FRONTIER EXPLORATION IN PAKISTAN

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- Geological Setting of Pakistan
- Why Frontier Exploration
- > Frontier Exploration Areas of Pakistan
- Useful Tools and Experiences
 - Low Velocity Zones in the core of anticline
 - Wide Line techniques for complex structures
 - Stress Field Detector (SFD) Air Bourn Survey
 - Geological data to resolve steeply dipping dips on seismic
 - Geochemical surveys
 - Importance of analogues to explore new plays
- > Take Home Message

PAKISTAN EXPLORATION & PRODUCTION OUTLOOK (AS OF DECEMBERS, 2015)



> Total Sedimentary Area: 827,268 Km2

Area under Exploration: 361,466 Km2

Exploration Licences: 179; Active Leases: 160

> Active Exploration Companies:

Operator: 30 (Foreign: 18 & Local: 12)

Non Operator: 25 (Foreign: 20 & Local: 5)

Active Seismic Crews: 12 ; Active Rigs: 31

Wells Drilled (Since 1868):

Exploratory: 957 (Success Ratio: 1:3)

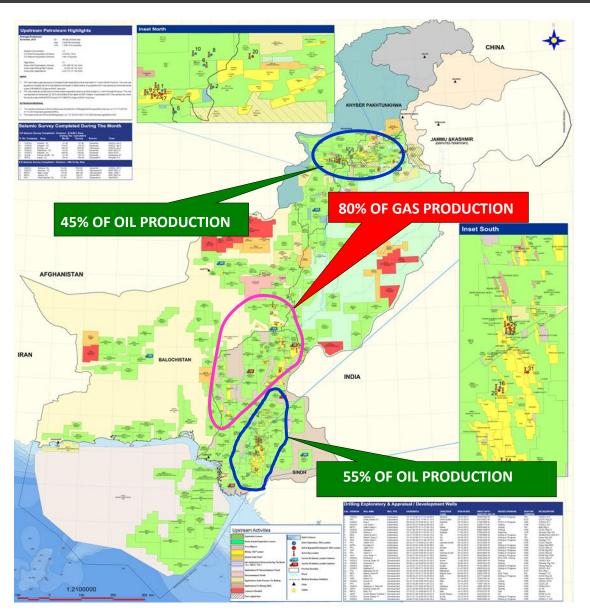
Discoveries: 329

Appraisal & Dev : 1,281 (33 before 1947)

> Avg. Daily Oil Production: 89,982 bbl/d (Dec, 2015)

Avg. Daily Gas Production: 4,083 MMscf/d (Dec, 2015)

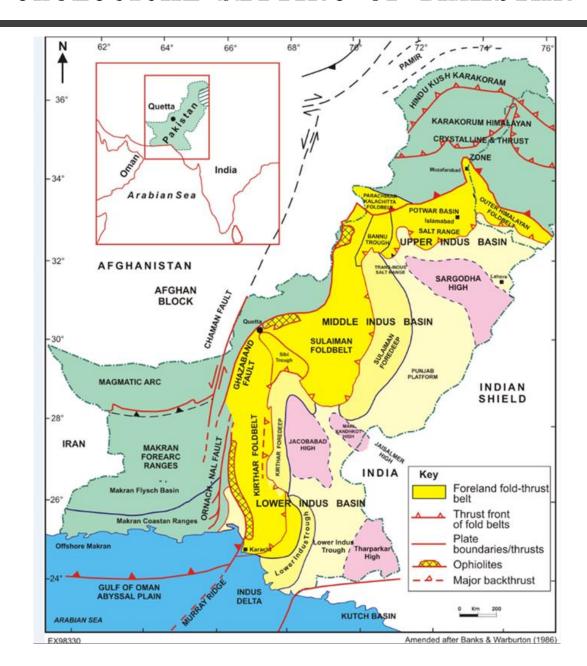
Reserves / Production (As of Dec, 2014)	Oil (MMBbl)	Gas (Tcf)
Original Recoverable	1,185.8	53.9
Cumulative Production	801.4	33.6
Balance Recoverable	384.4	20.2

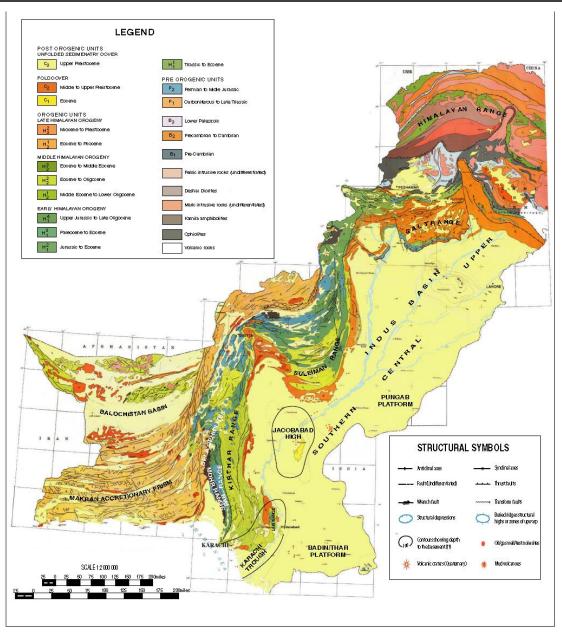


Source: PPIS

GEOLOGICAL SETTING OF PAKISTAN

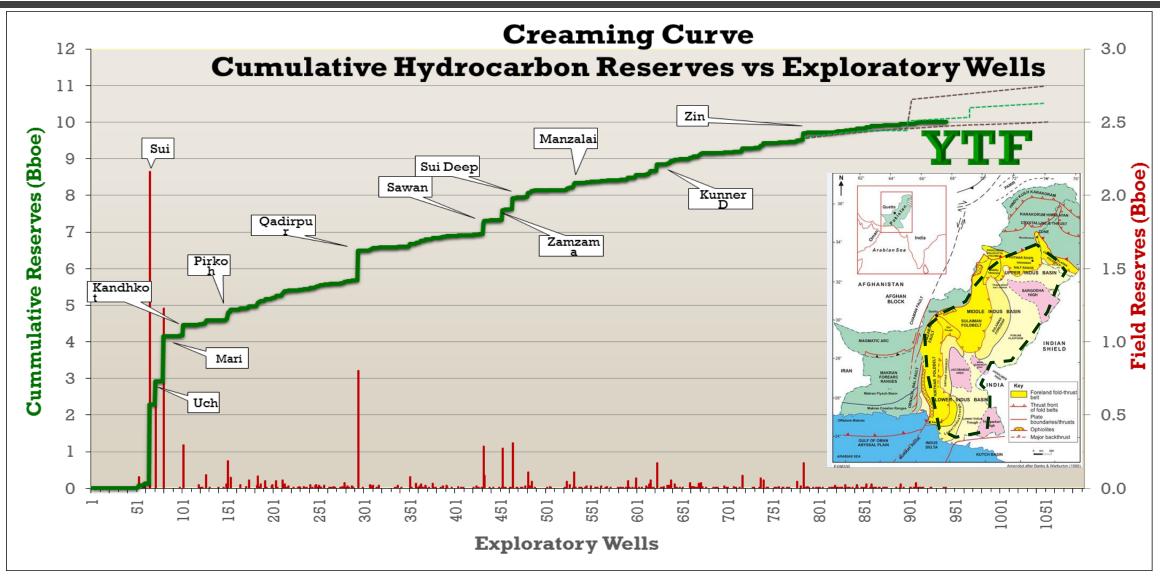






WHY FRONTIER EXPLORATION





The above estimate is excluding Balochistan basin & offshore Updates available as of 30 Oct 2015 for wells & 30 June 2015 for Reserves

EXPLORATION STATUS IN PAKISTAN

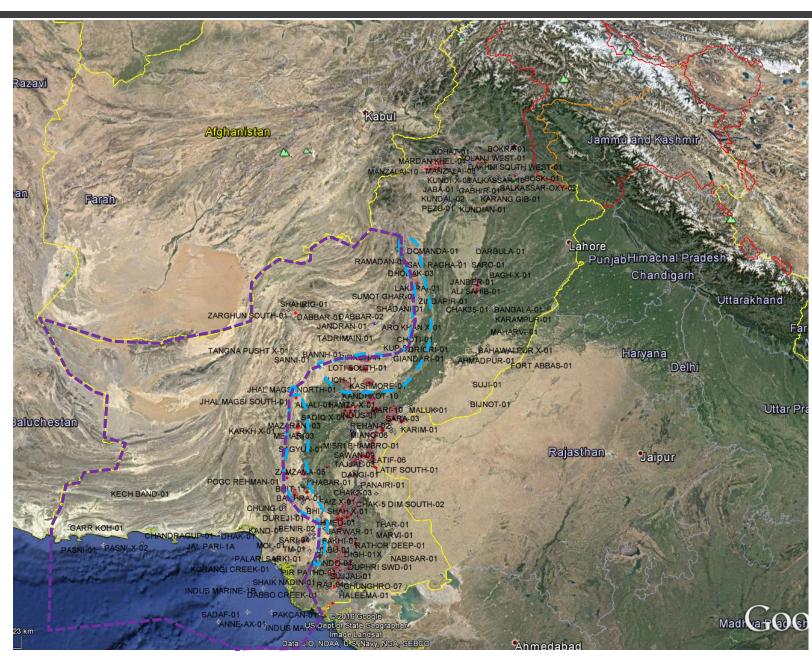


> Exploration wells: 980

➤ Discoveries: 350

➤ Success Ratio 1:3

The total discovered reserves are around 61 tcfe (approximately 88% gas and 12% oil).



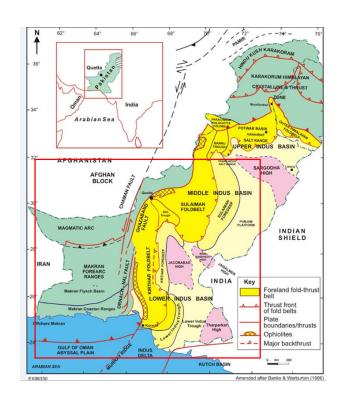
Frontal part of fold belts – big discoveries

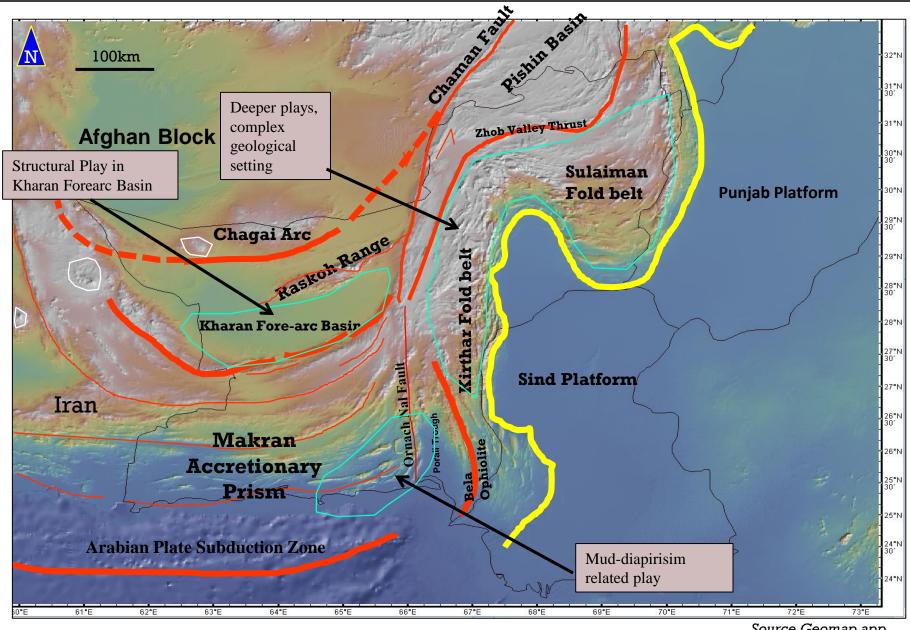
Frontier Basins

ONSHORE FRONTIER EXPLORATION



- Kharan Forearc Basin-Structure Plays
- Mud-diapirisim related traps play
- Deeper Plays with complex geological setting in Kirthar Foldbelt

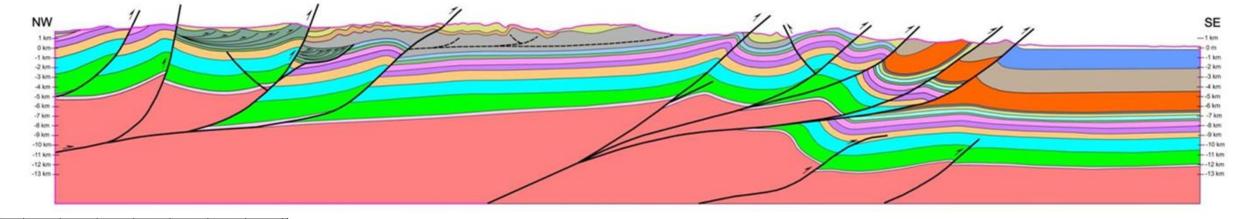


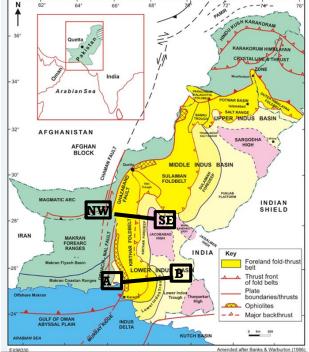


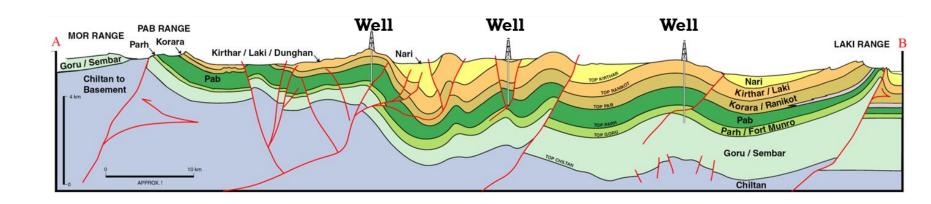
Source Geomap app

REGIONAL SETTING - KIRTHAR FOLD BELT



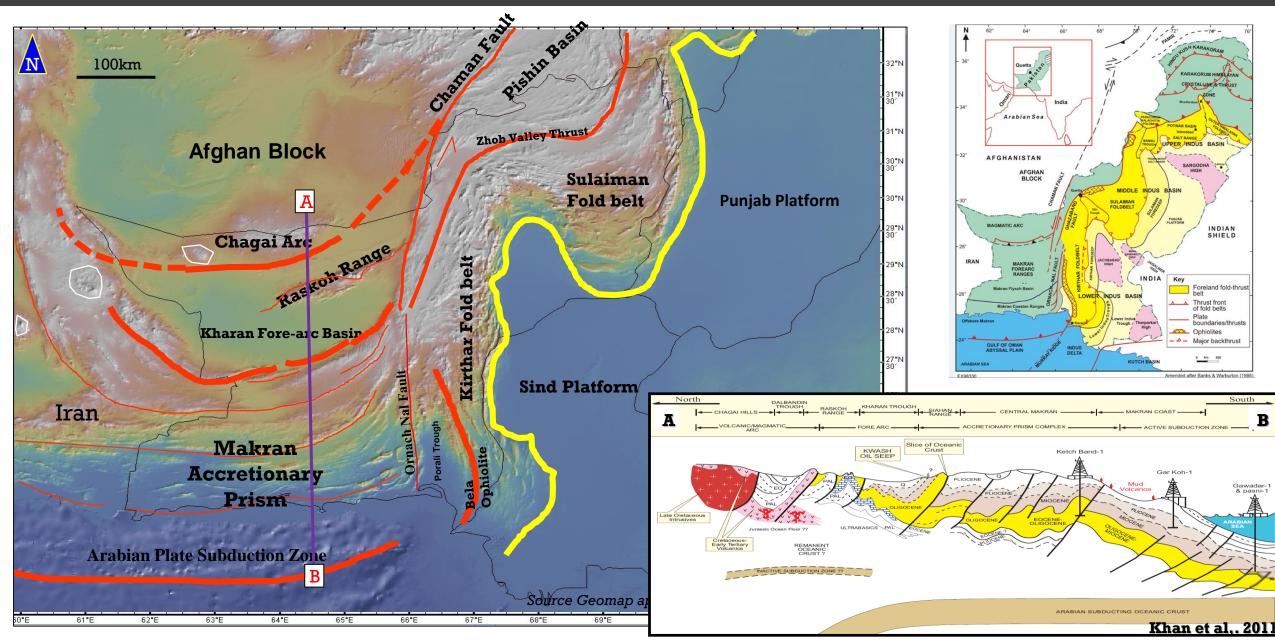






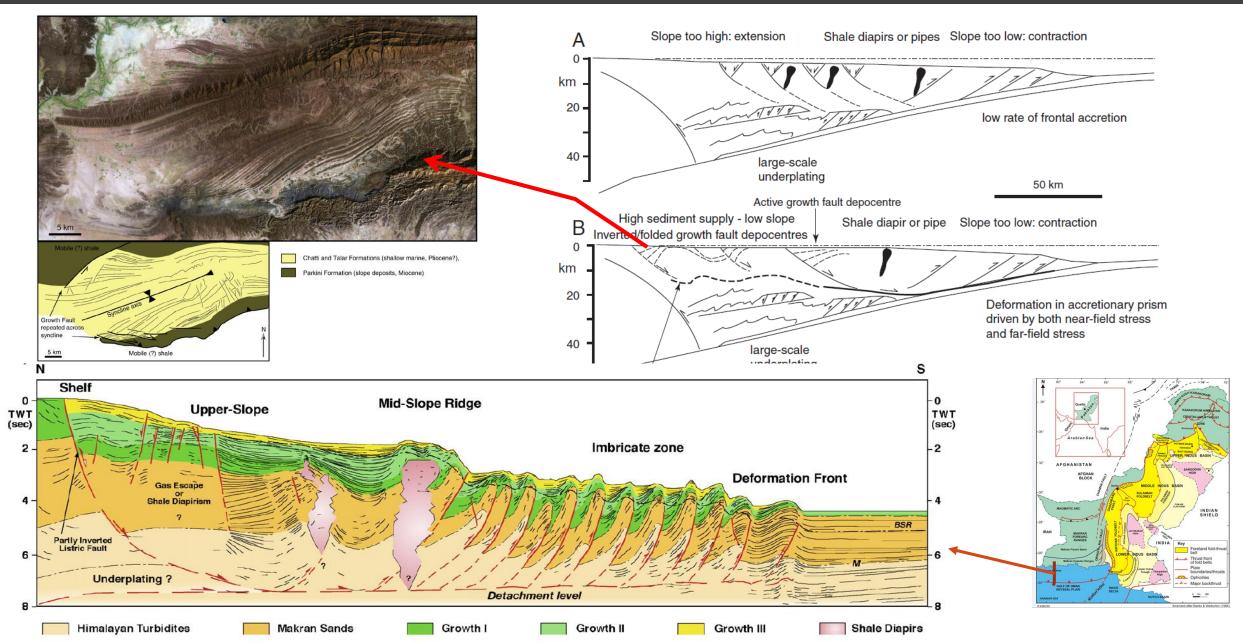
FRONTIER EXPLORATION AREAS - MAKRAN





REGIONAL SETTING - MAKRAN

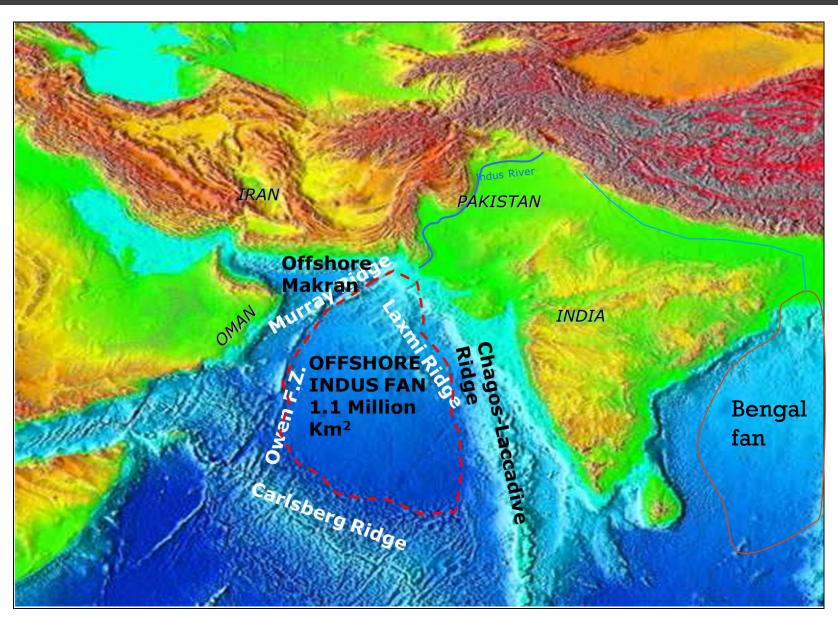




REGIONAL SETTING — OFFSHORE INDUS



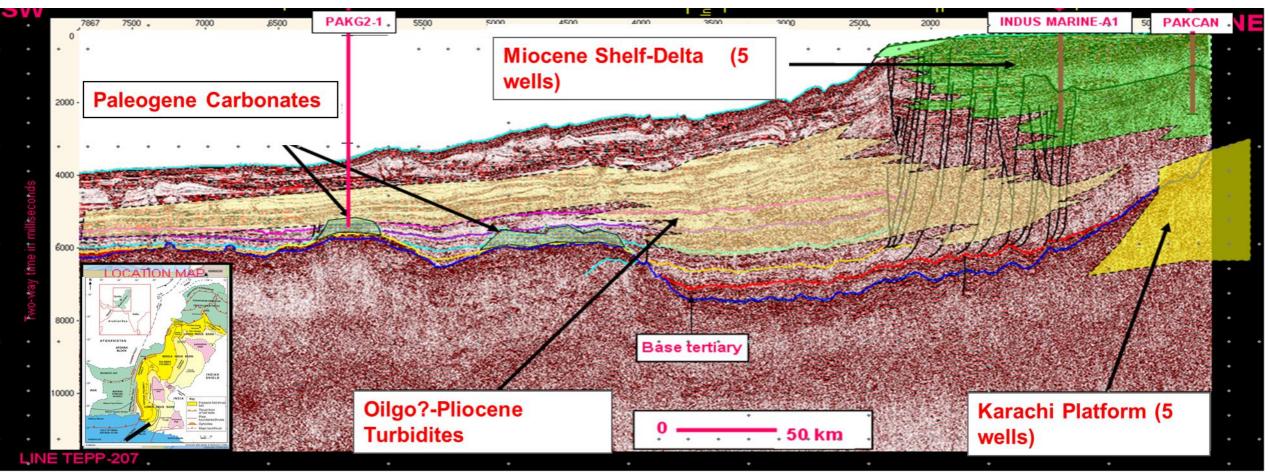
- Indus Offshore: Second largest delta/fan system, after Bengal Fan
- ➤ Water Depth 0 4500m
- Sediment Thickness 8 9 Km in Delta System
- Indus Delta system is analogous to other producing deltas



REGIONAL SETTING — OFFSHORE INDUS



Offshore Indus developed off the passive continental margin of Pakistan-India approx. 60 Million Years ago



REGIONAL SETTING — OFFSHORE INDUS



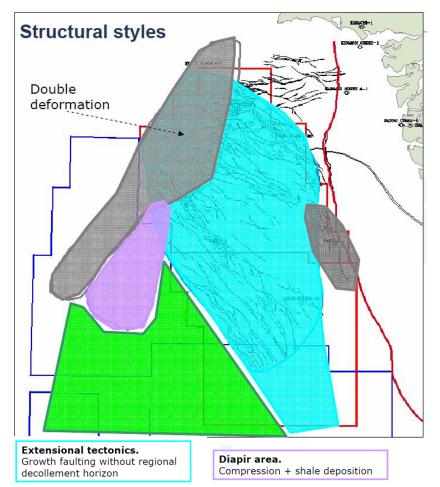
 A number of regional offshore evaluations conducted, Geology and HC potential yet to be unlocked



One of the last unexplored, high prospectivity basin in the world

or

A low prospectivity area, without commercial discoveries after 50 years of exploration?

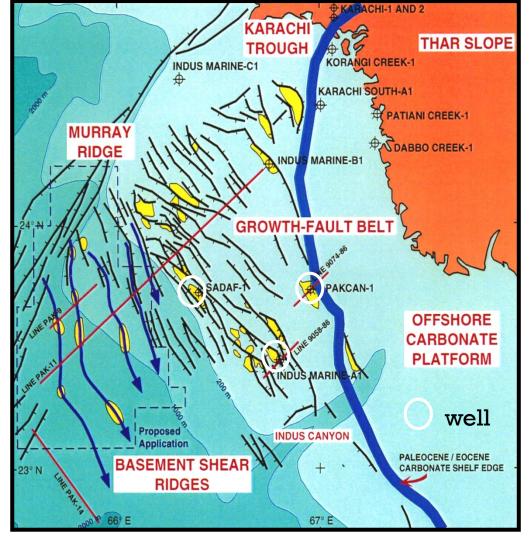


Compressional regime. 3-4 North-South thrusts related

3-4 North-South thrusts related to gravitational stress against the Murray ridge (or Himalaya collision.

Packan anticline = ?

Undeformed area. No structures but potential for large stratigraphic traps



ENI, PPL- 2008 Shell, 2008



USEFUL TOOLS & LESSON LEARNED

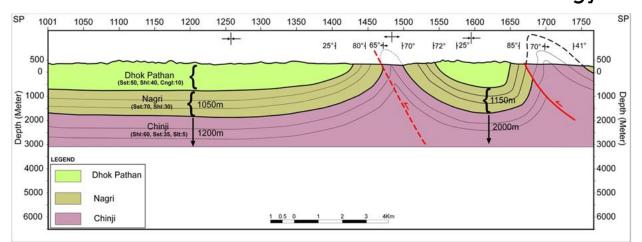
IMPLICATION OF CRUSHED ZONE WITH IN ANTICLINE

Possible low

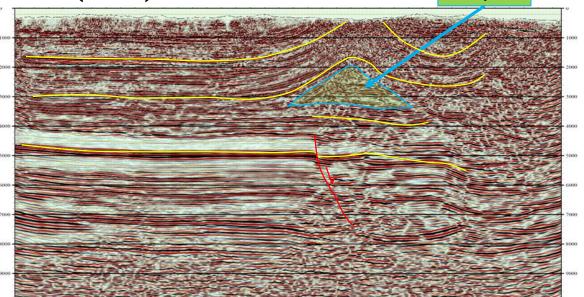
velocity zone



Structural Cross Section based on Surface Geology



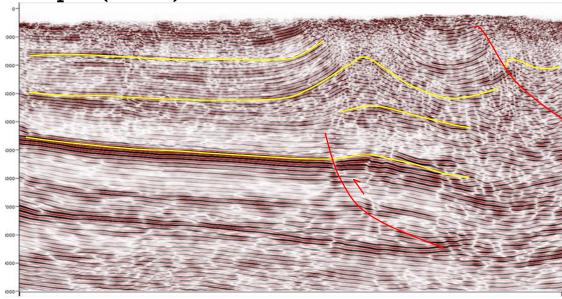
Time (PSTM) Section



Axis of the Anticline

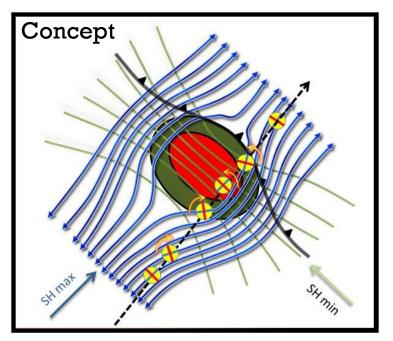


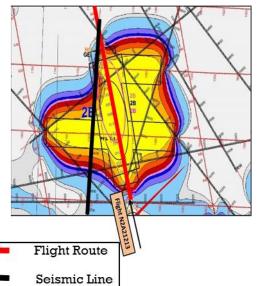
Depth (PSDM) Section



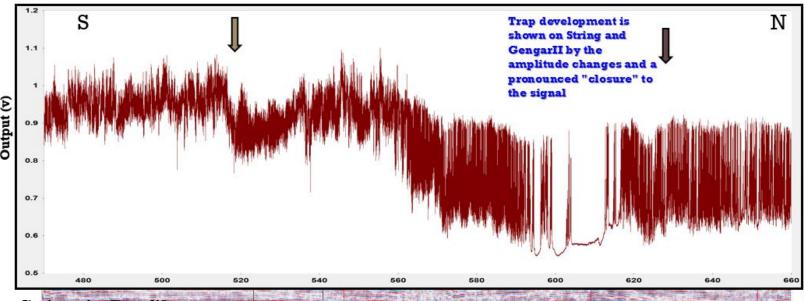
STRESS FIELD DETECTOR (SFD) IN FRONTIER AREAS

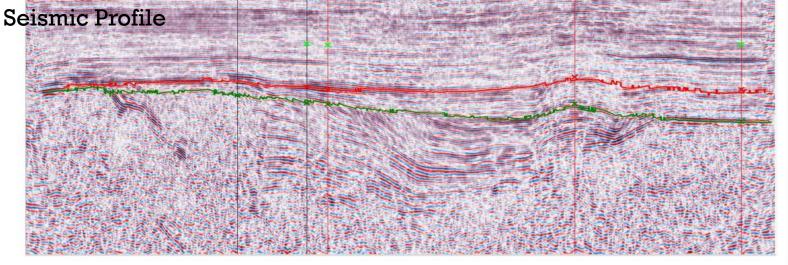






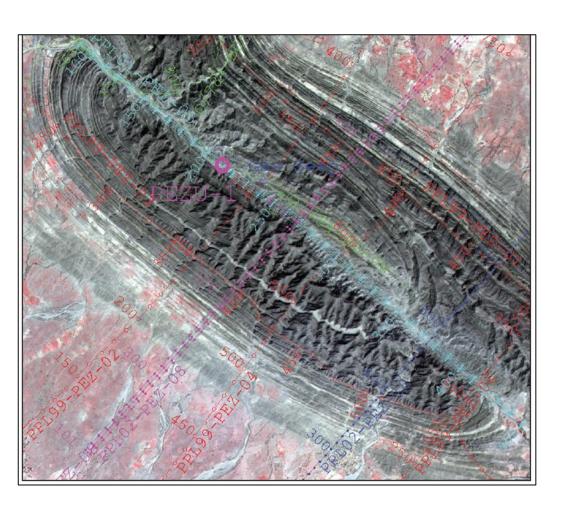
SFD Sensor Response



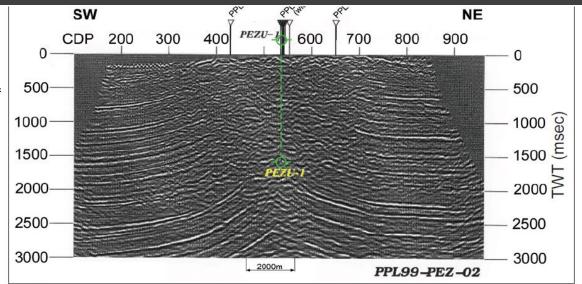


WIDE LINE SEISMIC DATA IN COMPLEX GEOLOGICAL SETTING

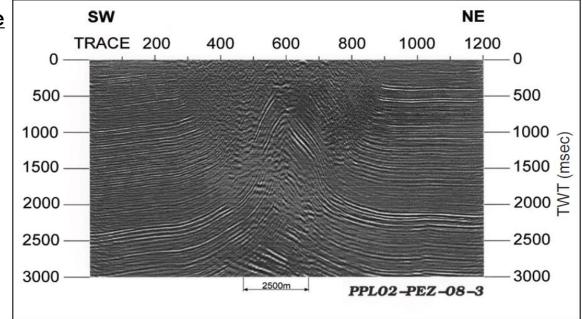




Conventional
2D Seismic
Line



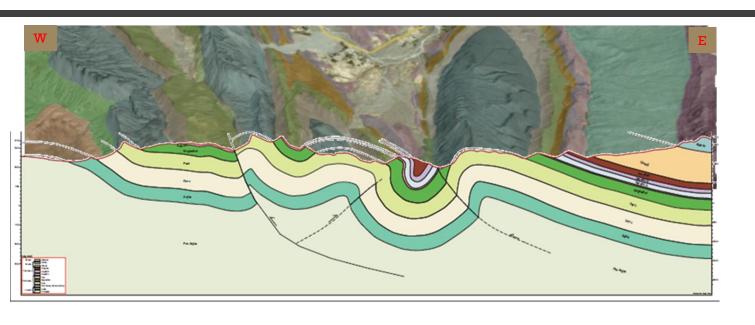
Wide Line

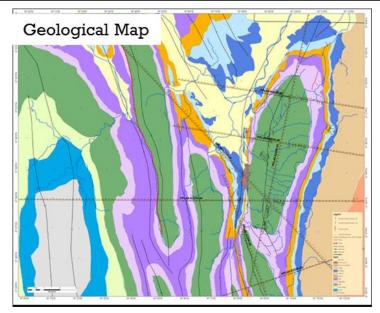


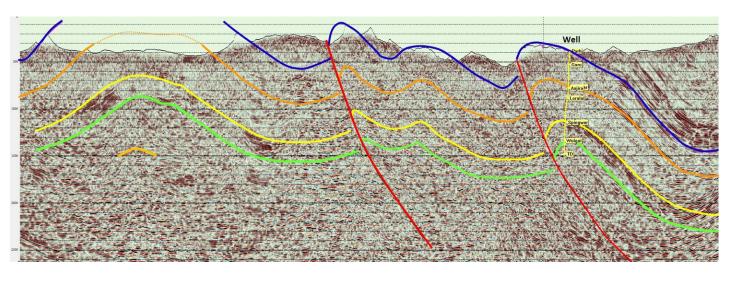
Ansari and Siddiqui, 2002

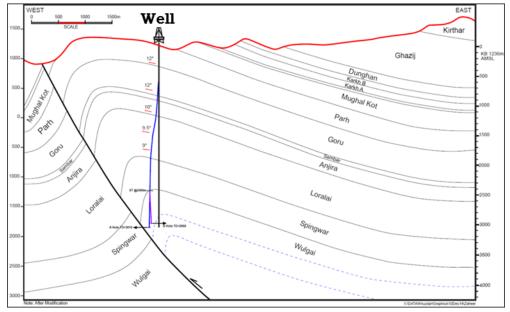
GEOLOGICAL DATA TO RESOLVE STEEP DIPS ON SEISMIC





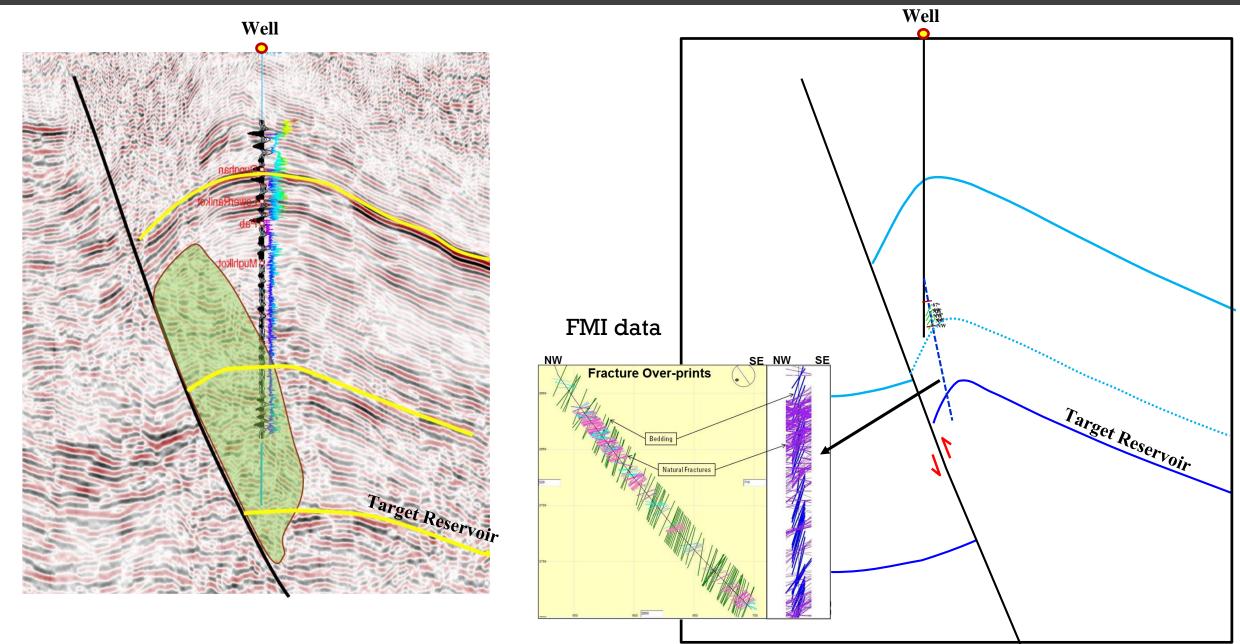






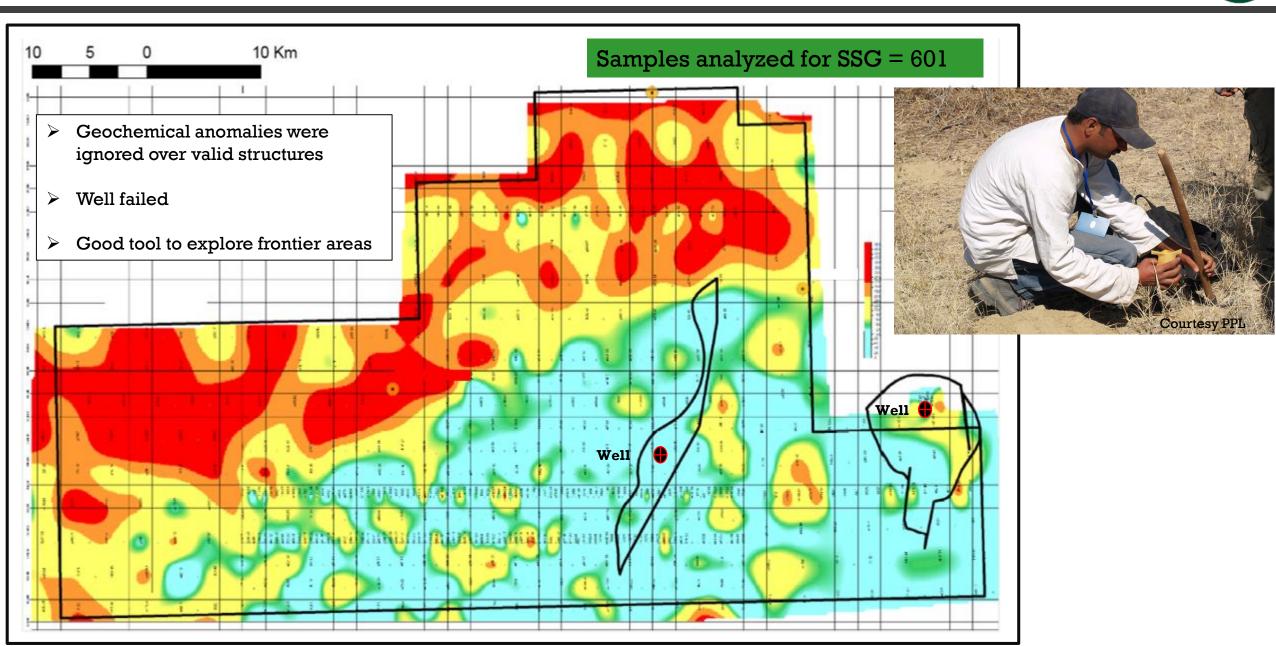
GEOLOGICAL DATA TO RESOLVE STEEP DIPS - III





GEOCHEMICAL TECHNIQUES IN FRONTIER AREAS



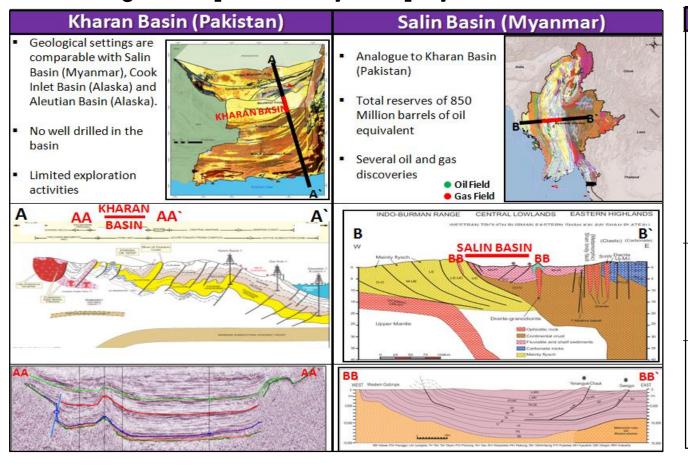


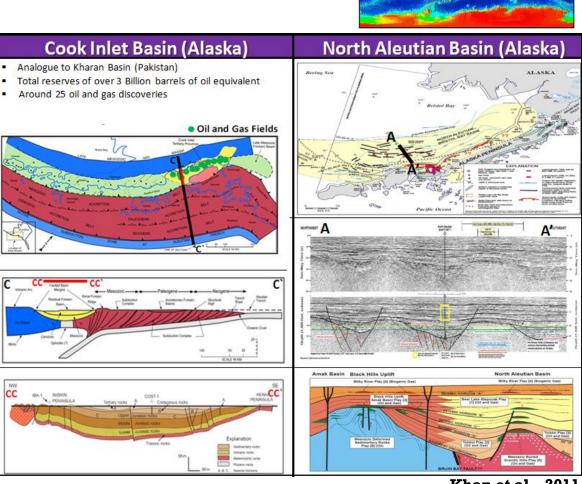
ANALOGUES — TOOL FOR FRONTIER EXPLORATION



Analogues:

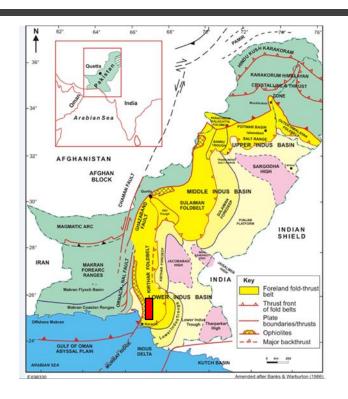
- Kharan Basin of Pakistan is analogous to Salin Basin (Myanmar), Cook Inlet Basin (Alaska) and North Aleutian Basin (Alaska).
- Analogues help to identify new plays

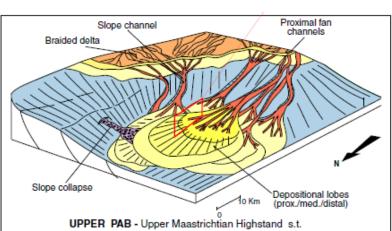


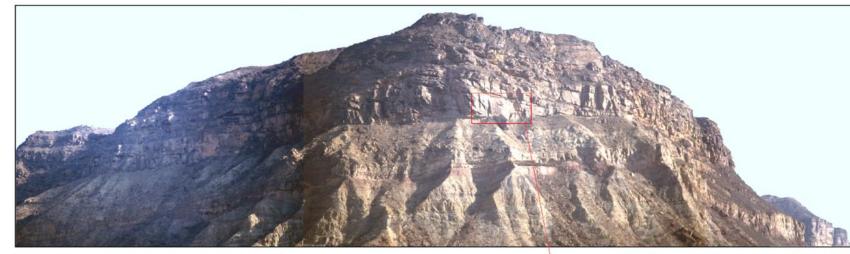


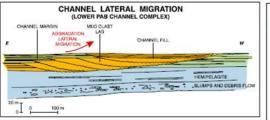
TURBIDITES AT PASSIVE MARGINS - HUGE POTENTIAL













Basal mudclast lag (slurry facies) overlain by coarse to very coarse grained sandstone





Massive channel fill eroding underlying levees



Detail of sandy levee with shale draping of beds made up of climbing ripples

IFP-2005

TAKE HOME MESSAGE



- > To explore geological complex frontier basins, artistic technologies are required
- Maximum tools should be utilized during prospect generation/evaluation in order to avoid surprises and not to miss the true potential
- > Classical geological data is usually of low cost but always equally important like expensive tools
- > Analogous are the key leads toward effective exploration of new areas