Managing Oil & Gas Exploration Risk in the Kurdistan Region of Iraq

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Photograph: Sarqala-1RE Jeribe Well Testing (May/June, 2011)
Agenda

• Kurdistan – An Emerging Region with Giant Oil & Gas Field Potential
• Geotechnical Risks & Mitigation
• Drilling Risks & Mitigation
• Summary & Key Learnings
Kurdistan: An Emerging Region with Giant Oil & Gas Field Potential

- Kurdistan is an underexplored, highly prospective part of the Zagros Fold and Thrust Belt
- Security and stability are significantly better than S. Iraq, where major field developments are underway by IOCs
- The Kurdistan Regional Government (KRG) has awarded over 40 PSC blocks since 2005
- Recent PSC awards to Hess and Repsol indicate continued growing interest in the area
- P50 prospective resources identified to date total 16 billion barrels and 55 TCF*

* KRG 2011 Preliminary Reserve & Resource Survey Results
Kurdistan: An Emerging Region with Giant Oil & Gas Field Potential

Northern Iraq Reservoirs and Oil Quality

- The number of oil and gas discoveries has increased from 6 (prior to KRG PSC awards) to 18 to date, several of which are giant fields, notably Tawke, Shaikan and Barda Rash
- P50 recoverable reserves from discoveries to date total 11 billion barrels and 40 TCF*
- Oil exports from the Kurdistan Region of Iraq have grown from zero to over 185,000 bopd and plan to exceed 200,000 bopd by end 2011
- WesternZagros has 2 very prospective PSCs in the region with 2 significant discoveries (Sarqala, Kurdamir)
- This area was primarily selected by WesternZagros as an early entrant into Kurdistan because it is on trend with the Kirkuk and Jambur fields and is traversed by the prolific Oligocene play fairway (main reservoir at Kirkuk)
Hydrocarbon prospectivity of northern Iraq’s structural domains

4 structural domains ranked by hydrocarbon prospectivity, quality and risk

Taurus Mountains Zone
- Generally heavy oil
- Large range in % oil recovery
- Scarce infrastructure
- Large in place resources
- Low to medium risk

Zagros Mountains Zones
- Gas prone; Minor oil shows
- Medium-high risk and cost
- Scarce infrastructure

Taurus Foothills Zone
- Generally heavy oil
- Probably low % recovery
- Low geological risk
- Large in place resources
- Limited infrastructure

Zagros Foothills Zone
- Large to supergiant oil/gas condensate fields
- Low geological risk, higher gas to oil ratios
- Medium to high drilling risk and cost
- Close to existing infrastructure

WZ blocks
Kurdistan: An Emerging Region with Giant Oil & Gas Field Potential

• Initial “pioneer” exploration in the area following the fall of Saddam Hussein in 2003 has been challenging:
  – Little available technical data e.g. seismic, wells
  – Immature service industry with limited experience & expertise
  – Little infrastructure
• However, these limitations were offset by the quality of the opportunities:
  – Giant oil field potential
  – Potential to apply new technologies
• With the award of over 40 PSCs to date, infrastructure and service industry support has significantly improved
Kurdistan: An Emerging Region with Giant Oil & Gas Field Potential

- Low Geological Risk
  - Geological Chance of Success (GCOS) very attractive (>75%)
- All Petroleum System Elements Present
  - Multiple, Stacked Reservoirs (most fractured)
  - Multiple Source Rocks
  - Multiple World Class Top Seals (evaporites & shales)
  - Excellent Structural Traps
  - Favorable Timing of Hydrocarbon Generation & Trap Formation
- Several Established & Emerging Plays
  - Tertiary Carbonates
  - Cretaceous Carbonates
  - Jurassic Carbonates
  - Triassic Carbonates
- Future Conceptual Plays
  - Stratigraphic Traps (e.g. Late Tertiary Sandstones)
Geotechnical Risks & Mitigation

- Oil versus Gas Prediction
  - Issues
    - Complex hydrocarbon generation, expulsion and preservation history
    - Breaching of fields and subsequent remigration of hydrocarbons common
  - Mitigation
    - Geochemistry studies to tie source rocks to reservoired oils
    - Basin modelling / Burial History studies

- Understanding Structural Styles and History
  - Issues
    - Surface anticlines often decoupled from reservoir targets
    - Seismic data often difficult to acquire and process
    - Some interpretation must be model driven
  - Mitigation
    - Detailed seismic survey design and forward modelling work to improve seismic quality
    - Field geology to identify analogues
**Kurdistan – An Emerging Region with Giant Oil & Gas Field Potential**

**Composite Seismic Cross-Section Across Garmian & Kurdamir Blocks**

- Gentle open folds above Miocene detachment
- Decoupling across several major detachment zones
- Numerous anticline targets not predictable from surface structural geology

**Legend**
- Lower Bakhtiar
- Upper Fars
- Lower Fars Evaporite
- Base Fars Detachment
- Lower Fars Transition Beds
- Jeribe
- Aaliji
- Shiransh
- Top Jurassic?
Geotechnical Risks & Mitigation

- **Understanding Fractured Reservoirs**
  - Issues
    - Most reservoirs, especially those of pre-Tertiary age, are highly fractured
    - Multiple phases of fracturing possible; not all are tectonic in origin
    - Fracture understanding key to optimizing well placement for maximum deliverability
  - Mitigation
    - Integration of fracture data at various scales
      - Satellite Images
      - Field geology studies
      - Wellbore image logs
    - Use of wide azimuth, high fold, seismic data for enhanced fracture detection
Geotechnical Risks & Mitigation

• Understanding Fractured Reservoirs
  – Most Kurdistan reservoirs have a complex history of fracturing
  – Fractures are not only related to the most recent phases of compression but also to prior tectonic settings
  – Fracturing is usually most intense in tight rocks and is often bed constrained
  – Published tectonic studies of the Zagros of Iran provide good analogues
  – Fracture porosity is usually low (~1%) but permeabilities are usually high
  – Fractured reservoirs can have high recovery factors (>80%) but fluid type is important
  – Fractured reservoirs containing heavy oil will likely have low recovery factors (~10%)
  – The Jeribe and Oligocene reservoirs in Western Zagros’s blocks contain both fracture and matrix porosities, and consequently have both excellent storage and permeability

Development and evolution of sub-seismic fractures. Casini et al., 2011
Drilling Risks

- Challenging Drilling
  - Issues
    - Complex Pore Pressure profiles
      - Overpressure
      - Frequent pore pressure changes over short drill depth intervals
      - Pore pressure, especially in carbonates, difficult to predict
    - Limited offset well data available, so pre-drill geologic prognoses are often poorly constrained
    - Areas with surface carbonates often have major shallow mud losses
    - \( H_2S \) (sour gas)
  - Mitigation
    - Detailed well design planning
      - Contingency casing strings
      - Use of third party design experts for verification
      - Detailed Well Risk Assessments / “Drill Well on Paper”
    - Pore pressure prediction / wellbore integrity studies
    - Use of advanced seismic time-to-depth conversion technologies (e.g. DMI Auto-Imager)
    - Well data exchanges with other Kurdistan operators
    - Sour service tubulars and equipment
    - Use of \( H_2S \) well surveillance and safety services
Drilling Risks

Overpressure

- Several types of overpressure
  - Rapid uplift with effective top seals e.g. Lower Fars Evaporites
  - Rapid sedimentation – shale retains pore fluids
  - Geomechanical stresses – active tectonic system
  - Present hydrocarbon generation and expulsion

- WZRs Sarqala-1 wildcat well encountered pore pressures over 2100 kg/m3 (17.5 ppg) mud weight equivalent pressures below Lower Fars Top Seal

- Complex lithologies make pore pressure prediction challenging; traditional Gulf of Mexico techniques not effective; Evaporite and carbonate lithologies in Kurdistan vs. clastics in GOM

- Enhanced analysis of seismic velocities in clastic sections can be utilized to refine pore pressure prediction
Drilling Risks

• Challenging Well Evaluation
  – Issues
    • Limited available offset well data
      – Majority of wells drilled are old (pre 1970 vintage) and wireline data is often poor
      – Traditionally a large number of open hole tests were run in old wells due to difficulty in evaluating cuttings, shows, and gas data
    • Commonly poor cuttings information; shows difficult to detect in fractured formations
  – Mitigation
    • Modern logging suites run including image logs for fracture identification and analysis
    • Utilized gas chromatography and advanced mud logging to detect hydrocarbon zones and type
    • Used quantitative fluorescence analysis techniques over potential hydrocarbon bearing zones to differentiate potential oil and gas zones
    • Carefully analyzed data for selection of test intervals for maximum reservoir fluid and pressure information
Drilling Risks & Mitigation

RISK ASSESSMENT PROCESS

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<th>What Can Go Wrong? - Risk</th>
<th>What Would Happen If it Did? - Impact</th>
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<th>Mitigation Measures</th>
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Severity of Hazard or Effect

Risk Probability Severity Residual Risk
Drilling Risks & Mitigation

- Remote Location with Immature Oil & Gas Service Industry Support
  - Issues
    - Latest technologies often not available
    - Time consuming import of equipment & supplies
    - Quality assurance / quality control
    - Service providers often inadequate focus on Health, Safety, Environmental (HSE)
  - Mitigation
    - Build relationships with key contractors to provide state-of-the-art equipment and qualified, experienced personnel
    - Detailed well & logistics planning needs to be done early
    - Maintain a large supply inventory at well location
    - Implement HSE and QA/QC management systems, supervision & “culture”
      - Incident tracking
      - Regular HSE and QA/QC performance reviews with main contractors
Drilling Risks & Mitigation

• Potential Rig Down-Time Due to Cultural Issues
  – Issues
    • High expectations of local national employment
    • Security clearances and visas
  – Mitigation
    • Build strong relationships with local and regional community
    • Implement a Community Relations program
      – Education, Water Supply, Health, Sport
    • Work closely with local Kurdish security authorities (Asaiash) on security clearances & visas

Hasira Village School Renovation
Summary & Key Learnings

Summary

– Kurdistan is a highly prospective oil & gas region with giant oil and gas field potential
– Overall, geological risk (GCOS) is low, but drilling risks are relatively high
  • Common cost overruns / wells may take longer than planned

Key Learnings

– Given Kurdistan’s immature stage of exploration, low cost field geology work can be especially valuable
– Detailed well planning is essential
– Risk assessments are a key tool
– Good relations with local nationals are critical