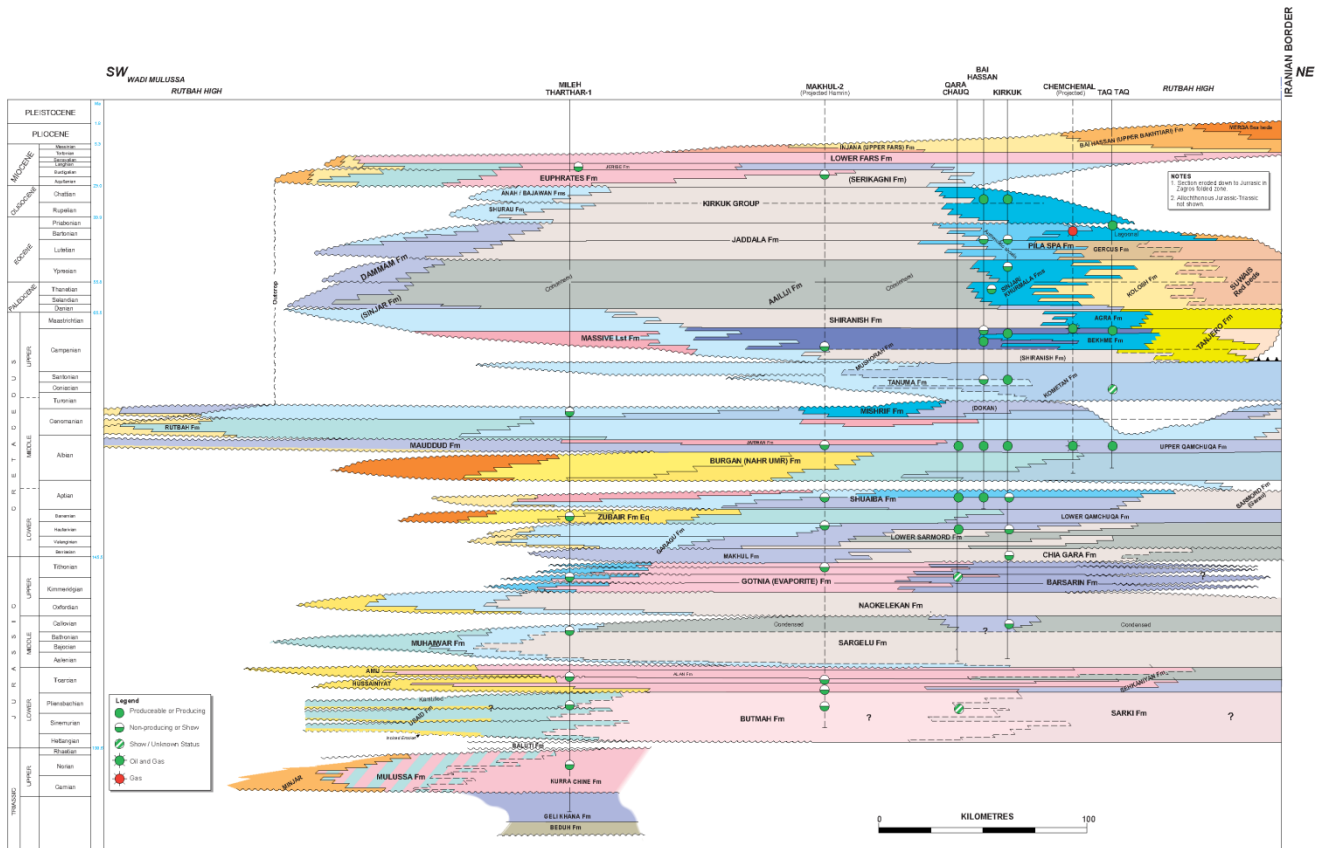


IRAQ - PETROLEUM SYSTEMS: AN INTERACTIVE GIS ATLAS AND TOOL-KIT

PROSPECTUS – July 2013



Executive Summary

The study uses the methodology and workflow refined by Lynx and David Boote Consulting in a comprehensive study of the petroleum systems of the Sirt Basin in Libya, (See <http://www.lynxinfo.co.uk/gis-libya.html>), but with a greatly enhanced geochemical component, based on a new geochemical modelling from leading UK geochemical consultancy IGI.

The report comes enabled with Lynx-developed plug-ins to ArcGIS to optimise usability for petroleum data.

Project Outline & Methodology:

The key factors governing the distribution of hydrocarbons throughout Iraq are described in this regional ArcGIS-based synthesis.

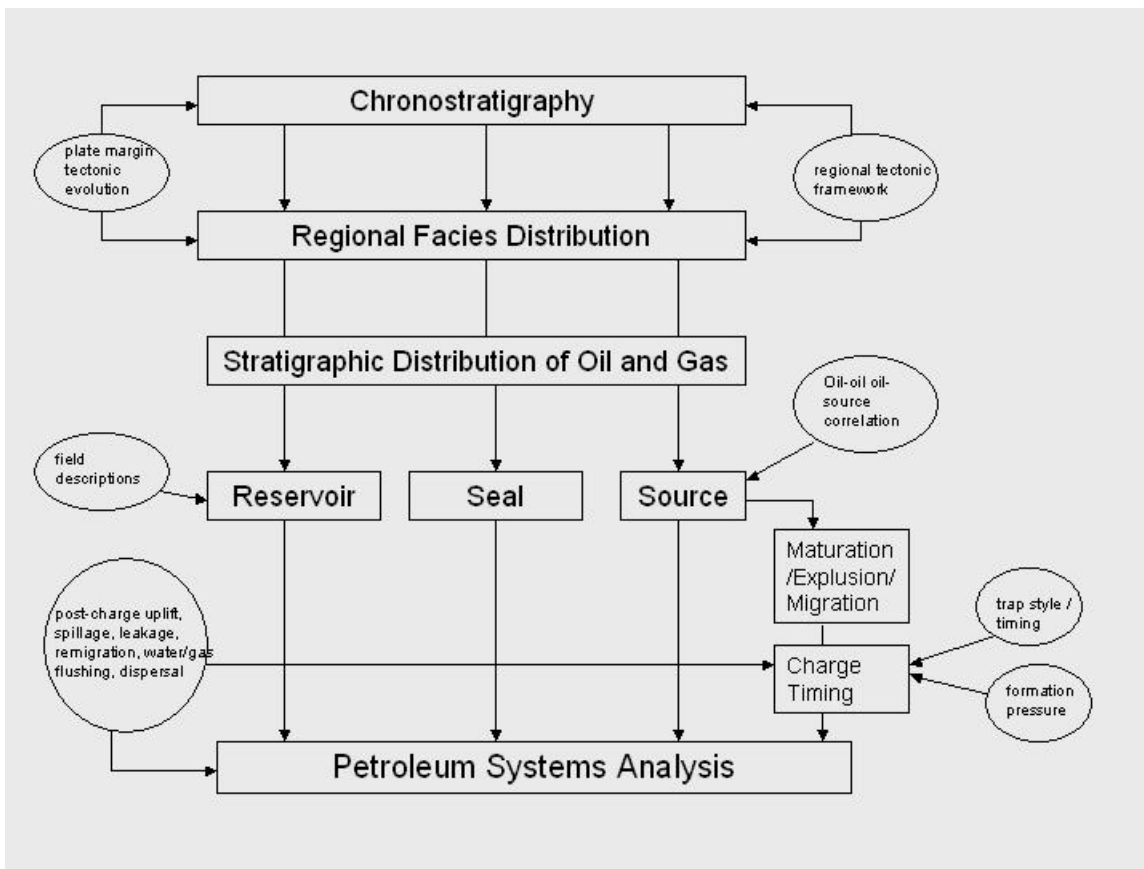
The Iraqi Petroleum Systems analysis and toolkit is presented in seven sections with supporting databases. The key factors governing the distribution of hydrocarbons are described and tabulated in these sections. This information can be linked and combined together interactively, allowing the interpreter to evaluate a broad spectrum of petroleum systems by integrating source facies distribution, generative areas, migration conduits, reservoirs, seals and expulsion/charge timing.

The analytic capability of this approach provides a very efficient way for the oil-company geologist to rank and risk plays and play trends on both regional and local scales.

There is an illustrated text and workflow (in PDF format), progressing logically from an overview of the regional geology and tectonics, through palaeogeography and source-rock distribution and quality, to an in-depth description and analysis of the individual petroleum systems known to be significant in Iraq.

Particular emphasis is placed on the new geochemical modelling by IGI using Zetaware “Trinity”.

The interactive workflow is described in this diagram:



Contents of Report

Executive Summary

Section 1: Introduction

A regional structural and stratigraphic overview of Iraq, and containing an in-depth, up-to-date database of fields and reservoir data, showing existing oil fields, "super-petroleum systems", solid geology, simplified tectonics

Section 2: Regional Tectonic Architecture

A summary of the regional tectonic architecture of Iraq by depth to basement and tectonic element maps, a composite regional seismic profile and simplified structural cross-sections. Key plate boundary events controlling its tectonostratigraphic evolution are illustrated by a series of Phanerozoic paleotectonic reconstructions and summary display.

Section 3: Regional Stratigraphic Architecture

A full study of stratigraphy and facies distribution, taking into account earlier key work by Dunnington, and many other authors. Illustrated by approx. 60 maps, showing tectonic evolution, paleogeography, and stratigraphic architecture. All these maps are also taken in to the ArcGIS project.

Section 4: Regional Hydrocarbon Distribution of Oil and Gas

Section 4 collates and summarizes information on selected fields in Iraq and surrounding areas, to illustrate structural and stratigraphic styles. It highlights the more significant reservoirs, seals and trap styles of fields or groups of fields, in each of the identified petroleum systems. A summary of Palaeozoic stratigraphy and a more detailed description of Mesozoic-Tertiary chronostratigraphic architecture across northern, central, and southern Iraq illustrated by 4 very detailed chronostratigraphic charts. This section is also illustrated by approx. 20 maps and charts and cross sections.

Section 5: Regional Hydrocarbon Environment

This section comprises of a number of sub-sections, illustrating the distribution of key source rocks, oil geochemistry and oil-source correlations, source maturation and expulsion timing, optimum migration directions and a provisional migration and charge history model for northern Iraq based upon Dunnington's classical hypothesis (Dunnington 1958, 1967).

Geochemistry of candidate source rocks, in part reconstructed from regional facies maps. Includes source rock distribution maps, maturity modelling (by IGI), migration and charge history, and post-charge modification.

The maturity of source rocks is assessed by comparing source distribution with maturity models. The maps provide a regional framework for reconstruction of migration directions and charge timing from each significant source horizon. Post-charge events (uplift, remigration, etc) are also analysed and mapped.

As far as possible all the mapped data are brought into the ArcGIS project. Burial history models are identified and placed on the maps.

Section 6: Regional Petroleum Systems Analysis

This section provides a synthesis of the data. These factors are taken into account: Regional facies distribution; Quality and effectiveness of reservoir and seal; Quality and distribution of source facies; Source maturation expulsion and charge timing; Post-charge modification. Maps are constructed in ArcGIS for each of the 11 identified petroleum systems. Analogue petroleum systems are also considered.

Although hydrocarbons are dispersed throughout the stratigraphic succession, regional correlations highlight a tendency for more significant accumulations to concentrate at discrete horizons, as dictated by reservoir quality and seal effectiveness. In this analysis, each of these more prolific intervals was recognized as a petroleum system. Reservoir, seal and source distribution, source maturity and associated hydrocarbon occurrences were collated for the more important and synthesized in play summary maps.

Section 7: Common Risk Segment Mapping



Lynx has generated a new CRS tool to simplify the CRS compositing of data in ArcGIS. A worked example of the Zubair petroleum system has been included, along with a step-by-step guide of the process.

The geological maps and sections describing the petroleum systems identified in Section 6 have been organised and catalogued in Section 7 of the ArcGIS compilation, providing an easily accessible and comprehensive data set for interactive play fairway/prospect analyses and risk assessments.



Petroleum systems evaluated in this fashion include:

Palaeozoic reservoir-Silurian sourced systems summarised in a general Palaeozoic 'exploration potential' map.

Kurra Chine (Triassic-Lower Cretaceous) petroleum system (shoal water carbonate reservoirs and Lower Cretaceous source).

Najmah & Muhaiwir (Upper Jurassic) speculative petroleum system (shoal water carbonate reservoir and Jurassic source).

Yamama (Lower Cretaceous) petroleum system (carbonate/oolitic reservoir and Lower Cretaceous source).

Zubair (Lower Cretaceous) petroleum system (clastic reservoir and Lower Cretaceous source/plus some vertical leakage from Jurassic source).

Burgan/Nahr Umr (Middle Cretaceous) petroleum system (clastic reservoir and Lower Cretaceous source).

Mishrif (Middle Cretaceous) petroleum system (clastic reservoir and Lower Cretaceous source).

Khasib-Tanuma-Sa'di (Upper Cretaceous) petroleum system (shoal water carbonate reservoir and Lower Cretaceous source).

Shiranish (& associated Upper Cretaceous horizons) petroleum system (fractured marl and argillaceous limestones reservoirs with deeper Cretaceous source(?)).

'Asmari' & Equivalents petroleum system (Oligocene Kirkuk/Main and Lower Miocene Euphrates & Jeribe carbonate and Ahwaz/Ghar clastic reservoirs with at least two Lower Cretaceous sources).

Other hydrocarbon bearing intervals including the Butmah (Triassic-Lower Jurassic(?)), Ratawi and Shuaiba (Lower Cretaceous), Maudud and Rumaila (Middle Cretaceous), Kometan and equivalents (early Upper Cretaceous) and Eocene limestones were less prolific and not examined in any detail here.

References

The report is makes full reference to the scientific literature.



SPECIMEN EXTRACT FROM REPORT: SUMMARY

Iraq is credited with 136 Bbbls oil and 108 Tcf gas proven, probable and possible (Verma et al., 2004) in 84 fields, with 17 additional discoveries of undeclared reserves. This resource appears to be clustered at particular geological horizons ranging in age from Ordovician to Pliocene, defining a number of distinct petroleum systems, each reflecting a particular reservoir-seal-source combination.

An extensive body of published and open file data has been used to identify the geological factors controlling the spatial distribution of these systems and provide a regional description of each source-reservoir-seal combination and its associated hydrocarbon environment. This information has been organised in a geologically coherent ArcGIS compilation, designed to facilitate interactive petroleum systems/ play fairway analyses and risk assessments.

The ArcGIS deliverable is modelled closely on the report structure, and is designed for use in context with the report. The facies and play/petroleum system maps are available as ArcGIS Layer files (.lyr) so they can be customized and combined with geospatially referenced data from other sources. Explanatory captions accompanying each map are embedded as metadata for each layer and can be accessed within ArcCatalog or ArcMap. Associated non-spatial information (including plate tectonic reconstructions, stratigraphic columns, facies diagrams and burial history models) can be accessed via hyperlinks between the ArcMap and relevant report page. In addition, a number of ArcMap (.mxd) documents have been constructed, to guide the user through key steps of the petroleum system analyses. The fields data from Section 4 (Table I) are also integrated within the GIS and can be used dynamically.

3pp follow with examples of

- (A) Extract from the Chronostratigraphic Architecture chart*
- (B) the analysis of the Burgan play*

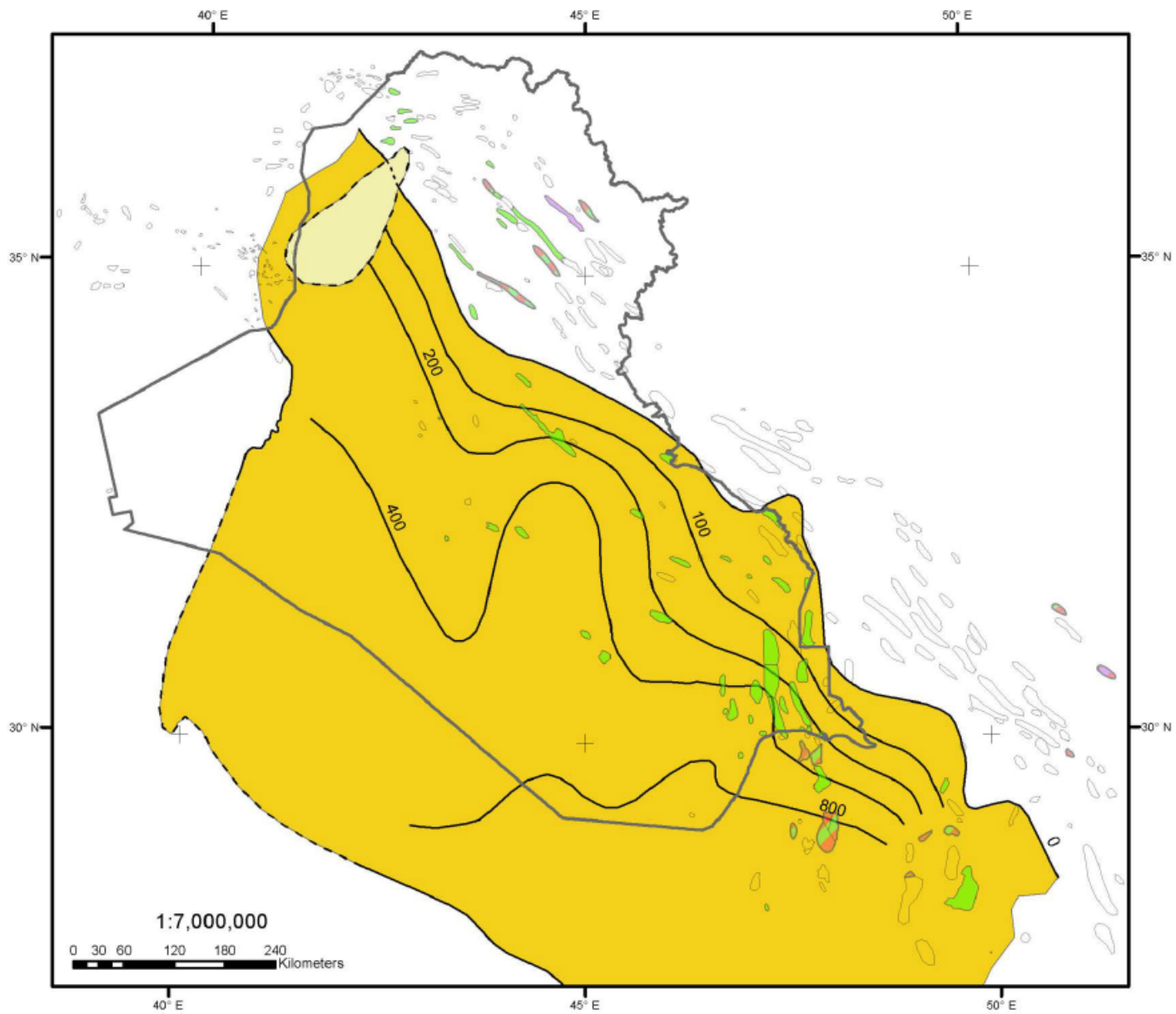


Figure 6.6-2: **BURGAN (Nahr Umr) Petroleum System – Nahr Umr/Burgan (intra-Albian) reservoir sandstone isopach (ft)**

Adapted and updated from Gehman & DuBois, 1972

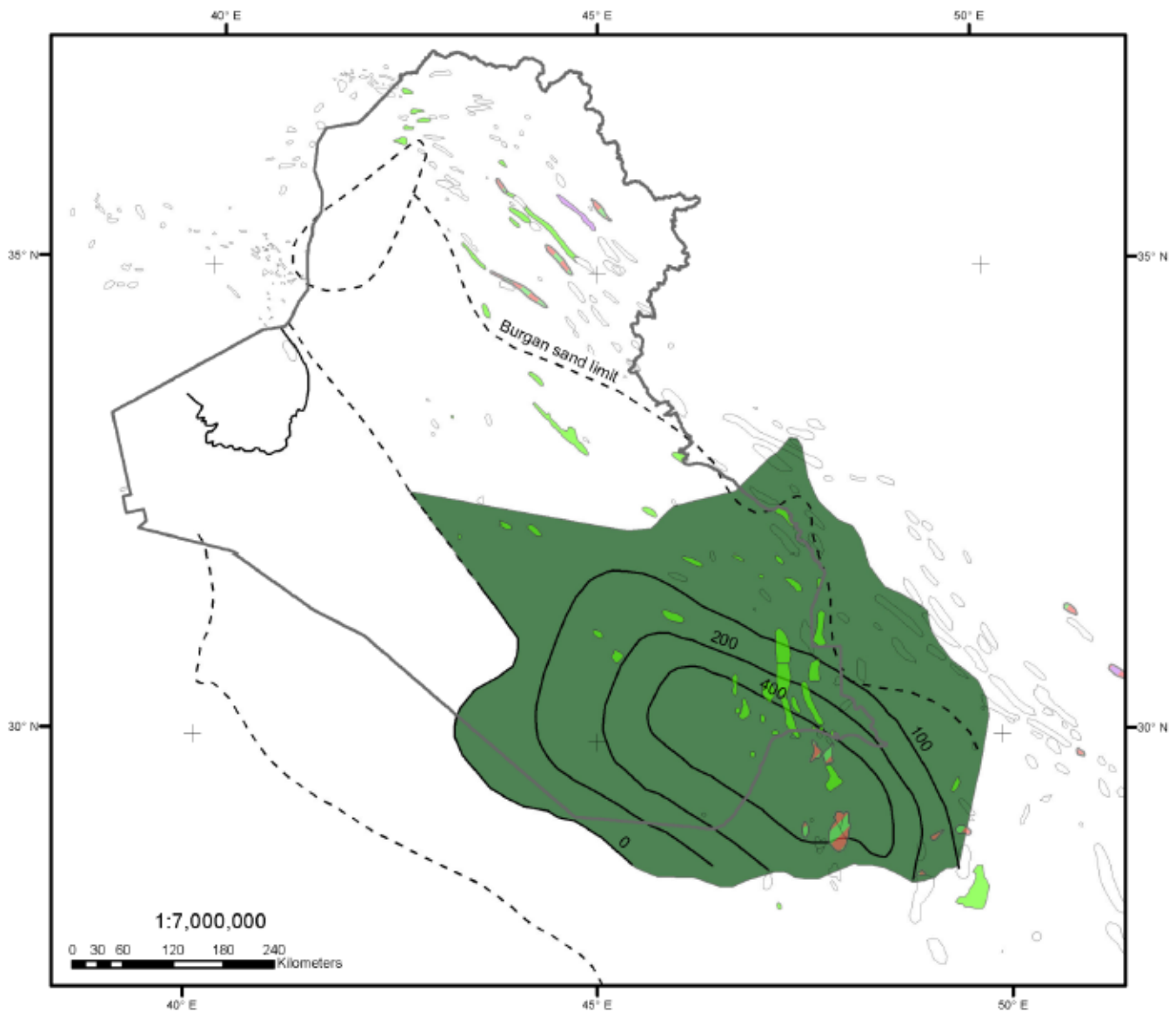


Figure 6.6-4: BURGAN (Nahr Umr) Petroleum System – Cenomanian Ahmadi Shale seal isopach (ft)

Although interbedded marine shale units within the Burgan sequence are significant locally as seals, the overlying Ahmadi shale is the most important limiting factor regionally because it extends furthest to the west. In some areas, oil has migrated vertically around the Ahmadi shale pinch-out and through erosional windows up into the Wara sand member and Eocene limestones above.

Adapted by Gehman & DuBois, 1972