

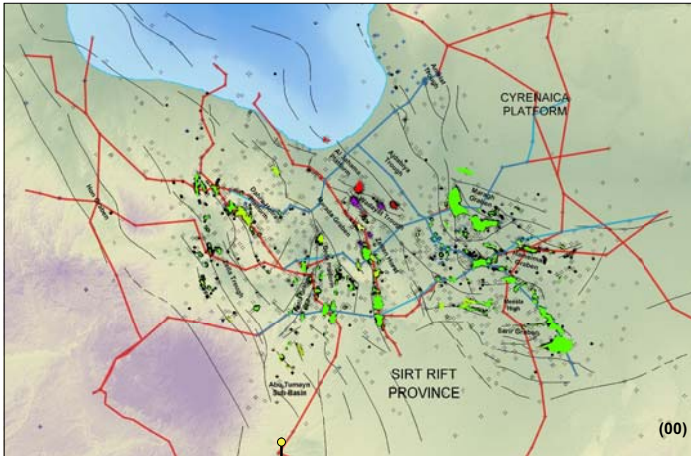
Outline

The use of Geographical Information Systems in Exploration New Ventures work is now firmly established within most oil companies.

The ability to generate dynamic maps through a combination of spatial and tabular controlled queries provides an efficient and highly effective way of analysing the multiple geologic variables that contribute to observed petroleum systems.

By bringing together results from different branches of work, some of it originating from more specialist G&G applications, a rich body of information can be assembled under a single working environment, providing a basis for holistic assessment of new play ideas and exploration opportunities.

In a study of the Sirt Rift Province, Libya, recently completed by DBConsulting and Lynx, results from traditional basin modelling techniques and source rock geochemical analyses were imported into ArcGIS and pooled with a library of both in-house and public domain-sourced maps, well & seismic data. A simple relational database was designed and populated with stratigraphic occurrence and geochemical data for oil and gas discoveries, such that these records could be easily queried and plotted alongside reservoir/source distribution and paleo-maturation maps to identify generative areas, optimum migration directions and resultant hydrocarbon accumulations. The construction of a GIS in this way enables play fairway maps to be readily created for each discrete petroleum system, new trends to be postulated and considered alongside click-on-demand field analogue data, and risk mapping to be carried out to assess undiscovered potential.



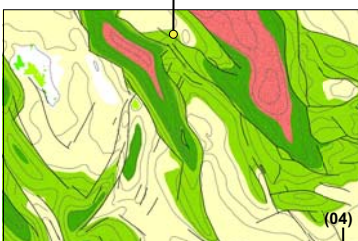
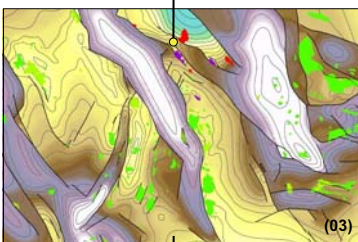
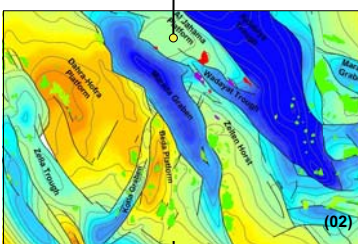
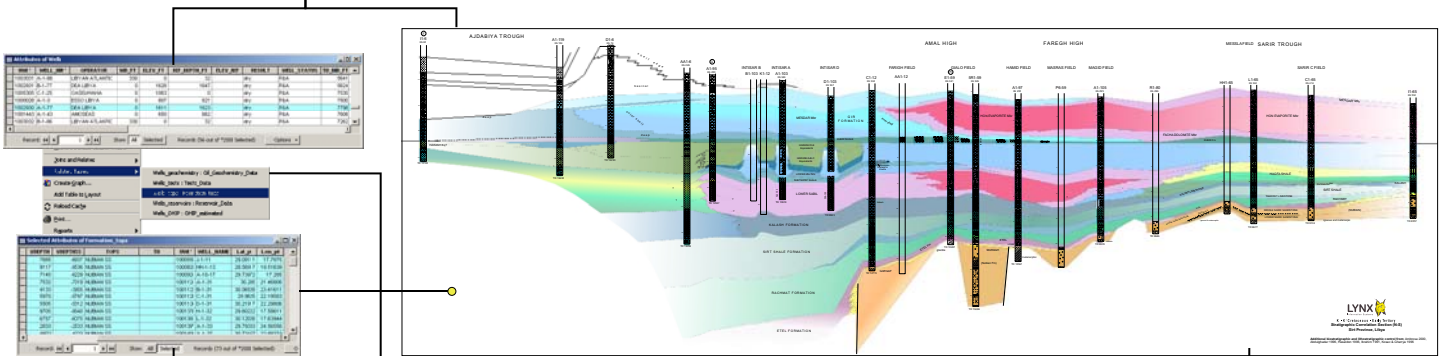
Sirt Rift Province Petroleum Systems

The Sirt Rift Province is a prolific hydrocarbon province with approximately 30 Bbbls proven reserves. Oil and gas accumulations are reservoired in granitic basement, sandstones and carbonates ranging in age from Pre-Cambrian to Oligocene, charged by syn and early post-rift, Triassic and intra-Cretaceous organic rich lacustrine and restricted marine shales.

Of the more significant reservoir horizons, 13 can be identified, whilst source-rock candidates include the dominant and laterally widespread Upper Cretaceous Sirt-Rachmat shales, the Etel Formation of mostly Turonian age, and earlier Nubian/intra-Nubian and Triassic interbedded shales of key importance in the east and southeast of the Province. Seal candidates are numerous and locally variable, whilst late Tertiary tectonic events in the western Zella Trough play a major role in vertical migration and re-migration of fluids.

The study was able to draw upon an extensive inventory of interpreted maps, well & seismic data and a number of previous studies undertaken by Lynx & DBConsulting, augmented by an exhaustive review of published work. Underpinning much of the work was access to a wells database containing formation tops records for over 3,000 wells.

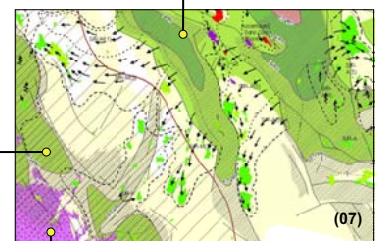
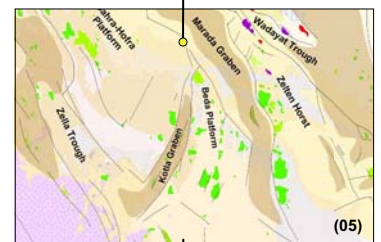
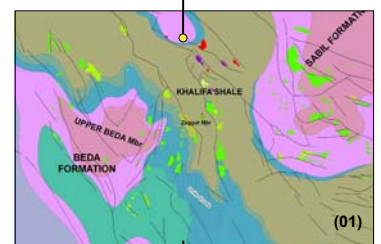
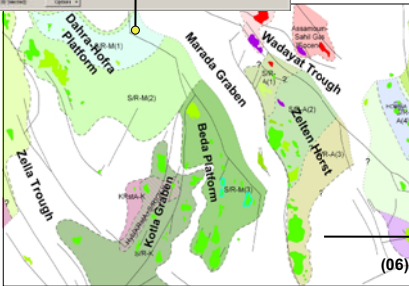
These data were used as the basis for regional interpretation of key structure and isopach maps, and for updating a series of regional E/W and N/S well correlation sections from which a set of paleo-lithofacies maps were derived.



ArcGIS data model and workflows described

The entire GIS was organised into a number of modules to describe and present each sub-discipline of work.

- (00) Overview: georectified surface geology, gravity, total magnetic intensity, relief (SRTM) and concession maps, well and field locations, bathymetry and other relevant cultural data. Oil and gas fields linked to field data bases, field structure maps and associated stratigraphic and structural cross-sections.
- (01) Regional lithofacies: gross lithofacies maps for all significant pre-rift (Palaeozoic), early syn-rift (Triassic/Jurassic), syn-rift (Early Cretaceous) and post-rift (?Albian/Cenomanian to Oligocene) reservoir, source and seal facies.
- (02) Regional Structure: generalized regional structure maps describing the structural architecture of the post-rift fill sequence.
- (03) Burial History (Regional Isopachs): sequential regional isopach maps describing the burial history of key source rock horizons.
- (04) Regional Maturity: regional maturity maps of key source rock/source rock equivalent horizons based upon sequential isopach maps calibrated by 1D burial history models at selected (well) locations throughout the province.
- (05) Source Rock Distribution: facies and distribution maps of recognized source rock horizons.
- (06) Oil Family Distribution: stratigraphic and geographic distribution of geochemically distinct groups of oils (oil families) correlated to parent source rocks.
- (07) Regional Oil Generation & Migration: source generative areas, maturation history and optimum migration directions (defined by integrating source, maturity and oil family distribution maps) described at discrete periods during the Cenozoic.



Play map examples

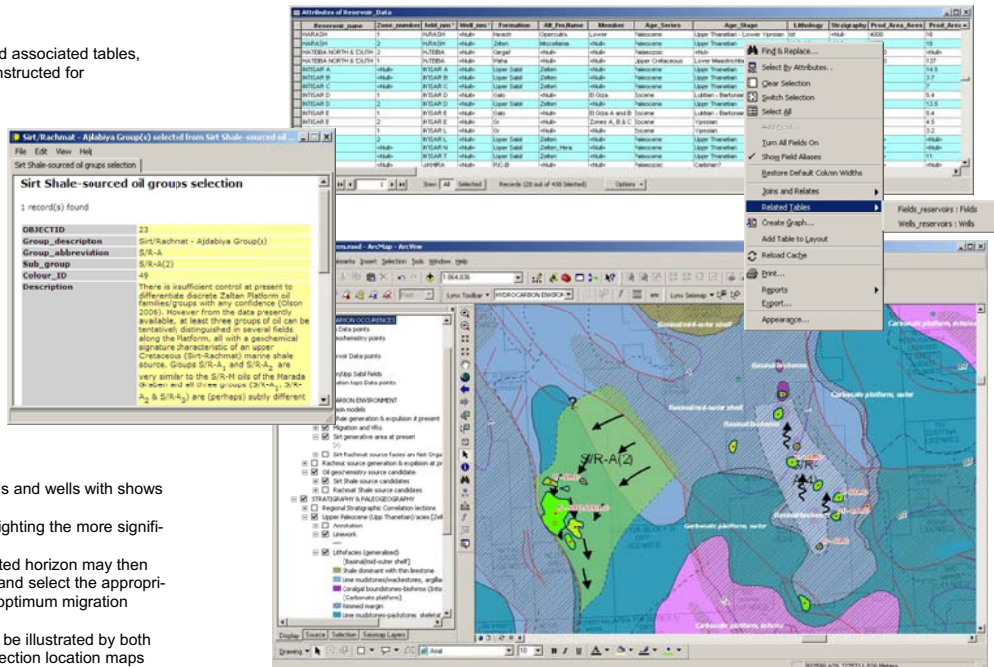
By selectively combining information from the GIS and associated tables, petroleum systems and play fairway maps can be constructed for each significant reservoir horizon in the Province. Key play/petroleum systems include:

CRETACEOUS/PRE-CRETACEOUS
 Waha-Samah-Bahi (Maastrichtian) System
 Tagrifet-Bahi (Santonian-Campanian) System
 Etef-Agrub-Bahi (Turonian) System
 Lidam-Bahi (Cenomanian) System
 'Nubian' (Sarir / Lower Cretaceous System)
 Palaeozoic & Basement System

CENOZOIC
 Diba-Arida (Oligocene) System
 Gialo (Middle-Upper Eocene) System
 Facha (Ypresian) System
 Zelten (Upper Thanetian) System
 Dahra (Lower Thanetian) System
 Beda (Montian) System
 Upper Satal (Danian) System

Play maps for each system can be produced by:

- 1) posting the relevant producing, non-producing fields and wells with shows at any selected horizon
- 2) selecting the appropriate lithofacies map and highlighting the more significant reservoir intervals.
- 3) The oil group/family of oils reservoir at the selected horizon may then be used to identify the more likely source or sources and select the appropriate generative area or areas, maturation history and optimum migration directions.
- 4) The stratigraphy of the highlighted reservoir(s) can be illustrated by both regional and field correlations selected from posted section location maps and used to supplement the gross lithofacies maps, while..
- 5) field reports (structural maps and sections, reservoir, fluid and OOIIP data) provide a robust perspective of the systems hydrocarbon environment



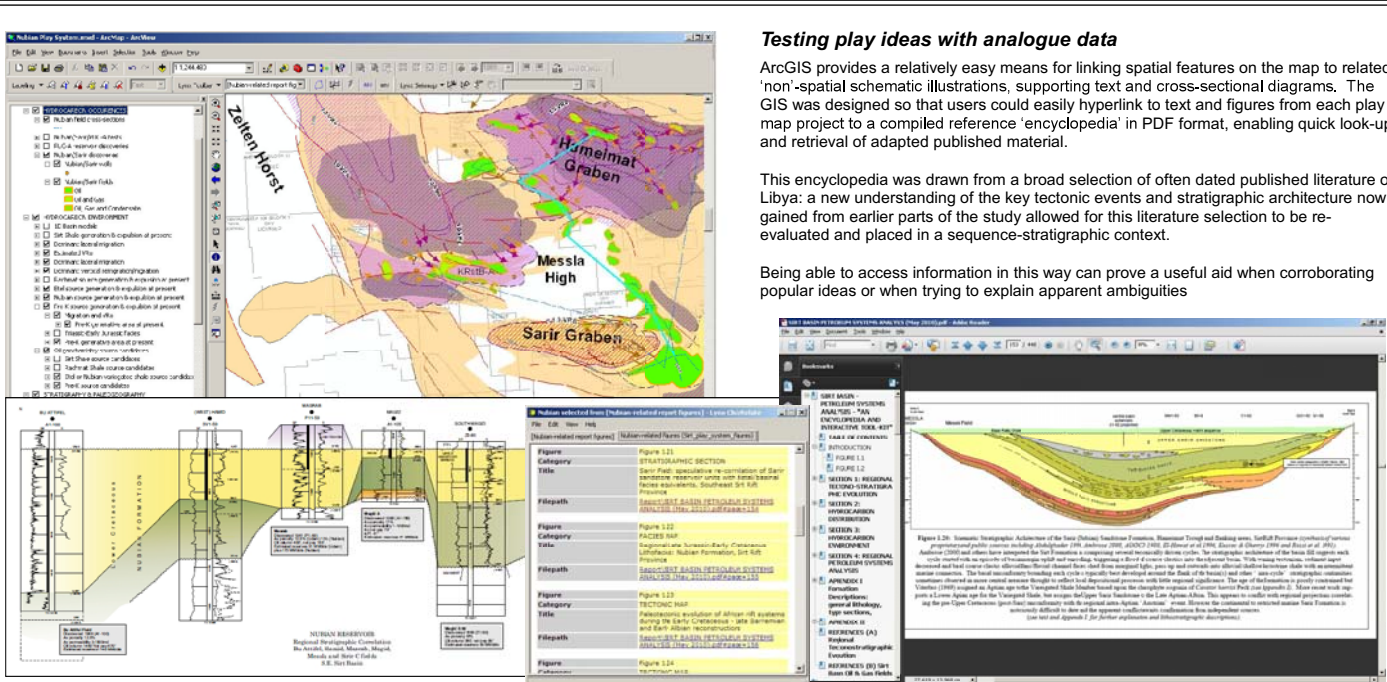
Zelten (Upper Thanetian) Petroleum System: The Intisar play fairway is centered on a number of topographically pronounced bioherms located in a deep embayment of the north facing Zelten-Upper Satal carbonate platform. Oils from the underlying Sirt-Rachmat source within the Adjabiya Trough migrated vertically upwards via faults through the porous Lower Satal Carbonate into the Intisar reefs above, sealed by Late Palaeocene-basal Eocene (Kheir and Harash Formations) shales and marls.

Testing play ideas with analogue data

ArcGIS provides a relatively easy means for linking spatial features on the map to related 'non'-spatial schematic illustrations, supporting text and cross-sectional diagrams. The GIS was designed so that users could easily hyperlink to text and figures from each play map project to a compiled reference 'encyclopedia' in PDF format, enabling quick look-up and retrieval of adapted published material.

This encyclopedia was drawn from a broad selection of often dated published literature on Libya: a new understanding of the key tectonic events and stratigraphic architecture now gained from earlier parts of the study allowed for this literature selection to be re-evaluated and placed in a sequence-stratigraphic context.

Being able to access information in this way can prove a useful aid when corroborating popular ideas or when trying to explain apparent ambiguities



CRS Mapping

Reasonably experienced ArcGIS users (those familiar with the Esri Spatial Analyst extension) can opt to use the GIS for combined risk segment mapping (CRS), a popular method for assessing play risk and chance potential for acreage under evaluation. This process can be streamlined through the building of an 'CRS wizard' interface, a tool which Lynx intends to make available as an ArcGIS extension.

