[PS] Jurassic and Cretaceous Sedimentary Fill of Intrashelf Basins of the Eastern Margin the Arabian Plate*

Thomas L. De Keyser[1] and Christopher G. Kendall[2]

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[1]Technically Write Consulting, LLC, Harrisburg, Oregon, US (dekeyser@wispertel.net)
[2]Earth Sciences and Resources Institute, University of South Carolina, Columbia, South Carolina, US (kendall@geol.sc.edu)

Abstract

Middle Eastern Mesozoic intrashelf basins (ISB) contain the world's largest oil fields, most in carbonates of the AP 7 Megatectonic cycle. Arabian Plate ISBs developed while rifting occurred in Yemen, the Indian Ocean and Tethyan margin. ISB began when a rapid sea level rise exceeded carbonate production over the platform interior. Basin fill started with an organic-rich condensed/starved section while platform carbonates aggraded surrounding a starved basin whose margin then prograded and infilled into water commonly of less than 100 m. Jurassic Arabian Plate ISBs include: Marrat, Hanifa, Najmah, and Gotnia, whose dominant fill is shallow marine arid climate limestones and dolomites with common evaporites and interbedded minor transitional marine shales and basin margin grain carbonates. Cretaceous ISBs include: Garau of Iraq, Kazhdumi of Iran and Bab of the UAE, Qatar, Saudi Arabia and Oman, that were filled by humotropic carbonate with dolomites and shales but few evaporates, while ISB margins accumulated rudistid clinoforms. Giant oil fields of both Jurassic and Cretaceous sections occur in grain carbonates while rudistid buildups are the reservoirs of Cretaceous intrashelf margins. Source rocks, include the Hanifa Fm. the Najmah Sh. the Naokelekan in Iraq, and the Aptian “tar” of the Bab Member of the Shuaiba Fm. Collectively Jurassic and Cretaceous source rocks formed the prolific petroleum systems of the ISBs. Expanding exploration now includes stratigraphic plays in the ISBs, providing new exploration opportunities. The shared geologic history of the Southern Tethys region means similar tectonic and depositional settings and a stratigraphy that can be correlated across the region.

Jurassic and Cretaceous Sedimentary Fill of Intrashelf Basins on the Eastern Margin of the Arabian Plate

Thomas L. De Keyser (1) and Christopher G. Kendall (2)
(1) Technically Write Consulting, LLC, Harrisburg, Oregon, United States;
(2). Earth Sciences & Resources Institute, University of South Carolina, Columbia, SC, United States.

Middle Eastern Mesozoic intrashelf basins (ISB) contain the world's largest oil fields, most in carbonates of the AP 7 Megatectonic Cycle. Arabian Plate ISBs developed while rifting occurred in the Mediterranean Sea, the Indian Ocean, and along the Tethyan margin. ISBs are initiated by: (I) a rapid sea level rise, exceeding carbonate production, resulting in a retreat of the margin to the platform interior, followed by; (II) aggradation of the new margin while condensed, organic-rich sediments accumulate in the starved basin center. The ISB margin then; (III) progrades and; (IV) infills the basin, which is commonly less than 100 m deep.

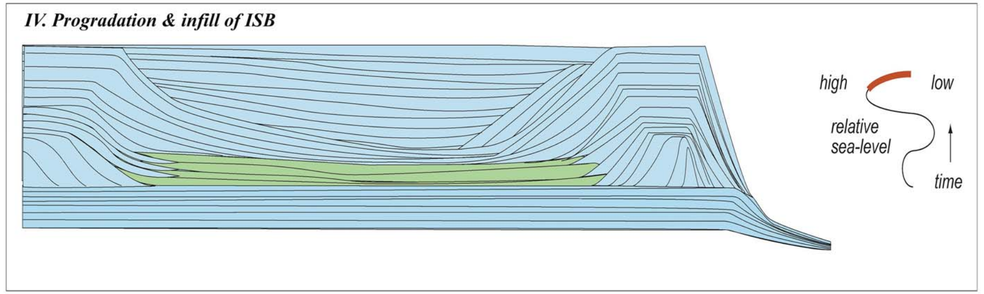
Jurassic Arabian Plate ISBs include: the Marrat, Hanifa, Najmah, and Gotnia. Fill is dominantly shallow marine, arid-climate limestones and dolomites with common evaporites and interbedded, minor transitional marine shales and basin margin grain carbonates. Cretaceous ISBs include: Garau of Iraq, Kazhdumi of Iran and Bab of the UAE, Qatar, Saudi Arabia and Oman. Fill dominantly humotropic carbonate with dolomites and shales but few evaporates, while ISB margins accumulated rudistid clinoforms.

Giant oil fields of both Jurassic and Cretaceous sections occur in grain carbonates while rudistid buildups are the reservoirs of Cretaceous intrashelf margins. Source rocks, including the Hanifa Fm., the Najmah Sh., the Naokelekan in Iraq, and the Aptian "tar" of the Bab Member of the Shuaiba Fm. Collectively Jurassic and Cretaceous source rocks formed the prolific petroleum systems of the ISBs. Expanding exploration now includes stratigraphic plays in the ISBs, providing new exploration opportunities. The shared geologic history of the Southern Tethys region means similar tectonic and depositional settings and a stratigraphy that can be correlated across the region.

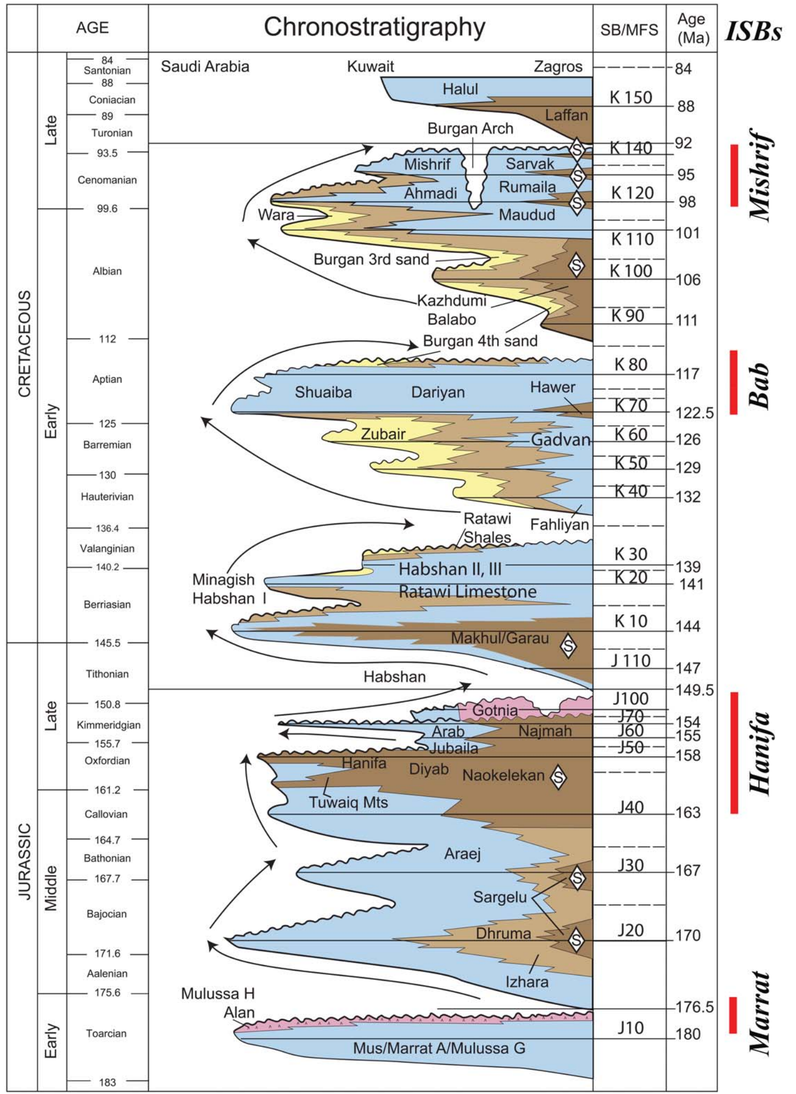
Discussion:

- *To cause the platform margin to retreat and re-form on a shallower part of the platform interior, the sea level rise must be rapid and of larger magnitude than the cyclicity typical of the aggradational platform cycles.*
- *The most common cause of such large changes of sea level are plate tectonic events which result in increases in the length of the ridge system and/or changes in rate of spreading.*
- *The ISBs discussed here occur at four specific time intervals and correlate with known oceanic anoxic events(OAEs): (1) early Toarcian, (2) Kimmeridgian-Tithonian, (3) Aptian-early Albian, and (4) Turonian-Cenomanian.*
- *OAEs are associated with increased total organic carbon (TOC), carbon isotope minima, and strontium isotope minima, such that all of these ISBs are associated with hydrocarbon source rock deposition.*
- *Many of the world's largest oil and gas fields are located near or within the limits of these ISBs and were sourced from them.*
- *ISBs occur throughout the Phanerozoic section on all continents and they should be included as a normal part of the exploration paradigm.*

FOUR STAGES OF ISB DEVELOPMENT, RELATED TO SEA LEVEL

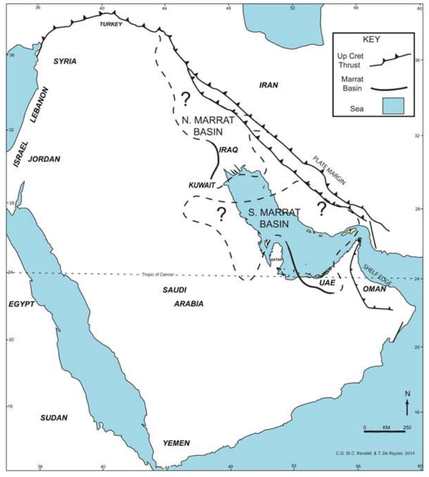


ARABIAN PLATE JURASSIC & CRETACEOUS ISBs

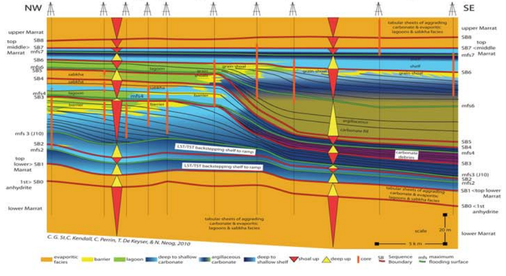


(Modified after Sharland & others (2001) & Haq & Al-Qahtani (2005))

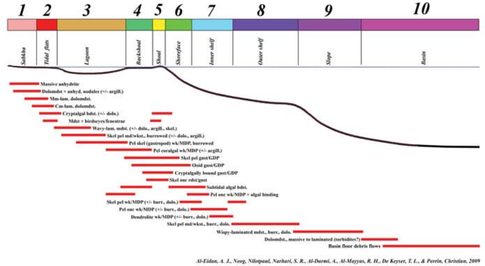
Toarcian - Marrat ISB



Sequence stratigraphic framework, Middle Marrat, Kuwait

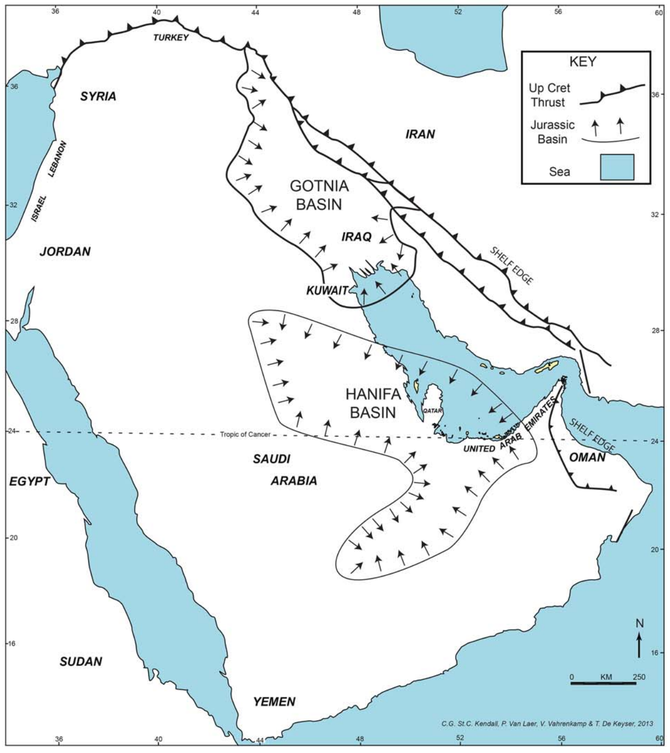


Calciclastic Shelf Depositional Profile

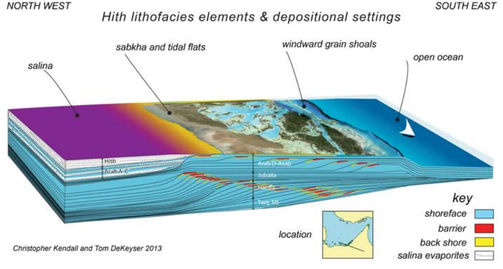


Al-Eidan, A. J., Nong, Nilopaul, Narhari, S. R., Al-Darmi, A., Al-Mayyan, R. H., De Keyser, T. L., & Perrin, Christian, 2009

Callovian-Tithonian - Hanifa & Gotnia ISBs



Geometry & facies changes across Hanifa ISB margin, Abu Dhabi



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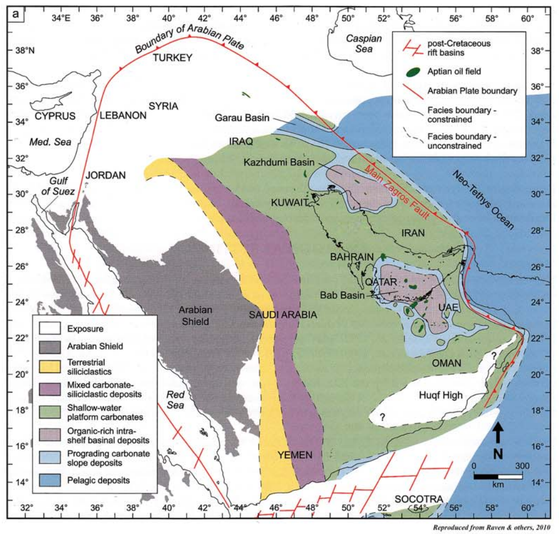
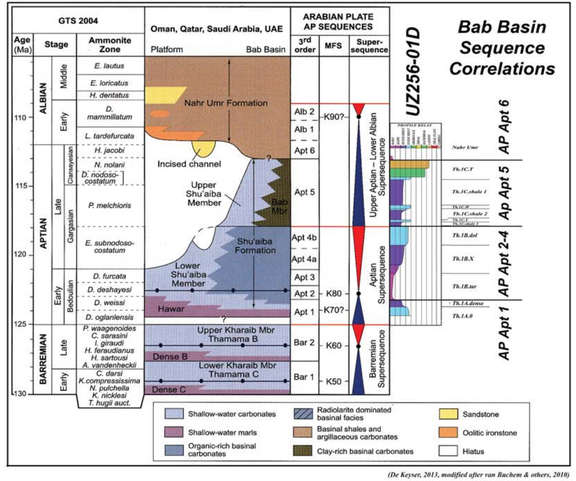
Aptian-Albian - Bab & Kazhdumi ISBs



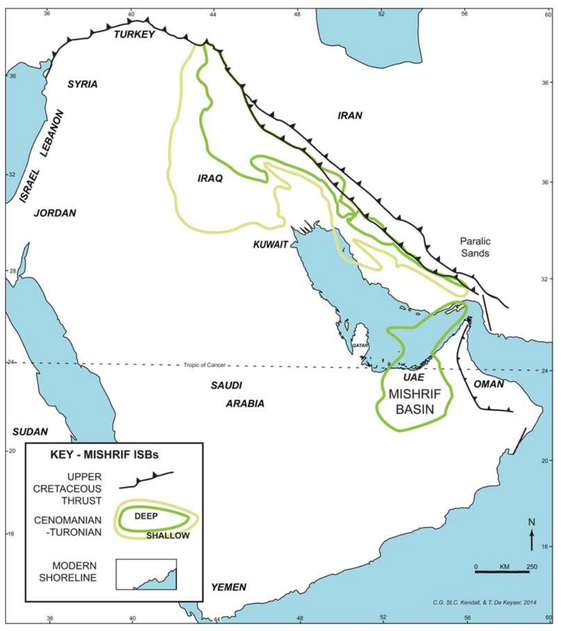
Reproduced from Raven & others, 2010

Chronostratigraphy, Bab ISB

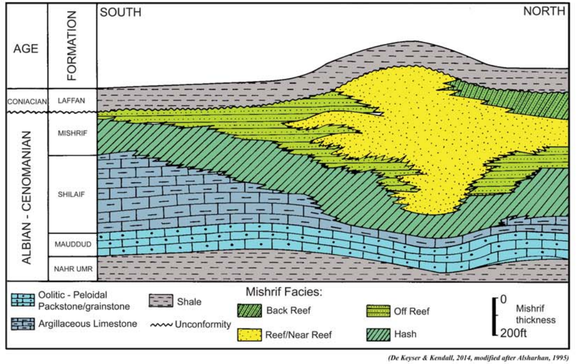


(De Keyser, 2013, modified after van Buchem & others, 2010)

Cenomanian-Turonian - N & S Mishrif ISBs

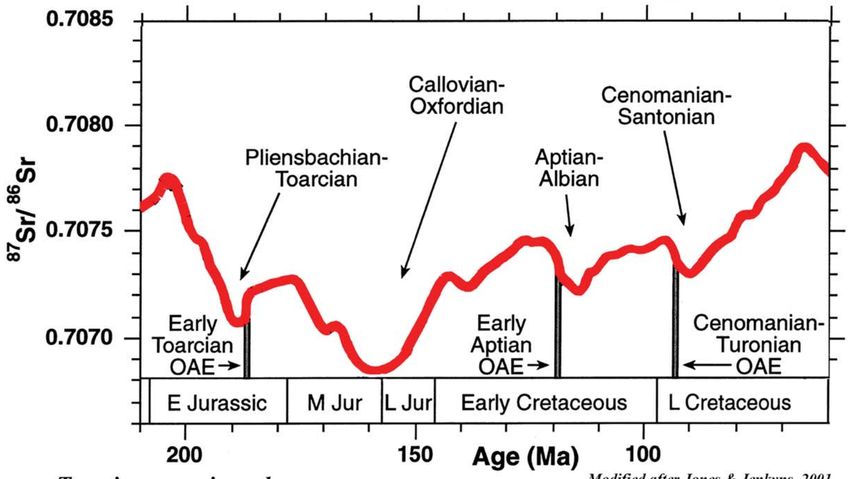


Lithofacies across Mishrif ISB margin in UAE



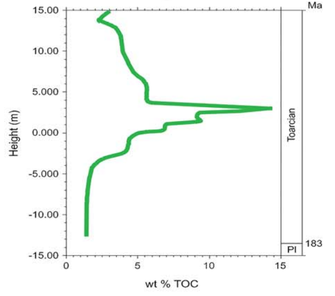
(De Keyser & Kendall, 2014, modified after Alsharhan, 1995)

ISB occurrences versus Strontium isotope ratio

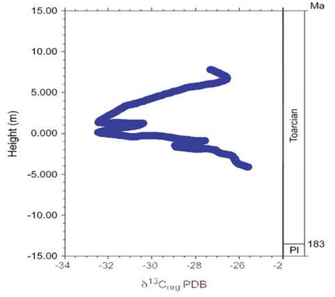


Modified after Jones & Jenkyns, 2001

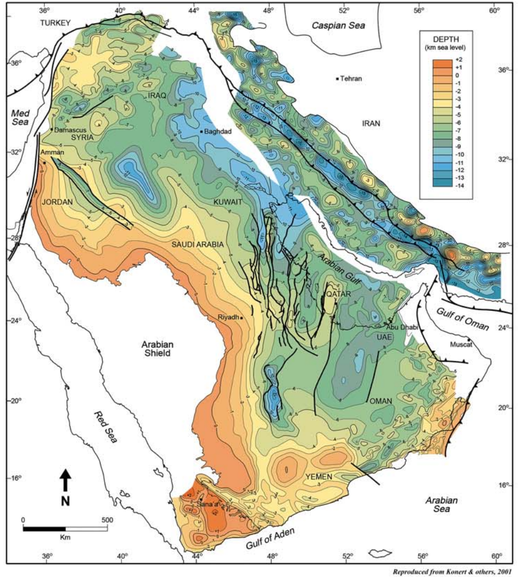
Toarcian organic carbon



Toarcian carbon isotopes

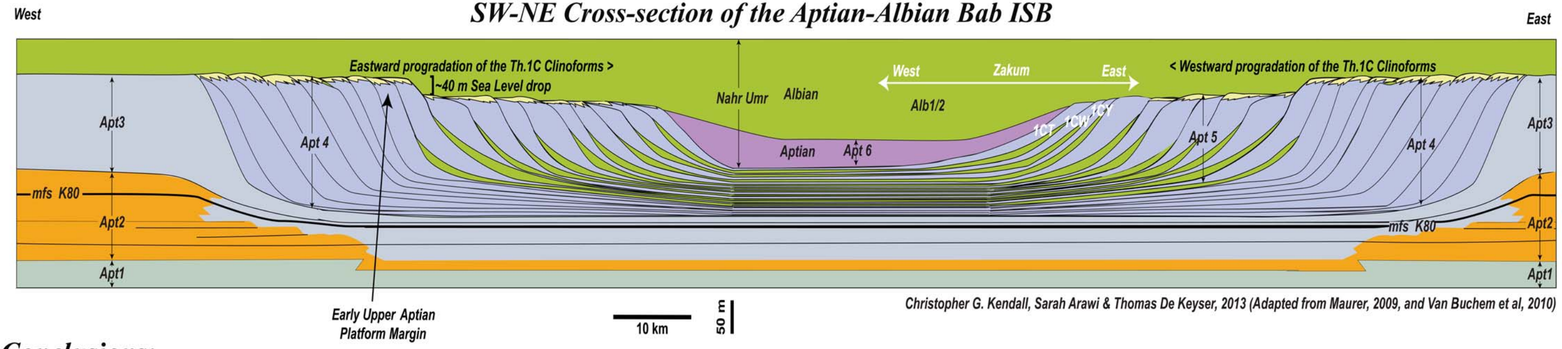


ISBs occur in areas of deep basin structure



Reproduced from Konert & others, 2001

SW-NE Cross-section of the Aptian-Albian Bab ISB



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Conclusions:

- *Four stages of ISB development are:*
  - *o Development of a drowning unconformity on a preexisting broad carbonate platform*
  - *o Formation of a new carbonate margin in a shallower area of the platform interior accompanied by accumulation of starved, organic-rich sediments above the drowning unconformity*
  - *o Aggradation of the new basin margin and inception of progradation into the ISB*
  - *o Progradation and infill of the intrashelf basin*
- *Current ISBs formed on the Arabian Plate are from four distinct times during the Jurassic and Cretaceous:*
  - *o Early Jurassic (Toarcian)*
  - *o Late Jurassic*
  - *o Early Cretaceous (Aptian)*
  - *o Mid-Cretaceous (Turonian-Cenomanian).*
- *The Southern Tethys region has similar tectonic and depositional history and stratigraphy correlatable across the region to identify old plays in new settings. By focusing on the ISBs new exploration opportunities and stratigraphic plays are likely in these ISBs.*
- *Portions of the several Jurassic and Cretaceous intrashelf basins are underexplored, particularly down-dip on ISB margins in the Lower Jurassic.*
- *Current oil fields are oldest in the western portions of the Gulf and are younger to the east.*
  - *o Using current oil fields as analogs for potential hydrocarbon plays, these are likely to occur in humotropic carbonate clinoforms inter-bedded with dolomites and shales sealed by updip evaporites and/or shales.*
  - *o Plays include grain carbonate shoals, and bioclastic buildups. The latter in particular are likely associated with rudists but not restricted to them.*
- *Source rocks for these prolific petroleum systems were generated downdip in basin centers in sediments that accumulated during the most rapid portions of a sea level rise.*
- *ISBs with hydrocarbon potential are not restricted to the Middle East and occur throughout the Phanerozoic section on all continents. They too are extraordinarily productive and are often included as a normal part of the exploration paradigm. For instance, in North America, these encompass:*
  - *o The Permian basin of West Texas and New Mexico*
  - *o Western Canada Sedimentary basin*
  - *o Williston basin*
  - *o Illinois basin*
  - *o Michigan basin*
  - *o ISBs also are known in Western Australia, with the Devonian of the Canning and Bonaparte basins.*

Arabian Gulf Oil Fields