Pakistan's Major Petroleum Plays - An Overview of Dwindling Reserves*

Athar Jamil[1], Abdul Waheed[2], and Riaz A. Sheikh[2]

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[1]Tullow Pakistan (Developments) Ltd. (athar.jamil@tullowoil.com)
[2]Saif Energy Ltd., Pakistan (abdulwaheed@pepl.com.pk; ras51@yahoo.com)

Abstract

The existing oil and gas reserves of Pakistan are on a very steep decline. Pakistan has already consumed more than 66.5% of its 934 million barrels of discovered oil and about 45% of its 54 TCF gas reserves. Most of the oilfields are at their mature stage of producing life where the production could drop even more rapidly. About 50% of Pakistan's reserves were discovered during first 10-15 years of history of exploration, while the remaining 50% reserves have been added during the last 40-50 years. Despite having a vast sedimentary area and world-class exploration success rate, the size of the new discoveries has dropped down to their commercial thresholds. Analysis of exploration data suggests that we have already explored most of conspicuous structural features and remaining potential of some of the plays seems to be marginal.

Major plays (almost all structural) which have contributed significantly toward the discovered oil/gas reserves include: Sui Main Limestone (54%), Lower Goru Formation (14%), Habib Rahi Limestone (13%) and Pab Formation (13%). Basin-wise success rate has been the highest for the Lower Indus Basin (due to strings of discoveries in quick succession in relatively small tilted fault blocks in the Lower Goru reservoir). This paper will give an assessment of creaming curve analyses of different plays and their remaining petroleum potential.

There is no quick fix for issues related to the oil and gas exploration in Pakistan. Major challenges facing Pakistan's Exploration and Production (E&P) industry are: (1) a negative reserves growth, (2) decreasing trend in size of oil/gas fields, (3) resolution of security-related issues, (4) development of an integrated exploration strategy for accelerating exploration efforts in under-explored/frontier areas, (5) establishment and strengthening of Research and Development (R&D) activities, and (6) training of geoscientists and engineers in the latest exploration/production skills.

Introduction

The first exploration well in Pakistan was drilled in 1866 at Kundal and the first commercial discovery of oil was made in the Potwar region in 1915. As of June 30, 2009, 742 exploration wells have been drilled and 221 oil/gas discoveries have been made (Hydrocarbon Development Institute of Pakistan, 2008; Pakistan Petroleum Information Service, 2009). As of December 31, 2008, total discovered reserves stand at 933.720 million barrels and 53.561 TCF of oil and gas, respectively. Oil and gas exploration in Pakistan has passed through various phases during its history. The first 10-15 years (since independence) of exploration history was the most successful period, when almost 50% of total reserves were discovered (e.g. Sui, Uch, and Mari discoveries). The exploration activities remained sluggish during the 1960's, 1970's, however during the 1980's several oil/gas/condensate discoveries in the Lower Goru Formation in the Lower Indus Basin were made. Exploration efforts geared up further in the 1990's when some significant gas discoveries were made in the Late Cretaceous clastics (e.g. Bhit and Zamzama discoveries). What about stratigraphic traps of Miano and Sawan? During the first decade of 2000, significant discoveries have been made (e.g. Manzalai, Makori, Mami Khel and Maramzai by MOL and Mela and Nashpa by OGDCL). Otherwise, during the last decade, exploration activities and foreign investment have both have declined.

Pakistan's total sedimentary basinal area is approximately 827,000 sq km. Historical data suggests that only 10-20% of the total sedimentary area of Pakistan has been explored and a large part of the country is still either frontier or remains under-explored. The estimates of Yet-to-Find reserves vary widely. The most optimistic numbers come from GOP, e.g. 3585 MMBO and 66.2 TCF of gas (Investment Opportunities in Pakistan's Upstream Oil & Gas Sector, Ministry of Petroleum and Natural Resources). Based on a recent basin study, Fugro Robertson has estimated a Resource Potential of 3675 million barrels of oil (934 million barrels exploited so far) and 67 TCF of gas (54 TCF exploited so far).

The objective of this paper is (1) to give an overview of past exploration for oil and gas, (2) to describe contributions from different play types, and (3) to suggest measures that can be taken to accelerate the pace of exploration.

Play Types

The basinal classification (used in this paper) and the major play types in each basin along with their contributions of oil and gas reserves are shown in Figure 1 and Figure 2. The major plays are:

- Sui Main Limestone (e.g. Sui Field)

- Habib Rahi Limestone (HRL) (e.g. Mari Field)

- Chorgali/Sakesar/Paleozoic (Potwar sub-basin fields)

- Lokhart/Hangu/Lumsiwal/Samana Suk (Kohat sub-basin fields).

- Pab Ss (Bhit and Zamzama).

- Lower Goru (e.g. Badin area fields, Sanghar area fields, Sawan, Miano, Kadanwai, Mari Deep and other fields).

Some other plays (both clastics and carbonates) also have their minor contributions like Miocene (Murree Formation at Khaur Oilfield, assumed to be migrated oil), Eocene (Bhadrar, Margalla Hill and Pirkoh formations), Paleocene (Patala, Nammal, Dunghan and Ghazij formations) Cretaceous (Lumshiwal, Moghul Kot and Parh formations), Jurassic (Datta, Chiltan and Samana Suk formations), Permian (Tobra, Amb and Wargal formations), and Cambrian (Khewra, Kussak, and Jutana formations) (Wandrey et al., 2004a; Wandrey et al., 2004b). Although hydrocarbons have been tested from several plays, Pakistan's sedimentary basins are still largely underexplored. The major contribution to reserves has come from only a few plays (Figure 2). The exploration well density of Pakistan is still very low. The average success rate is 30% and there is the possibility of large discoveries. The terms of fiscal regimes are attractive. However, some major reforms and a comprehensive exploration strategy are required to attract foreign investment and to tap undiscovered oil/gas resources.

Reserves Increments: Creaming Curves

As mentioned earlier, about half of the oil and gas reserves were added from Eocene reservoirs in the early part of the exploration history of Pakistan (Figure 3). Sui Main Limestone is the major contributor to the gas reserves. SML is the main producer at Sui (the first "giant" gas discovery), Uch and Kandhkot gas fields. The discovery of these fields dates back to the 1950's. After a small discovery at Mazarani in 1958, it was not until 1990 that significant gas reserves in SML were discovered at Qadirpur. Recent efforts in the Lower Indus Basin have added reserves from some smaller gas discoveries (e.g. discoveries in Block 22 and its adjoining blocks).

Another discovery in an Eocene carbonate unit (Habib Rahi Rahi Limestone) was made at Mari. However, this is the only gas discovery (considered to be a "giant" gas discovery) from Habib Rahi Limestone in Pakistan. Tertiary and Paleozoic reservoirs in the Kohat-Potwar Basin have been major contributors of oil/gas reserves (Figure 4). While Potwar reservoirs seem to have matured, significant oil/gas discoveries are still being made in the Kohat sub-basin (Shah, 2009). There appears to be significant remaining

potential, although limited open acreage is available in Kohat sub-basin where all concessions are currently held by OGDCL and MOL. An effective petroleum system in the Kohat-Potwar Basin is present in the Kohat sub-basin (Shah, 2009; Wandrey et al., 2004a; Wandrey et al., 2004b). Gas was first discovered in Paleocene clastics (Ranikot) at Pirkoh in 1977. This reservoir, although extensively developed in the Indus Basin, did not contribute significant quantities of reserves except for small discoveries at Loti (1985), Dhodak (1976) and Savi Ragha (1994). Very small reserves were also discovered at Sari, Hundi and Kothar. The main cause of poor and anomalous reservoir characteristics displayed by Lower Ranikot in Indus Basin is attributed to the frequent facies changes.

A significant discovery was made in the Late Cretaceous clastics of Pab Formation at Bhit in 1997, followed by another large discovery in the following year at Zamzama. The subsequent exploration efforts pursuing this reservoir have mostly resulted in dry holes (e.g. exploration wells drilled in the former Dumbar Block). However, Early Cretaceous clastics of Lower Goru Formation have been prolific producers of oil and gas/condensate in Badin and Sanghar areas and parts of the Lower Indus Basin (Figure 7).

Starting with first discovery at Khaskeli in 1981, more than 120 oil and gas/condensate discoveries have been made. Most of the early discoveries were made in the Upper sands of Lower Goru Formation, however subsequently reserves were added by discoveries from the Middle and Basal sands of the Lower Goru Formation. Although compared with world standards, the size of discoveries are not very large, but these discoveries led to a very favorable success rate in Pakistan. The quantity of reserves added from sands of Lower Goru is now decreasing (Figure 7). Recent efforts targeting stratigraphic accumulations in Lower Goru/Sembar Formation have met some marginal success in the Lower Indus Basin. Sembar Shale source, Upper Goru shale seal and Lower Goru sandy reservoirs are the hallmarks of an effective petroleum system in the Lower Indus Basin (Wandrey et al., 2004b).

Several plays have been tested in the offshore Indus Basin and Makran Offshore/Onshore areas without any success. It is, however, heartening to note that several exploration blocks are currently under active exploration in the Indus Offshore areas.

Major Challenges

To achieve self-sufficiency in oil and gas resources, we need to discover new plays and to extend our exploration efforts to the under-explored and frontier areas. In this regard, it is imperative to address some basic issues, as suggested below.

The most critical issue for Pakistan is a "negative reserve replacement". Pakistan is producing more oil and gas from discovered fields than adding new reserves to its inventory. The production from existing oil and gas fields is on a steep decline. With current daily production of about 64,000 barrels per day of oil and around 4 billion cubic feet per day of gas, Pakistan has so far consumed over 65% of oil and 43% of oil/gas reserves. Pakistan is producing oil at a rate which hardly meets about 15% of requirements.

The remainder of the country's demand is met through imports. Production trends and forecasts suggest that we are left with oil reserves only for 10 years and gas reserves for 15-20 years. Since most of the oil fields are at their late stage of life, production could drop even more rapidly than envisaged.

● Another major challenge is decrease in oil/gas discovery size. The average oil discovery has declined to its mere commercial threshold (with the exception of a few). Despite maintaining an average success rate of around 30% (world average is 10-20%) we have not made a major discovery recently. Only 6-7 medium-size discoveries were made in the last 7 years. Most of the known petroleum plays have reached their maturity and almost all conspicuous structures have been drilled. Now the time has come to review our exploration strategy and explore for new petroleum plays, which are albeit more risky, but can add material value to our remaining oil and gas reserves.

● Security issues need to be addressed immediately. In the past, only certain areas of the Balochistan Province were inaccessible for exploration, but now most of the NWFP and Balochistan provinces are almost "no go" areas for E&P companies. As a result, foreign companies who are still in Pakistan are reluctant to invest and are changing their business strategy. Political instability has further aggravated the situation. Security and political stability are the key considerations for investment decisions by multinationals.

● The development of a well-thought out exploration strategy is needed for discovering new oil/gas reserves. Exploration strategy needs to be based on analysis of historical data and ground realities. The main focus of a future strategy should be on discovering new plays and reservoirs in frontier areas. National oil companies (NOCs) can act as catalysts to bring in the foreign investment. NOCs could engage foreign companies through joint ventures and spec studies. Some “real" and "focused" efforts are needed for international exploration. Large amounts of foreign exchange, which otherwise is spent on imports, could be saved through international production. The national companies can pool together their resources and can make joint efforts in international exploration and acquisition of exploration/production assets. The current global financial down-turn has opened up a window of opportunity for Pakistan to secure some good-sized oil/gas assets. While Pakistan offers reasonably good fiscal terms, periodic changes in the petroleum policy are required to make it more attractive for investors. Petroleum policy needs to be compatible with the prospectivity level of our sedimentary basins.

● Sustained growth in Exploration and Production can only be achieved through Research and Development activities. In developed countries, university-based research centers are the backbone of the E&P industry. Most of the major companies are spending huge amounts on R&D projects. Unfortunately, we have neither research support from academia, nor from the industry itself. Government could encourage the oil industry, through policies, to make investment in R&D mandatory to develop new ideas/skills. Agreements like Joint Study Agreements (JSAs) between companies and academia could help cope with this issue. Mandatory provisions can be

made in Petroleum Concession Agreement to encourage oil companies to spend a part of their investment on Research and Development in collaboration with the universities.

● The last, but not least, important aspect to accelerate oil and gas exploration in Pakistan is to focus on our technical resources. Hidden oil and gas reserves can only be tapped if we have the right skills and technology. Pakistani professionals are quite good and competent. Government can encourage and facilitate these professionals through financial incentives and to provide them with a conducive working environment. Induction of professionals well versed with the latest technology could make significant changes in national corporate culture.

Conclusions

● At the current rate of production, Pakistan is rapidly exhausting its known oil and gas reserves.

● The main contribution to reserves has come from Paleocene-Eocene carbonates and Cretaceous clastics.

● Basin-wise, the Lower Indus Basin discovery rate has been the highest.

● To replace the produced reserves, efforts must be focused on exploration in the under-explored and frontier areas, and on the development of new plays.

● GOP policies must be frequently revised, keeping in view the global oil/gas exploration-production scenario and domestic ground realities (i.e. prospectivity level of sedimentary basins of the country).

● Security issues, which are hindering smooth Exploration and Production activities, must be resolved urgently.

● Training of geoscientists and engineers in the latest Exploration and Production skills, and intra-industry and industry-academia synergies needs to be promoted on a fast-track basis.

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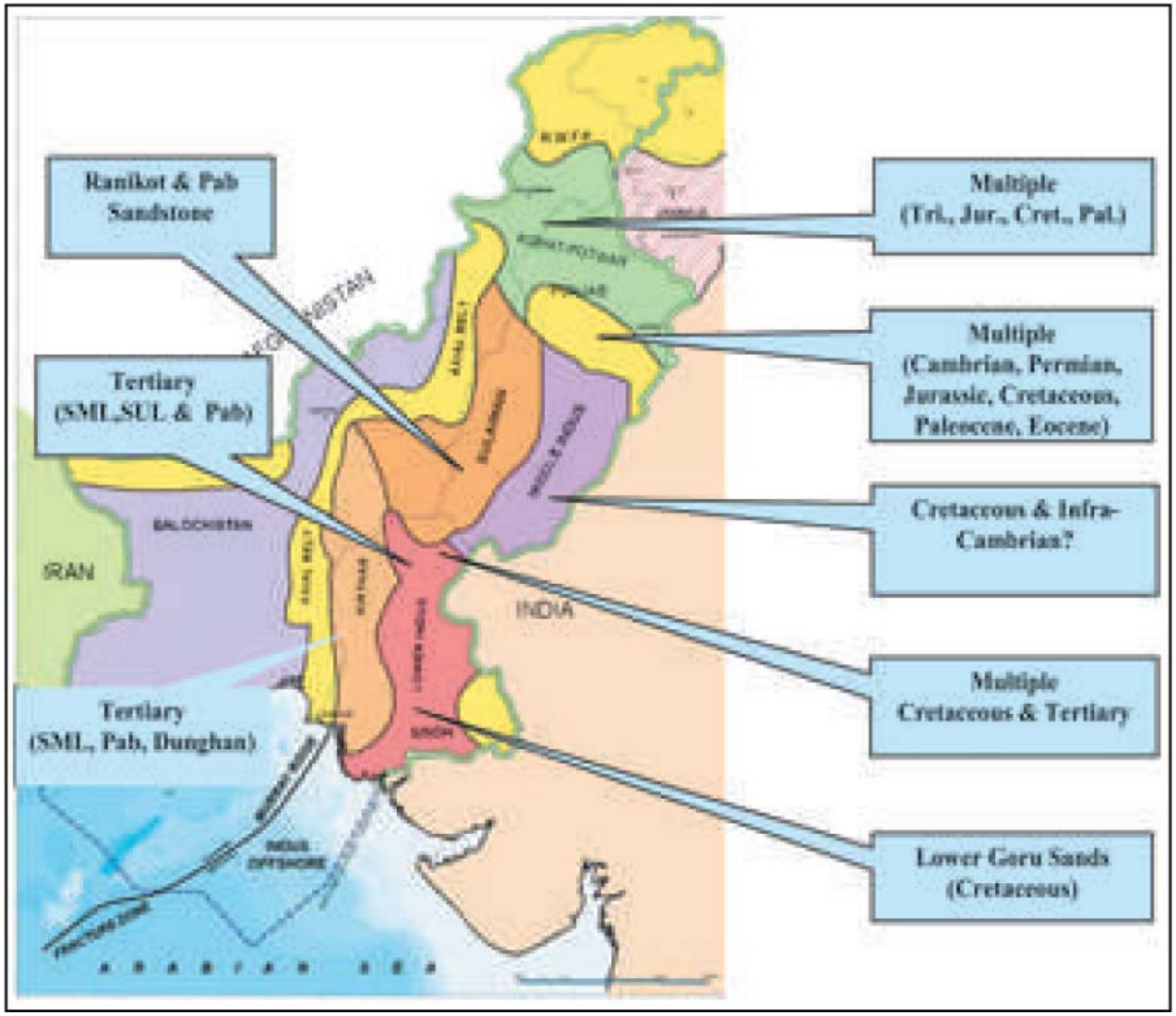

Figure 1. Major play types in Pakistan.

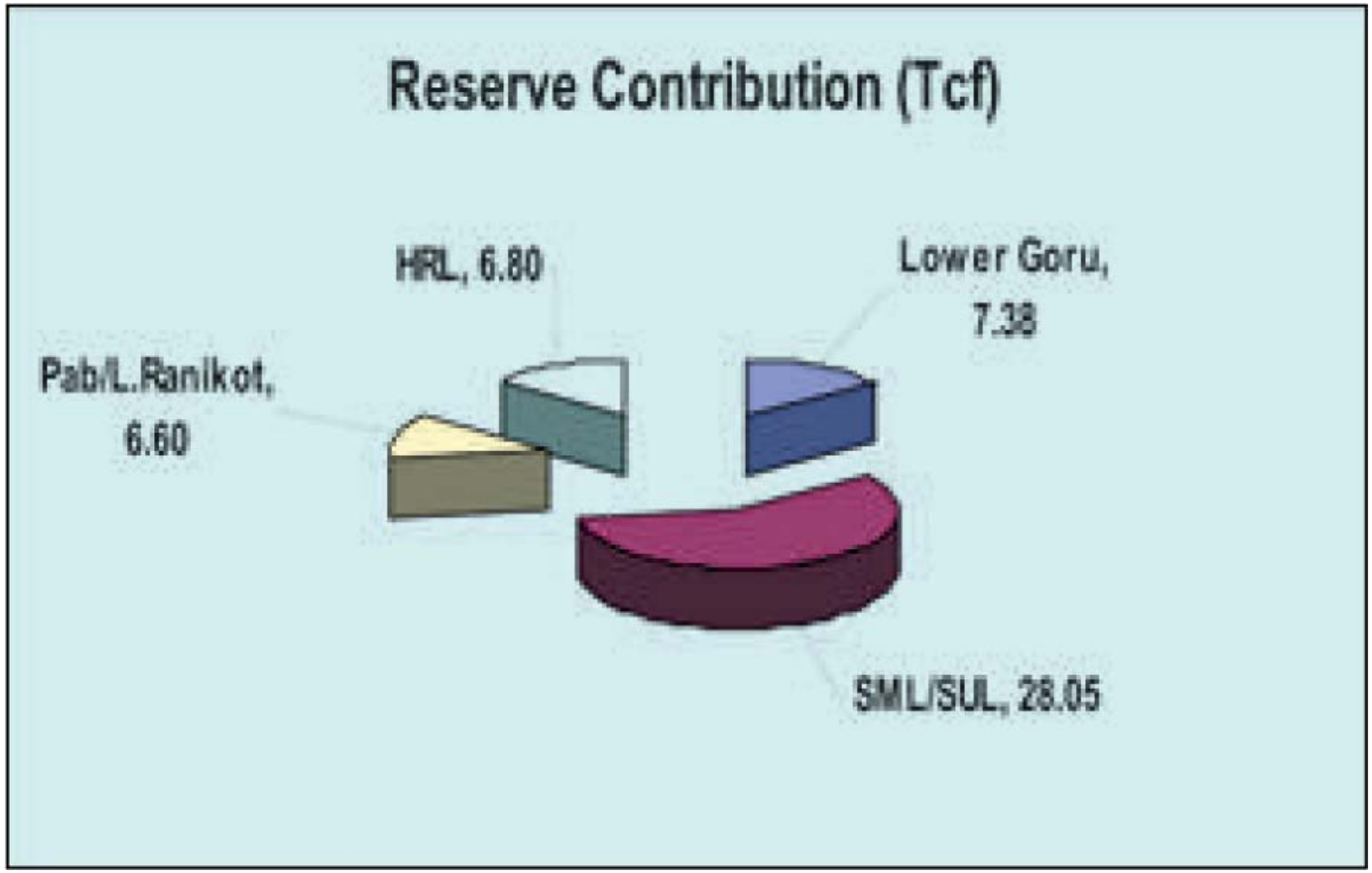

Figure 2. Gas reserves contributions from main play types.

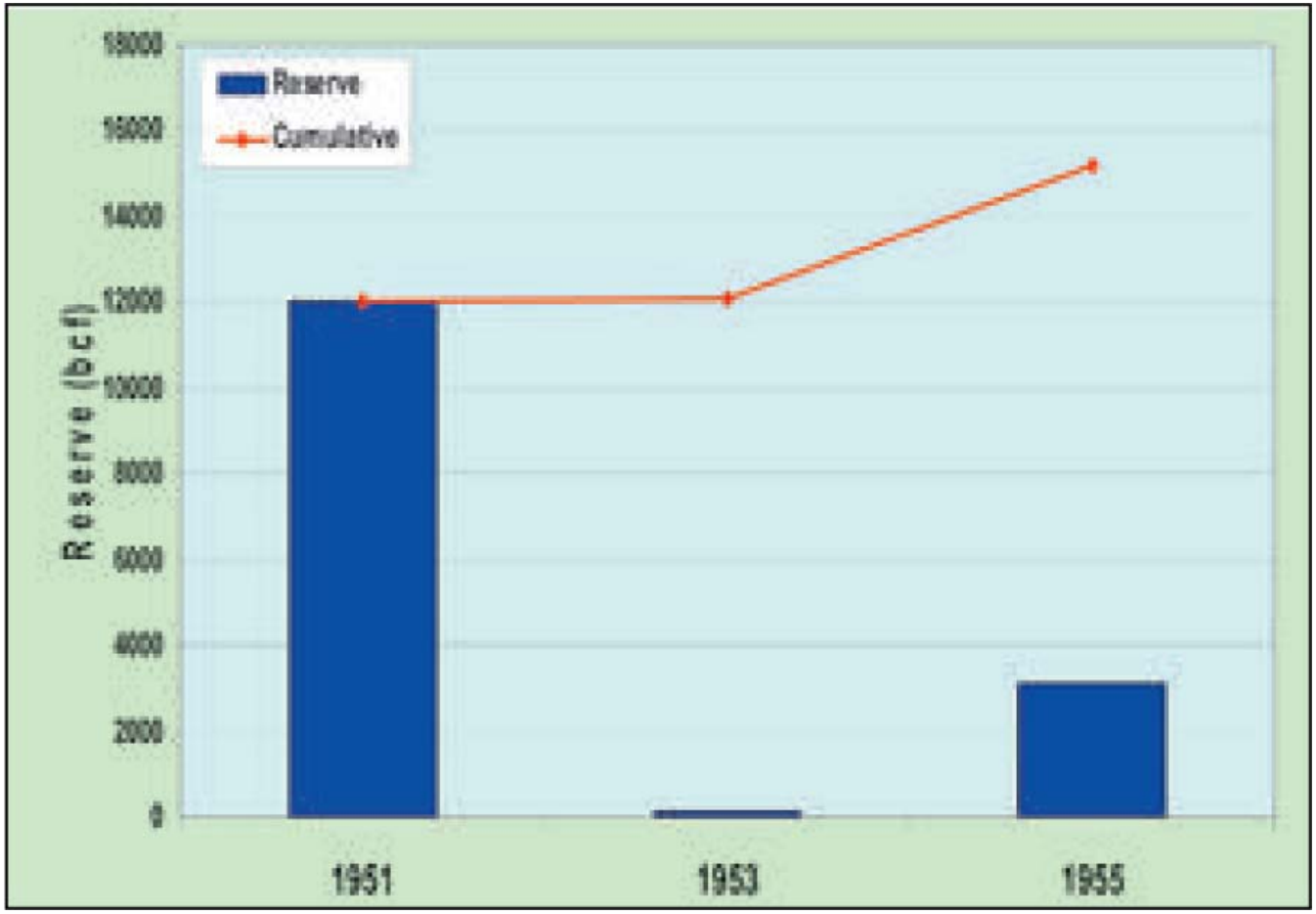

Figure 3. Creaming curve and field size distribution of Eocene in Sulaiman Foldbelt.

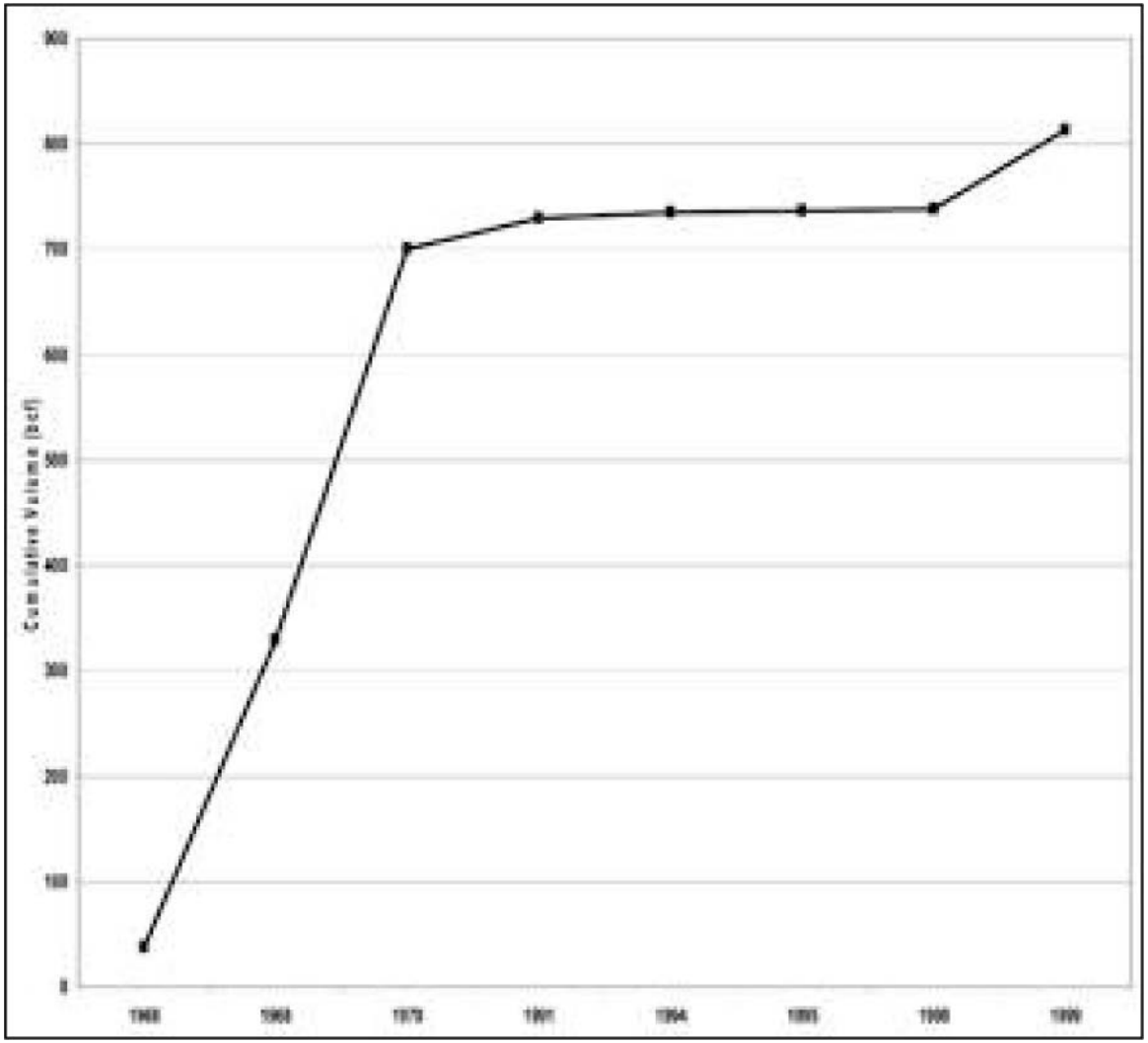

Figure 4. Creaming curve of Paleozoic play in Potwar.

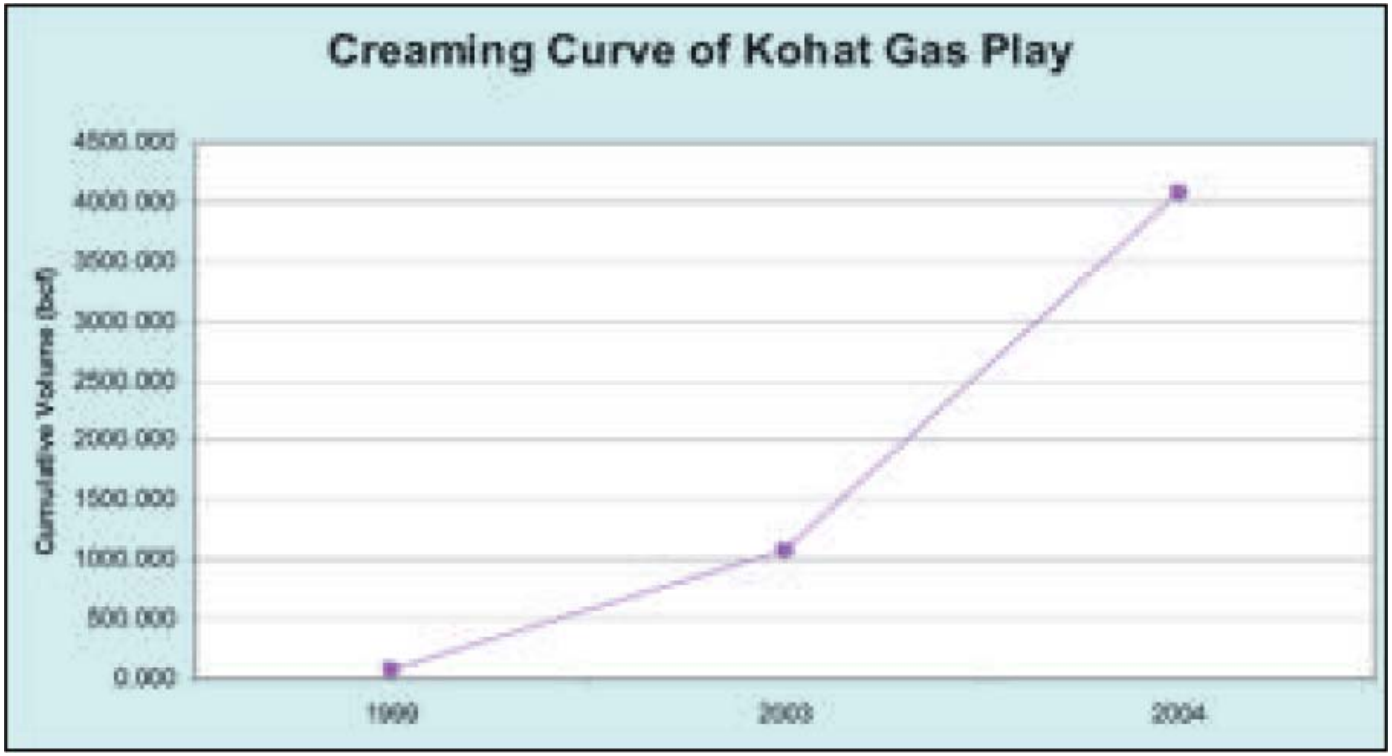

Figure 5. Creaming curve (combined) of Kohat gas play.

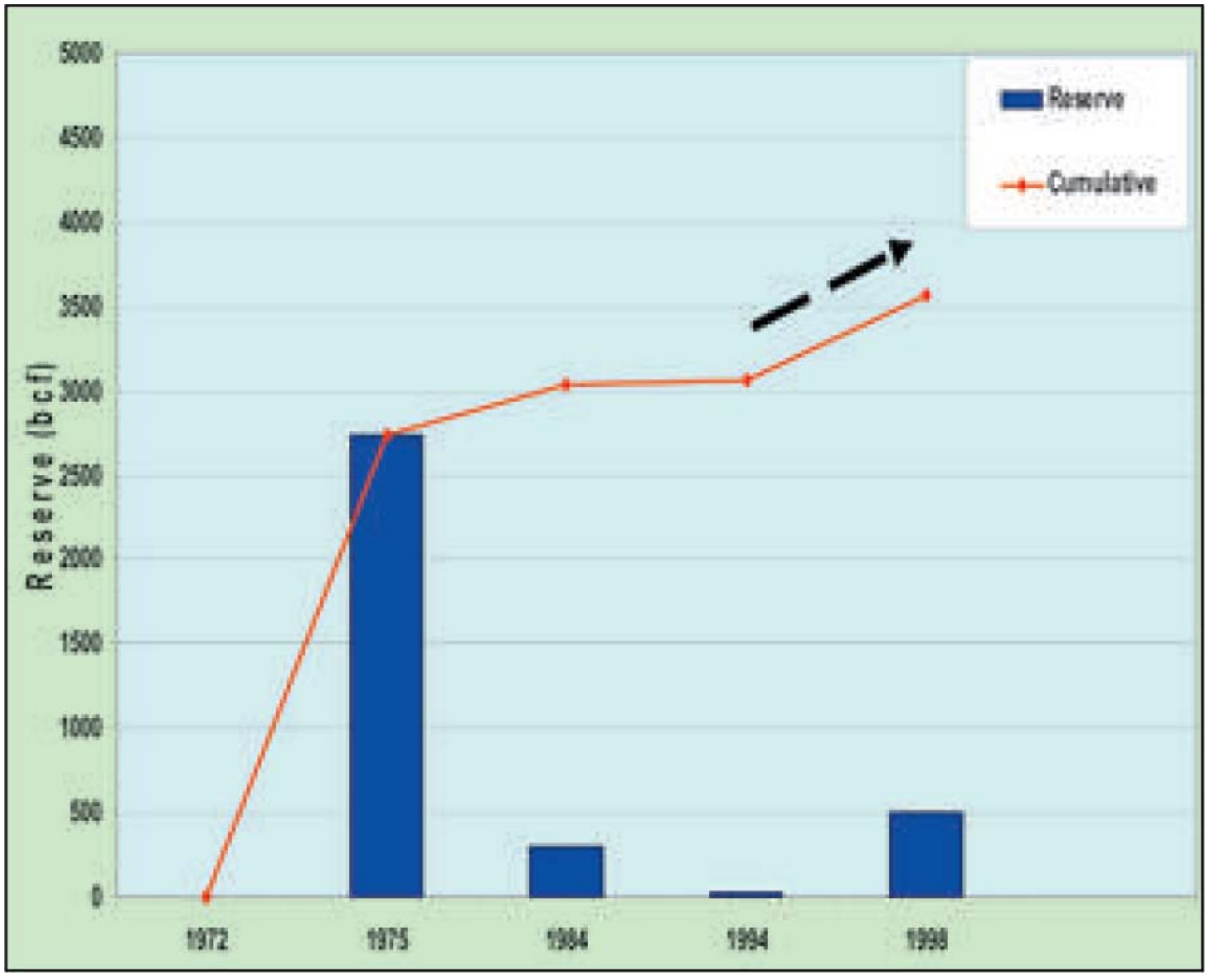

Figure 6. Creaming curve of Pab/Ranikot Foldbelt.

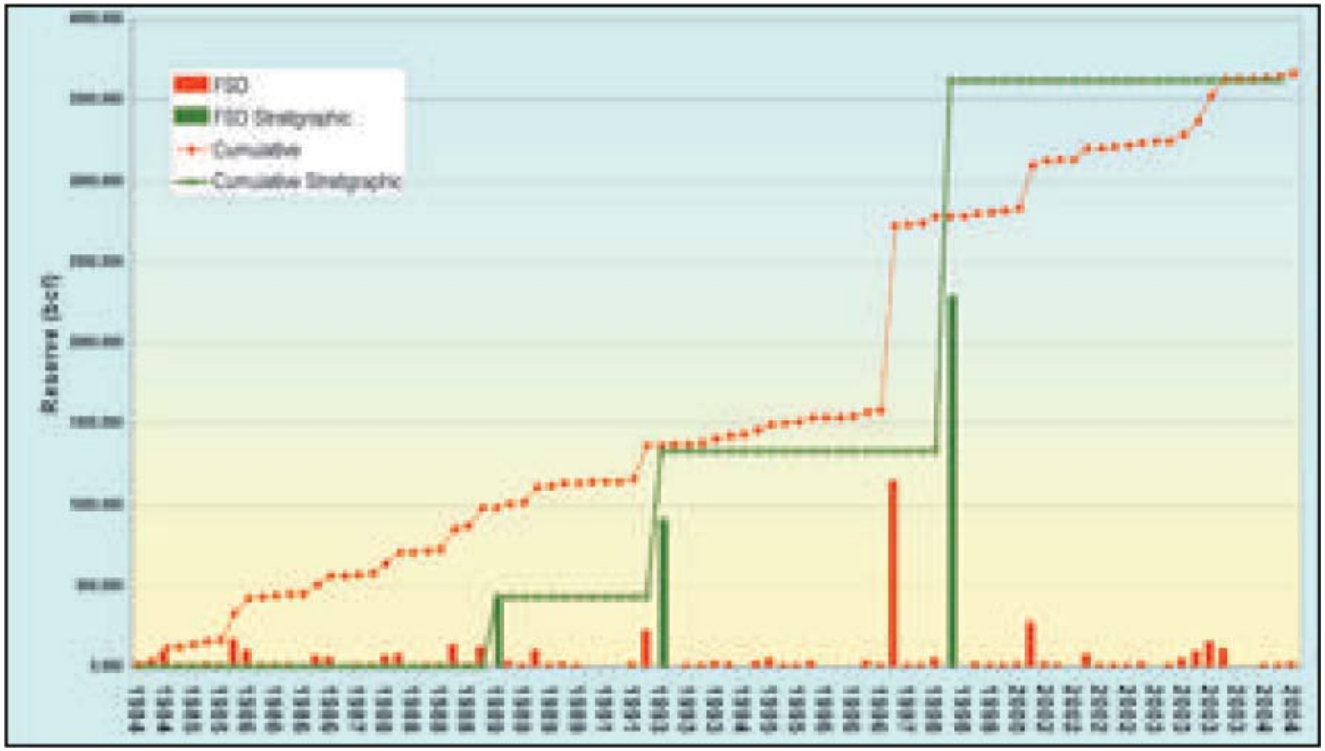

Figure 7. Creaming curve of Lower Goru Play.