King Fahd University of Petroleum & Minerals

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Term Paper

GIS Applications in Petroleum Geology of North Afghanistan

CRP 514

Geographic Information System

Instructor: Dr. Baqer M. Al-Ramadan

Submitted by: Syed Haroon Ali

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Abstract:

GIS improves efficiency in field. Development of Afghanistan's oil and gas resources is essential to the country's economic development. As part of the current Oil and Natural Gas Project in Afghanistan, scientists with USGS have worked to obtain and review all available geochemical, geologic, seismic, tectonic, and petroleum exploration and production data in order to accurately characterize the country's petroleum geology. It was essential to make a GIS database to predict future of this country. In cooperation with the Afghanistan Ministry of Mines and Industry (AMMI), USGS has also undertaken a comprehensive assessment of undiscovered oil and gas resources. The assessment is based on the geologic elements of total petroleum systems defined in the geologic province. The goal of this paper is to apply the Geographic Information System in to petroleum geology. The predictable results of the project will be essentially organized and summarized by GIS data and tabular data composed in the digital format. The GIS data will help in choosing and then arranging the geologic data intelligently.

Introduction:

Afghanistan is a land of mountains and desert plains situated at the western end of the Himalaya range. It covers an area of about 647, 500 square kilometres and is bordered to the west by Iran, to the north by Turkmenistan, Uzbekistan and Tajikistan, to the east by China, and to the southeast by Pakistan (figure-1) (Wandrey, 2006).

Afghanistan has some of the most complex and varied geology in the world. The oldest rocks are Archean and they are succeeded by rocks from the Proterozoic and every Phanerozoic system up to the present day. The country also has a long and complicated tectonic history, partly related to its position at the western end of the Himalaya (see figure-1). This diverse geological foundation has resulted in a significant mineral heritage with over 1400 mineral occurrences recorded to date. Historical mining concentrated mostly on precious stone production, with some of the oldest known mines in the world believed to have been established in Afghanistan to produce lapis lazuli for the Egyptian Pharaohs. More recent exploration in the 1960s and 70s resulted in the discovery of significant resources of metallic minerals, including copper, iron and gold, and non-metallic minerals, including halite, talc and mica. The bedrock geology of Afghanistan can be thought of as a jigsaw of crustal blocks separated by fault zones, each with a different geological history and

mineral prospectivity. This jigsaw has been put together by a series of tectonic events dating from the Jurassic(figure-2) (Wandrey, 2006).

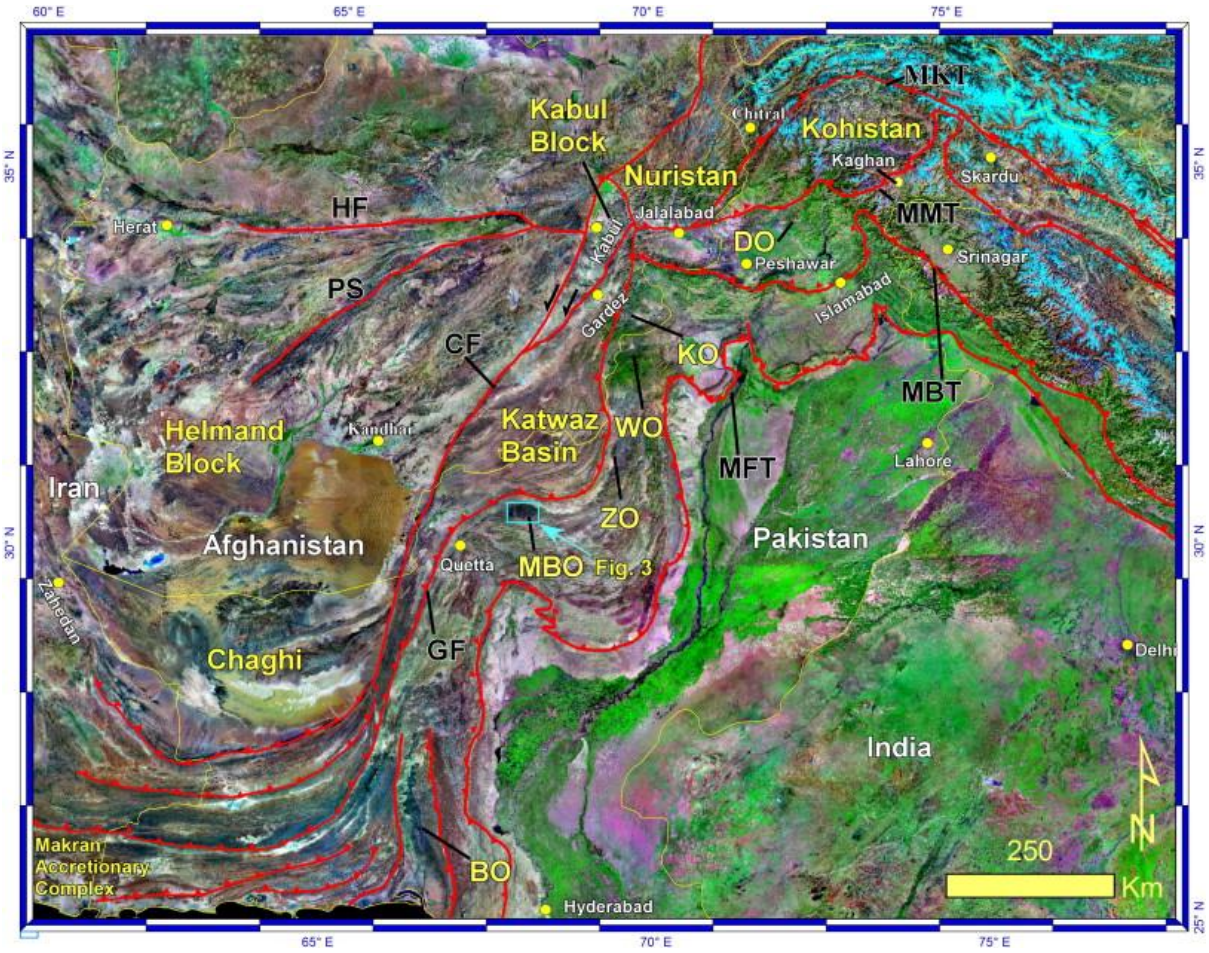

Figure 1.Landsat image showing the location of major structures in Afghanistan and its adjoining countries like Pakistan and Iran.

Problem Statement:

Afganistan is considered as new frontier for minerals and petroleum in the world. Especially for natural gas and oil (Ulmishek, 2004). And recently this topic gained enormous recognition in this region because of US interest in this area (Steinshouer et al., 2006). The data collected from the surface and subsurface give limited information because of varied terrains and it is hard to hold such and enormous amount of data. So the ArcGIS is used for the explorationist to predict the future efforts in this area based on important and useful parameters. The handling of data and production of model is quite difficult job.

Motivation Statement:

The limitation of techniques and difficulties to determine the detail of this project due to accessibility and political issues. The database gives information about rocks body dimension, size and orientation which is unavailable from the traditional surface maps. The well logs and seismic section are included give a sufficient knowledge about the understanding of the reservoir behavior. The direct benefit of such input is to improve exploration and development of hydrocarbon in this area. The key role of GIS in this aspect is to provide the best way of selecting the sites for drilling. In term of better viewing and exploring geologic data, arc scene is used. The main application is the production of smart maps that links the tabular information to graphical data. Finally this results in the comprehensive and solid decisions.

Methodology:

This part contains three steps that are related to each other, the first one is the selection of the out crop i.e. study area this is done with the help of GIS software. The second is the collection of the samples and other useful information from the satellite and field. The third one is to arrange and handle that data and prepare the outcome results.

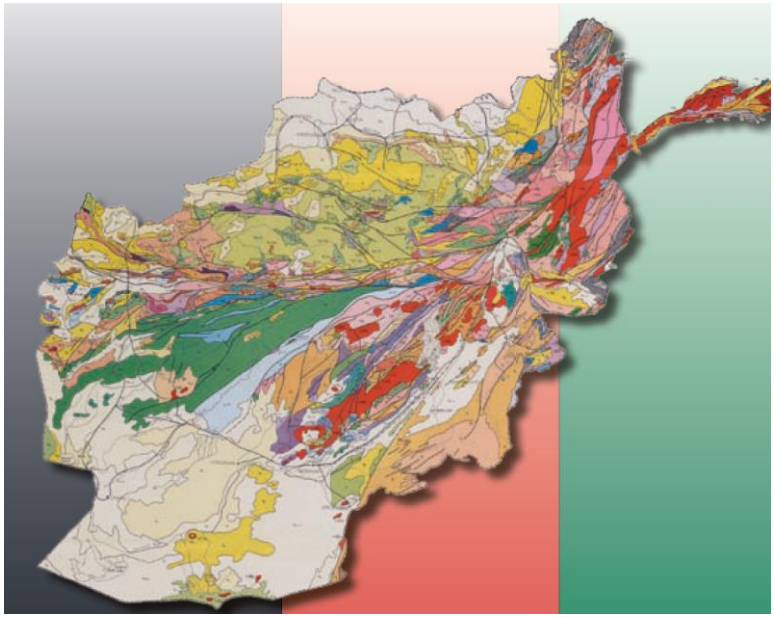

Figure-2 Showing geologic Map of Afghanistan

Site Selection

The site selection is a complex job, because this stages is done is at office before going to field. For this purpose the Arc Map is used. Several different basins are present in Afghanistan Amu Darya basin is needed to be digitized(Figure 3.) (Steinshouer et al., 2006).

Point, line and polygon is used in the Arc Map to explain the well locations, seismic sections and lithostructural mapping of the area respectively. Many locations within the Amu Darya Basin are digitized as polygon. Nevertheless due to best introduction only few oil (seven) and gas (eight) wells are selected. Its area is about more than 40000 sq. km and considered as best location for our study.

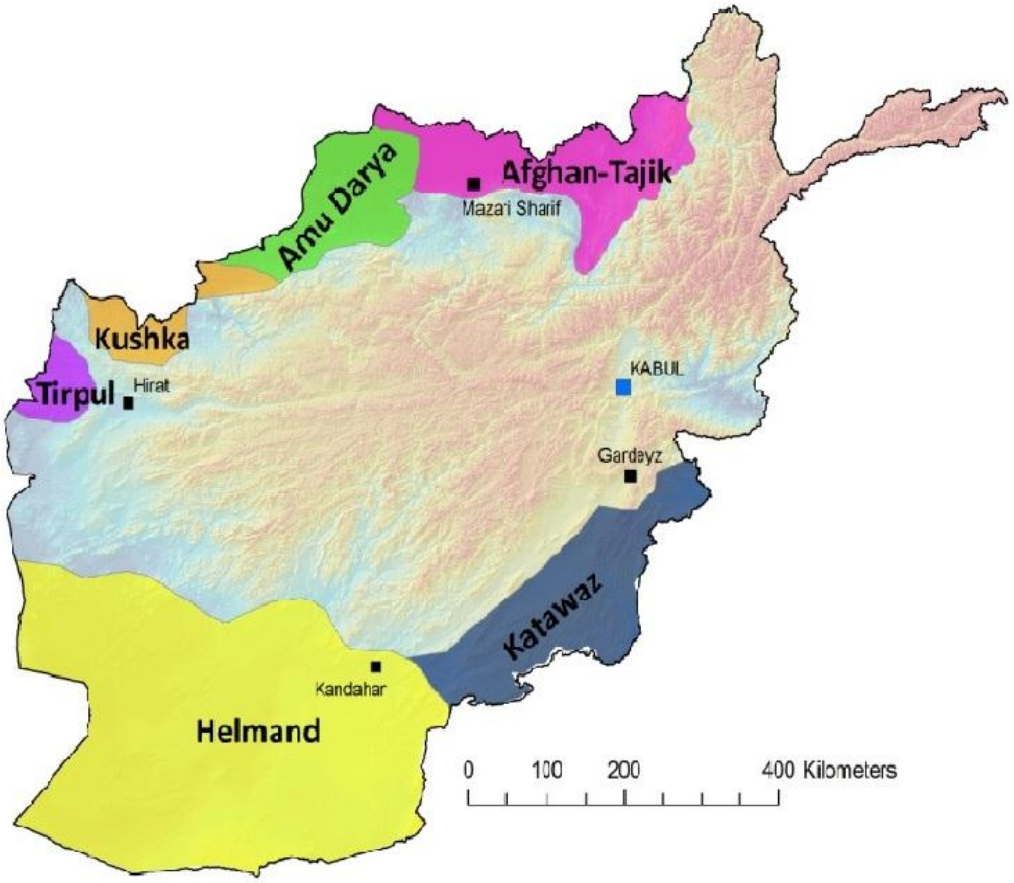

Figure-3 Showing Site Selection for the term project

Sample Collection and Data Acquisition

The sample is collected from well logs for exploration studies. The pattern of collection is to cover the whole subcrop from bottom to top and cover the whole area. About eleven samples are collected to cover the area from all sides. The samples are then analyzed for further exploration and to get useful information. Several other data is acquired for example structure geology of the area, geochemical samples, oil samples, rock samples, seismic lines, oil and gas fields, geologic provinces, geological contacts, geologic age.

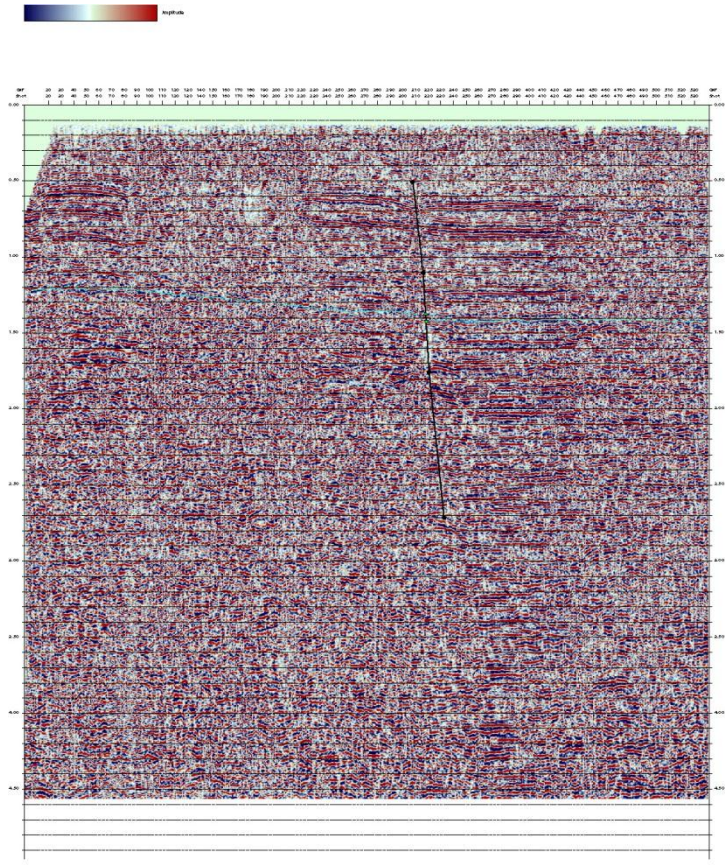

Figure-4 Showing the seismic section and location of the Well within Amu Darya Basin, Afghanistan(Steinshouer et al., 2006).

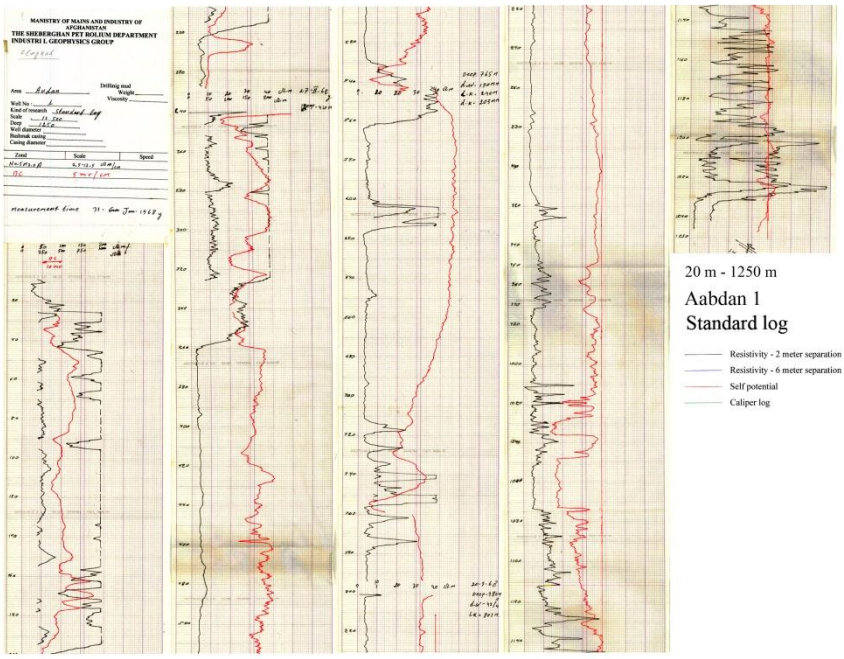

Figure-5 Showing the well log of Abadan Well within, Amu Darya Basin Afghanistan(Steinshouer et al., 2006).

Management of data in Arc Map

All the data collected is handled well in the software, and for each sample location the attributes are assigned. These attributes contains well number, structure geology of the area, geochemical samples, oil samples, rock samples, well logs(figure-5), seismic lines(figure-4), oil and gas fields, geologic provinces, geological contacts, geologic age etc. Moreover, the beauty of the arc map is that its hyperlink property helps in assigning the thin section to relevant sample.

Presentation of Arc Map Tools

The important Arc map tools used are:

1. Standard Tool bar
2. Layout Tool bar
3. Spatial analyst
4. Editor Tool
5. Geo referencing Tool
6. Layout
7. Layer and attribute data management
8. Graphical representation of result
9. Topology
10. Data frame properties

And other useful tools are used in handling data and manipulating the data for creation of models and graph for example arc catalog and arc tool box.

The standard tool bar contains several useful functions. With the help of add data button, when data in the form of image or scanned copy is added. The next step is to add the shape file which is also added from standard tool bar (Figure 3). The shape file is prepared in the arc catalog and drags it in the arc map. For the current project, the scanned image of Amu Darya Basin Afghanistan is uploaded in the arc map, the next step is the creation of shape file in the form of point line and polygon. After that the several helpful tools are added from arc tool box window. The very important steps are the geo referencing of the map. So with the help of “Geo referencing tool” the map is geo referenced. The map is now ready for digitization. So with the help of “Editing tool” the map selected for editing and target layer is selected. First of all the polygon layer is selected to digitize the Amu Darya Basin

Afghanistan (Figure 3). Majority of the Amu Darya Basin subcrop is located in the north of the map.

Conclusion

GIS improves efficiency in field by helping you find oil and gas with less waste and less surface disturbance. GIS can be used to appraise basin analysis, geophysical studies, well positioning, seismic interpretation, geological features, faults, depositional environment prospects, size, volume and attributes (Steinshouer et al., 2006).

Development of Afghanistan's oil and gas resources is essential to the country's economic development. In cooperation with the Afghanistan Ministry of Mines and Industry (AMMI), USGS has also undertaking a comprehensive assessment of undiscovered oil and gas resources (including crude oil, natural gas, and natural gas liquids/condensates), primarily in the northern part of the country. The purpose of this project is to provide data necessary to implement rebuilding and development of Afghanistan's energy infrastructure.

The current valuation is based on the geologic elements of total petroleum systems defined in the geologic province, including (1) source rock presence, maturation, petroleum generation, and migration, (2) location and quality of reservoir rocks, and (3) character of traps and time of formation with respect to petroleum migration. Detailed studies of geochemistry, petroleum geology, geophysics, and tectonics combined with an analysis of previous exploration efforts were used to estimate the number and size of undiscovered petroleum accumulations.

References:

- Bonham-Carter, Graeme. *Geographic information systems for geoscientists: modelling with GIS*. Vol. 13. Pergamon press, 1994.
- Champ, Paul. "Building a robust groundwater model for the southern Perth Basin, WA: 3D visualization and modelling of geology using PetrelTM."
- *Christine Winter* "MANITOBA'S PETROLEUM INDUSTRY GIS INFORMATION MODULES"(Power Point Presentation)
- Dixon, R. J., and J. Pearce. "Tertiary sequence stratigraphy and play fairway definition, Bruce-Beryl Embayment, Quadrant 9, UKCS." *Norwegian Petroleum Society Special Publications* 5 (1995): 443-469.
- Douglas W. Steinshouer, Timothy R. Klett, Gregory F. Ulmishek, Craig J. Wandrey, Ronald R. Wah, Ronald J. Hill, Michael Pribi, Mark J. Pawlewicz, J. David King, Warren F. Agena, David J. Taylor, Abdulla Amirzada, Amir Mohammad Selab, Abdul-Salam Mutteh, Ghulam Naqshband Haidari and Moeengul Gullabudeen Wardak(2006) "Petroleum Resource Potential GIS of Northern Afghanistan" U.S. Geological Survey, Denver, Colorado,
- Ford, Alistair. "The visualisation of integrated 3D petroleum datasets in ArcGIS." *Proceedings of 24th ESRI user conference*. 2004.
- Ford, Alistair, and Philip James. "Integration of 3D petroleum datasets in commercial GIS." *Agile 2005, 8th Conference on Geographic Information Science*. 2005.

- “GIS for Petroleum” ESRI, 2007(Power Point Presentation)
- “GIS for Renewable Energy”, ESRI 2010(Power Point Presentation)
- Grant, Shona, Nick Milton, and Mark Thompson. "Play fairway analysis and risk mapping: an example using the Middle Jurassic Brent group in the northern North Sea." *Norwegian Petroleum Society Special Publications* 6 (1996): 167-181.
- Rajabi, Mohammad A., “Geospatial Information Systems”A Management Tool in Petroleum Industry, Assistant Prof. & Head, GIS Division, Dept. of Geomatics Eng., University of Tehran. (Power Point Presentation)
- Ulmishek, Gregory F. *Petroleum Geology and Resources of the Amu-Darya Basin, Turkmenistan, Uzbekistan, Afghanistan, and Iran*. US Department of the Interior, US Geological Survey, 2004.
- Wandrey, C. J., et al. "The Afghanistan Oil and Gas Research Assessment Team (2006),“Assessment of Afghanistan’s Undiscovered Oil and Gas (Open-File Report 2006-1095)”." *US Geological Survey and Afghanistan Ministry of Mines and Industry Cooperative*.
- Wade, G,”GIS IN PETEROLEUM” HELPING TO SUPPORT THE ENTERPRISE, ESRI (Power Point Presentation)
- Welcome to ESRI Petroleum, Petroleum Seminar(Power Point Presentation)