Increasing production from old, onshore oil fields, Azerbaijan – a case study

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ABSTRACT: As part of an effort to try to halt the decline in onshore oil production and accelerate production from onshore fields in Azerbaijan, a World Bank-sponsored study of four fields was carried out: the Bibi-Eybat, Kala, Buzovni-Mashtagi and Zirya fields. The study integrated geoscience, engineering, economics and environmental issues. This paper concentrates on the determination of methods for increasing production rates and recovery. The characteristics of the subject fields are summarized and their current status described. Methods for improving oil production rates in the fields include: mechanical work-overs, artificial lift optimization, sand-control and changes to well completion practices. Our work indicates that production rates could be raised between two- and ten-fold through the application of modern oil-field practices, but financial constraints have prevented their widespread use. Well intervention techniques form the basis of several outline field development plans, described with the associated production forecasts. A brief review is made of possible exploration plays which exist in and around the subject fields.

KEYWORDS: *Azerbaijan, FSU, Pliocene, depleted reservoir, development*

INTRODUCTION

The existence of hydrocarbons beneath the Apsheron Peninsula has been known since ancient times. The first recorded commercial use of oil from the Apsheron Peninsula dates back to 700–600 BC, and wells were being dug there to extract oil in the tenth century (Yusifzade 1996). Development of these reserves accelerated in the mid-nineteenth century and, by the turn of the century, oil production levels were around 36 000 m^3 per day. Development of the extensive oil deposits both onshore and offshore Azerbaijan has continued to the present day.

In recent years, much interest has been expressed by international oil companies in the large, undeveloped structures which lie offshore Azerbaijan. However, there are some 37 onshore oil fields currently producing in Azerbaijan, some of which lie close to the capital, Baku (Fig. 1). Most of these onshore fields are at an advanced state of development, with a very large well stock, low oil production rates and high water-cuts; many wells will not produce without artificial lift. The collapse of the former Soviet Union has caused economic difficulties within Azerbaijan and has led to a reduction of investment in the onshore fields. As a result, onshore oil production rates have fallen (Fig. 2) to the point where it will take over 100 years to deplete some old, onshore fields fully at current depletion rates. This situation is compounded by poor environmental conditions in and around the onshore oil fields, where decades of environmental neglect have left a bitter legacy for future generations.

A significant proportion of the country's developed reserves lie in old, onshore fields. The challenge facing Azerbaijan is to accelerate recovery from them in an economic fashion. The State Oil Company of the Azerbaijan Republic (SOCAR), in trying to address these challenges, recently carried out a World Bank-sponsored project in conjunction with GeoQuest Reservoir Technologies (GRT) to investigate ways in which this could be achieved. Four fields, managed by two Field Management Units (NGDUs), were selected for study: the Bibi-Eybat field, managed by the Bibi-Eybat NGDU, and the Kala, Buzovni-Mashtagi and Zirya fields, managed by the Tagiev NGDU. A number of topics were investigated during this project, including field operations, NGDU organizational structure, the potential for increasing production, environmental conditions, reserves calculations, economics and field promotion. This paper concentrates on the potential for increasing the production rate and recovery from the subject fields.

GEOLOGICAL SETTING

The reservoir horizons currently under development in the subject fields are of Pliocene age, and are known collectively as the 'Productive Series'. This is the main hydrocarbon-bearing formation in the existing oil fields, both onshore and offshore Azerbaijan (Abdullaev *et al.* 1998; Narimanov *et al.* 1998). Below the Pliocene sediments, and separated by the Pontian shale, lie the hydrocarbon-bearing diatomaceous sediments of Miocene age. This formation has not been developed in either NGDU because of drilling problems associated with the Pontian

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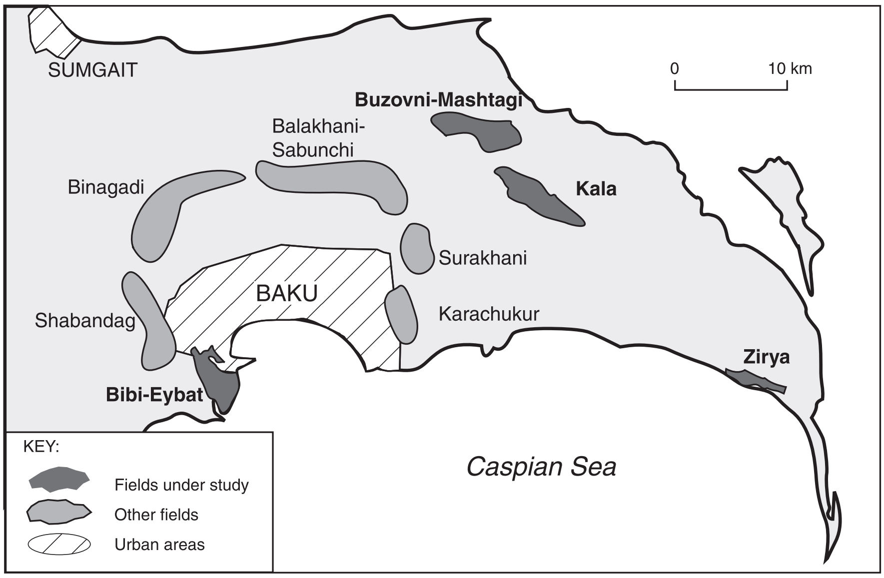

Fig. 1. Location map, Apsheron Peninsula.

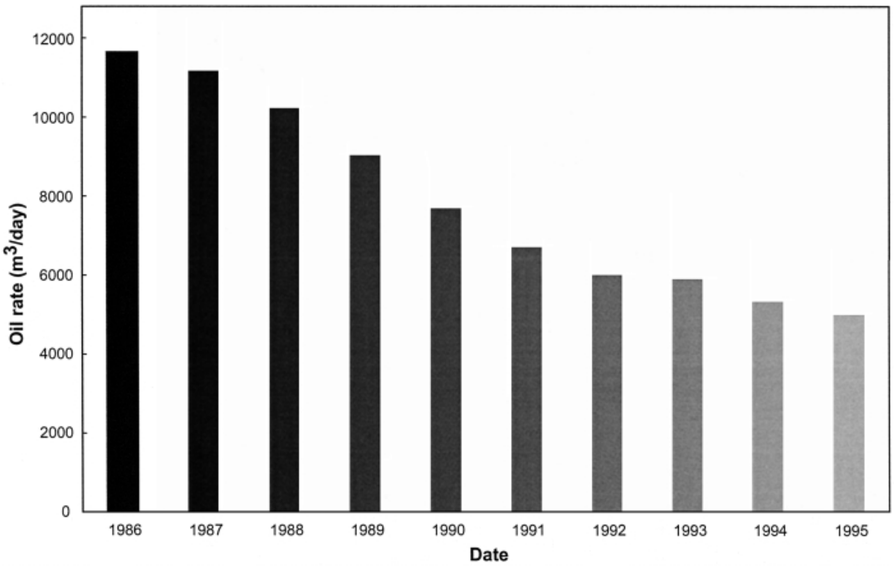

Fig. 2. Average annual onshore oil production rate (1986–95).

shale. This formation is commercially productive in the North Karadag Field, and, therefore, represents an attractive exploration play in both NGDUs.

The Productive Series consists of a series of stacked sandstones, siltstones, claystones and shales, which were deposited in a predominantly deltaic environment, though some horizons (for example, those of the Pereriva Formation – see below) were deposited on a fluvial plain (Abdullaev *et al.* 1998). The alternating lithologies are indicative of cyclical trangression and regression associated with changes in the level of the Caspian Sea. The total thickness of the Productive Series varies from around 1300 m at the crest of the Buzovni–Mashtagi structure to 1750 m in the Bibi-Eybat Field.

The subdivision of the Productive Series has been described by a number of workers, most recently by Reynolds *et al.* (1998). The most important subdivision is that between the Lower and the Upper Productive series which is marked by an unconformity. The Upper Series consists of the Pereriva, Balakhani, Sabunchi and Surakhani formations, and the Lower Series of the post-Kirmaki clay suite (NKG), post-Kirmaki sand suite (NKP) and Kirmaki (KC), Pre-Kirmaki (PK) and Kalin (KaC) formations (Narimanov *et al.* 1998). These formations are further subdivided for reservoir management purposes, with the subdivision varying between fields. A schematic lithological column is shown in Figure 3.

The Upper Series is capped by the Akchagil Formation, which consists of calcareous clays and sands of varied colours. The rocks of this formation outcrop at the surface in the Bibi-Eybat Field, and to the west of the Kala and Buzovni-Mashtagi fields. Above the Akchagil Formation lie progressively more Recent deposits, culminating in the modern Caspian Sea sand and clay deposits, which outcrop at many locations on the Apsheron peninsula. None of the Recent deposits are of commercial interest to the oil industry.

The reservoir structure of the oil fields of the Apsheron peninsula follows closely the surface topology. Most of these oil fields are elongate in the NW–SE direction along a major fold axis. This major fold is asymmetric, with the northeastern flank having a relatively shallow dip (4–12°), and the southwestern flank a slightly steeper dip (8–20°). One of the exceptions is the Buzovni–Mashtagi Field which is made up of a series of ancient, buried highs (Kurdakhani, Mashtagi and Buzovni),

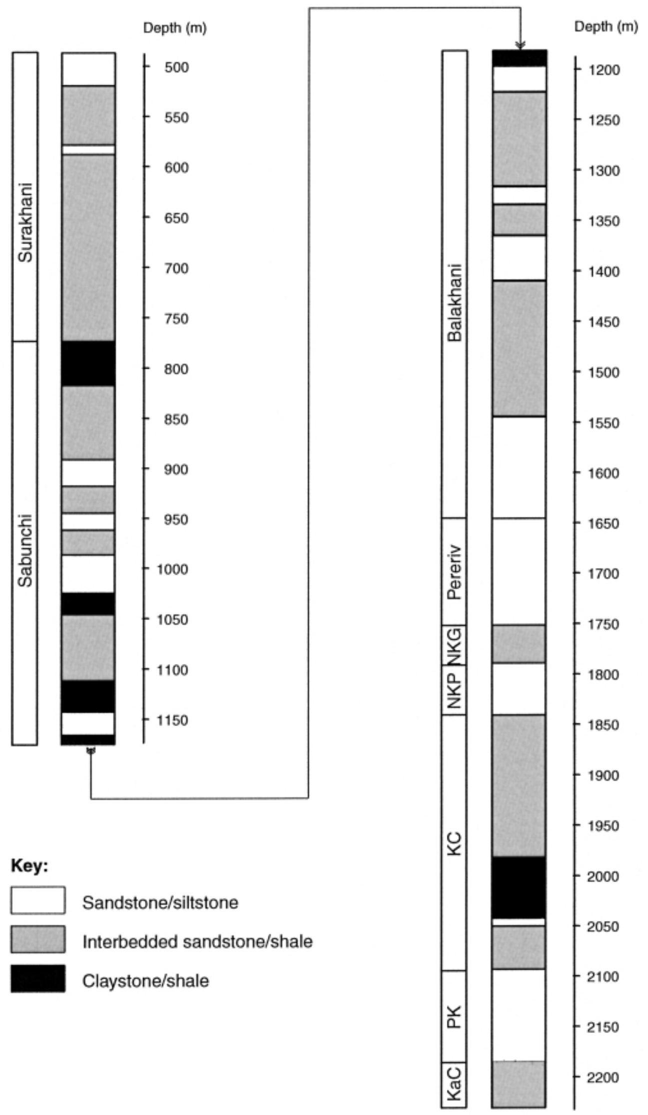

Fig. 3. Schematic stratigraphic column, Productive Series.

linked together. This structure has been folded asymmetrically, with the northeastern leg of the fold having a shallower dip (4–6°) than the southwestern leg (12–16°). The field is broken up by a series of faults which are either parallel or perpendicular to the main fold axis.

ONSHORE PRODUCTION IN AZERBAIJAN

At the time of writing, there were 37 onshore oil fields producing in Azerbaijan. Production from these fields is controlled by 18 Field Management Units (NGDUs). At the start of 1997, their combined oil production rate was just over 5000 m^3 per day with an average water-cut of 92%. Collectively, these NGDUs employ 15 000 employees, who look after all aspects of production from the fields, from manning work-over rigs through maintenance to field management. These old onshore fields are of strategic importance to the government of Azerbaijan for a number of reasons including:

- reserves – over 16×10^7 m^3 (10^9 STB) oil remain in onshore fields;
- low lead time and cost for re-development compared to offshore fields;
- they provide employment for a large number of workers.

The GRT/SOCAR study concentrated on rehabilitating the fields operated by two of these NGDUs: Bibi-Eybat and Tagiev (GeoQuest 1997). A short history and summary of the current status of these fields is given below:

Bibi-Eybat NGDU

The Bibi-Eybat oil field is situated on the coast of the Caspian Sea, 3 km to the south of Baku. Production began in 1873, making the field one of the oldest oil-fields in the world. Figure 4 shows the historical field production since 1936. In all, some 3730 wells have been drilled in the field but only 1250 or so are currently capable of production, most of the remainder having been abandoned. Of the remaining wells, 571 were producing and 683 shut-in at the start of 1997, mainly because of lack of spare parts. Most wells sit on reclaimed land, protected by dykes against the rise of the Caspian Sea. Some wells have been drilled on the slopes of the Bibi-Eybat valley, which rises to the north, and others lie just offshore, on piled-structures: all of these offshore wells are planned to be abandoned for safety reasons. All the remaining wells use some form of artificial lift, the most common being sucker rod pumping. In 1996, the average well production rate was around 0.8 m^3 per day oil at a water-cut of 92%. The reserves (A+B+C_1 reserves – FSU

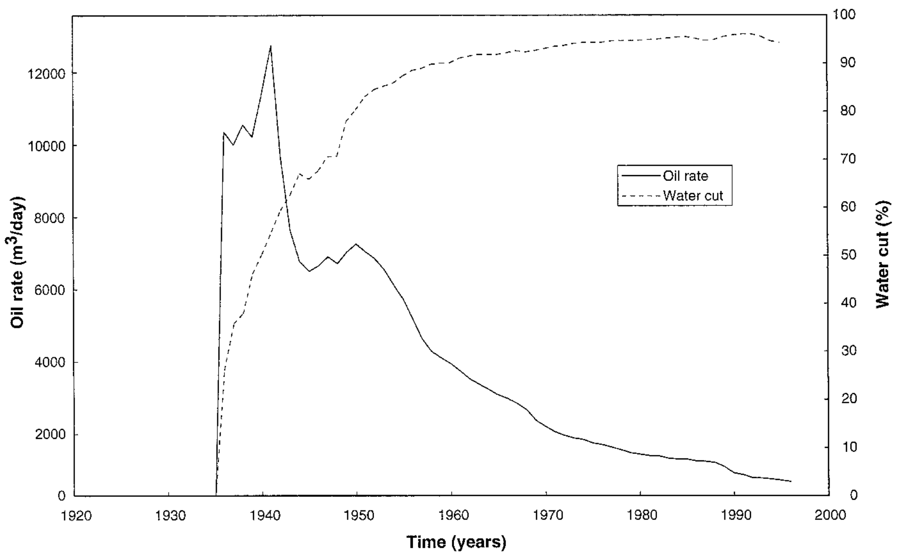

Fig. 4. Historical production performance, Bibi-Eybat Field (1936 onwards).

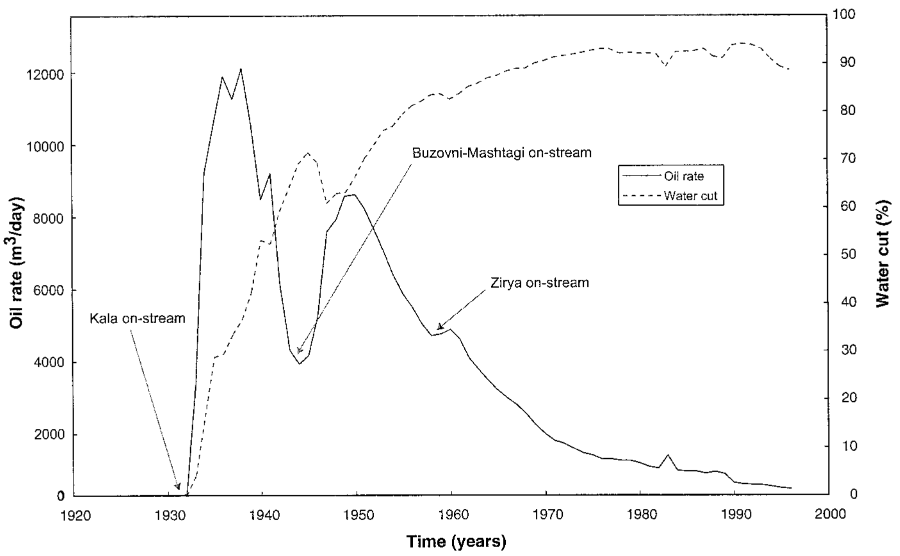

Fig. 5. Historical production performance, Tagiev NGDU-operated fields.

Reserves Categories) at 1 January 1997 were 10.3×10^6 tonnes oil. In addition to the low production rate and high water-cut, the field is also in a poor environmental condition.

Tagiev NGDU

The three fields operated by the Tagiev NGDU (Buzovni-Mashtagi, Kala and Zirya) are located 30–60 km east of Baku, on the northeastern part of the Apsheron Peninsula. Apart from a small part of the Zirya Field, these oil fields are all located onshore. Production from the fields began in 1932 (Kala), 1941 (Buzovni-Mashtagi) and 1956 (Zirya). At the beginning of 1997, 191 active and 235 inactive wells remained out of the total of 2567 wells. Like the Bibi-Eybat oil field, almost all the remaining wells need some form of artificial lift to enable them to produce. The average well production rate in 1996 was around 1.1 m^3 per day oil with an average water-cut of 88%. Remaining reserves ($A+B+C_1$ reserves – FSU Reserves Categories) at 1 January 1997 were 15.0×10^6 tonnes oil. The environmental conditions of the fields operated by the Tagiev NGDU are somewhat better than those of the Bibi-Eybat NGDU. The historical field production performance is shown in Figure 5.

FIELD CHARACTERISTICS

The general characteristics of the four fields described above are summarized below.

The Bibi-Eybat Field

The Bibi-Eybat Field is approximately 7 km long and 3 km wide (Fig. 6). The Productive Series has been subdivided into 29 main producing horizons for reservoir management purposes. Although most of these horizons have separate oil–water and gas–oil contacts, they are considered to belong to the same hydrodynamic regime. Some of the intervening shales act as pressure seals, giving rise to pressure differentials of up to 40 bar between layers. The producing intervals lie at depths between 150 and 2000 m below surface. The formation porosity and permeability are in the range 18–26% and 40–400 mD respectively. The crude oil is essentially undersaturated, except in the KC and PK formations (Fig. 3), where there are small gas caps. The reservoir oil currently has a low gas–oil ratio (16–24 m^3 m^{-3}), and moderate oil viscosities (3–8 cP).

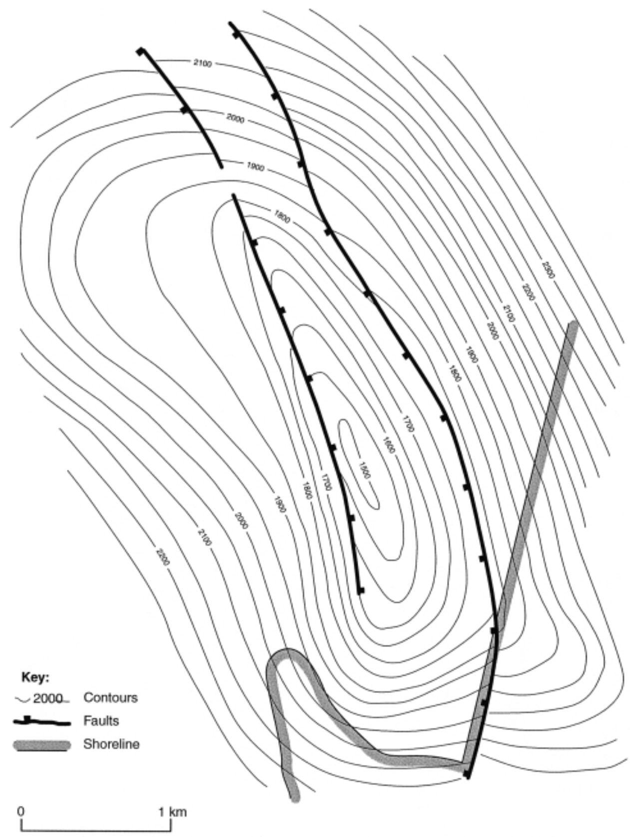

Fig. 6. Structure map, top PK Formation, Bibi-Eybat Field.

The main production mechanism in the field is aquifer influx, though water is injected into 5 of the 29 producing horizons to provide additional pressure support. Some pressure support is also provided by gas cap expansion (in those reservoirs which contain an initial gas cap) and solution gas drive.

Wells are completed on a single horizon, and are generally perforated 'bottom-up'. Producing horizons are plugged-back whenever oil production becomes uneconomic, and the overlying horizon perforated. In some wells, however, where the lowermost undeveloped horizon is already perforated in an adjacent well, a 'top-down' completion strategy is adopted. In the early days of production, the field was divided into a

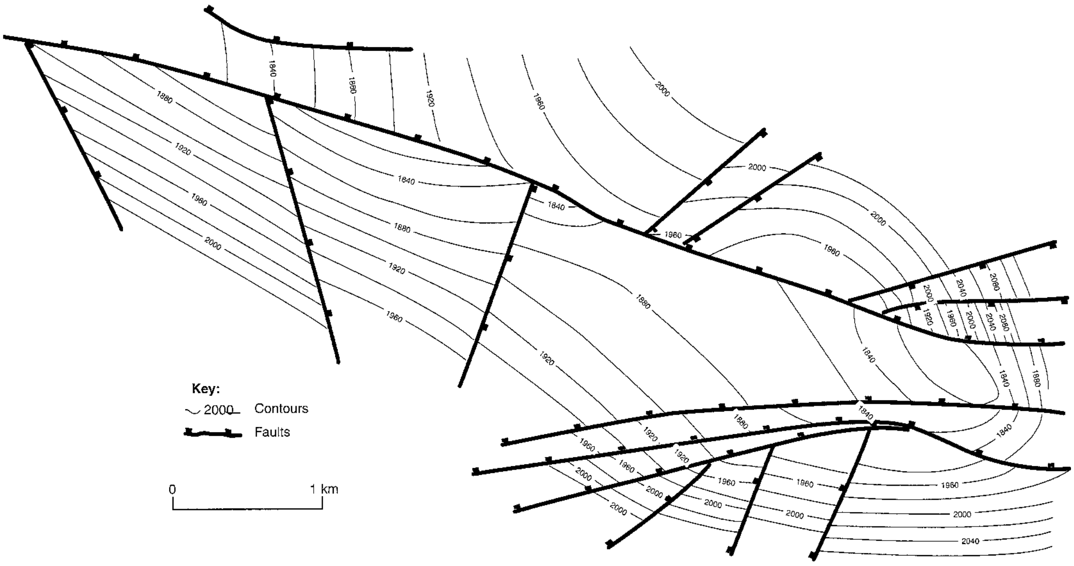

Fig. 7. Structure map, top PK Formation, Buzovni-Mashtagi Field.

number of leases and was not unitized. The early wells were therefore placed along the lease line boundaries to prevent lease line flux. Selection of well locations was rationalized during the Soviet years, but the field does not conform to any particular drainage pattern.

The Buzovni-Mashtagi Field

This field is the nearest to Baku of the fields operated by the Tagiev NGDU and lies directly to the north and east of Baku airport. The field measures around 8 km in the E–W direction and 3 km in the N–S direction, and has been divided areally into six separate fault blocks, which are believed to be isolated from each other (Fig. 7). There are 12 main producing horizons in the field, lying at depths between 1170 and 1970 m, but only formations of the Lower Productive Series produce at present. The porosity ranges from 19–27%, and the permeability from 100–250 mD. Apart from a small gas cap in one horizon, Buzovni-Mashtagi crude was initially under-saturated; the GOR is similar to that in the Bibi-Eybat Field. The main production mechanism for this field is a combination of natural depletion and aquifer influx. However, five producing horizons currently receive water injection. Almost 80×10^6 m^3 water have been injected into Buzovni-Mashtagi since 1948, which corresponds to the volume of fluid produced from the reservoir.

The completion philosophy in Buzovni-Mashtagi is essentially the same as that adopted in Bibi-Eybat. Wells are completed on a single reservoir horizon, and re-completed, usually upwards, when this horizon becomes unproductive. Three-quarters of the Buzovni-Mashtagi wells use sucker rod pumping, with the remainder on gas lift using compressed air as the lift gas. Unfortunately, many of the air-lift wells are currently shut-in because of a lack of compressed air. Some formations of the Buzovni-Mashtagi Field (mainly PK, NKP, NKG) are also prone to heavy sand production, and each well requires washing-out after approximately one month. Pilot sand control projects (gravel packing and sand consolidation) have been carried out successfully in Buzovni-Mashtagi; for example, two wells gravel-packed by an international service company (one in 1986 and one in 1996) have since remained sand-free.

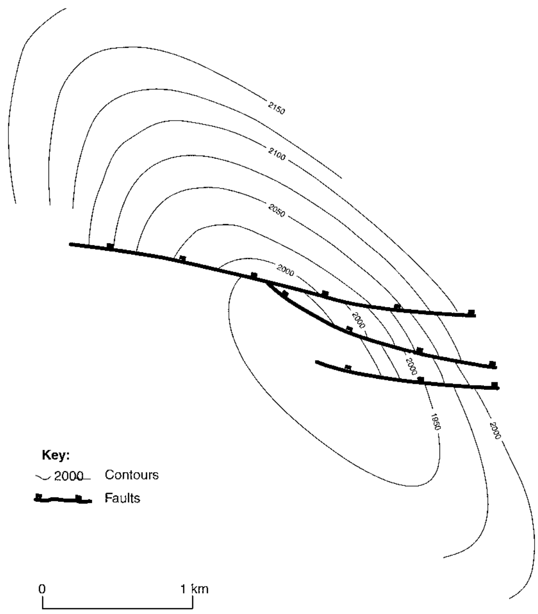

Fig. 8. Structure map, top PK Formation, Kala Field.

The Kala Field

The Kala Field is divided into two main areas, the Kala Field and the Old Kala Field. The two fields merge into one another, but the Old Kala Field, located towards the southeast, contains only the formations of the Lower Series. Here, the Kirmaky and Pre-Kirmaky formations lie unconformably on the Kalin Formation, which is absent in the Kala Field itself. The field measures around 5 km in the NW–SE direction and 2 km in the NE–SW direction (Fig. 8). The producing horizons lie at depths between 650 and 1970 m. The porosity ranges from 20–30% and the permeability from 50–500 mD. As with Buzovni-Mashtagi, the Kala Field contains only a small gas cap in the KC and PK horizons; the crude oil is generally under-saturated with a low gas–oil ratio (50–90 m^3 m^{-3}).

The main production mechanism for this field is a combination of natural depletion and aquifer influx. The field has been subject to water injection, but only around 10% of the reservoir voidage was replaced in this fashion. As with the

Bibi-Eybat and Buzovni-Mashtagi fields, wells are completed on a single reservoir horizon, and re-completed (usually upwards) when this horizon becomes unproductive. All wells require artificial lift, with sucker rod pumping being the most common lift method (80% of active wells). The lack of air compression is more severe in the Kala Field than in the Buzovni-Mashtagi Field, and few of the currently active wells produce under air lift. Sand production is less of a problem in Kala, compared to Buzovni-Mashtagi, and so ESPs are used in a number of the more productive wells.

The Zirya Field

The Zirya oil field is situated at the southeastern tip of the Aspheron Peninsula. Most of the field lies onshore, but part of it extends offshore. The Zirya Field differs from the other three fields in that it contains both gas condensate and oil reservoirs. The field is also much deeper than the other fields – the average depth of the producing horizons is 4500 m – and only the Lower Productive Series contains hydrocarbons. Development began in 1956 and production continued up to 1967. Seventy wells have been drilled in the field, although only three wells are currently active: two of these currently produce oil, and a third produces gas at an average rate of 7000 m^3 per day. The field is currently active in name only and needs to be completely re-developed. There are also a number of appraisal drilling targets around the field.

TODAY'S CHALLENGES

The challenges currently facing onshore production in Azerbaijan are summarized as follows:

- improving the rate of extraction and recovery for the remaining proved reserves;
- determining additional reserve potential in the vicinity of the fields;
- upgrading reserves in the 'probable' and 'possible' categories to the 'proven' category;
- developing a systematic programme to plug-back abandoned and sub-economic producing wells;
- designing an environmental programme to rehabilitate contaminated surface area and return the land to more productive uses;
- determining the requirements for new equipment, technology and production practices on these fields;
- developing mechanisms to attract the required capital investment from involvement of foreign investors and joint venture partners.

The technology, equipment and skills needed to overcome these challenges exist. For SOCAR, the main problem is a lack of finance within the country to carry out the required work. The GRT/SOCAR study addressed all these challenges; in the following sections we discuss methods of improving the rate of extraction and determining additional reserve potential.

IMPROVING THE RATE OF EXTRACTION

The production rate in the two NGDUs could be increased above present-day levels through a variety of well entry operations that are described in more detail below.

Restoring inactive wells to production

Just over half of the wells capable of production in the two NGDUs are inactive. The majority of these wells could be returned to production through simple work-overs using the equipment and facilities currently available within the NGDUs. Such remedial work includes replacing the required equipment, re-perforating the current horizon or recompleting the well on an over- or underlying horizon. A number of wells require more complicated work-overs to free stuck tubing (usually as a result of sand build-up) or to repair collapsed casing. These activities have generally not been carried out by the NGDUs because of a lack of the required drilling equipment. We estimate that current production levels in the Tagiev NGDU could be doubled, and tripled in the Bibi-Eybat NGDU, by returning currently inactive wells to production.

Artificial lift optimization

Almost all wells operated by the two NGDUs use artificial lift. There is considerable scope for increasing the production from these wells by optimizing the artificial lift systems. At present, the sucker-rod pump wells, which form the bulk of the well stock, generally have their pumps installed hundreds of metres above the perforations. There are two main reasons for this: first, there is a shortage of rods and tubing; second, setting the pumps so high is one way of preventing sand from entering the pump (see below). By installing sand-tolerant pumping equipment, and using sand exclusion techniques such as screens or gravel packs, pumps could be set deeper in many of the wells, thus reducing the back pressure and increasing the production rate. We estimate that, on average, the production rate from an average sucker rod pump well could be increased by a factor of 2.5 in this fashion. The surface pumping units used at present have sufficient capacity to accommodate such production increases, though new rod strings may be required in some cases. There is also scope for optimizing the performance of the air lift system (air is used to reduce the hydrostatic column in the tubing in place of hydrocarbon gas). The compressors currently supply a relatively small volume of air at a delivery pressure of 30 bar. More air lift wells could be brought on line if the delivery capacity were increased. Furthermore, an increase in air delivery pressure to 50 bar will allow air to be injected deeper in the tubing with a consequent increase in production. We estimate that the production capacity of air-lifted wells could be doubled by upgrading the air compression system.

Sand control

Sand production is a problem in both NGDUs; it is most serious in the Buzovni-Mashtagi Field. Two wells in this field were gravel-packed by an international service company in 1986 and 1996, with great success. Both wells have remained sand-free to this day. Only lack of finance has prevented a more widespread sand control programme from being implemented. The advantages of installing some form of sand exclusion are considerable and are summarized:

- increased well availability – more wells could be brought on line and the average well uptime could be increased;
- reduction of the number of wells abandoned prematurely as a result of sand production;
- increased draw-down;
- improved well productivity in sucker rod wells by preventing a sand column forming in the production casing between the pump and perforations. This sand column reduces the draw-down that can be applied and thus restricts the flow rate.

Combined, these could have a beneficial effect on the production rates in all fields studied, especially in the Buzovni-Mushtagi Field. Overall, we estimate that implementing a

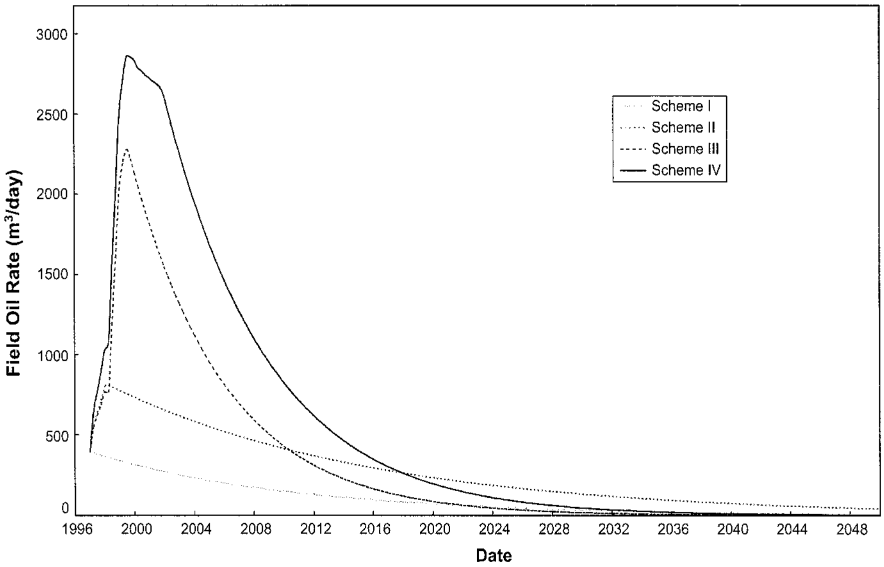

Fig. 9. Composite production forecasts, Bibi-Eybat NGDU.

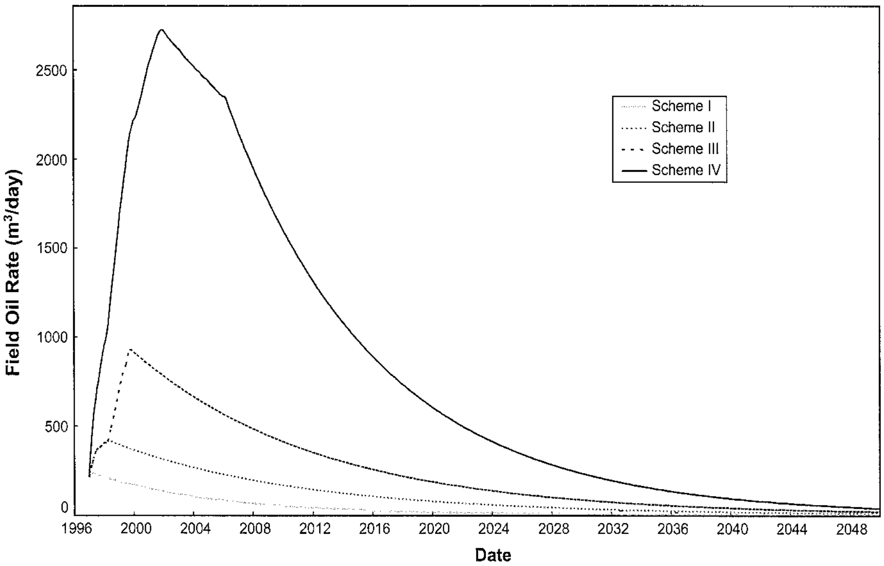

Fig. 10. Composite production forecasts, Tagiev NGDU.

tailored sand control policy would allow the production rate of suitable wells to be doubled.

Perforating

Formation damage restricts production from wells in all fields. The main causes of this damage are the use of a non-inhibitive drilling mud and the current perforation policy which is to perforate over-balance in dirty completion water. The performance of the Russian PKS perforating guns available to the NGDUs is poor compared to international standards, so that it is unlikely that the perforation tunnels penetrate the damage zone. We believe that by modifying the completion techniques, for example by perforating under-balance in clean water, an increase in productivity of around 50% is possible, even using PKS guns. By combining these techniques with more powerful perforating charges, up to 10-fold increases in productivity may be possible.

Drilling new wells

Several of the productive horizons currently have few wells completed in them. One obvious way of increasing the production rate from such horizons is to drill new wells. Even using the current drilling practices, we estimate that the production rate from a new well will be two or three times greater than that of the wells currently producing. By applying modern drilling practices, we expect that substantial increases in oil production rate will be possible.

FIELD DEVELOPMENT SCHEMES

Above, we outlined a number of activities through which production could be increased from individual wells within the subject fields. We have combined the incremental production profiles from these activities into a set of field production profiles for four development scenarios. Composite production forecasts for the two NGDUs are shown in Figures 9 and 10.

Scheme I: 'Current Development Scheme'

This is a minimalist development scheme. It assumes that the current economic situation continues and that no additional investment is made in these fields. Currently, the decline in the field oil production rate is higher than has been observed

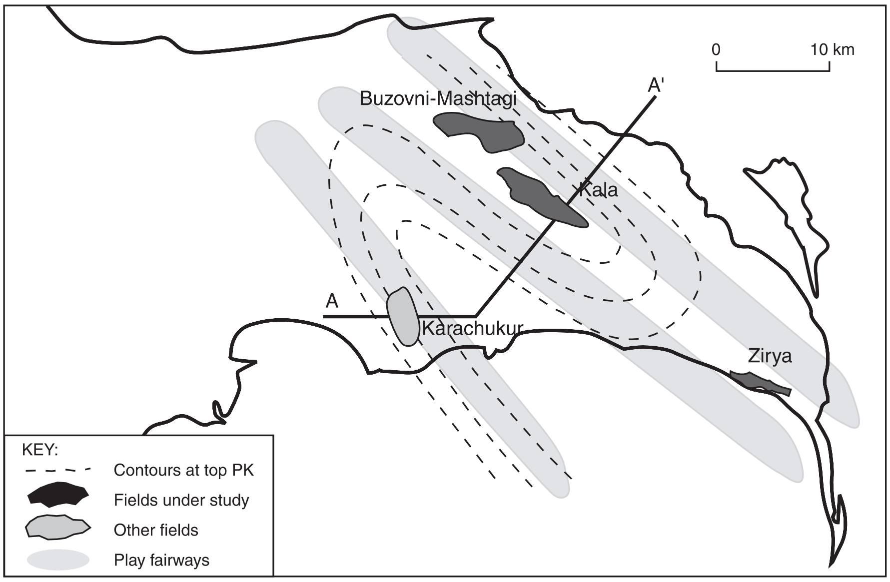

Fig. 11. Schematic structure map, top PK Formation, eastern Apsheron Peninsula.

historically. The main reason for this is the continuous reduction in the number of active wells through lack of provision of the equipment needed to keep them on production. For this development scenario, we have assumed that this situation continues. The corresponding production forecast is therefore a simple extrapolation of the recent historical production performance.

Scheme II: 'Extended Care and Maintenance'

Under this development scheme, we have assumed that sufficient capital has been provided by an investor not only to reactivate all inactive wells in the Bibi-Eybat, Kala, Old Kala and Buzovni-Mashtagi fields, but also to replace worn-out tubing, sucker rods, 'nodding donkeys' etc. as required for the active wells. Once this equipment has been installed, we assume that the fields simply continue to be operated as at present. In particular, we assume that none of the activities for increasing oil production described earlier are implemented; for example, there is no optimization of artificial lift, no drilling of new wells etc.

At the current rate of work-over in the two NGDUs, the required equipment would have been installed in all wells within a period of three years. The work-over capacity of the NGDUs, combined with the new equipment installed in the wells, should allow the future field decline rates to return to the values experienced historically.

Scheme III: 'Additional Investment'

This development scheme is an extension of Scheme II. We assume that not only are inactive wells brought back to production, and active wells repaired where necessary, but that additional equipment such as extra tubing, more powerful pump jacks, gravel packs, sand exclusion screens, etc., and improved completion practices are applied to allow the production rates from the three fields to be increased even further. At this stage, however, no new wells are drilled.

Scheme IV: 'New wells'

The final development scheme examines the effect of drilling new wells. These wells will accelerate recovery from the subject fields, and allow more efficient drainage of some of the areas of the fields.

ADDITIONAL RESERVES POTENTIAL

Additional reserves potential exists both within and outside the fields discussed here, and is described briefly below.

Reserves potential within the subject fields

The mature stage of development of the Bibi-Eybat, Buzovni-Mashtagi and Kala fields means that there is little likelihood of finding undeveloped reserves behind pipe. In general, the formation recovery factors currently achieved by the NGDUs (45–60%) are already high, and reflect the relatively dense (3–6 Ha drainage area) well spacing. As was mentioned above, the drilling of additional wells would be one way of accelerating the development of formations in which the well spacing is currently less dense. Detailed reservoir models may exist, but are not widely available. The location of additional drainage points is therefore generally based on an examination of the production performance of adjacent wells.

Although most formations within the subject fields already have high recovery factors, there are instances where the recovery factor in one formation is significantly lower than in the same formation in the other fields. For example, in the Kirmaky (KC) Formation in Bibi-Eybat, the recovery factor (24%) is around half that obtained from the same formation in the Buzovni-Mashtagi (43%) and Kala (48%) fields. The main difference between the development of this formation in the three fields is water injection.

Examination of the production performance of the lower Prekirmaky (PK_B) Formation in the Zirya Field indicates the potential for a large increase in gas condensate reserves from the currently developed horizons. Based on the assumptions used, we estimate that an initial production rate of around 4×10^6 m^3 gas per day is possible for the PK_B Formation; this is two orders of magnitude higher than the present-day rates. We have also examined the production performance of the Kalin (KaC) Formation in the Zirya Field and estimate it could produce, initially, at around 300 m^3 oil per day.

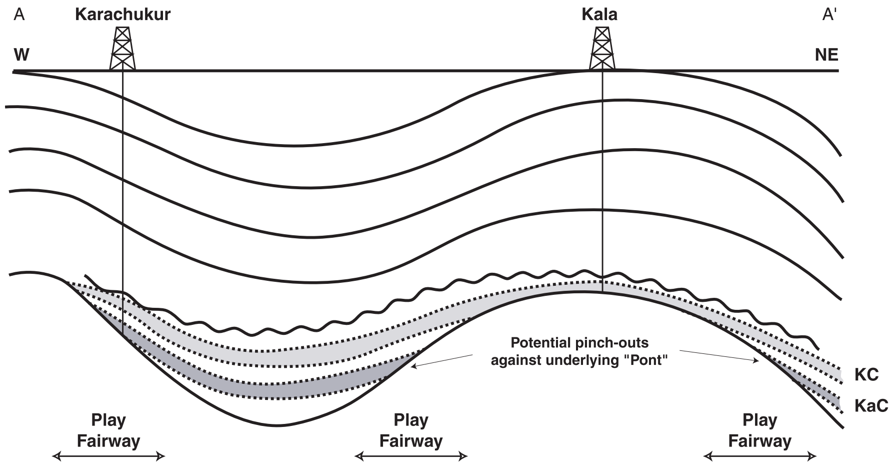

Fig. 12. KaC stratigraphic trap concept, eastern Apsheron Peninsula.

Reserves potential outside the subject fields

The exploration potential around the two NGDUs was reviewed briefly during this study. 2D seismic data are available over the eastern half of the Apsheron Peninsula, including the area operated by the Tagiev NGDU. The most promising exploration targets appear to be sub Pontian (Miocene) play below Bibi-Eybat, and stratigraphic traps in the KaC Formation between the Kala and Zirya fields.

The presence of oil in the Miocene diatomaceous formation has already been established by three appraisal wells drilled in Bibi-Eybat; there is oil production from the diatomaceous formation in the North Karadag Field, not far from Bibi-Eybat. Unfortunately, the Bibi-Eybat appraisal wells encountered kicks and had to be abandoned. The main problems with developing these reserves are associated with the severe drilling problems encountered in the Pontian Formation and those below.

KaC stratigraphic traps have already been discovered between the settlements of Torkan and Gofsan but have not been developed due to their proximity to Baku Airport. This exploration play has been recognized and several exploration well locations have been planned by the Tagiev NGDU for future drilling. There is also the possibility of increasing reserves in the lower KaC Formation of the Zirya Field through an appraisal drilling campaign. The play concept for these stratigraphic KaC traps is illustrated in Figs 11 and 12.

CONCLUSIONS

Oil companies active in Azerbaijan at the present time are concentrating on the exploration and development of the large structures which are believed to lie offshore in the Caspian Sea. Onshore production has been largely neglected by foreign oil companies, though a few joint ventures have been established to rehabilitate some of the onshore fields. This paper outlines methods by which oil production could be increased from the old, onshore fields. Although these fields are at a mature stage of development, it is technically feasible to boost their production using techniques which are readily available and simple to apply. These include: the replacement of worn-out well completion equipment; recompletion onto overlying formations; installation of sand control equipment; use of more efficient well completion techniques; optimization of artificial lift. Adoption of such production practices is expected to lead to an increase in oil production rate of between two and ten times. The cumulative effect of applying these well operations to individual wells has been used to prepare a number of outline field redevelopment schemes. These range from a scheme in which existing wells are reactivated and repaired, to one in which additional wells are drilled using international oil industry standard practices. These field redevelopment schemes are predicted to boost the production rate, in some cases up to 10 times that currently experienced. In most cases, the skills needed to apply these schemes already exist in Azerbaijan – the main problem is in attracting the necessary investment capital.

Although most formations are expected to be drained adequately, there is still some scope for improving the recovery from some formations from a change in development mode, for example implementing water injection. In addition, exploration potential exists around both NGDUs. We have described two possible exploration plays associated with the fields under study: stratigraphic traps in the Kalin Formation and structural trapping in the underlying diatomaceous (Miocene) formation.

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