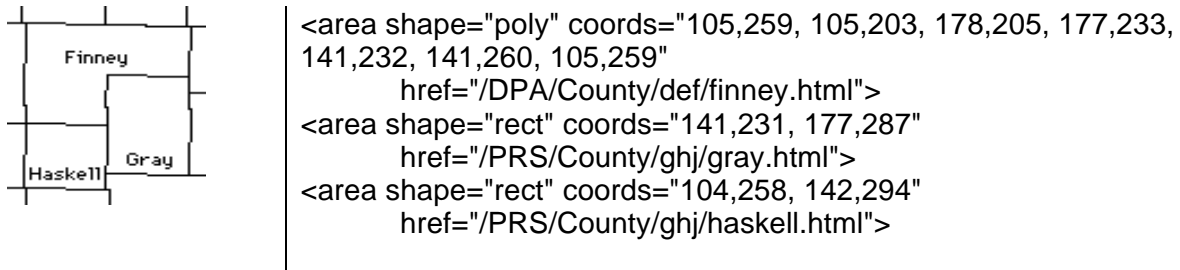
Figure 11. A sample of detailed well report generated from a query to well and production databases. Results are arranged into a web page. Query is in the form of http://magellan.kgs.ukans.edu/abyss/public/dpa.chase.MainID?f_wellused=15159014780000.

Linking maps with HTML

Navigation by clicking on areas of map images to access web pages is provided by the "Imagemap" command of HTML. The creator of the web page can assign web Uniform Resource Locators (URLs) to geometric shapes (rectangles, polygons, and circles). The figure below shows a part of a larger map and the shapes defined for the map. Finney County is defined by a polygon of 7 points. If the user clicks in the polygon, the page at "/DPA/County/def/finney.html" is displayed.


```
<area shape="poly" coords="105,259, 105,203, 178,205, 177,233,
141,232, 141,260, 105,259"
        href="/DPA/County/def/finney.html">
<area shape="rect" coords="141,231, 177,287"
        href="/PRS/County/ghj/gray.html">
<area shape="rect" coords="104,258, 142,294"
        href="/PRS/County/ghj/haskell.html">
```

Haskell and Gray counties use rectangles for ease of creation, even though technically they would be better modeled by polygons. The coordinates of the user's browser determine access to one of several static web pages (Figure 12).
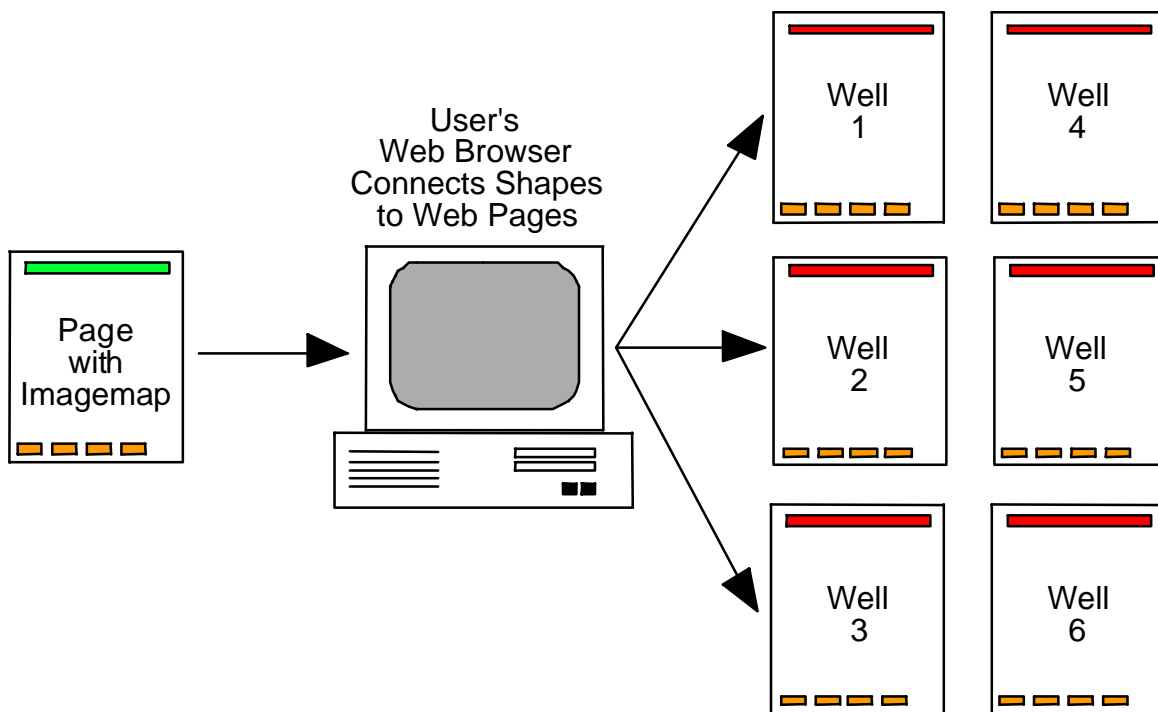

Figure 12. With an imagemap, the user's browser decides what web page will be asked for based on the coordinates of the mouse click.

Relational database tables and procedures

The ImageMap command of HTML can also be used to ask a question of a database. Here is an ImageMap syntax fragment for the map of a portion of Chase-Silica Field (Figure 9):

```
<area shape=rect coords="408,54,478,124"
href="http://magellan.kgs.ukans.edu/abyss/public/dpa.chase.mainTRS?twn=18&
rge=10&sct=36">
```

The link shows that the computer called " magellan.kgs.ukans.edu" is asked for a web page. On that computer, the words " abyss/public/" mean that the Oracle database called "abyss" will be called with a publicly available question. The program that will run the database query is "dpa.chase.mainTRS." Finally, the program needs township, range, and section values ("twn=18&rge=10&sct=36"). Even though 36 sections are "imagemapped" for each township scale map, the process uses search and replace functions that are very efficient.

Software provided with relational database management systems, such as Oracle, is used to connect the web pages to the database. This "middleware" receives the parameters from the web browser, formats them, and sends them to the programs stored in the relational database (Figure 13). After each query is executed, the database sends the data back through the middleware. The results appear to the user with a web browser just like any static web page (Figure 13).

A number of separate tables in the relational database are used to support the DPA web pages. The main table is a list of wells located in the Chase-Silica field. Technically, this table is not needed, since a table containing all wells in Kansas could be used as the source with Chase-Silica wells extracted as needed. However, pre-creating a smaller file of wells improves performance. The relational database uses the main table of 10,378 records in the well list and additional subsidiary tables (e.g., lease production) to create well pages as needed for any well in the field. To the user the pages generated from the query to the database appears and acts exactly as the static, hand-created pages.

The subsidiary data files accessed by the DPA are often not maintained by project personnel. Kansas Geological Survey personnel, and even other state agencies, provide update the information in the tables as part of other projects (Figure 14). An example would be monthly oil and gas production data obtained from the Kansas Department of Revenue. The DPA structure is used to extract up-to-date data from those external tables and present to the user web pages that look and act just like normal DPA pages. The result is that parts of the DPA are automatically maintained and updated and will continue to be maintained after the project has ended ("a living publication").

While the static pages already built for Arroyo, Big Bow, and the other small fields in the DPA will not be completely replaced by pages from relational databases, links to selected data are being changed from static pages to database-created pages (e.g., production).
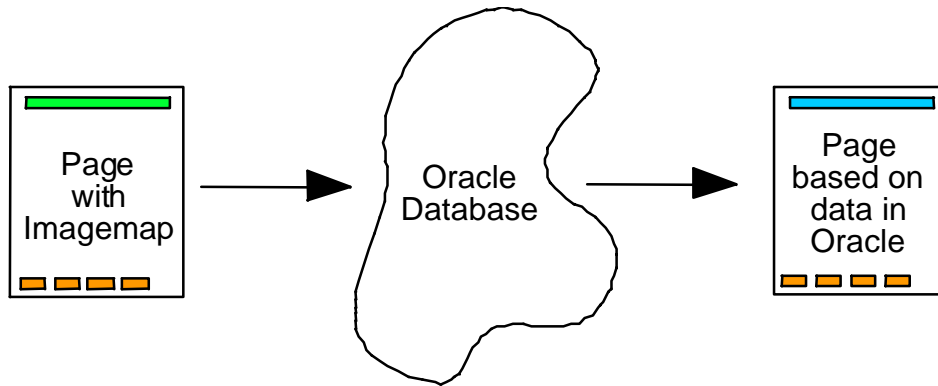
Figure 13. Instead of presenting an existing web page, the imagemap can call a database. The database can be used to create a web page based on the parameters sent and the data currently stored in the database. By clicking on section 36 in Figure 9 the user were generate the following commands and parameters:

```
<area shape=rect coords="408,54,478,124"
href="http://magellan.kgs.ukans.edu/abyss/public/dpa.chase.mainTRS?twn=18&
rge=10&sct=36">,
```

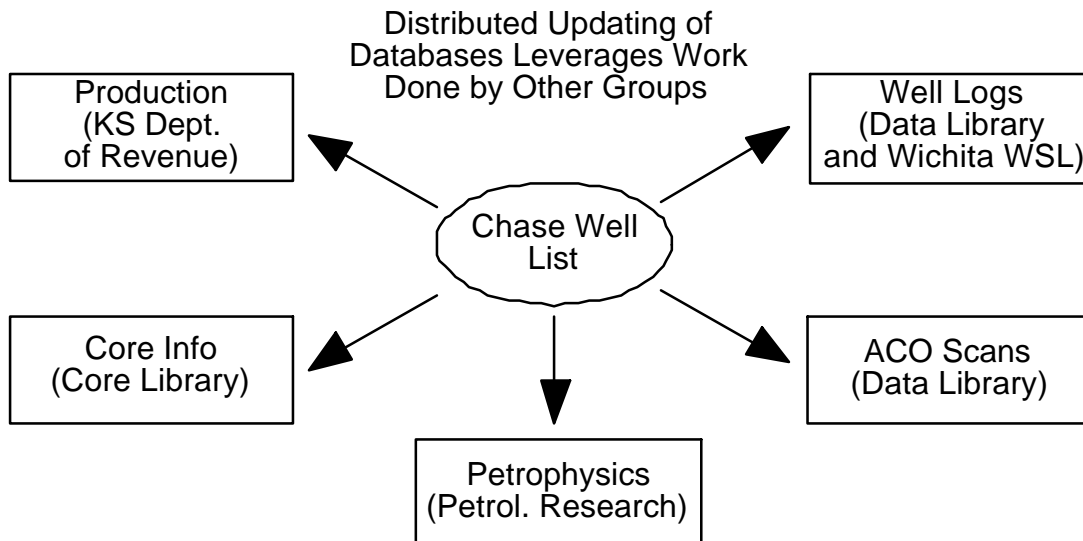and would produce the output shown in Figure 10.

Figure 14. A well query in the Chase-Silica Field accesses numerous relational databases. The DPA personnel only maintain the main well list for Chase-Silica Field, but other staff maintain and update the other tables. The result is that updated data is automatically available to the user and overhead of maintaining the DPA is significantly reduced.

SUMMARY OF YEAR 3 ADDITIONS TO ATLAS CONTENT

As the DPA began, the primary task was gathering data at the field and well scale and placing this data online. As a home page, we created an interactive map of Kansas linked to all the counties in the state (Figure 1). The Kansas DPA Home Page remains the primary portal, and provides numerous paths to access Kansas petroleum information and technology at the various geographic scales and topical areas. Access is provided to reviews of the regional geological setting, overviews of oil and gas plays and to information and technology at the county, field and well levels. The total number of static web pages exceeds 6,000, but this is a decrease from previous years. Pages constructed using programs that access relational databases are replacing static web pages.

The DPA provides access to a number of regional maps, studies and data sets (e.g., gravity and magnetics, and discussions of Kansas oil and gas provinces). In year 3, the major addition to regional maps was an extensive linked set of statewide structure and isopach maps with overlays of oil and gas production (Figure 15). These regional maps permit the user to toggle among a number of maps covering all major oil and gas producing intervals. The user can also select map type (i.e., structure or isopach), and type of production overlay (i.e., oil or gas).

Kansas Home
Searches
Regional Maps
Oil & Gas Plays

Kansas Digital Petroleum Atlas

Statewide Production Maps--Lansing-Kansas City
Select a map type (oil production or gas production) or
select another Productive Horizon to explore.

Map type...
Gas Production || **Oil Production**

Productive Horizon...
Niobrara || Red Cave || Chase || Council Grove || Admire || Wabaunsee || Topeka
Douglas || **Lansing-Kansas City** || Marmaton || Cherokee || Atokan || Morrowan || Mississippian
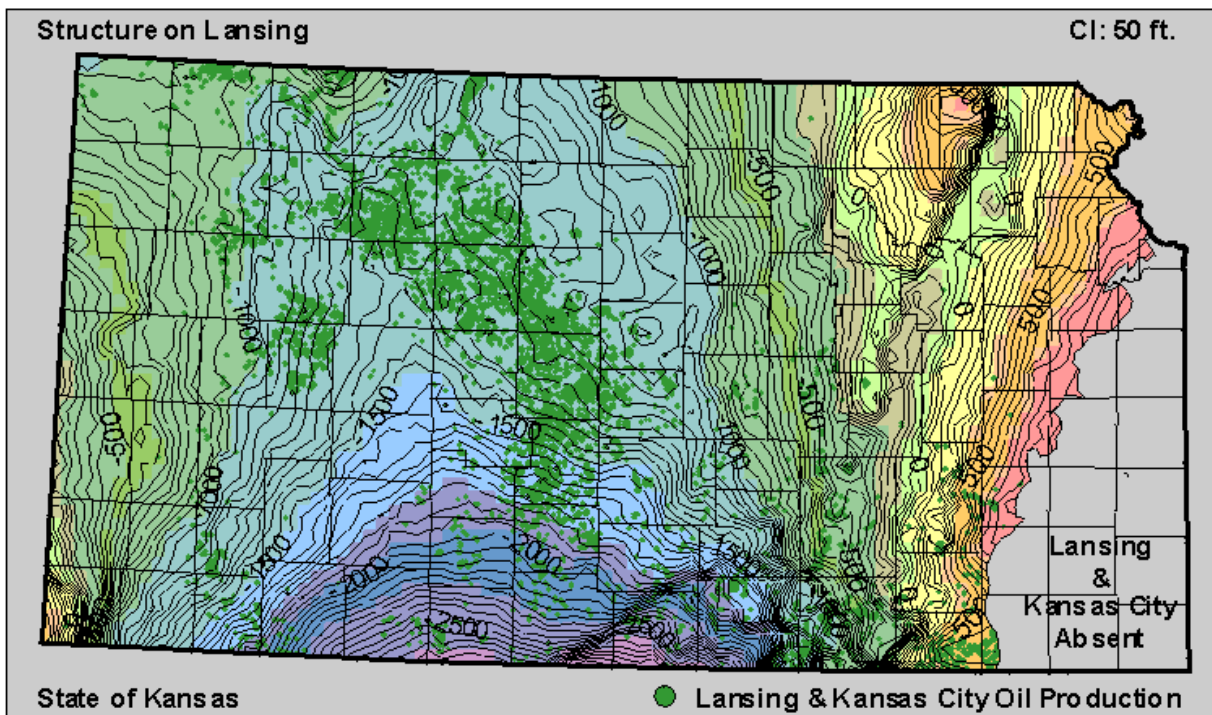Misener || Hunton || Maquoketa || Viola || Simpson || Arbuckle || Reagan || Precambrian

Figure 15. Regional structure map on the top of the Lansing Group showing the distribution of all leases in Kansas that reported oil production from Lansing and Kansas City groups. Similar structure and isopach maps with overlays of oil and gas production are available for all major-producing intervals (http://www.kgs.ukans.edu/DPA/Plays/ProdMaps/lgkc_oil.html).

As part of third year of the DPA project, studies were undertaken at two Kansas fields and producing areas. These were added to the previously existing field studies. The two additions are:

- McKinney Field (Producing Formations: Kansas City Group--multiple zones, Marmaton Group--multiple zones, Pleasanton, Morrow, and Mississippian) in Meade County (figures 2, 17, 18);

- Chase-Silica Field (Producing Formations: Kansas City Group--multiple zones, Marmaton Group--multiple zones, and Mississippian) in Rice, Barton and Stafford county (figures 8-11, 16).

The Chase-Silica Field is notable because of its geographic extent (eight townships), number of wells (> 10,000) and development of new methodologies to reduce the number of static web pages. The McKinney Field provided the first application of "zoom" and "pan" to access and navigate detailed geologic and field maps (Figure 18).

New data and research products continue to be added to each field study, as they become available. Publication in the DPA is an ongoing process that continuously updates the data and technology associated with each field study. The addition of the ability to query relational databases increased the efficiency of updating previously completed field studies. Each field study homepage provides a map of the field area, basic field and discovery information, and a standardized set of links to additional geologic, geophysical, engineering and production data.

For each county and field page in the DPA a paper mockup of a standard set of field pages was created on a bulletin board. The paper mockup allowed for flexible thinking in terms of button layouts, numbers of buttons, and basic navigation issues. Based on trial and error a basic page style evolved and appears to be stable.
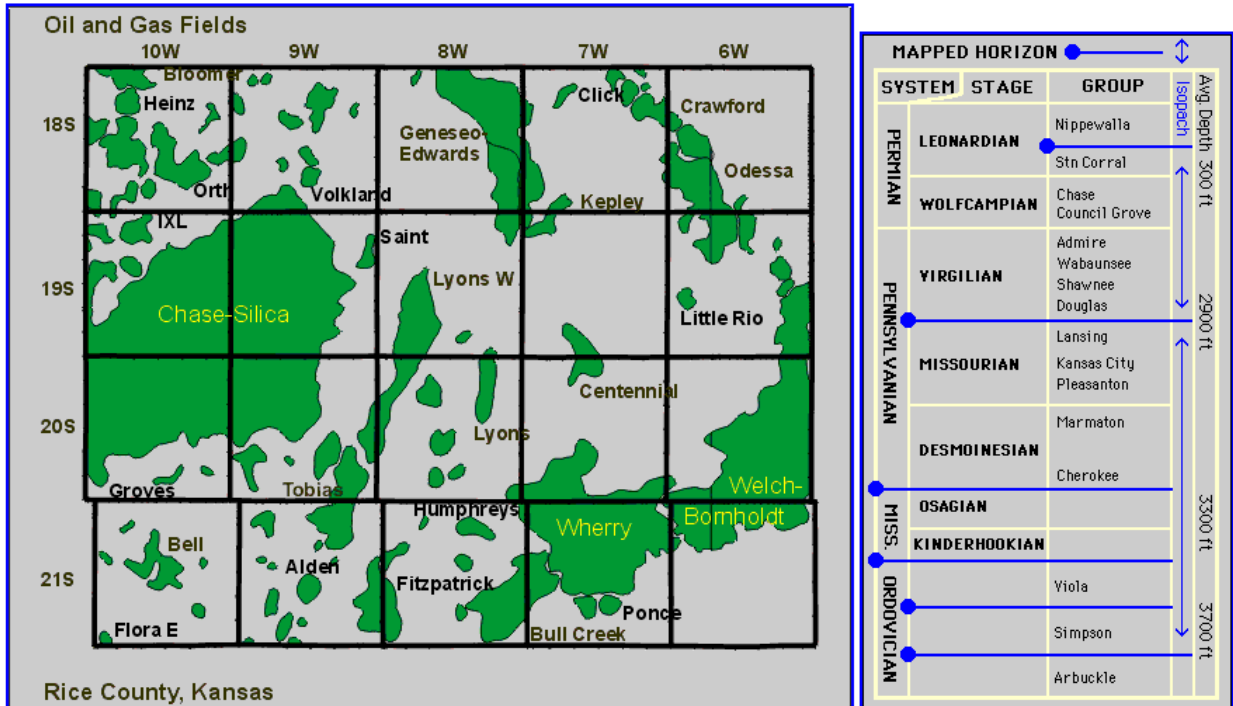
Figure 16. Sample county page from the Digital Petroleum Atlas that contains a field study showing navigation buttons and page layout. Map and stratigraphic column are interactive and linked to other county scale and field pages.

Figure 17. Sample field page covering McKinney Field, Meade County from the Digital Petroleum Atlas. Map shows navigation buttons, page layout, field outline. The field page contains links to topical data, maps, cross-sections and technical discussions. Clicking on a selected township provides a detailed geologic map (Figure 18). Not shown is stratigraphic column that controls selection of horizon for structure or isopach map.

Figure 18. Sample of detailed geologic map covering a portion of McKinney Field, Meade County. Page shows navigation buttons, panning controls to move map location and selection of stratigraphic horizons. Map contains links to topical data, maps, cross-sections and technical discussions.

TECHNOLOGY TRANSFER ACTIVITIES

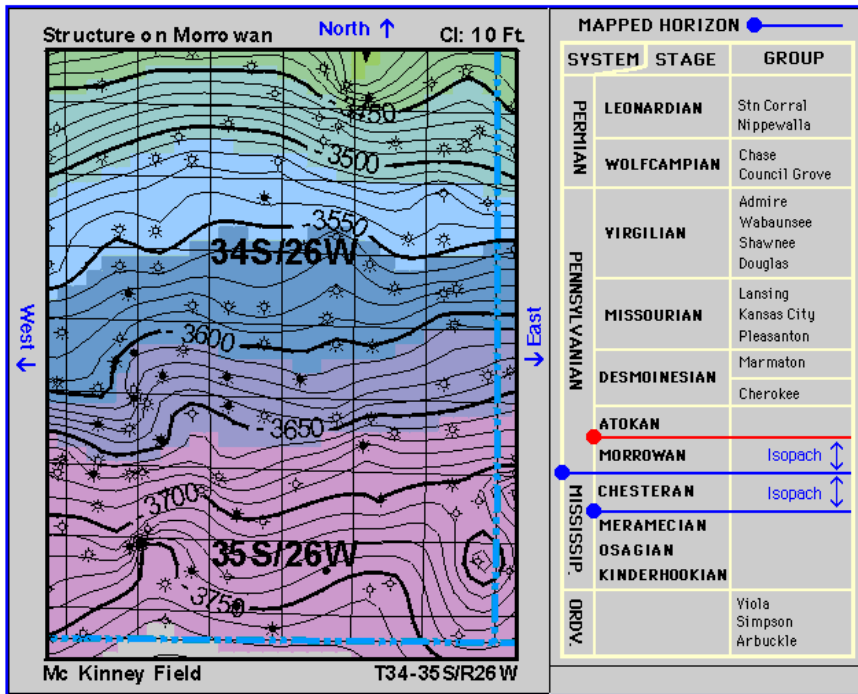The world-wide-web and publish as-you-go design of the Digital Petroleum Atlas Project provides immediate and ongoing technology transfer activities. Based on increased usage statistics and informal industry feedback, the DPA model appears to provide an efficient method of technology transfer to the geographically dispersed high technology petroleum industry (Figure 3 and Appendix A). The pages that comprise the DPA are among the most visited on the Kansas Geological Survey web site and usage continues to grow (figures 3-5). Periodic email updates provided to interested operators and individuals have been well received. As part of technology transfer efforts, a formal talk and paper were prepared and presented to local and national meetings (Table 1; Buatois, et. al. 1998; Carr, et al. 1998; Buchanan and Carr, 1998). In addition, the Digital Petroleum Atlas Project has been integrated into the Internet for the Petroleum Professional Course. This is a popular course for oil and gas producers and is taught as part of the North Midcontinent part of Petroleum Technology Transfer Council (For example see online version of the Internet course at http://www.kgs.ukans.edu/General/Tutorial/Internet/findex.html).

Table 1. Presentations undertaken as part of third year of the Digital Petroleum Atlas Project.

- Canadian Society of Petroleum Geologists - Society of Economic Paleontologists and Mineralogists, Joint Convention, Calgary, June 1998

- PTTC Workshops on Internet for the Petroleum Professional, Tyler, Texas, June 1998

- PTTC Workshops on Internet for the Petroleum Professional, Kalamazoo, Michigan, August 1998

- Workshops on Kansas Online Resources at Kansas Independent Oil and Gas Association (KIOGA), Wichita, Kansas, August 1998

PROBLEMS ENCOUNTERED

The Digital Petroleum Atlas was designed to be a dynamic product with the constant addition of new information and ideas. Within this changing environment defined tasks of the year three DPA were completed. In using the DPA, oil and gas operators and the interested public proposed many of the ongoing changes and additions. The prototype DPA project was completed within budget and cost sharing was in excess of 20%.

RECOMMENDATIONS FOR FUTURE WORK

Results from the year three Digital Petroleum Atlas Project have significantly exceeded expectations. We continue to expand the breath and depth of plays, fields and reservoirs covered, enhance the included petroleum technology, expand the geographic coverage, and improve the navigation and technology for online access to continuously updated relational databases. Work to document procedures for construction of a generic digital petroleum atlas that could be replicated in other oil and gas producing areas of the United States.

CONCLUSIONS

As the third year of a longer-term effort, the Digital Petroleum Atlas (DPA) has developed a new methodology to provide efficient and timely access to the latest petroleum data and technology for the domestic oil and gas industry, public sector research organizations and local governmental units. The DPA provides real-time and cost-effective electronic publication of materials typically found in published paper oil and gas atlases. The latest technologies and information are continuously "published" electronically when individual project components are completed, reducing the lag and expense of transferring technology using traditional paper publication. Additional information and technology are constantly being added and older information updated to the DPA increasing its scope and detail. Active links, graphical user interfaces and relational database search mechanisms provide a published electronic product with which the operator can interact in ways that are impossible in a paper publication. Contained in the DPA are forms of publication that can only be displayed in an electronic environment (for example, animated exploration histories through time, and special queries). Through complete and flexible user access to technology, interpretative products and the underlying geologic and petroleum data, the DPA changes the relationship between interpretative result and data, between technology generation and application. Improved access to petroleum data and technology represents one of the best and cost-effective options that available for maintaining domestic production.

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SELECTED COMMENTS AND SUCCESS STORIES FROM PRODUCERS
(Names are on file at the Kansas Geological Survey).

To: webadmin@crude2.kgs.ukans.edu
Subject: Keep up the god work

The digital petroleum atlas is one of the few worthwhile petroleum sites on the internet. You are demonstrating what can be done with the Web. We need more states to start doing what you are doing. Until we see more products like this the small independent will not be one the internet.

An Geologist at a Small Independent Producer
_____

To: lee.moore_hall@msmail.kgs.ukans.edu
Subject: KGS Digital Petroleum Atlas

I examined the new digital petroleum atlas (Stanton Co., KS) and I am very impressed. Congratulations on a great product. I am currently working for NARCO on a consulting job in KS and have found the info in the digital atlas to be of great help.

Best Regards,

An Independent Geologist
_____

To: webadmin@crude2.kgs.ukans.edu
Subject: Kansas Petroleum Data

I think the Kansas Digital Petroleum Atlas and O&G database is great and wish the project much success. I wanted to know when monthly well and field data would be available. Also will injection data also reside in the database eventually? Have you thought about writing Java applets that would plot data various ways and do decline analysis.

Will log and well completion data also be available someday?

An Independent Producer
_____
To: webadmin@crude2.kgs.ukans.edu
Subject: DPA
Content-Length: 314

Hey KGS:
I really like the direction you're taking with the Digital Petroleum Atlas. This is the kind of information I've been hoping for from KGS and PTTC. Can't wait for you to start on other counties (like Lane and Ness for example hint, hint). Keep up the great work.

Owner of Small Independent Oil and Gas Company
_____

To: webadmin@crude2.kgs.ukans.edu
Subject: Kansas Atlas

One of the few projects that DOE has supported that has been really useful in my work.

Geologist from a Large Oil Company

_____

To: webadmin@crude2.kgs.ukans.edu
Subject: DPA

You do not realize how much of the Digital Petroleum Atlas that I have downloaded and used in a current prospectus. Also I noted DPA maps and x-sections were in evidence at the latest NAPE Conference (North America Petroleum Expo).

A Independent Geophysical Consultant

_____

A Success Story

The Kansas Geological Survey's Digital Petroleum Atlas (DPA) played an important role in helping Denver geologist, Gary Wilkins discover new production from the Morrow formation at the Dietterich Field (Discovery well is Stelbar 1-25 Roberts, 25-28S-41W).   Mr. Wilkins used the geological, geophysical, and production data in the DPA to demonstrate the potential for reservoir quality sandstone in the Morrow formation at the Dietterich Field area.

Quote from Gary Wilkins. "The regional geological maps available on the DPA Web site are a tremendous help in defining new play areas in the Morrow formation. I also appreciate the comprehensive Arroyo Field Study. The geological information does an excellent job of clearly demonstrating the trapping mechanism and reservoir distribution. The geophysical information allowed me to demonstrate that the reservoir was clearly imaged by both 2-D and 3-D seismic. The easily available production data on the field and wells is a time saver."

Figure 19 shows relationship of discovery of Dietterich Field to Arroyo Field a Digital Petroleum Atlas field study.
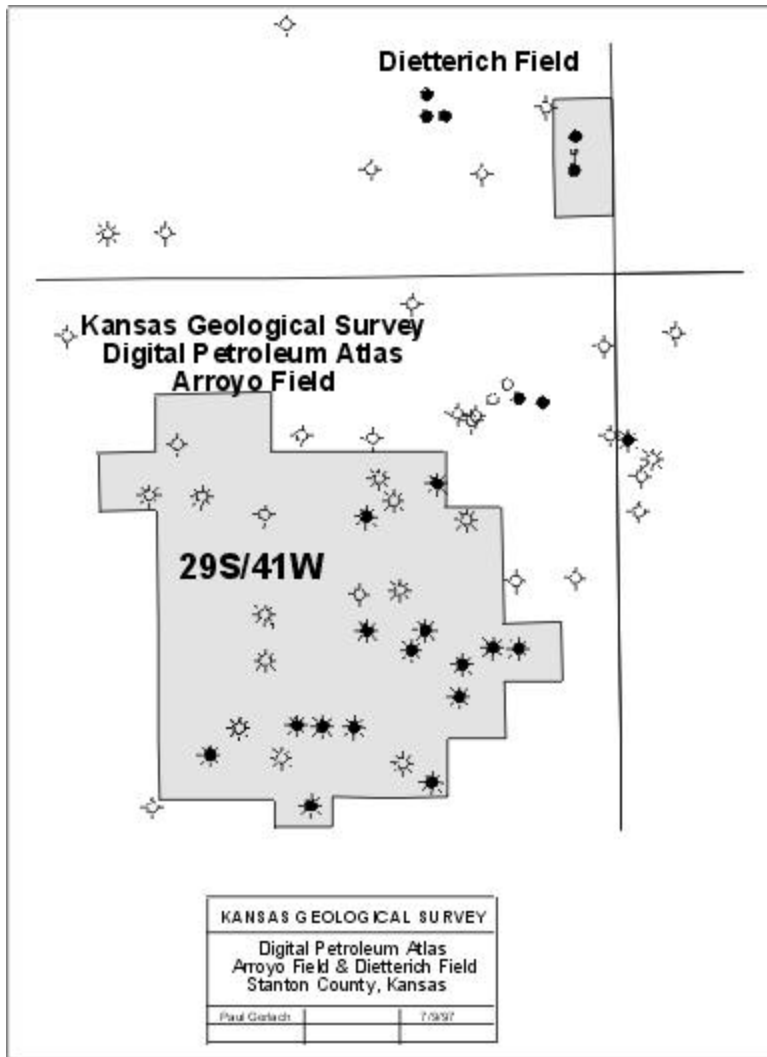
Figure 19. Relationship of discovery at Dietterich Field to Arroyo Field a Digital Petroleum Atlas field study. The information in the DPA was used as an analog in assisting discovery.