

Yemen – for the smaller players

Despite Yemen's modest and, as yet not fully explored, oil resources, the country has shown an impressive progress in the business. Since the preliminary geological studies started in the eighties, Yemen has managed to attract significant international interests in oil exploration and field development. Yemen is considered a newcomer in the world of petroleum, but the operating companies predict a promising future, based on their in-house studies and estimates.



The Republic of Yemen occupies the south-western tip of the Arabian Peninsula. It borders the Gulf of Aden and the Indian Ocean on the south and the Red Sea on the west. Covering an area of 630,000 sq km, the country is about the size of France. A long, narrow coastal plain (1,130 km) in the south gives way to flat-topped hills and a rugged mountainous region that continues into the desert interior plateau area of the Arabian Peninsula. Numerous wadis (characteristic canyons or valleys) radiate from the highlands, including the 500 km long Wadi Hadramaut. Yemen has no permanent streams, but local springs provide water for the Oases. Yemen on the whole has a desert climate, but it is particularly hot, dry and harsh in the eastern desert. Along the coast it is hot and humid and the western mountains, although temperate, are affected by seasonal monsoon.

With a population of almost 19 million, Yemen is the most populous country on the Arabian Peninsula. The great majority of the population is Muslim and speak Arabic. Most people live in or near small villages where agriculture is the major occupation. The largest urban centre is the capital, Sanaa. The population in southern Yemen is concentrated in a few areas, including the towns of Hadramaut, the highlands and the urban areas around Aden City. By contrast, a far greater proportion of the population in the North is scattered over a great number of town and villages.

The Republic of Yemen was established on May 22, 1990, when pro-western North Yemen and the Peoples Democratic Republic of Yemen merged after 300 years of separation. The decline in Soviet economic support in the South was an important incentive for the merger. Yemen reported strong economic growth in the mid-1990s with the onset of oil production, but was harmed by low oil prices in 1998. Besides the increasing petroleum enterprise, Yemen has several geological resources at varying stages of exploration and exploitation, including rock salt, marble, small deposits of coal, gold, lead, nickel and copper.

The rough topography is a challenge for the geologist operating in the Yemen desert. Shooting seismic in high mountain plateau with dramatic wadis cutting 300 m deep with an irregular orientation is a huge challenge, and much more expensive than seismic operations off-shore. Thousands of holes must be drilled two metres into the ground before dynamite is dropped in, and covered by sand. The drilling equipment is often brought to an inaccessible part of the seismic line by helicopters and professional mountain climbers. Despite these demanding activities, the operating companies can generate detailed geological models, models that enable profitable exploitation of reserves. Besides the geological aspects, its unique culture and landscape are also good reasons for visiting Yemen.

Mona Holte

It seems that Yemen is for small companies. Big companies have chosen to stay out, which gives room for the smaller players. This is the general observation of the two senior geoscientists Ole Gunnar Tveiten and Ole Herman Fjelltun of the small independent oil company DNO. Since 1998, DNO has served as an efficient operator and partner of two producing licenses with a third due next summer. Two new exploration licences give promises of a long-term involvement. Since the takeover of Block 32, DNO has increased the ultimate reserves more than four times in six years. DNO's business strategy, which is to generate good economic performance and sustainable growth through exploration and appraisal of small oilfields, has been perfectly followed through in Yemen.

Block 32- the success story

Block 32 is located in the Say'un al Masilah Basin in the Hadramaut region. It was here the adventure started in November 1998. DNO then acquired 20% of Block 32, and took over as operator of the Production Sharing Agreement (PSA).

A marginal discovery had already been made in the Tasour field with well number six, but the initial estimate of the reserves at that time was only 5.3 million bbls.



Photo: Halvor Jahne

Thanks to skilled local Yemeni workers, seismic acquisition is possible in the desert heat. The favourable positions of boreholes for production are on the plateaus. Drilling wells from the wadi floor is normally not an option, due to environmental impact and occasional flooding during rain periods.

During 1999, DNO drilled three more wells on the field, carried out a feasibility study and subsequently agreed with the partners on a development plan of the Tasour Field. In 2000, DNO acquired addi-

onal interests in block 32. Following the drilling of two more wells, the building of a central processing facility (CPF) and a 60 km long pipeline to the existing infrastructure in block 14, operated by Canadian Nexen Petroleum Company, the first oil flowed on November 3 that year.

In the following years the production has exceeded the expectations significantly. After the first year, the production was 34% better than estimated in the Field Development Plan (FDP). Reserves have also increased by five times compared to the original estimates. The Tasour Field has already produced 20 million bbls and proven reserves left to produce are about 5-6 million bbls. At the same time, DNO's economy has benefited from the oil price, which has increased by a factor of 4-5 since the company first came to Yemen. Today the reserves in Tasour are estimated to nearly 30 million bbls of oil ultimate recovery.

This is a small-scale success story from Yemen. "Our excellent co-operation with Yemeni technical expertise in both PEPA (Yemen Petroleum Exploration and Production Authority) and the Ministry, combined with extensive field work, is the recipe for success," says Ole Gunnar Tveiten, head of DNO Yemen G&G team. He continues:



Photo: Mona Holte

DNO's business strategy, to generate good economic performance and sustainable growth through exploration and appraisal of small oilfields, has been perfectly followed through in Yemen. The geoscientists Ole Herman Fjelltun (left) and Ole Gunnar Tveiten (right) are determined 'Yemen geologists', who have taken part in the oil-adventure of Yemen, where DNO is currently operating four licenses and playing an active role as partner on a fifth license.

"DNO appears as a credible operator, and the Yemeni government, which has the power to distribute licenses and negotiate PSA terms, is a supporting agent to our activity. This results in a quick response to our applications for licenses and development."

Where classic fieldwork is essential

Geologically, Yemen is divided into two main areas. The West Hill is considered a part of the Arabic shield, and consists mainly of sedimentary, metamorphic and igneous rocks. The middle and the eastern region are formed of sedimentary layers that date back to the Palaeozoic and Mesozoic eras.

The Say'un Al Masilah Basin, a structural feature associated with the Mesozoic break-up of Gondwanaland, is a symmetrical graben oriented NW-SE, similar to the other oil provinces in Yemen. About 90% of the reserves within the Say'un Al Masilah basin are produced from the Lower Cretaceous Upper Qishn Clastics. There is also production from distinct reservoir units consisting of Lower Cretaceous and Middle to Upper Jurassic age clastics and carbonates as well as fractured Cambrian granitic basement.

"Classic field mapping is essential in our exploration, and the Masilah area is ideal for mapping surface structures because the outcropping fault escarpments often reflect the same structure as the deep reservoir horizons. This is true within the Tasour field, where a roll-over anticline observed at surface reflects the underlying reservoir structure," says Ole Herman Fjell-tun, an experienced field geologist. "Also true-dip data measured in the borehole is a very important source of structural information."

Challenging tasks in the desert

Despite the 'straightforward' structural geology, the difficulty lies in seismic imaging. "Shooting seismic in the desert is an expensive, hot and demanding task. The rough surface terrain, where wadis and faults create dramatic elevation changes, is a troublemaker both with respect to locating the seismic lines, and with respect to near-surface inhomogeneous wadi fill as sand, gravels, boulders and water. Thus seismic modelling of sub-surface layers is hampered with great variations and uncertainty in seismic velocity."

Petroleum in Yemen

The first attempt to find oil in Yemen was in 1938, when the Iraqi Oil Company accomplished seismic studies in a few areas. That was followed by other surveys conducted by foreign oil companies in the fifties and sixties. The exploration activity implemented before the sixties, did not result in any commercial projects.

It was not until 1984, when the American company Hunt Oil declared the first commercial quantity of oil discovered in the Marib-Al-Jawf block in former north Yemen, when the country's oil era started. A number of foreign companies began placing their request for oil exploitations privileges in Yemen, and by the mid eighties, more than eleven oil firms had signed agreements of cooperation in several oil productions project with the Government of the Yemen republic.

The building of oil infrastructure and pipelines followed another discovery in 1991 by Canadian Oxy in the Masilah block 14. The encouraging quantities of oil that were discovered enabled former North Yemen to intensify its work in oil and gas, and to establish the Yemen Company for Oil and Mineral Investment.

In 1994, most oil exploration companies left due to the war associated with Yemen's unification. After the withdrawal of major international oil companies, the Government of Yemen has targeted smaller independent oil companies to take part in

Production Sharing Agreements (PSAs). New and accelerated momentum in the oil industry increased the oil explorations as new oil discoveries were reported. Yemen had suffered economic hardship until the discovery of oil in the mid-eighties. Today, oil income makes up an estimated 70% of total Yemeni government revenue. In 2003 Yemen's gross domestic product increased 4% and is expected to grow 4.2 % this year.

Despite its recent success, Yemen remains a small, non-OPEC oil producer. According to BP Statistical Review of World Energy, Yemen today has estimated oil reserves in the order of 4 billion barrels. Although this is only slightly less than neighbouring Oman (5.5 billion barrels) the Yemen oil reserves are dwarfed by the oil richness of Saudi Arabia (260 billion barrels). Yemen's gas reserves are the estimated to be relatively small, 0.5 trillion m³ (16.9 trillion cubic feet) and no gas is being exported.

The daily output of oil was 470,000 barrels last year, and recently, the Government of Yemen announced a one-million-bbl/d-production target for 2006. However, according to Yemen's Petroleum Exploration and Production Authority (PEPA), average production has actually fallen in the first half of 2004 to an estimated 400,000-420,000 bbl/d, due to declining production in Masilah and Marib, Yemen's two largest oil fields.



Photo: Halvor Jahre

Producing oil from the Nabrajah Field.

Shibam – Manhattan of the desert

Between two high cliffs hides awe-inspiring Wadi Hadramaut, an oasis valley 120 km long. Wadi Hadramaut is the largest and most fertile Wadi of the Arabian Peninsula, and was once the most flourishing of the Yemeni States.

Situated upon a cliffy plateau in the wadi, Shibam city rises up in the area as the first sky-scrapers-city in the world, made of mud and clay. And because of the densely built, 600 mud-brick skyscrapers, Shibam is known as 'The Manhattan of the Desert'. The clay houses of Shibam city in Hadramaut province rise high up in the sky by thirty to forty metres height.

The ground floors of such houses vary in wall thickness between one and half and two metres. Traditionally, roofs were covered with a robust mixture incorporating lime, ash and clay, making a more or less waterproof layer, plastic enough to move with the main body of the building, yet hard enough to take a polished finish.

Shibam City of Hadramaut has a surrounding wall fence that reaches seven metres high. This encircling wall has only one entrance gate. The streets in the city are narrow, with curving rounds and turnings.



Photo: Halvor Jahre

To give an all-round picture of Shibam Hadramaut, it is fair to say that the city looks like a splendid portrait that attracts both residents and non-residents. In 1982, The City of Shibam was admitted to UNESCO's exclusive World Heritage list for protection and preservation, because it is the oldest and best example of urban planning based on the principle of vertical construction. These sites are considered to be of outstanding value to humanity.



Photo: Halvor Jahre

The concentrations of mud tower high houses, fenced by a wall rising up seven metres from the ground are characteristic in Shibam, the Manhattan of the desert. The houses seem to have grown directly from the earth below.

During the spring of 2004, DNO shot and processed a new 3D seismic survey that aimed to further resolve the structural characteristics of the Tasour Field. The seismic shooting challenge in Yemen has been resolved over a decade of trial- and error. Instead of the original and straightforward seismic lines, which gave poor portrayal of the structures, several thousands of shot holes has been drilled to a depth of two metres in the ground, before the dynamite is dropped in and covered with sand.

"This job is for strong, muscular fellows," says Fjelltun. "To transport equipment in this harsh terrain, both helicopters and professional mountain climbers are employed. Such seismic operations require key-focus on safety. With temperatures rising up to 60°C during a normal summer day, it is self-evident that safety measures have to be taken, also regarding the heat. The 60 km/h speed limits for all vehicles were strictly obeyed during this work. "We are proud of the zero accidents record achieved by our Chinese contractors doing this work," says Tveiten.

"Inevitably, shooting seismic in the desert is expensive, about 16,000 USD pr line-kilometres. However, the production and transportation cost pr. barrel in Yemen is less than half the price compared to the same activity in the North Sea, so we have capability to efficiently recover this exploration costs," Fjelltun says.

Where does the future lie?

"For us, it is essential to integrate seismic data, geologic profiles, satellite images and elevation models to build a robust seismic velocity model," says Tveiten. "This integration has improved our geological models. The new 3D seismic surveys acquired in the Tasour Field have provided an invaluable tool to increase oil recovery and further appraisal of the area. In block 53, where British Dove Ltd has headed the operation and DNO has been an active partner with 25% interest, the production is above 20,000 bbls/day."

For the reader looking for the DNO's formula for success, Tveiten discloses more. "Currently, a development plan for the Nabrajah Field in block 43, where DNO is Operator, is under preparation. Oil has already been tested in this field, and appraisal drilling is ongoing." Tveiten says with a smile. Do we hear the beginning of the same old story?