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Resources Assessment: Methodology and Its Application in Tarim Oil/Gas Exploration and Development Activities

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Foreword

Oil/gas resources are the basis for the existence and development of petroleum industry, and the exploration and development are technology and capital intensive commercial activities with high risk and high rewards. Resources assessment is a key in oil/gas exploration and development wherever the activities are carried out, from new frontier to mature regions. Hence a reliable and scientific resources assessment method is necessary for us.

Due to the importance of oil/gas, a justifiable resources assessment needs to be done not only by oil companies, service companies and some consulting agencies, but also by both resources countries and consumption countries. Oil companies, NOCs, majors and independent oil companies, all have their own resources assessment methodologies and procedure. Then how to scientifically assess the oil/gas resources?

Since 1995, the newly discovered proven oil/gas reserves have been increasing steadily with continuously decreasing finding costs for the Majors. Effective resources assessment is the key to these companies to materialize their exploration strategies of finding commercial scale reserves by picking up favorable regions globally to carry out in-depth exploration activities. And the higher drilling economic success rate can only be assured through an in-depth study on petroleum system and play based on the available geological and geophysical data.

1. Methods of resources assessment adopted by the Majors

The objects for oil/gas exploration and development activities are basins, blocks and oil/gas fields. There classified new frontier, immature and mature regions based on the exploration activities carried out there and the understanding. A resources assessment procedure involves Tectono-Stratigraphic Provinces and Trend, Petroleum System studies and Play evaluation, Play Fairway and Prospect screening and ranking.

The focus of resources assessment is to establish a dynamic geology – economic evaluation system based on data processing, specific studies and comprehensive evaluation [2]. An optimized database is essential to evaluation system, it requires a broad data sources from various aspects (table1). The comprehensive evaluation means multi-science studies combine together for the purpose of establishment of the geology – economic evaluation system, and evaluation of the reserves, risk and commerciality. Then choose favorable exploration opportunities and targets through effective and multi-level risk mitigation procedures.

Geological evaluation based on the geological concepts and models needs to be done step by step according to a well established procedure to enhance the predictability of the modeling.

1.1 Geology study

The geological evaluation procedure adopted by the Majors is demonstrated in figure 1. That is (1) explore regional geological features by tectonic evolution; (2) source rock study and source/reservoir fluid comparison to establish petroleum system based on source rock distribution and kerogen evolution modeling; (3) to set up a structure interpretation model through balanced section analysis; (4) study the reservoir configuration and properties through sedimentary facies analysis; (5) pinpoint the fair pooling location through source rock and seal rock evolution, and computerized migration modes and direction simulation; (6) carry out resources assessment for various plays under the guidance of petroleum system; (7) to identify structure types and choose favorable prospects, through screening and ranking, for exploration drilling (figure 1). The quantitative resources assessment methods include volumetric, Delphi (analog), Geochemical (genesis method), Probabilistic and history analog (stochastic).

Table 1 The relationship between exploration maturity and resources assessment

Maturity	Frontiers		Immature	Mature	
	Early stage	Late stage		Early stage	Late stage
Seismic	Regional	Extensive 2D	3D and 2D	Extensive 2D & 3D	
Drilling	None	Few	Dozens	many	many
Discoveries	None	None	Some	many	many
Production	None	None	Some	increasing	decreasing
Major tech & method	Comprehensive basin analysis		Fair plays	In-depth field study	
Assessment method	Analog	Play fairway evaluation Prospects screening and ranking			
Assessment rank	C	B		A	

Modified from Exxon (1995)

1.2 Economic evaluation

There are two sets of economic index for project screening and ranking, i.e. static (undiscounted) and dynamic ones (discounted). The static indexes include net profit, maximum exposure and payback period. To get these results, the following assessments need to be done: 1) sum of the net profit during the project life; 2) cumulated maximum cash flow out; and 3) time to recover investment. The dynamic indexes include NPV (net present value) and ROR/IRR (rate of return/internal rate of return).

To use a geological-economic model to determine the reserves, risk and its commerciality will provide a reliable basis for investment decision-making. Exxon picked 9% of the basins in the world with only 5% of the plays for potential commercial discoveries through its own geological-economic evaluation modeling, but the resources of these comparatively fewer prospects contain 32% of the resources in the world, with 28% in new plays and 4% in the play fairways. The value and factors for geological-economic evaluation modeling varies in different regions and different exploration/development activities, such as the Majors' evaluation benchmarks in North American and overseas projects are significantly different.

1.3 Monte Carlo simulation technology

The Majors adopt Monte Carlo simulation technology to do the comprehensive evaluation, i.e. from reserves estimates, basic reservoir parameters acquisitions, to recovery reserves estimates, and to economics. This procedure produces a simulated probability distribution for the outcome, such as the reserves, economics and the risk, from which the decision-maker can gain a reasonable idea of what is likely to happen if he pursues an assumed course of action.

2. Application of the resources assessment methods by the Majors in Tarim basin cooperation projects in China

2.1 BP Resources assessment in southeastern Tarim basin

BP started its preliminary geological study and economics for 5 blocks in southeastern Tarim in 1993 during the first round bidding. They predicted that it is unlikely to find 250 million bbl of recoverable reserves in these 5 blocks, and it is difficult to achieve a well productivity of 1000 bpd, hence the potential is not commercial.

2.2 Resources assessment done by Exxon in Tarim basin
Exxon has completed their study on the regional framework in Tarim basin in 1998. The oil/gas resources and plays evaluations included: a) establish the thermal evolution model in the basin; b) distribution of source rocks; c) Source rock evaluation; d) Migration, and e) Resources potential assessment in fair plays.

2.3 Nature Gas studies in Kuche area of Tarim basin
It was estimated by ExxonMobil that the OGIP of Kela2 gas field is 205-280 bcm in Kuche of Tarim basin, with the mostly value of 246.8 bcm, which is very close with our estimates.

Headings: oil/gas resources assessment, economic evaluation, Monte Carlo simulation, Duplo reservoir simulation, Tarim basin

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Tectono-Stratigraphic Provinces   functions tudies

Basin
      Space
      Tectonic structure
      Sea level
      Climate/Oceanography
      Sedimentology
      Structure Geology

Petroleum system   GeoChemistry
      Petrophysics
      Fluid movement

Key geological factors evaluation and prediction
 Source rock
  Reservoirs
   Sealing play
    Timing
    Maturity
     Expulsion
     Migration
     Accumulation fair play/trap pressure unit/system
     Maintenance

Figure 1 Resources Assessment Procedure