Stratigraphy and Petroleum Systems of the Paleozoic Succession of Qatar

Created by: Troy Howard

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Where is Qatar

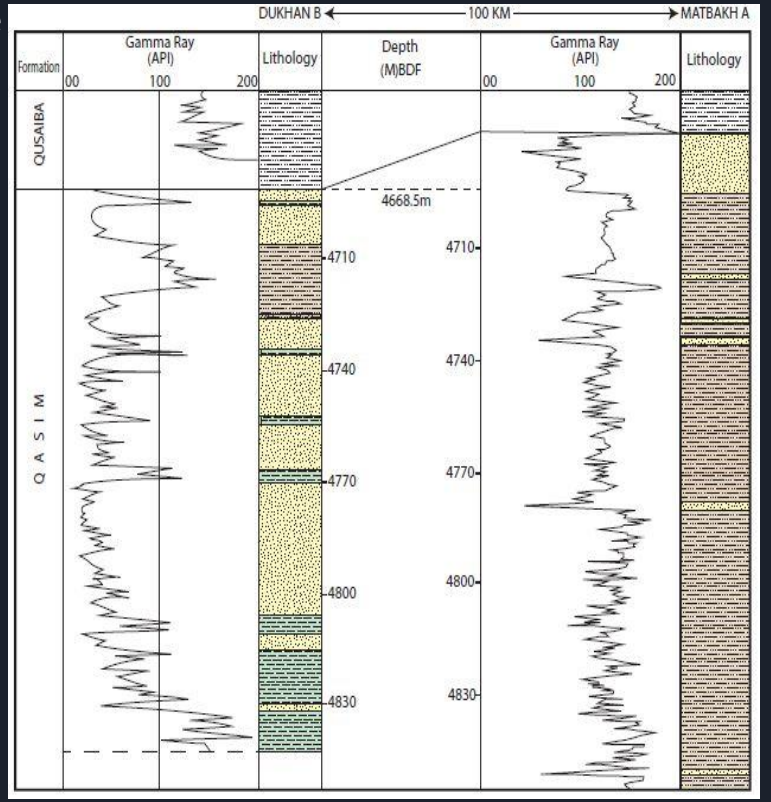
- Located
  - In the persian gulf
  - East of Saudia Arabia
  - On the Arabian Plate
- There is little information on the Pre-khuff formation but a lot of information on the permian Khuff
- The hydrocarbon potential of the pre-Khuff has yet to be investigated

Wells drilled in Qatar

- Three wells were drilled
  - Matbakh A - First well drilled (in Qatar) 1983 - 1500m deep
  - Dukhham A
  - Dukham B
    - Well logs, core samples, thin section, and porosity and permeability was measured
    - First evidence of the Pre-Khuff succession
      - Tayma group (Early cambrian) -- later referred to as the Qasim formation
      - Qalibah group (Silurian)
      - Huj group (Late Silurian) -- later referred to as the Tawil formation

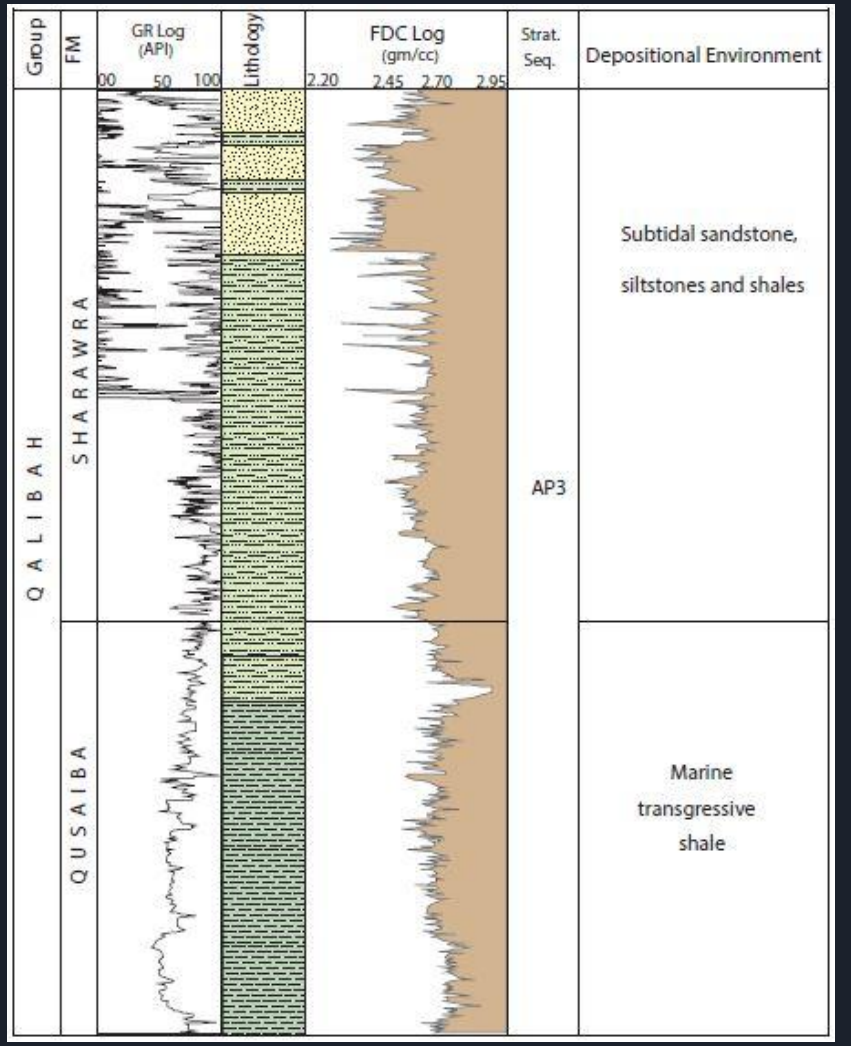
Tayma group --- Qasim formation

- Includes all the Paleozoic sediment which were deposited before the late Ordovician glaciation
- Includes four formations
  - Siq
  - Quweira
  - Saq
  - Qasim - which is the only formation found in Qatar
- Age Cambrian - late ordovician
  - Due to trace fossils (cruziana and Skolithos)
- Consists of up to 1600m of shallow marine classics ranging from claystone to sandstones
  - No evidence to support fluvial or glacial sediment (found in Saudia Arabia)
- Gamma - log
  - Shales have high gamma radiation (Greater than 100)
  - Sandstones have low gamma radiation (less than 100)



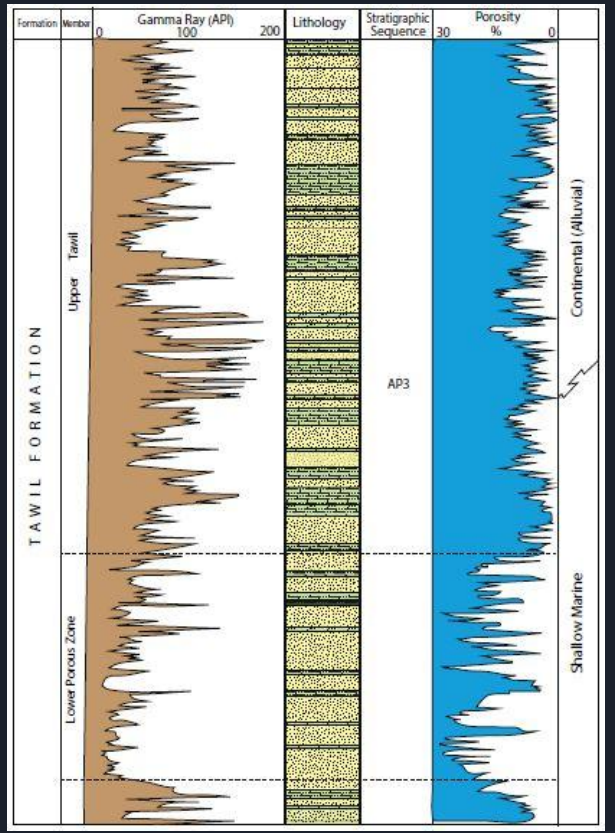
Qalibah Group

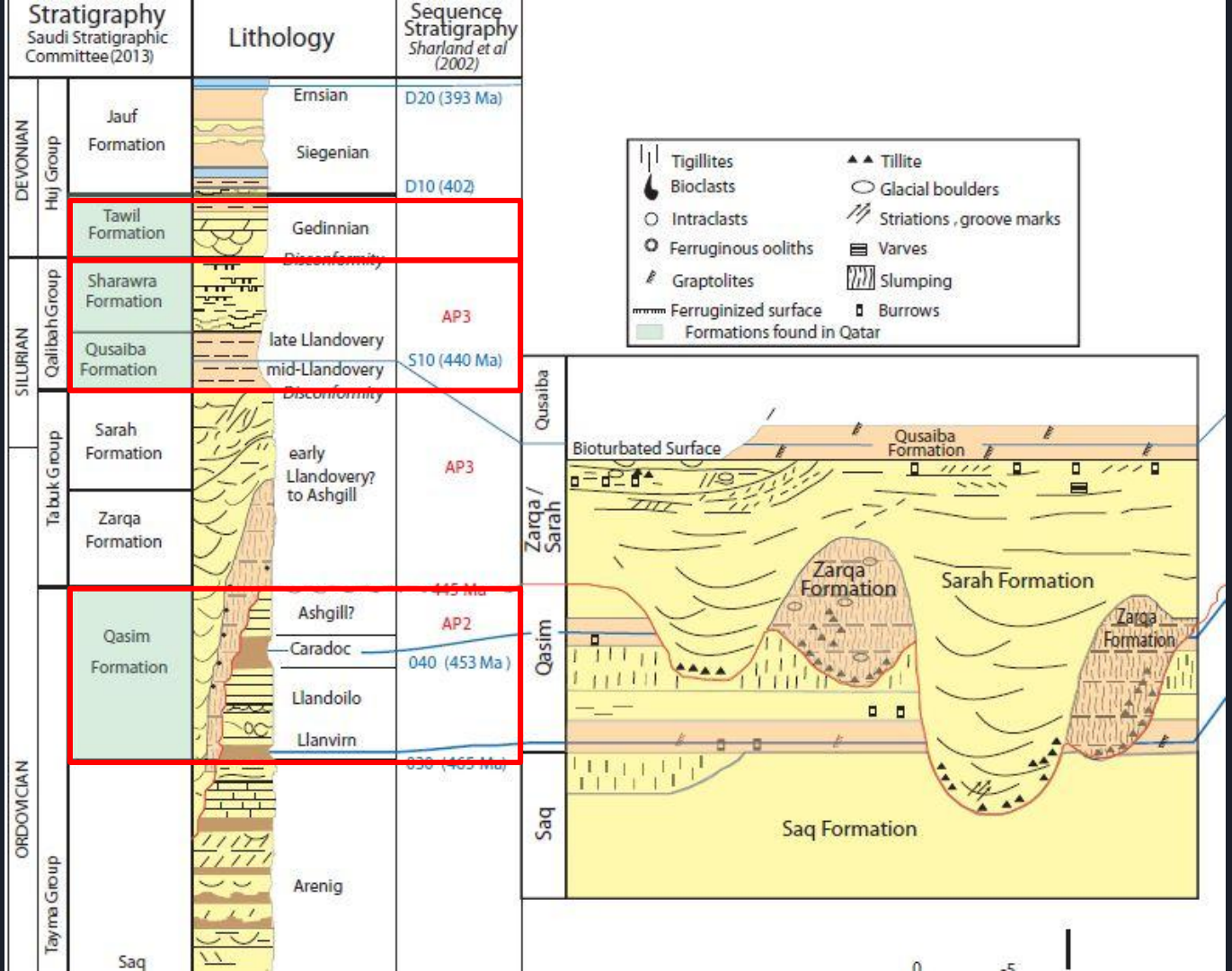
- Three formations found in group
  - Silurian uqlah - not found in Qatar
  - Sharawra
    - Upward coarsening
    - Thin bedded sandstones
  - Qusaiba
    - Fine-grained sandstones
      - Ripple marks
      - Cross Bedding
      - Bioturbation
  - Formation density log (FDC)
    - Sandstone is denser than the shale
    - Shows where fluid is likely residing



Huj group ---- Tawil formation

- Includes three formations
  - Jauf
  - Jubah
  - Tawil - only formation found in Qatar
    - Divided into three sections
      - Lower - unnamed
      - Middle - Lower porous zone
        - 100m thick
        - Represents important gas reservoir in the pre-Khuff succession
        - Cross bedded sandstones - wavy and flaser bedding
      - Upper - Upper Tawil
        - Low angled sandstones
          - Plant remains, Mica flakes, Cemented quartz and siderite
    - No major fossils - age controversial
    - Possibly early Devonian
      - Microflora from well samples
      - Jauf formation (which overlays Tawil) middle Devonian
    - Shallow marine and continental (fluvial) depositional environment
    - Low gamma rays high porosity (graphs are mirrored)




Stratigraphy
Saudi Stratigraphic Committee (2013)
Lithology
Sequence Stratigraphy
Sharland et al (2002)
DEVONIAN
SILURIAN
ORDOVICIAN
Huj Group
Qalibah Group
Tabuk Group
Tayma Group
Jauf Formation
Tawil Formation
Sharawra Formation
Qusaiba Formation
Sarah Formation
Zarqa Formation
Qasim Formation
Saq
Ernsian
Siegenian
Gedinnian
Disconformity
late Llandovery
mid-Llandovery
Disconformity
early Llandovery? to Ashgill
Ashgill?
Caradoc
Llandoilo
Llanvirn
Arenig
D20 (393 Ma)
D10 (402)
AP3
S10 (440 Ma)
AP3
AP2
040 (453 Ma)
Tigillites
Bioclasts
Intraclasts
Ferruginous ooliths
Graptolites
Ferruginized surface
Formations found in Qatar
Tillite
Glacial boulders
Striations , groove marks
Varves
Slumping
Burrows
Qusaiba
Zarqa / Sarah
Qasim
Saq
Bioturbated Surface
Qusaiba Formation
Zarqa Formation
Sarah Formation
Zarqa Formation
Saq Formation

Stratigraphic sequence

Tectono Stratigraphic Sequence (TMS'S)

Large scale layering of rock sequences

- AP2 - Megasequence
  - Early Cabrian to late Ordovician
  - Qasim Formation
  - Two maximum flooding surfaces
    - O30 - Based of Qasim formation (basel shale unit)
    - O40 - Middle shale unit
  - During deposition
    - Qatar - broad / shallow water shelf
      - Received continental clastic material
    - Consisted of 2 cycles
      - Sag - not in Qatar
      - Under the O40 MFS (Base of Qasim)

Maximum flooding surfaces (MFS)

Transition from transgressive to regressive

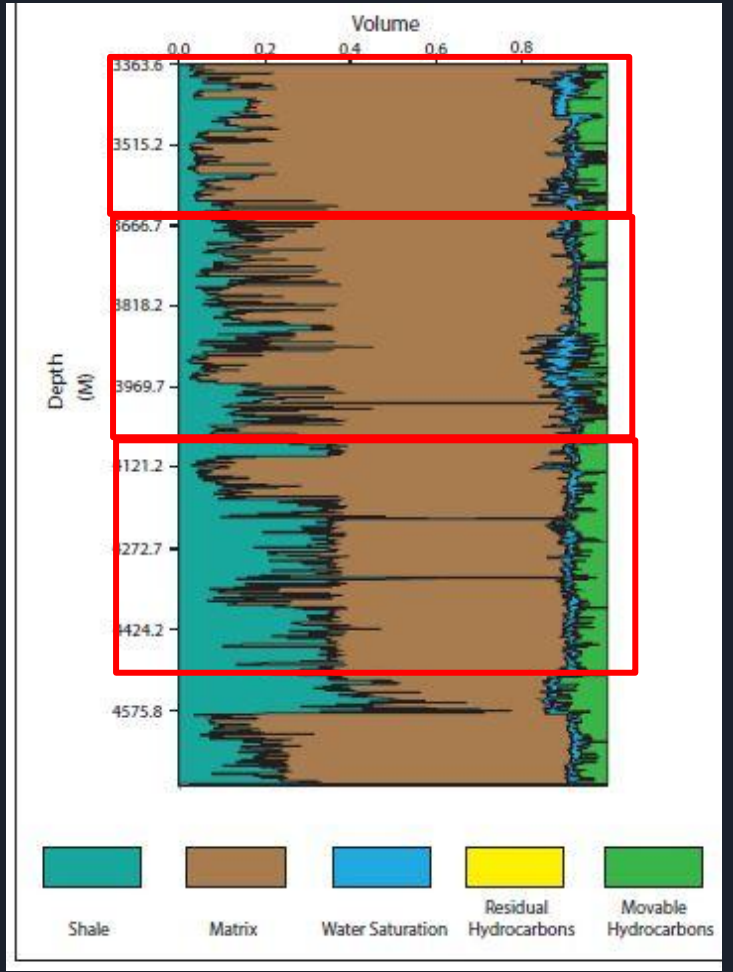
- AP3 - Megasequence
  - Upper Ordovician to Upper Devonian
  - Placed above the Ashgill unconformity
  - Consists of
    - Qalibah group
    - Tawil formation
  - Two Maximum flooding surfaces
    - S10 - Based of Qusaiba group
      - Second order deposition
    - S20 - Based of Tawil formation

Source rocks in Qatar

- The source rocks are found in the Qusaiba and the Sharawra formations
  - Qusaiba formation
    - Hydrocarbon generated during late permian
    - Generated oil until late Jurassic
      - Then began to expel gas and condensates (continued until present day)
  - Sharawra formation more in depth on next slide
  - These source rocks consist of
    - Grey-black sandstones and claystones
    - Intervals contain sapropelic organic matter
    - The total organic carbon content ranges up to 7.3% weight

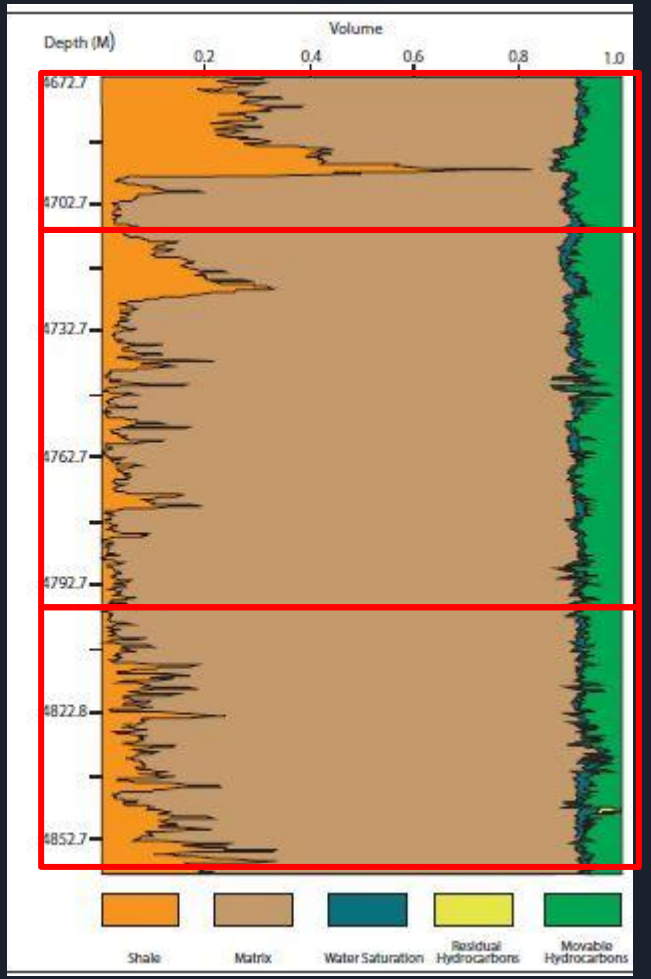
Sharawa Formation

- Contains organic matter
  - Ranges up to 7.3% rate
  - Good porosity and permeability (mouldic)
    - Organic material weathered away leaving holes in the rock
    - Porosity 3 to 21% (average 10%)
- Upper (3330-3630m)
  - Shale volume 2 to 40% (average 12%)
  - Matrix volume between 52 and 92%
  - Movable hydrocarbons vary from 0 - 2%
- Middle (3630-4080m)
  - Shale volume 1 to 95% (average 21%)
  - Matrix volume 0 - 69%
  - Movable hydrocarbon constituent 15%
- Lower (4080-4668m)
  - Shale volume 4 to 99% (average 32%)
  - Matrix 0 - 88%
  - Movable hydrocarbon reach 15%



Reservoir rocks

- Qasim formation
  - Deposited in shallow marine - Locally deltic setting
  - Upper section (4668-4710m)
    - Matrix between 1 and 88 (average 67%)
    - Movable hydrocarbons volume rangers from 6 to 13% (average 9%)
  - Middle section (4710 -4800m)
    - Shale volumes between 4 and 34%
    - Matrix average around 84%
    - Movable hydrocarbons average 8%
  - Lower section (4800-48630)
    - Shale volume average 10%
    - Matrix average 91%
    - Movable hydrocarbon averages 10%
  - Porosity ranges from 4 to 14% (average 9%)
    - Permeability 0.5mD
    - Pores small in size & not connected
- Poor reservoir characteristics due to thin laminations of sandstone beds (<5cm thick)



Conclusion

- Qatar is an Arabian country
  - Has petroleum of paleozoic age (Rare)
- There were three wells drilled which helped to learn the stratigraphics of the country
  - Matbakh A
  - Dukhham A
  - Dukham B
- These well gave evidence of the pre-khuff succession through three formations
  - Qasim - Reservoir rocks
  - Qalibah - Source rocks
  - Tawil
- The Qusaiba Shale is an important source rocks that generated oil until the Late Jurassic and then started to generate gas
  - This discover has paved the way for other exploration into petroleum in the Paleozoic era.

Thank you