DEVELOPING A WORK FLOW FOR CREATING A DATA PORTAL FOR THE EAGLEBINE OIL AND GAS PLAY

An Undergraduate Research Scholars Thesis

by

WILLIAM NIVEN

Submitted to the Undergraduate Research Scholars program
Texas A&M University
in partial fulfillment of the requirements for the designation as an

UNDERGRADUATE RESEARCH SCHOLAR

Approved by
Research Advisor: Dr. Juan Carlos Laya

May 2016

Major: Geology

TABLE OF CONTENTS

ABSTRACT

Developing a Workflow for Creating a Data Portal for Eaglebine Oil and Gas Play

William Niven
Department of Geology
Texas A&M University

Research Advisor: Dr. Juan Carlos Laya
Department of Geology

The oil production in Texas is growing rapidly with the discoveries of new methods such as Hydraulic Fracking and discoveries of new Oil Plays like The Eagleford Shale Play. The growth is so fast and so large that great amount of data is being produced every day. The ability to compile and research this data is very limited. This is the problem that we are attempting solve by creating and managing a workflow on how to gather and input geological, geophysical and geographical data into a database that will support research from several departments at Texas A&M University. This workflow comprise different stages. First, collecting data from various sources. Second, the data sorting and formatting. Third, the database creation. After the data is transformed into a 2D and 3D interactive webpage that allow the data to be accessed by the users. The advantage of this database is to combine resources from different departments on campus to use this data for research. This instrument will be useful in obtaining data for projects in an oil and gas play area. However the lack of help from industry and problems with free data available to the public can present a challenge. If user do not upload processed data files then the growth of files would be hampered.

ACKNOWLEDGMENTS

I would like to thank Dr. Dan Goldberg and Aaron Harmon for the creation of the web based data portal, Dr. Walt Ayers for the well logs contributed to the data base and Dr. Carlos Dengo and Dr. Juan Carlos Laya for guidance and direction.

CHAPTER I

INTRODUCTION

Within the last decade unconventional resource plays have been an important part of the oil and gas industry. Much of Texas's economy relies on the oil industry. As of 2014 Texas produced about 40% of the oil in United States (Smith 2015). The ability for researchers to have access to well logs and other forms of subsurface data is very important. There are over one hundred thousand well logs within the State of Texas. The large drop in oil prices has reduced production in many formations around the United States such as the Bakken in North Dakota and the Permian Basin in west Texas. The Eagle Ford in south Texas seems to be producing more. Predictions indicate an increase in production of barrels per day (bbl/d) from roughly 133,000 bbl/d in November to about 159,000 bbl/d in January 2015 (Ageton and Krane 2015). In Brazos County alone there are over 2000 well locations (Figure 1). The volume of this activity involves huge investments. For the reason industry, academic, and other researchers are in need of a better understanding about these unconventional plays. Easily accessible subsurface data from Texas will help discover and develop new ways to be more efficient in producing more oil and gas from those reservoirs.

Objectives

The objective of this project is to correlate, integrate, manage and store geological, geophysical and geographical data of well bores within the State of Texas into a functioning web based data portal and to eliminate the problem of lacking subsurface data. The creation of a work flow to construct and manage the data portal and a work flow to develop a project with the data is a vital part to the creation of the data portal. This will greatly reduce the amount of time and resources spent by users of this information while researching the geologic and geographic topics.

The reduction of time and resources will be based on the easy access to a vast amount of data stored on a server accessible by the internet. The availability of having access to subsurface data should fix the problem that limits making subsurface models and interpretations (Enge et al., 2007). Researchers will be able to access at no cost several different types of data from a continuingly growing database. They will also be able to use the data portal as a tool for simple tasks such as mapping, measuring distances, comparing images of well logs and other simple tasks. The database will be continuingly growing by the users themselves adding data they compile or gain access to.

The advantage of this database will be reducing costs to acquire data multiple times from third party companies. An additional advantage will be helping research collaborate by faculty and students in different academic departments. The data portal will contain almost a well log from almost every well bore in the State of Texas. The main focus of this study will be the Cretaceous intervals including Eagle Ford and Woodbine Formations and Paleozoic formations in the Permian Basin. Data from other plays could be added in the future. The Railroad Commission of Texas has a similar database, but lacks the tools and user friendliness of this data portal.

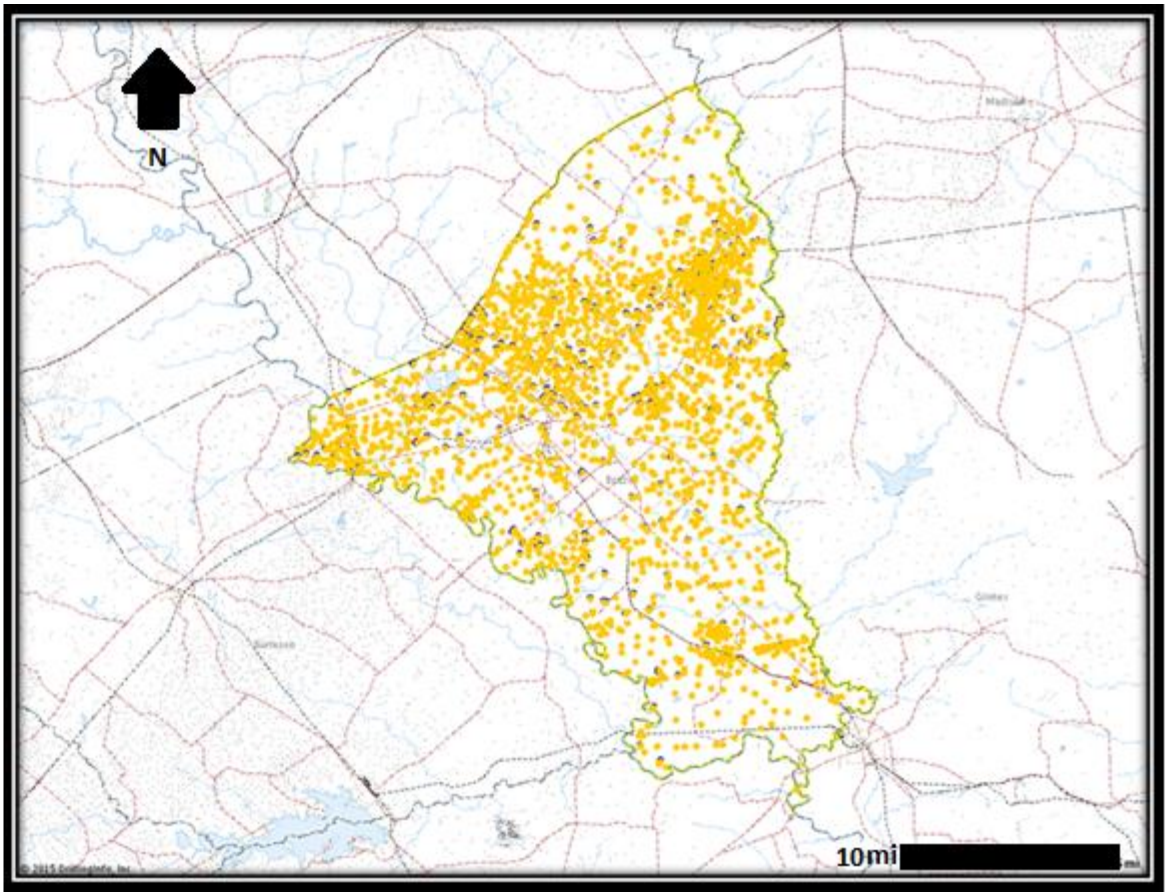

Figure 1: Map of well locations in Brazos County limited to just 1000 wells (from Drillinginfo.com)

There are several commercial companies that have data available for purchase such as Drillingingfo.com. There is free data made available to the public from the Texas Railroad Commission (TRRC), but it also has deficiencies in the data offered. The creation of the a database with an abundance of data that can be updated, expanded and used for free by Texas A&M faculty and students would greatly impact the amount of research conducted in the areas of interest.

Geological background

The major "plays" included in the database are the Eagle Ford of south Texas, the Eaglebine of east central Texas and the Permian Basin in west Texas. A Play is a term used by oil and gas industry to name a specific geologic region that will has potential for exploration and to produce natural resources for economic gains (Rahm 2011). The Woodbine and Eagle Ford are groups. A group is a lithostratigraphic unit consisting of formations as defined by the North American stratigraphic code. The Woodbine Group is an Upper Cretaceous coarse siliciclastic sedimentary unit in the East Texas basin that thins eastward toward the Sabine Uplift (Hentz and Ambrose 2014).

The Eagle Ford Formation is formed of shale, and carbonate mudstones and wackestones that filled shallow basins during the Late Cretaceous period in South Texas (Carr and Adams 2010). It has a subsurface depositional sequence of two members. The upper member is a retrogradational and the lower is progradational (Donovan and Staerker, 2010). The Eagle Ford has been known for years as a shale resource rock, but with advances in horizontal drilling and hydraulic fracturing it has only recently become a viable play for production (Mullen 2010). The boundary between the Eagleford and Woodbine is a region that contains the Eaglebine Play (Figure 2). The Eaglebine is a combination of the Eagle Ford and Woodbine together. It is a subsurface distribution of both groups. It is comprised of Turonian Eagle Ford Group, siliciclastic facies of Maness Shale and Woodbine Group (Ambrose, Hentz and Smith 2014).

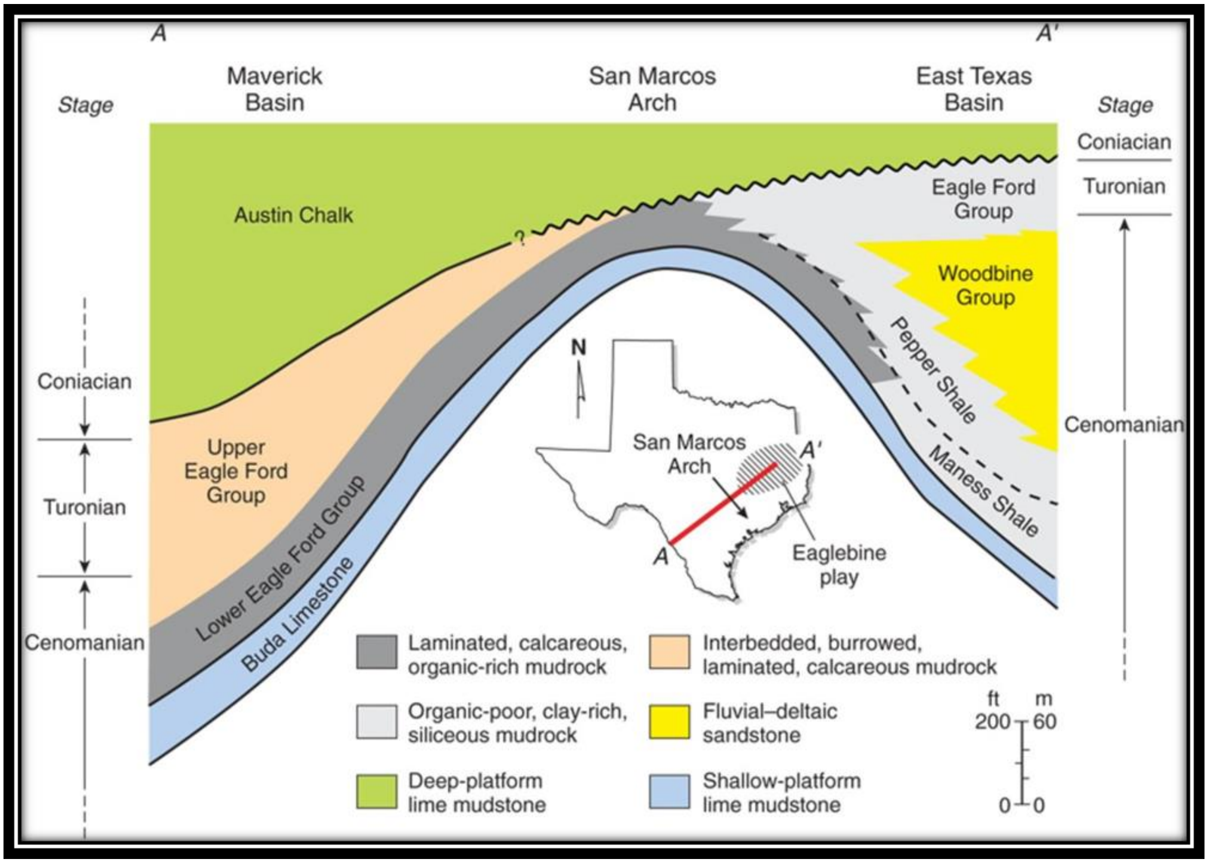

Figure 2: Illustrated cross section of lithostratigraphic and facies relationships across Eagle Ford Group (Ambrose and Hentz, 2014).

The Eaglebine play is bound to the west by the Mexia-Talco Fault Zone, on the east by the Sligo Shelf Margin, the south by the San Marcos Arch and the north by the East Texas Basin and Sabin Uplift. (Ambrose, Hentz and Smith 2014). The Stratigraphic boundaries are the upper limit being the Austin Chalk and the lower limit being the Buda Limestone formations (Figure 2) (Adkins and Lozo 1951).

The Permian Basin lies in west Texas and New Mexico (figure 3) and was first discovered to have oil in 1921 (Ward et al., 1986). It produces roughly two million barrels of oil per day and is the most productive tight oil province in the United States (Engle et al., 2016). It is a vital part of the Texas economy.

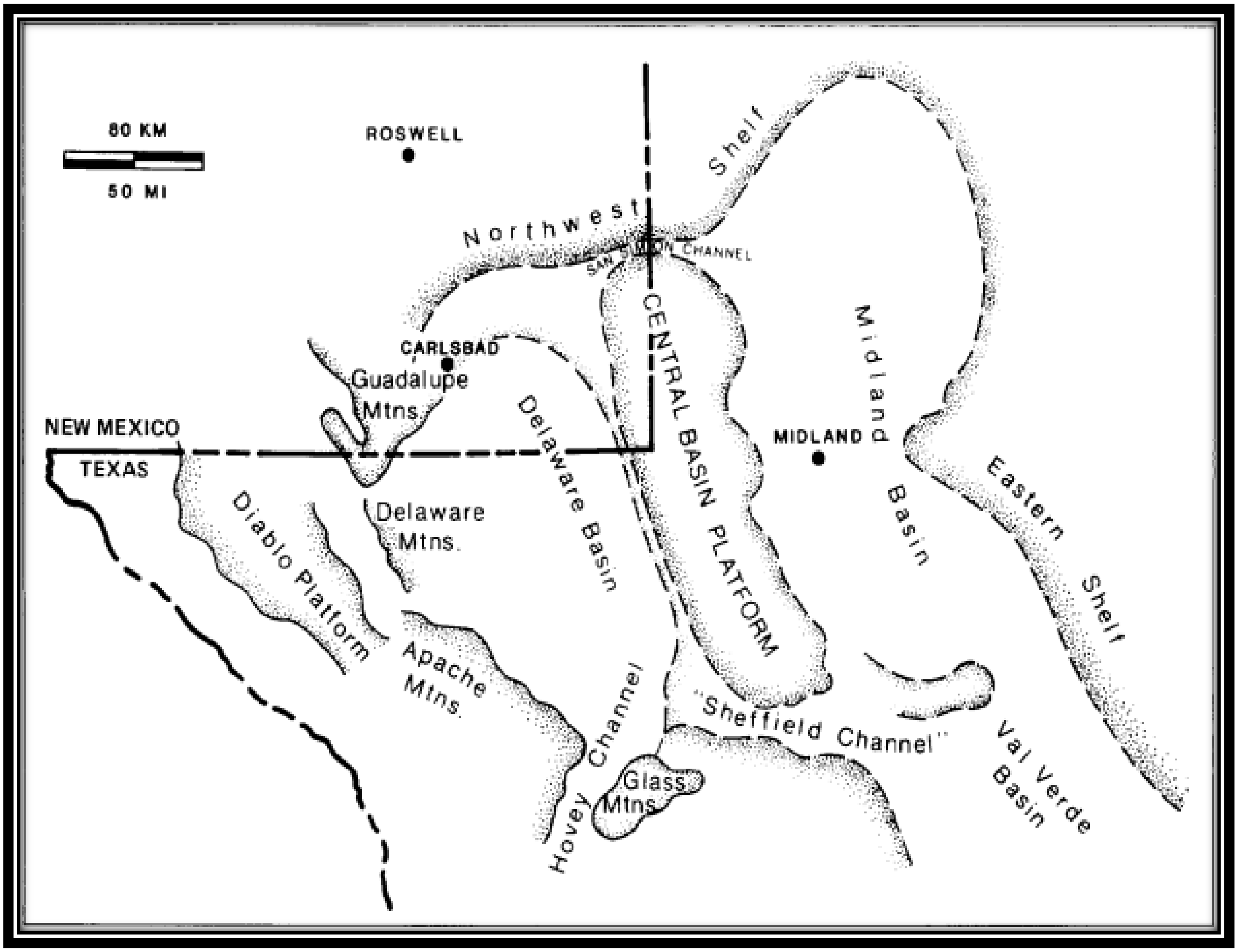

Figure 3: Map of the Permian Basin showing large scale features shown by using subsurface studies and exposed strata. (Ward et al., 1986)

CHAPTER II

METHODS

A series of activities are part of this project including: 1) data mining to compile a vast amount of different data types from several resources, 2) data storage to keep the data types in a secure and organized server that will be accessible and 3) Interface display construction which will design the interactive data portal for users to be able to retrieve the data they need to use for research.

Workflow

The work flow created consists of two categories. The first is a process to construct and manage the creation of a database for the Eaglebine Play and the second is a process to develop a project from data gathered from the database. These processes are connected by a step that allows user to input processed data back into the database.

Process to construct and manage the creation of a database

The first step in constructing the database is to select an area or areas of interest in which the database will cover. This will reduce the amount of data needed to be stored and increase the focus on the area. Second, collect reliable data from the area. To ensure data is usable it would be checked for quality, usefulness, the information is true. Then store the data and display it on a web based platform. Managing the database is done after construction. It is to make sure that users can continue to access data and make sure newly added data is reliable. To make sure the users have access to data the website will be periodically checked for functionality. If there is a problem it will be fixed in a timely manner. Also if there needs to be updates to fix bugs or to improve functionality this will be done. When users import data back into the database it will be checked for quality. This means that is will be checked to make sure the API number, location, what type of measurements, formatting and other criteria are correct (Figure 10).

Process to develop a project from gathered data

The first step in developing a project from the acquired data is to select the area of interest. Second, select data by filtering data by what is needed. There are tools available to help narrow the search result to specifics of what type of data is need. Once the data is selected then download and process data if it has not already been processed. Once the data is processed then input the new form back into the database. Once submitted it will go through a quality check and be entered in. Once the data is processed use an interpretation software or method to complete project (Figure 11).

Data mining

Data mining is a process of gathering useful data from databases (Pujari 2001). It can be done manually or by writing a script to do it automatically. When the project first started manual data mining was done to gain a few different types of data to make a prototype model of the data portal. There are three sources of data: 1) drillinginfo.com (DI), 2) Texas Railroad Commission (TRRC) and 3) Industry. While using data from these sources they were labeled from the source from where they came. Labels were placed on them to create the platform of the database, for use of the public.

Drillinginfo.com (DI) is a web portal which is an oil and gas data provider. This is where industry companies can purchase various sets of data to be used for exploration. Credits were issued in an account for research use by the Berg Hughes Center. While using DI there were specific criteria put in place for data downloaded. The criteria was data had to be in digital format and within our defined boundaries of the Eaglebine Play. Gathering data from DI helped reduce the amount of data needed to be purchased and sorted through and gave a building block for the design of the platform (Figure 4).

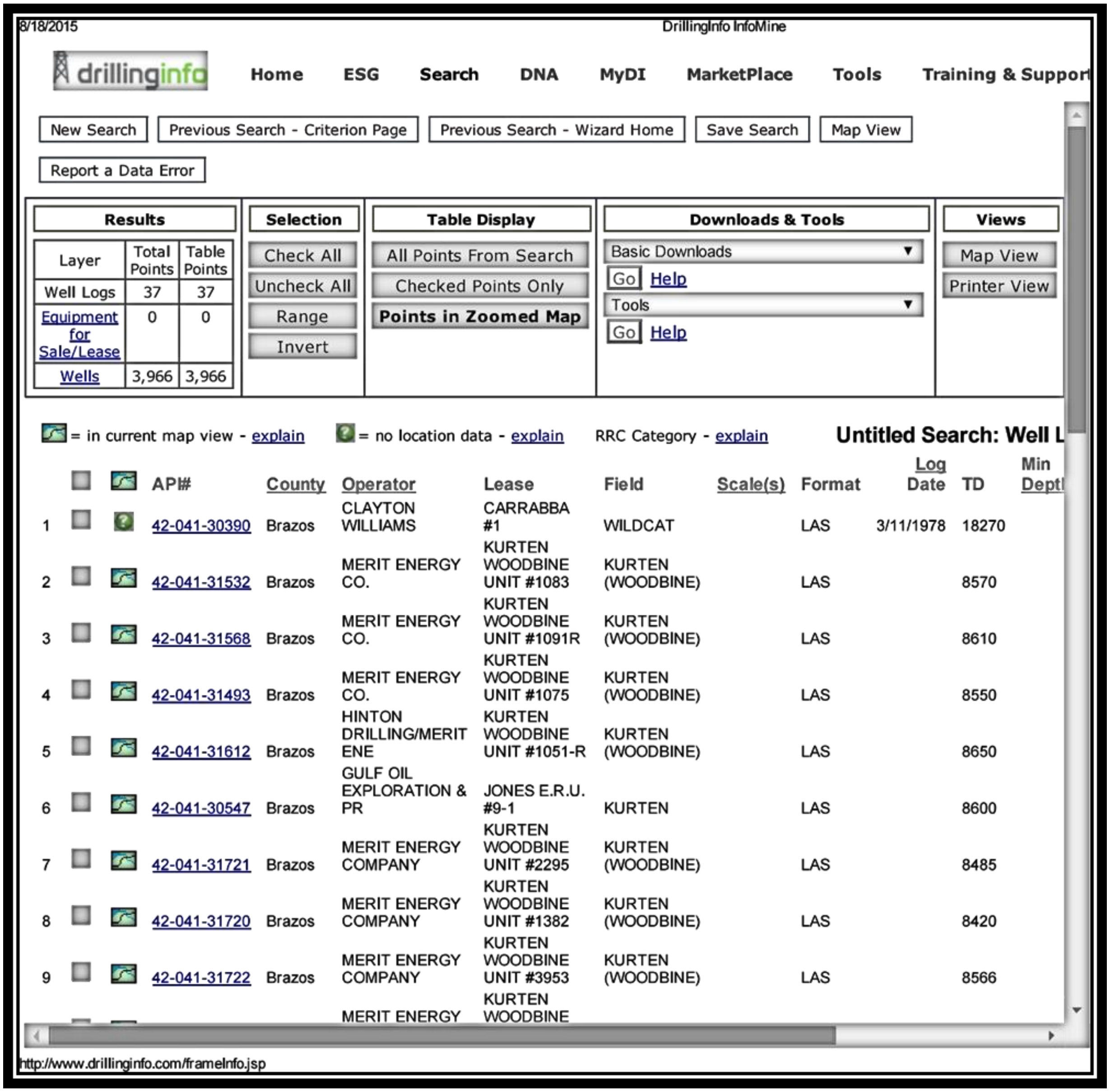

Figure 4: Screen shot of Drillinginfo.com search page (Drillinginfo.com)

TRRC is the Texas State Agency that regulates and enforces natural resources in the state. TRRC makes well logs, production data and other information available to the public. They have an online database that houses over hundred thousand well logs. The bulk of the data obtained during this project came from them whether it was purchased or manually downloaded off their website. The files are then named after their API number which is a “unique, permanent, numeric identifier assigned for identification purposes to a wellbore" (Railroad Commission of Texas, 2015).

TRRC provided the GIS information for the wells used in this project. It is an excel file with API number, latitude, longitude, depth, start date and other information. The State of Texas owns property that they lease out to companies to operate on. This is called the University Lands Program (ULP). Since it is publicly owned land everything done on the land is open to the public. They provide a GIS Shapefile that has all their locations and well logs. This has been added to the system and is very helpful since a lot of the wells are in the Permian Basin which is a highly sought out area of research.

Data types

Data types stored in the data portal are be well logs, production data and locations of a vast amount of wells in Texas. The different types of data are used for various type of work. With a database containing all of them it is easier to integrate data and correlate trends. A well log is a log of measurements that are measured using several different types of tools that can either be placed in an open bore hole after drilling or logging while drilling (LWD) tool which is used to make measurements while drilling. There are also other types of tools available for use. Well logs are attached to a well bore by the unique API number. API numbers are the main and most common way of identifying a well bore.

The logs are normally measured by depth, time or both. There are several different measurements that can be taken. The main categories are electrical resistivity, spontaneous potential, electromagnetic propagation, nuclear, nuclear magnetic resonance, acoustic, dipmeter and imaging, formation testing and sampling, and seismic. There are several sub different measurements within these. (Anderson 2011) Not all measurements are done for every well. The measurements are done on a needed basis. The most common and useful measurements for geological study are electrical resistivity, gamma ray, porosity and seismic.(Figure 5) These measurements are done and recorded on the well log for use after or during the drilling and production phases.

Electrical resistivity can be used to find oil and gas reservoir content and formation characteristics (Archie, 1942). Electrical resistivity is the measurement how electrical current is conducted through rock layers. The pores in the rock filled with different ratios of saline water and various other liquids such as oil or gas hydrates. The rocks layers themselves also can have conductive properties. The different ratios will give off the resistivity of the electrical current. This measurement can be interpreted by hand or by software to determine different rock units, porosity, and existence of gas hydrates or oil within the section that has been drilled (Collett 2001).

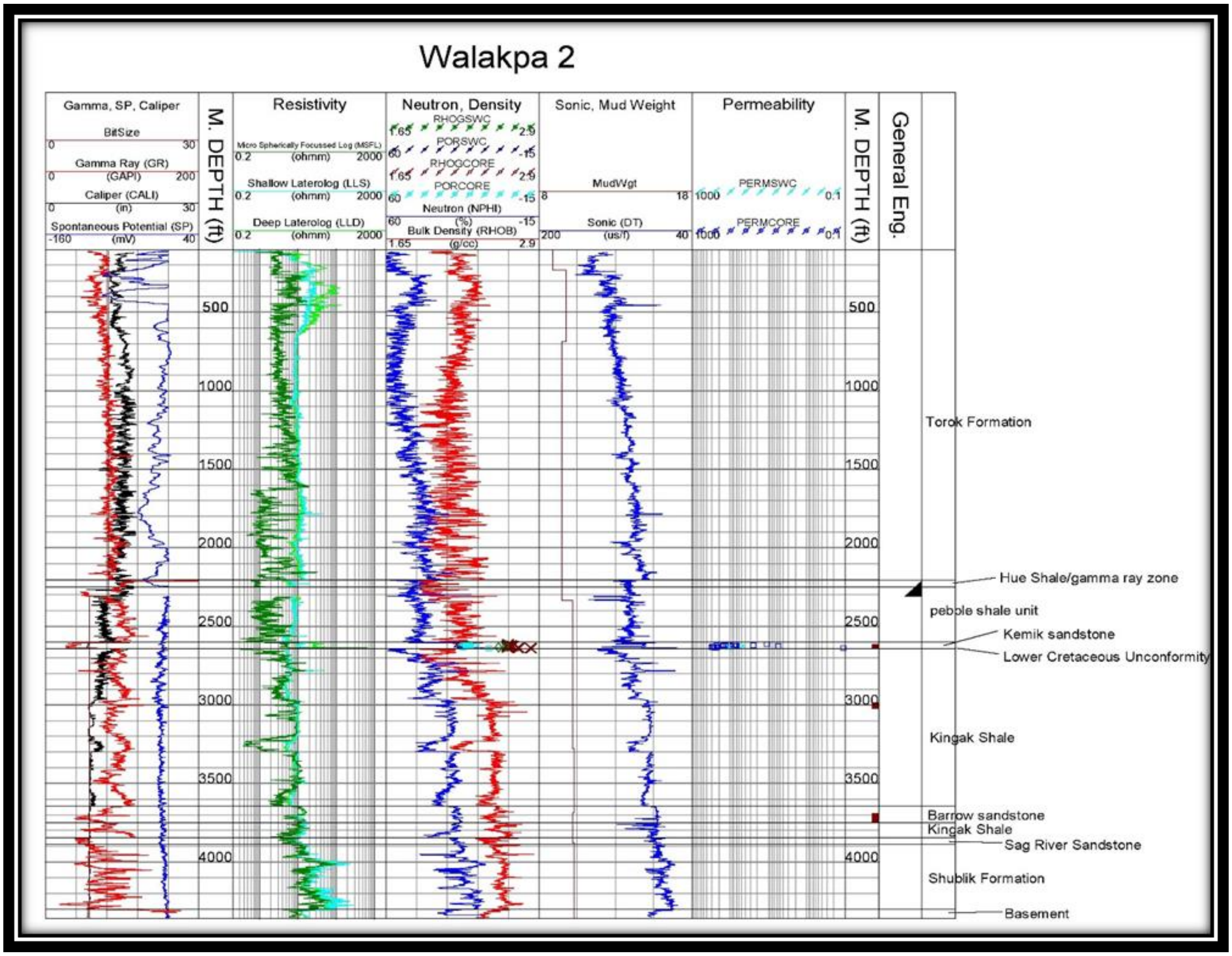

Figure 5: Example of a well log showing the various measurements from well bore Walakpa in Alaska (http://certmapper.cr.usgs.gov/data/PubArchives/OF00-200/WELLS/WALAKPA2/INDEX.HTM).

Porosity is the amount of open space within a rock or formation. The inside the pores is how fluids travel or are stored. Different rock types how different porosities. A sandstone will have a higher porosity than a shale. Neutron measurements or sonic logs are an effective way of gathering porosity although they may over estimate porosity in clay rich coal (McNally 1990). Sonic logs use sound waves to determine compressional wave velocity differences. The way sound travels through a rock can determine porosity and minerals with the rock. This measurement is one of the most affect because it directly measures the primary wave and does not estimate from empirical relationships like other measurements. (McNally 1990). Neutron logs use neutrons to determine the hydrogen ion and water content of the rock by emitting neutrons from a source and counting them with a detector.

Well logs contain measurements from a specific well bore. Each well bore is has a unique API number. Measurements are stored on a well log which interpreted by geologists to determine the different rock layers the well bore has drilled through. The well logs stored in the data portal are mostly Tagged Image Files or more commonly called tiff which is an image file. The image file can be turned into a Log ASCII Standard (LAS) text file and uploaded into interpretation software such as Schlumberger's Techlog and other industry standard software. This software allows multiple well logs to be interpreted at once. There are tools within to be able to draw and map tops and bottoms of formations to determine several characteristics of a formation.

Types of files to be stored

Tiff images of well logs from bore holes throughout Texas are stored in the data portal to allow quick access to them for researchers. Users will be able to view the well log image and determine if they can use it. Users can download the image and use a program Neuralog to convert the image into a .LAS file. The capabilities of storing PDF, excel and text files will be available. PDF files which are image files will be available. These can hold various amount of information such as potential drill sites. Text files will hold data such as LAS. Excel files will be available for download. Users will be able to select an area and download the basic well information such as API, latitude, longitude, county and several other useful information. The users will also be able to upload various information back into the database such as the LAS so others who wish to use that well log do not have to do the process of converting. This will keep the database constantly growing with help from the users.

Data storage

Data will be stored on servers within the College of Geosciences at Texas A&M. The Berg Hughes Center will be the owner of the server. The server will have 5 terabytes of storage which will be ample amount to store the over 100,000 well log images, texts and other well data. A standard well log tiff image is 1500 kb. The total storage of the images will be 0.13 TB. The servers will be accessible through a web based platform. There will be security in place so only Texas A&M students, faculty and staff may access the general records. There may be additional security for the well data provided by private companies, so their information is safe and not taken by competing companies.

Geographic web-based portal

The web based portal will be a user friendly interface that is accessible only to Texas A&M students, faculty and staff. The platform has been designed to make searching for well data fast and easy to understand. The user will see a map of Texas displaying all locations by API number that have data correlated with them. The data will be displayed by colored points (figure 7) and will have their data displayed on the right of the screen when user selects a certain point. The user will be able to select points and obtain the latitude and longitude associated with the well and load them into ArcMap to use the data (figure 6).

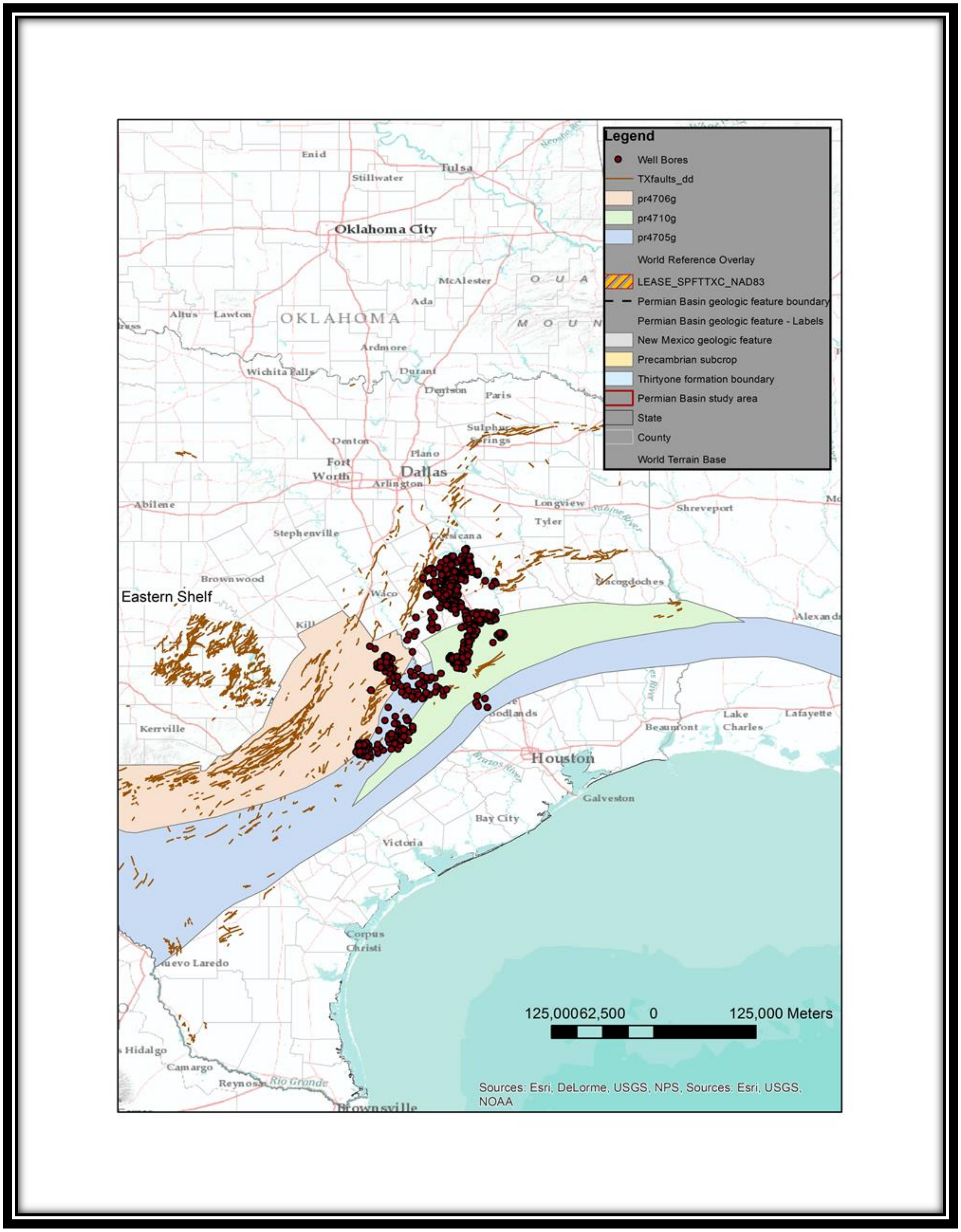

Figure 6: Screenshot of ArcMap 10.3 layout displaying well bore locations, faults and other geological data

There will be options of placing overlaying layers. A layer is a shapefile that has been made to visually distinguish geographical, geological or other boundaries. This will help the user narrow down their search. Once the user has identified the point they want to see they will click the point and can get view the well log image or download it. ArcMap 10.3 which is a program that integrates mapping and spatial data to create an interactive map. This map created with the latitude and longitude of the wells is the background of the web platform. The latitude, longitude and API number are entered in with and excel document.

There will be tools within the platform to enhance the usability of the data portal. Users will be able to draw, measure, upload or create their own layers, and compare images. There will be a search engine that will allow users to quickly find a well if they know the API. They will also be able to use criteria to narrow wells based off certain factors. The database will be continuing its growth through administers and user input. There will be a tool in place that may not have functionality at the beginning. The tool will be a compare to that will allow users to see side by side measurements from two different points. Users will be able to select an entire area and download all well data within that area. This will greatly speed up the process of obtaining well data.

CHAPTER III

RESULTS

The portal displays a map of the world, but is fixed on the State of Texas with points depicting where well bores with supporting well data are located (Figure 7). There are options to have several different map layers overlain such as a geologic of Texas map, structure map, and major plays such as the Eagle Ford and Permian Basin onto the digital map. Tools have been created to help efficiently speed the process of filtering well bores that meet certain criteria created by the user.

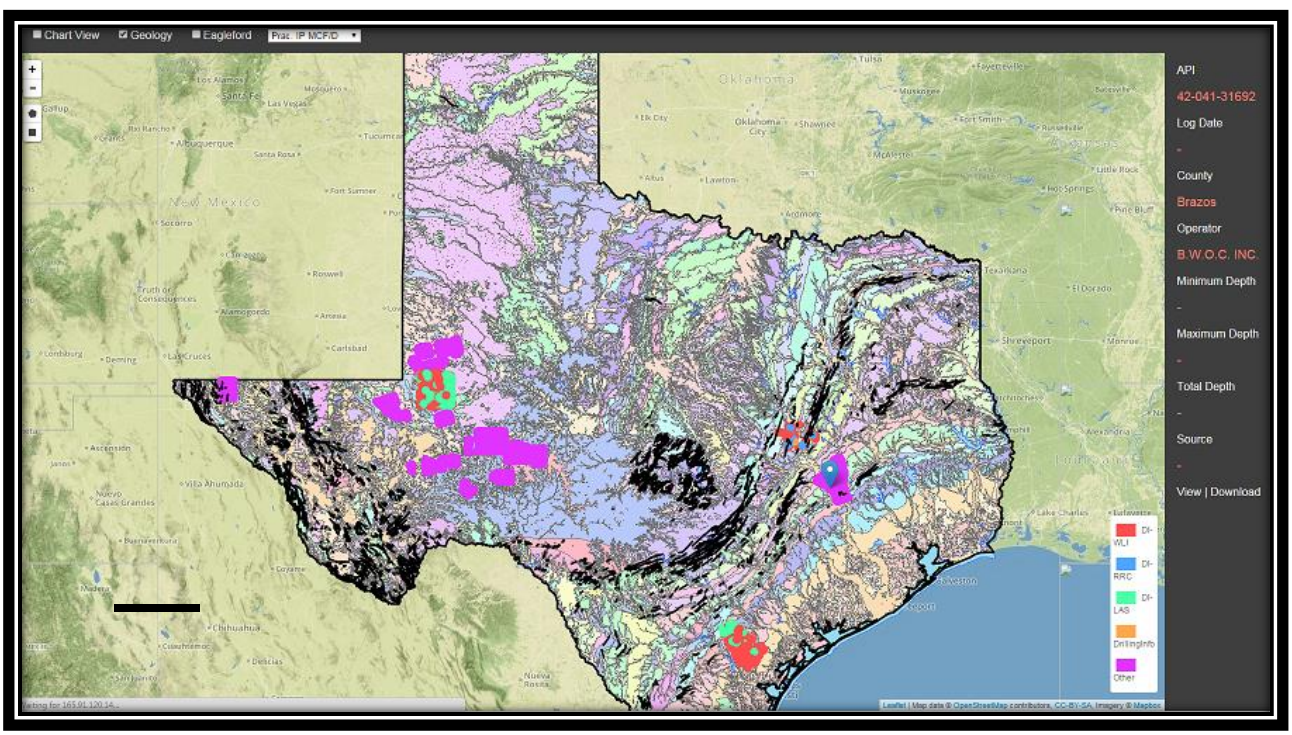

Figure 7: Screenshot of web page displaying points depicting locations of well locations. On the right of the screen is general information from the selected such as API number, maximum depth, log date and the operator of the well.

The web based portal is able to collaborate and integrate subsurface data, production data, and geographical surface data between the Colleges of Geoscience and Engineering very smoothly and efficiently. The database has created a centralized location for subsurface data for multiple departments. The centralized database will increase the access to well data availability throughout the departments. This has increased access to data sets that has been purchased or donated and also allows data sets to have continuous use after the original recipient has finished. This allows data sets to be able to be used after the obtainer leaves, graduates or finishes project. This has reduced the problem of lacking access to subsurface data to make subsurface models and interpretations.

This portal has shown to be more than just an online data base. It has become a tool that can be used to further research by being able to effectively increase the amount of usable data by being able to search by certain criteria such as depth, location and production (Figure 8). The tools available allow use prefabricated geographic and geologic layers to filter data. Geographic layers include geographic boundaries of formations and plays. Geologic layers are going to include interpreted formation tops and structure maps.

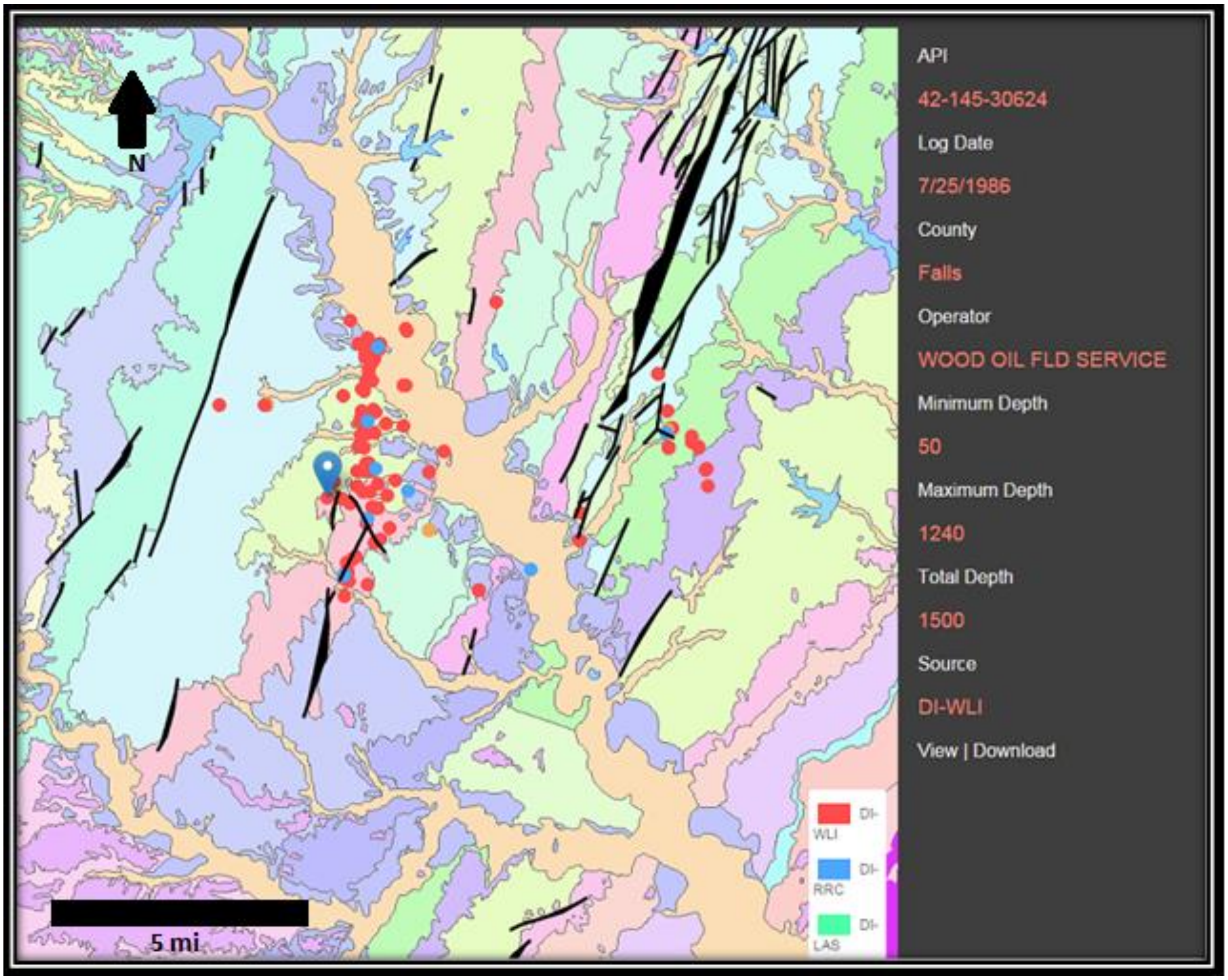

Figure 8: Screenshot of webpage displaying well locations in Falls County, Texas with underlying geological units and general information displayed to the right. The wells are colored by the source of the data.

These tools and data storage make this data portal a useful tool for researching geology, geography, geophysics and petroleum engineering in the State of Texas. It will prove to be a valuable asset for many years as it will continue to evolve for the growth of the studied areas. The growth of the data base will increase by letting users upload well data they have acquired or have digitized.

A correlation project has been done with gamma ray well logs found within the database by using the work flow to develop a project with gathered data (Figure 11). The well logs were in LAS format and were easily uploaded into an industry software called Petrel. Using five well logs from Brazos County, Texas and the interpretation tools within Petrel a top and bottom was created for the Austin Chalk (Figure 9).

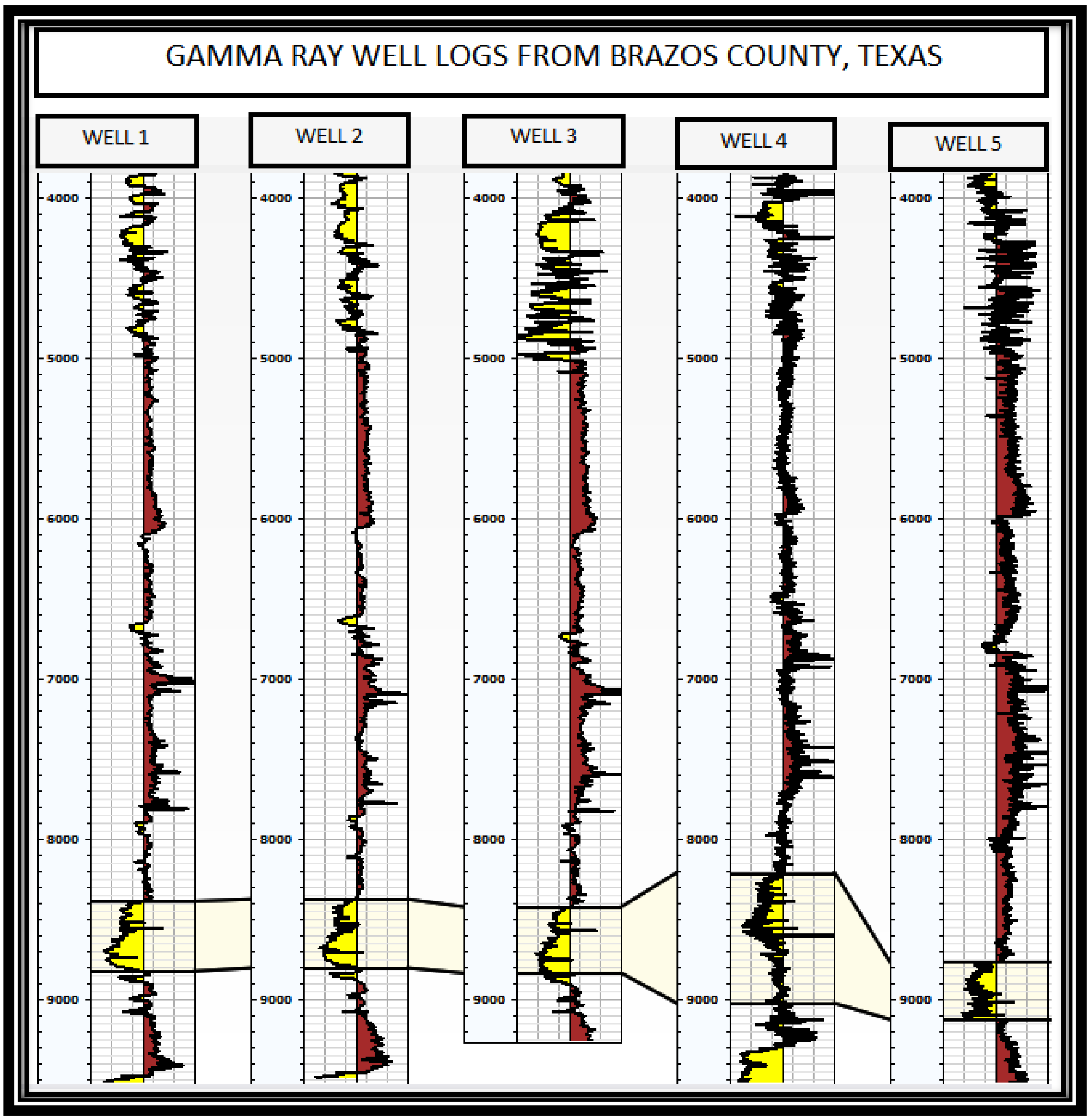

Figure 9: A well log correlation using commercial software with data from database. This correlation shows the top and bottom of the Austin Chalk in Brazos County, Tx.

There are a few potential issues that may occur for the work flow and managing of the data base. The selected areas may not cover all the wells that are of interest. Since not all wells have the same type of measurements taken there could be a problem of finding wells that fit certain criteria. Users that download data that needs to be processed may not put the processed data back into the database. Subsurface data may not be available for all areas being covered by the database. Users that download data may not adhere to the rule of not publishing exact data such as API number and exact location. This would result in a violation of copyright laws. Industry software may change to using other file forms.

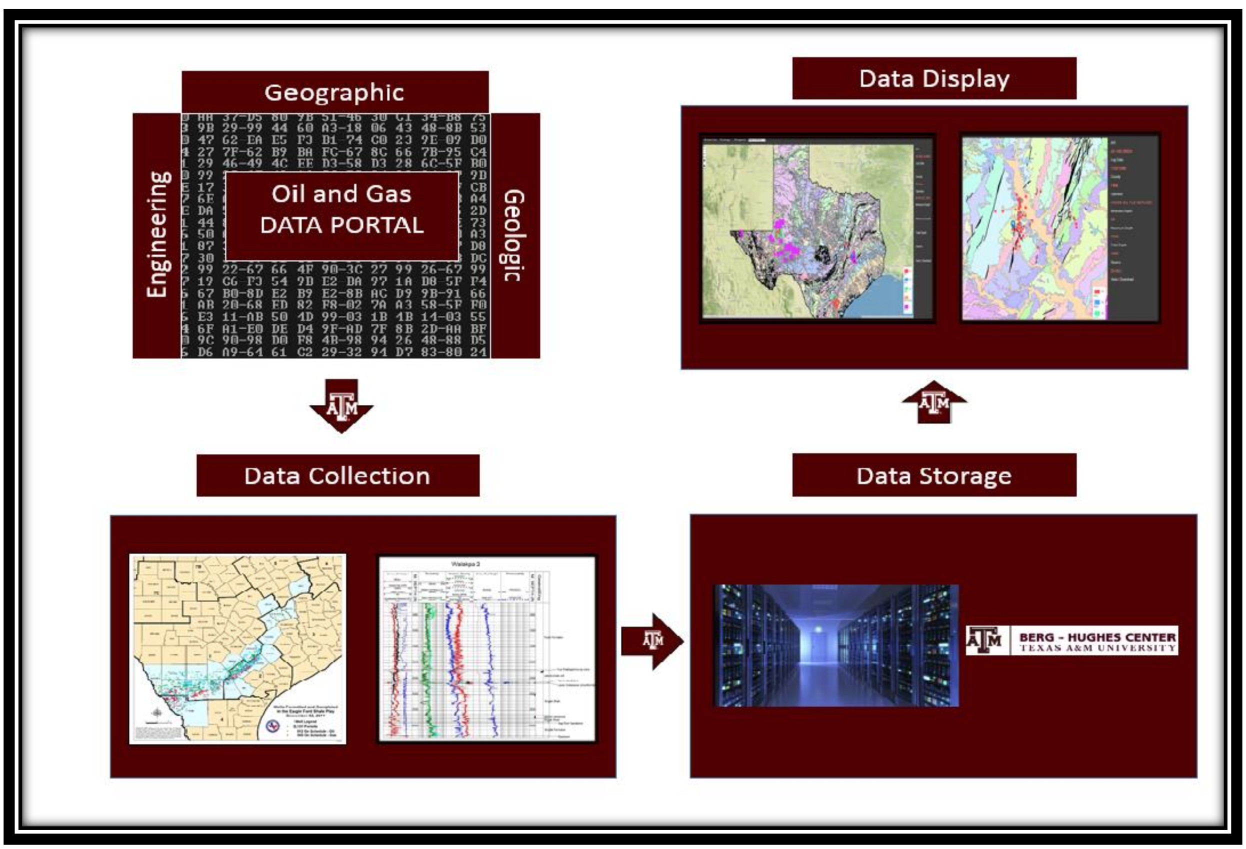

Figure 10: A work flow chart depicting the steps for creating a database for an oil and gas play. Starting with the bottom left corner and going counter clockwise. First is data collection, second is storing the dataset and third is displaying the data and making available for download.

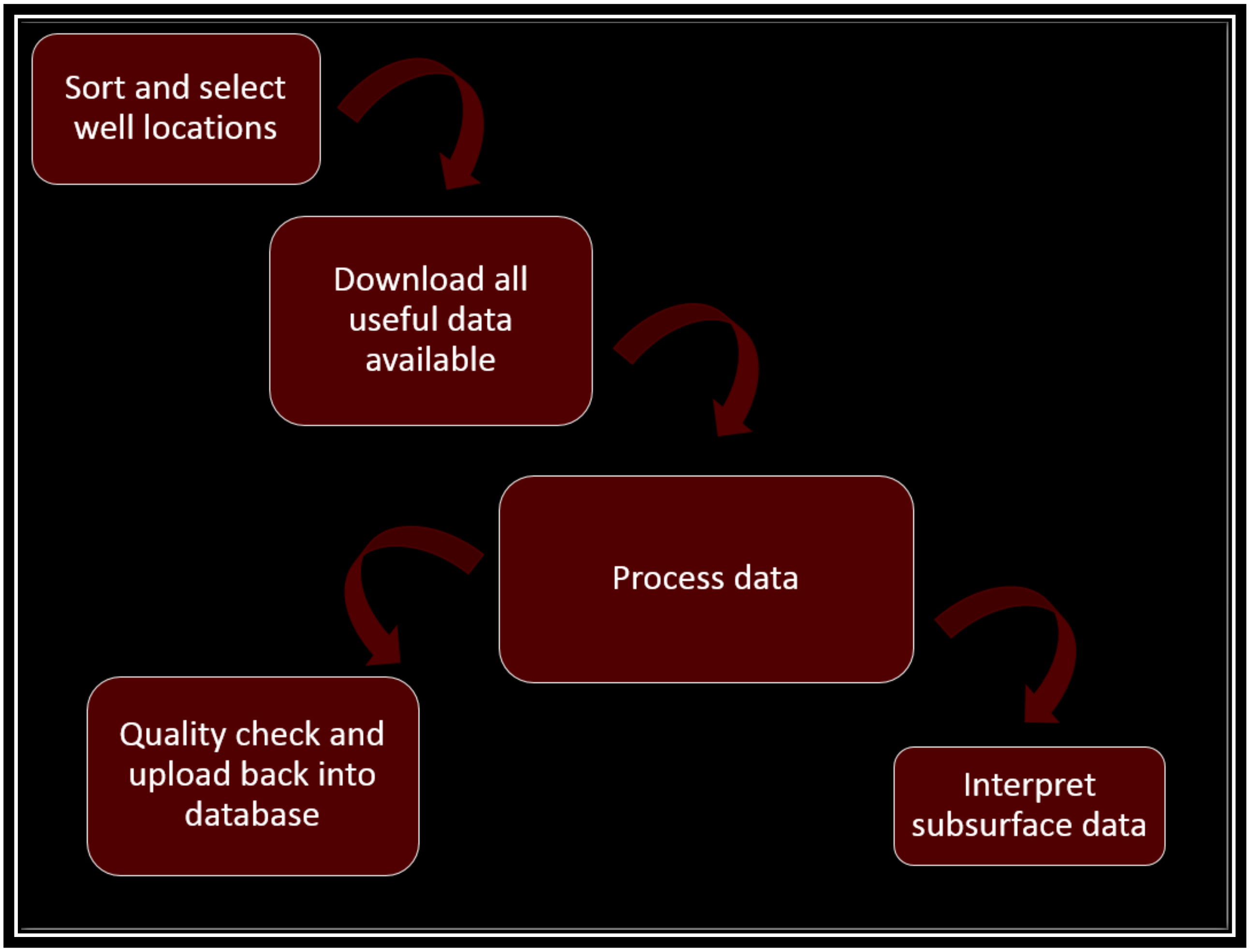

Figure 11: A work flow depicting the process of developing a project from gathered data. First select and sort well locations based on criteria, second download all the useful data for the criteria such as subsurface, production, seismic and geographic, third process the data so that it can be uploaded to industry interpretation software, if data must be processed upload the data back into the database for quality check and last interpret the data for the project.

CHAPTER IV

CONCLUSIONS

The work flow created (figure 10) has produced a database that is capable of delivering a web based data portal that can effectively and efficiently display data associated with major play areas in Texas. The database has user friendly tools that help expedite the process of selecting well data for research. Now data can be easily shared amongst researcher at Texas A&M when the database becomes available online in the summer of 2016. The process of allowing users to input data into the database will allow the growth of the available data and allow access to data that may not have been known previously. Online access now allows for direct data download and eliminates having to put data unto a flash drive to transfer it from one computer to another. The correlation project shows that subsurface data after downloading is easily put into industry software for interpretation.

REFERENCES

Adams, R. L., & Carr, J. P. (2010). Regional depositional systems of the Woodbine, Eagle Ford, and Tuscaloosa of the US Gulf Coast.

Adams, R. L., Carr, J. P., & Ward, J. A. (2014). The Lower Woodbine Organic Shale of Burleson and Brazos Counties, Texas: Anatomy of a New "Old" Play.

Adkins, W. S., & Lozo, F. E. (1951). Stratigraphy of the Woodbine and Eagle Ford, Waco area, Texas.

Anderson, M. (Ed.). (2011). Discovering the Secrets of the Earth. Oilfield Review, 60-61.

Archie, G. E. (1942). The electrical resistivity log as an aid in determining some reservoir characteristics. Transactions of the AIME, 146(01), 54-62.

Collett, T. S. (2001). A review of well-log analysis techniques used to assess gas-hydrate-bearing reservoirs. Natural Gas Hydrates: Occurrence, Distribution, and Detection, Geophysical Monographs, 124, 189-210.

Donovan, A. D., and T. S. Staerker, 2010, Sequence stratigraphy of the Eagle Ford (Boquillas) Formation in the subsurface of South Texas and outcrops of West Texas: Gulf Coast Association of Geological Societies Transactions, v. 60, p. 861-899.

Enge, H. D., Buckley, S. J., Rotevatn, A., & Howell, J. A. (2007). From outcrop to reservoir simulation model: Workflow and procedures. Geosphere, 3(6), 469-490.

Engle, M. A., Reyes, F. R., Varonka, M. S., Orem, W. H., Ma, L., Ianno, A. J. & Carroll, K. C. (2016). Geochemistry of formation waters from the Wolfcamp and "Cline" shales: Insights into brine origin, reservoir connectivity, and fluid flow in the Permian Basin, USA. Chemical Geology, 425, 76-92.

Hentz, T. F., & Ambrose, W. A. Stratigraphic and Depositional Context of the Eaglebine Play: Upper Cretaceous Woodbine and Eagle Ford Groups, Southwestern East Texas Basin. In Southwest Section AAPG Annual Convention.

Hentz, T. F., Ambrose, W. A., & Smith, D. C. (2014). Eaglebine play of the southwestern East Texas basin: Stratigraphic and depositional framework of the Upper Cretaceous (Cenomanian–Turonian) Woodbine and Eagle Ford Groups. AAPG Bulletin, 98(12), 2551-2580.

Home - Drillinginfo. (n.d.). Retrieved September 15, 2015, from http://info.drillinginfo.com/.

Krane, J., & Agerton, M. (2015). Effects of Low Oil Prices on US Shale Production: OPEC Calls the Tune and Shale Swings. Baker Institute Research Paper.

Mullen, J. (2010, January). Petrophysical characterization of the Eagle Ford Shale in south Texas. In Canadian Unconventional Resources and International Petroleum Conference. Society of Petroleum Engineers.

Nomenclature, S. (2005). North American stratigraphic code. AAPG Bulletin, 89(11), 1547-1591.

Oil and Gas Well Records - Online. (n.d.). Retrieved January 15, 2016, from http://www.rrc.state.tx.us/oil-gas/research-and-statistics/obtaining-commission-records/oil-and-gas-well-records-online/.

Pujari, A. K. (2001). Data mining techniques. Universities press.

Rahm, D. (2011). Regulating hydraulic fracturing in shale gas plays: The case of Texas. Energy Policy, 39(5), 2974-2981

Smith, N. (2015, January 13). Oil May Not Mess With Texas. Bloomberg View. Retrieved March 24, 2016, from http://www.bloombergview.com/articles/2015-01-13/oil-may-not-mess-with-texas.

USGS Open File Report 00-200: Walakpa 2 LAS-format Well Log Data. (n.d.). Retrieved January 15, 2016, from http://certmapper.cr.usgs.gov/data/PubArchives/OF00-200/WELLS/WALAKPA2/LAS/WA2LAS.HTM.

Ward, R. F., Kendall, C. G. S. C., & Harris, P. M. (1986). Upper Permian (Guadalupian) facies and their association with hydrocarbons--Permian basin, west Texas and New Mexico. AAPG Bulletin, 70(3), 239-262.