Chronostratigraphic Isopach mapping of sequences of the Arabian Plate: Product and Process

By Walter H. Pierce
Problems and Talk Objectives

• Mapping across nomenclature changes and country boundaries.
• Mapping sequences versus Formations.
• Pay attention to zero-edge accuracy
  – maps will be used for subcrop, worm’s eye, subsidence
• Process that is updateable and adaptable.
• Show process and “bag of tricks.”
• Show products
Talk Organization

- Preliminary View of Products
- Scale and Database
- Surface Geology Constraint
- Queries
  - wells spudding in subcrop (Red)
  - wells with interval missing in subsurface (White)
  - Wells with thicknesses (Black)
  - Wells with penetrations (Gray and Yellow)
- Construction of Composite Table for Mapping
- Quality Control
- Review of Products and importance of specific maps
Comparison of scale of Arabian Plate versus lower 48
Database

- 2819 wells
  - mappable
  - 2 or more tops in well
- 46,911 tops records
  - mappable
- 481 unique ages
- ~600 unique lithostratigraphic units.
Assigning Ages to Tops

- The process begins with assigning a 9 digit code to stratigraphic names.
  - Attempt to have the code relate to age and superposition.
- A spreadsheet - database cycle focuses on code superposition problems.
- Repeat cycle, adjust, repeat .. And so on... until codes obey superposition.
- Finally 9 digit codes are converted to absolute ages.
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Spreadsheet - Database Cycle for correcting superposition problems

1. Shift and Subtract Sequence Code in Spreadsheet

2. Use Database to Query out smaller Negatives to find Superposition Problems

Up To 6 cycles

3. Prioritize and Adjust Sequence Codes
Graph of Stratigraphic Database showing Number of Well cuts through each age: Arabian Plate
Using Surface Geology to constrain mapping

- A grid of points has been run through each surface geology polygon.
- By putting the grids into a database we make composites subcrop geology at System level to constrain isopach mapping.
Database of Surface Geology Points created to enable constraint of isopach zero edges
Query (RED) for wells that spud in subcrop

- Query out wells that have a minimum age older than the earliest age of the interval to be mapped.
- Give these wells a thickness value of -11
Query to find wells that spud below interval: Plotted as red symbols given value of -10 for gridding.
Query (WHITE) for wells missing tops from the interval to be mapped

- For wells that have records older and younger than the interval.
- Remove records that are younger or older than interval to be mapped.
- Count remaining records for each well.
- Assign thickness value of -5 to wells that have no records.
- Plot these wells as white dots.
Query to find wells with subsurface pinch outs:
Plotted as white symbols given value of -5 for gridding
Dual Query System: First Thickness Calculation

- From the set of wells that have records younger and older than the interval.
- Find the maximum and minimum depth record for each well and subtract the minimum depth from the maximum depth. Then store this result as a table.
Dual Query System:
Second Thickness Calculation

- From the set of wells that have records above and below the interval.
- From well top records with ages within the interval, find the minimum depth for each well.
- From a set of well top records with ages older than the interval find the minimum depth.
- Subtract the smaller depth from the larger depth.
Dual Query System for Sequence Thickness

1) Match depths to time.
2) Calculate thickness for Query 1 and Query 2.
3) Subtract for error checking
4) Filter out problem wells.
5) Take maximum thickness
Stratigraphic Thickness Elevation Plot for Upper and Middle Jurassic

- Abu Dhabi
- Iran
- Iraq
- Israel
- Jordan
- Northern Emirates
- Oman
- Qatar Bahrain Kuwait
- Saudi Arabia
- Syria Lebanon
- Turkey
- Yemen

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Penetration wells: GRAY & YELLOW

- Wells that do not penetrate entire sequence
- Find by query.
- Adjust for:
  - Zero edge extension
  - Depocenters
Query to find wells with penetrations that impact interpretation: Plotted as value of penetration and given yellow symbol. Gray symbol designates wells that penetrate but do not impact interpretation.
Contrast of Maps showing thickness constraints only with system used in this Study: Upper and Middle Jurassic example
Quality Control

- Superposition and age assignment
- Step Plots
- Dual thickness query
- Laying on map for comparison (five query products)
  - surface map subcrop
  - wells spudding in subcrop
  - interval missing in subsurface
  - wells with thickness calculation (Dual Query)
  - wells with penetration and taking selective action
  - mapping result
- Filters
  - 1) data quality and 2) structural repeats
Example (Lower Cretaceous sequence) of one of the chronostratigraphic isopach maps of the Arabian Plate

Review well control symbols
Black = thickness = variable
Dusky Red area = subcrop outcrop = -10
White = subsurface missing = -5
Red = well subcrop spud = -11
Gray = well penetration
Yellow = well penetration with action = variable
If you will go to my web site listed below you will be able to see a set of small thumb nail images of the isopach maps of the sequences mapped to date of the Arabian Plate. In addition to sequence isopach maps there are thumb nail of sub-crop and worm’s eye maps.

www.whpierceexploration.com
Explanation Slides to go with sequence isopach map

www.whpierceexploration.com
Importance of Neogene

- Evaporite Seal for Zagros Dezful and Northern Iraq
- Subsidence Driven Maturation Northwest boundary of Arabian Plate
Importance of Oligocene

• **BIG OIL**: Provides major reservoir (Asmari) for Zagros and Iraq.
• Note restricted distribution sandwiched between Neogene above and Paleocene-Eocene below.
• Where will the first major stratigraphic discovery be made?
Importance of Paleocene-Eocene

- Broad regional subsidence brings vast area to regional threshold of maturation.
- Source of gas and oil in northern Dezful embayment of Iran.
- Behaves as vertical carrier system
  - Note isopach thin in area of Kirkuk, northern Iraq may have aided focusing of carrier system
Importance of Upper Cretaceous

- Many individual Basins differentiated, for example the Euphrates Graben.
- Major Oil: Majnoon
- Three or more distinctly aged source units.
- Difficult to correlate.
- Under-explored.
Importance of Middle Cretaceous

- **BIG OIL**: Burgan, Safaniya Sandstone Reservoirs
- Source Rock
- Important carbonate reservoirs
Importance of Lower Cretaceous

• **BIG OIL:** Zubair sandstone reservoirs, Shuaiba carbonate reservoirs, Thamama carbonate reservoirs.

• **Sleeper Sequence:** overlooked carbonate reservoirs and source rock

• **Problem:** producing multiple thin reservoirs
Importance of Upper and Middle Jurassic

- BIG OIL: Ghawar and other Saudi fields, carbonate reservoirs
- source rock, reservoirs, seals
- At just the right burial depth for a large part of Basin
Importance of Lias and Triassic

- Immature exploration except for Syria and Northern Iraq.
- Oil and gas reservoirs, carbonate
- Further potential in Turkey, Jordan, and Israel
  - potential for small companies
- Source rock, seals, and reservoirs
- Frontier
Importance of Permian

- **BIG GAS**: North Dome, North Pars, South Pars, etc. carbonate reservoirs, anhydrite seals
- Basal sandstone reservoirs in Saudi Arabia and Oman oil play, red bed seals
- Sourced from below: Silurian and late Precambrian and Cambrian, across unconformity
Importance of Carboniferous

- Almost restricted to Syria
- Significant gas reservoirs
- Possible gas source: coals
- Observe impact of Hercynian erosion on isopach distribution of Carboniferous, Devonian, Silurian, and Ordovician.
Importance of Devonian

• Major Gas reserves in deep Ghawar
• Could become a major gas and oil play on the Arabian Plate
• Definitely “Frontier”
• Near shore marine sand and carbonate reservoirs.
Importance of Silurian

- Major Source rock interval
  - multiple intervals, wide spread
- Source of both oil and gas
- Sandstone reservoirs at Akkaz, western Iraq
- Seal sequence with potential underlying Ordovician sandstone reservoirs.
Importance of Ordovician

- Frontier
- Gas Production at Risha in western Jordan
- Shows of oil and gas in Turkey
- Facies: sandy in south grading to more fine-grained to north.
Importance of Cambrian

- Late Precambrian
- Oman
- Source rock (very rich and thick, Salt, salt-related trapping and salt tectonics)
- See “Half Graben” on isopach