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MASTER THESIS

Title: Analyzing and intensification field development of Shallow Water Gunashli

Master Student: JeyhunAlipanakhov

Supervisor: Associate Prof. Dr. GashamZeynalov

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ABSTRACT

The actuality of theme: In XX century, rapidly development of the oil industry has created a strong manufacturing base and research centers. 1970-1990 years of Azerbaijan oil industry was characterized as the development of Deepwater oil fields. Gunashli field plays an important role in Azerbaijan oil industry. Gunashli field is located 120 kilometers east of Baku and its deep-water section is a part of the ACG project and called Deep Water Gunashli (DWG). The Western part of Gunashli field is called Shallow Water Gunashli (SWG). SWG is one of the richest oil field, which operated by SOCAR and about 170 million tons of oil and gas has been extracted for the terms of 35 years. Residual recoverable reserves are more than 43 million tons. Oil production of "SWG" is approximately 60-70 % of the total oil production of SOCAR. From this point, all researches about SWG are important for present and future developments of national oil industry.

Gunashli anticline was discovered in 1958-1963 years due to seismic works. Deep exploration drilling has begun with the drilling of the north-west periclinal structure with the well №1 in 1977. Cross-section of SWG is consisting of several layers. These layers include sediments from upper Miocene period to present old sediments. VII, VIII, IX, X horizons, PS, NKCS, NKSS, PKS are productive horizons in SWG.

The theme of this thesis is analyzing field development of SWG and finding appropriate research methods of increasing oil recovery for particular field.

In the following thesis, current production stage of Gunashli field was defined by analyzing annual production history recordings. Several plots were built in order to graphically represent whole production cycle of Gunashli field. Based on annual production reports cumulative production curve of recovered liquids and injected water was plotted.

By using field data initial and residual reserves were estimated based on volumetric calculations. According to calculations initial oil in place reserves are 263.3 million tons were defined at the exploration stage from which 158 million tons are potential recoverable (ultimate oil recovery factor 0.6).

Efficiency of secondary recovery technique is analyzed based on data of water injection wells. Considering that Gunashli field is on the declining stage, appropriate EOR methods were proposed by using classification model.

Results, carried out from thesis can be practically implemented at scheduling of the development program of SWG and to the analysis of analogical fields.

Matter of thesis

The master thesis consists of introduction, four section, conclusion and references.

In introduction is given primary information about Gunashli field and role of Gunashli oilfield in Azerbaijan Petroleum Industry.

First chapter includes general information, history, exploration, stratigraphy, lithology, tectonics and oil–gas bearing zones of Gunashli field.

Second chapter includes geological and technological characteristics, field development of Pereriva Suite of Gunashli Field.

In third chapter, water injection processes and its efficiency in Pereriva Suites are clarified.

Forth chapter is about selection and application enhanced oil recovery methods to Pereriva Suite at current field development stage.

In conclusions and recommendation, result of analyzing water injection process in Pereriva Suite and efficiency of new applied methods to increase oil recovery has been included.

XÜLASƏ

Mövzununaktuallığı: XX əsrdəAzərbaycandaneftsənayesininsürətləinkişafınəticəsindəgüclüistehsalbazalarıvəelmi mərkəzləryaradılmışdır. 1970-1990-ci illərdəAzərbaycandaneftsənayesidərindənizneftyataqlarınınişlənməsiiləsəciyyələnir. Bu baxımdanGünəşliyatağıAzərbaycanınneftsənayesindəmühümroloynayır. GünəşliyatağıBakıdan 120 kilometrşərqdəyerləşirvəonunşərqhissəsiAzəri-Çıraq-Günəşlilayihəsinintərkibhissəsidirvə Dərin Sulu Günəşliadlanır. Günəşliyatağınınqərbhissəsinisbətəndayazdırvə Dayaz Sulu Günəşliadlanır. Dayazsulu Günəşli SOCAR tərəfindən istismar olunan ən zəngin neft ehtiyatına malik yataqdır və istismarolunduğu 35ilmüddətindəburadan 170 mlntonnefthasiledilib. Qalıqçıxarılabilənneftehtiyatlarıtəqribən43 milyontondur. Dayaz Sulu Günəşlininnefthasilatı SOCAR-ın nefthasilatının 60-70 faizinitəşkiledir. Bu nöqteyi-nəzərdən,Dayaz Sulu Günəşlihaqqındaaparılanbütünaraşdırmalarmillineftsənayesininbugünküvəgələcəkinkişaf ıüçünəhəmiyyətkəsbedir.

Günəşli antiklinalı 1958-1963-cı illərdə seysmik işlər nəticəsində aşkar edilmişdir. Dərin kəşfiyyat qazma işləri 1977-ci ildə 1 №-li quyunun qazılması ilə başlayıb.Yatağın geoloji kəsilişində məhsuldar qat 18 neftqazlıhorizont və lay dəstələrindən ibarətdir. FLD, QÜG, QÜQ, QA və VII, VIII, IX, X horizontlar Günəşli yatağının ən məhsuldar laylarıdır.

Bu dissertasiyasının mövzusu Dayaz Sulu Günəşlinin işlənmə göstəricilərinin təhlili və neft hasilatının artırılması üçün müvafiq metodlarını seçilməsidir.

TezisdəDayaz Sulu Günəşlininillik hasilat profili təhlil edilərək yatağının hazırkı işlənmə mərhələsi müəyyənləşdilimişdir. Yatağının hasilat profili qrafikdə öz əksini tapmışdır. Eyni zamanda yataqdan illik çıxarılan mayenin və vurulan suyu qrafiki qurulmuş və müqayisə olunmuşdur.

Tezisdə FLD-nin göstəricilərinə əsasən ilkin və qalıq ehtiyatları həcmi hesablamalar əsasında qiymətləndirilib. Hesablamalara görə, ilkin neft ehtiyatı 263.3 milyon ton, potensial çıxarıla bilən ehtiyat 158 mln ton təşkil edir.(son neftvermə əmsalı 0.6-dır).

Suvurucu quyularının məlumatları əsasında suvurma prosesinin effektivliyi təhlil olunmuşdur. Yatağın hasilatın düşmə mərhələsində olmasını nəzərə alaraq neft verminin artırılması üçün təsnifat modelindən istifadə olunması təklif olunmuşdur.

Tezisdən əldə olunan nəticələr Günəşli və analoji oxşar yataqların işlənmə proqramının planlaşdırılmasıda praktiki olaraq tətbiq oluna bilər

Magistr işinin məzmunu

Magistr işi, giriş, dörd bölmə, nəticə və təkliflərdən ibarətdir.

Giriş hissədə Günəşli neft yatağı haqqında ilkin məlumat və Günəşli yatağının Azərbaycanın neft sənayesndəki rolundan bəhs edilir.

Birinci bölmədə Günəşli yatağı haqqında ümumi məlumat, yatağın tarixi, aparılan kəşfiyyat işləri, yatağın litologiyası, tektonikası, stratiqrafiyası, neft və qazlılığı haqqında məlumat verilir.

İkinci bölmədə Günəşli yatağının fasilə lay dəstinin geoloji-texnoloji xüsusiyyətləri və işlənmə mərhələləri təhlil olunmuşdur.

Üçüncü bölmə Günəşli yatağı Fasilə lay dəstinə (FLD) suvurma prosesinin analizi aparılmış və suvurma prosesinin effektivliyindən bəhs olunmuşdur.

Dördüncü bölmə FLD-nin hazırki işlənmə mərhələsində neftvermə artırılması üçün üsulların seçilməsini və tətbiqini əhatə edir.

Tezisin nəticələr və təkliflər hissəsində suvurma prosesinin təhlinin nəticələri və neftvermənin artırılması üçün yeni üsulların tətbiqinin effektiv olacağı qeyd olunur.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

Gunashli field is one of the richest oil field in Azerbaijan which is 170 million tons of oil and gas has been extracted for the terms of 35 years. The field also keeps its importance from the point of the national petroleum industry. Hence, remaining recoverable reserves is more than 43 million tons.

Efficient development of the SWG is important for the fuel-energy complex of Azerbaijan Republic that is why Pereriva Suite of field attracts great attention. Here the problems of development of remaining oil in the background of geotechnical projects are involved. The main scope of this dissertation work is to deal with the extraction of remaining oil reserves which are of great importance. The current oil production rate requires 30-40 years, so the current hydro-technical infrastructure does not sustain that long of production period for the recovery of the reserves. Therefore, relevant geotechnical projects should be improved in order to increase oil production rate and last oil production index.

Graduate work has been completed in 2016. I express my gratitude to my supervisor Associate Professor GashamZeynalov, who helped me to complete my thesis.

CHAPTER I. GEOLOGICAL AND GEOPHYSICAL CHARACTERISTICS OF SHALLOW WATER GUNASHLI

Gunashli is an offshore oil field in the Caspian Sea, located 120 kilometers (75 miles) east of Baku, Azerbaijan, 12 kilometers (7.5 mile) southeast of Oil Rocks and its deep-water section is a part of the larger Azeri–Chirag–Gunashli (ACG) project. The depth of seawater of the Western part of Gunashli field is shallower than eastern part and this part of the field is called Shallow Water Gunashli (SWG) (Figure1.0). SWG is not a scope of the ACG project, lies in 120 meters (390 ft.) depth of water and developed by State Oil Company of Azerbaijan Republic (SOCAR) while the Deepwater section developed by BP within ACG project is at 175 to 300 meters (574 to 984 ft.). The field initially was explored in 1958–63. The first offshore platform was installed by 1976 and production in this section started in 1982. It has consisted of 4 steel jackets for drilling of 10 wells. As per 1980 data, the platform produced 320 tons of oil per day. As of 1995, Gunashli was producing 120,000 barrels per day (19,000 m3/d) of oil. Deep exploration drilling in Gunashli field has begun with the drilling of northwest periclinal structure of number 1 well since 1977. The main aim in exploration was studying geological structure of field, lithofacies of productive zones and oil-gas saturation.

Discovery of SWG relates to production of number 4 exploration well in 1979. During tests of 3455-3423m interval in X-horizon of Balakhani layer well flowed naturally with 230 tons per day rate. Later well number 6 gave natural flow of 320 tons per day during tests of Pereriva Suite in 1980 November.

The oil and gas bearing of productive series and, upper and lower section of productive zone sediments was discovered during exploration work. Oil, gas and condensate reserveswas calculatedduring field development period, in 1985, 1998, 2005 and 2011.

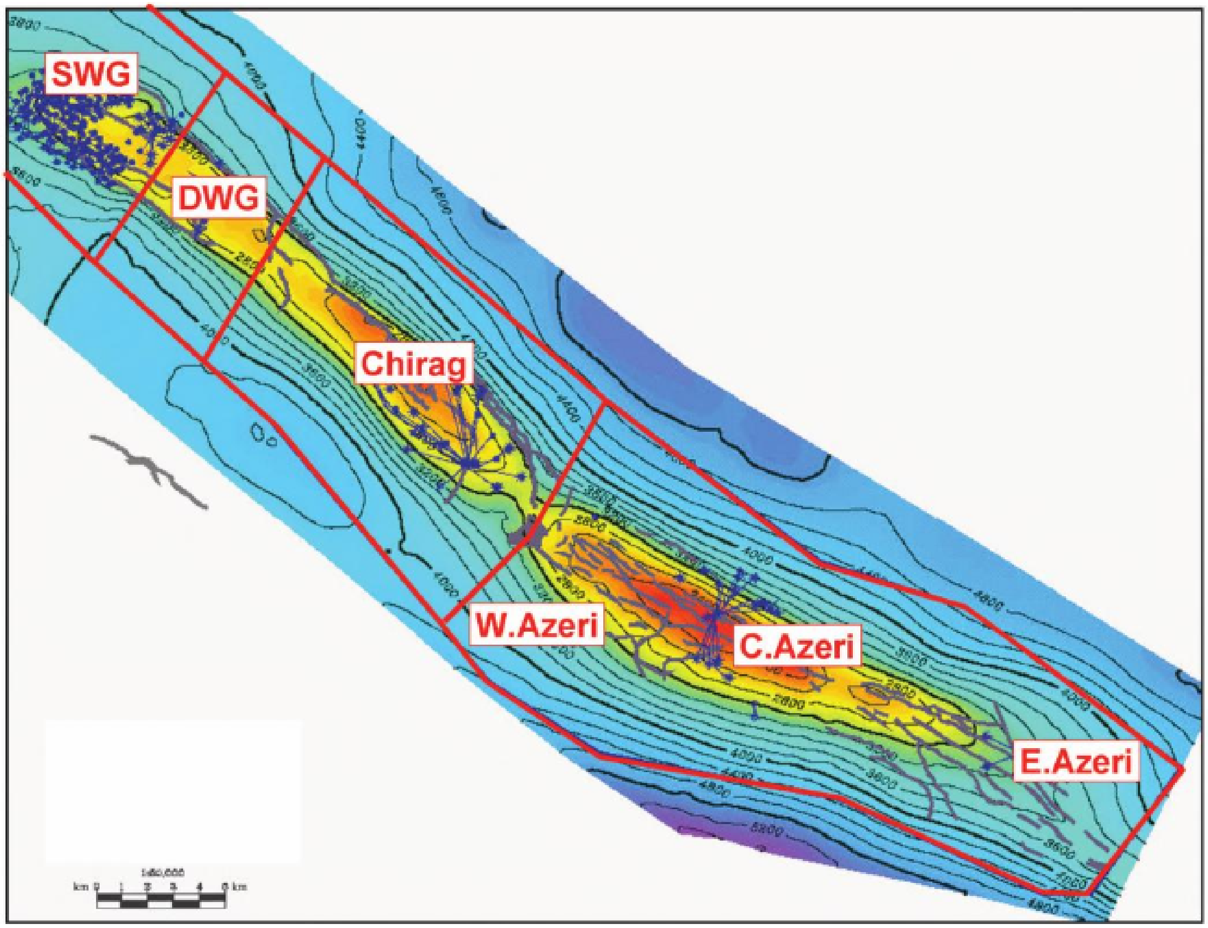

Figure 1.0 Shallow Water Gunashli field location

The deep water section of Gunashli is also called DWG. DWG has been included for development within the ACG project's Phase III. First oil from DWG was produced on 20 April 2008 from one of 10 pre-drilled wells. DWG now produces nearly 320,000 barrels per day (51,000 m^3/d) of the total 1 million barrels per day (160×103 m^3/d) from ACG fields complex.(1)

1.1 Discovering and exploration history of SWG

Gunashli anticline was discovered in 1958-1963 years due to seismic works. Beginning from 1974-year seismic exploration works were done by covering Gunashli

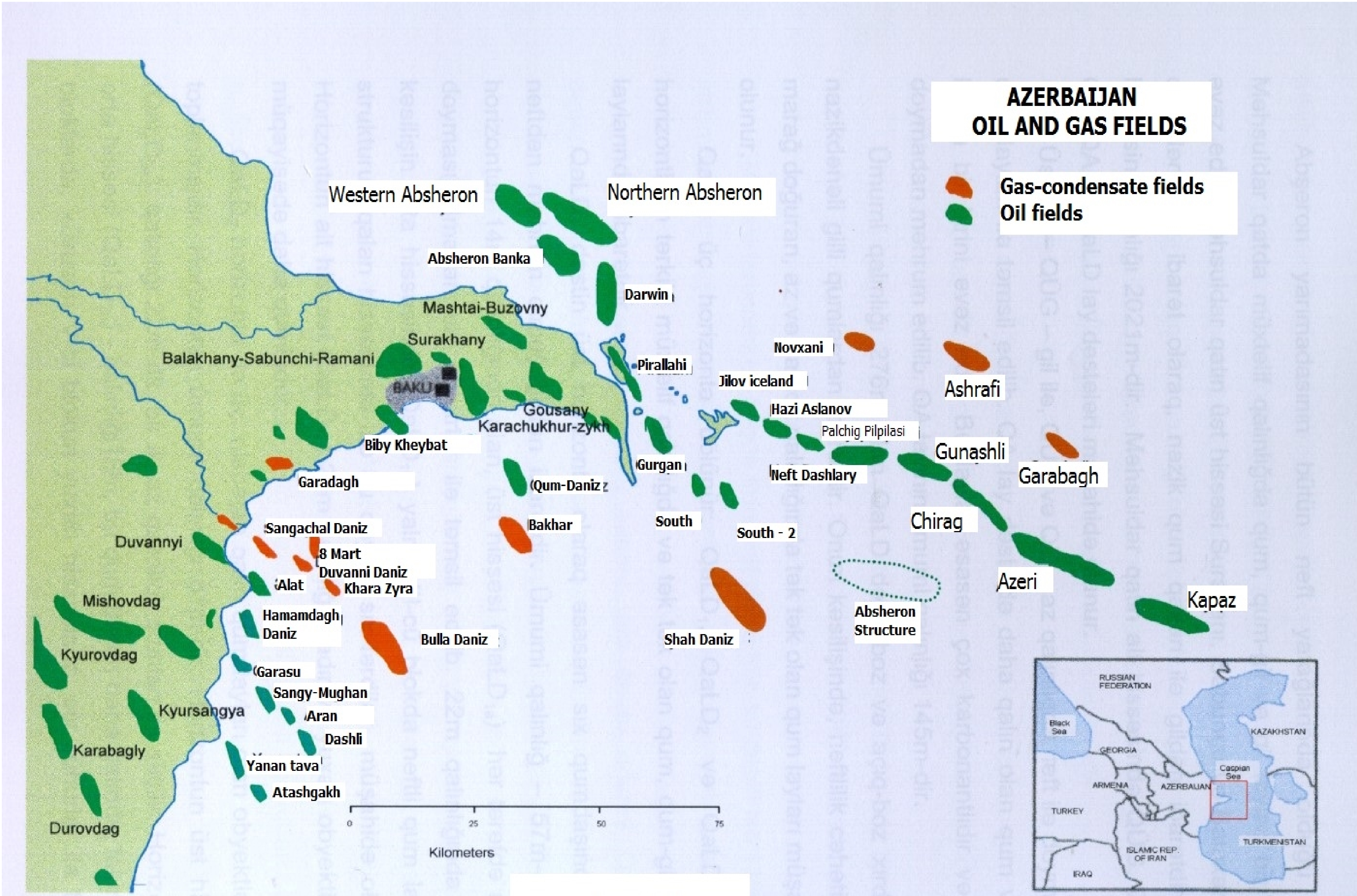

Figure 1.1 Location oil and gas fields of Azerbaijan

field several times in Azerbaijan and Turkmenistan sections of Caspian Sea, as a result this anticline was discovered.

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Gunashli field locates in Caspian Sea, 12 km southeast from well-known Oil Rocks, sea depth changes between 84-300 m in the area of the field (Figure1.1). Oil-gas saturation in upper and lower zones of production zones was discovered during exploration work. The calculation of the oil, gas, gas condensate was carried out in the laboratory of the “Oil Gas Scientific Research Project” Institute department “Estimation of oil and gas reserves”.

Oil, gas and condensate reserves was calculated during operating period in 1985, 1998, 2005 and 2011.

1.2 Stratigraphy

Main oil and gas bearing zones of SWG are connected with sediments of the Productive Zones in the geological cross-section of the field. The cross-section is consisting of layer complex, which has 4300-meter thickness. These layers include sediment from the Miocene period to modern-year. (2)

Eighteen oil (condensate) and gas bearing horizons and layers participate in the cross-section of the Productive Zones of SWG. The thickness of these layers is 2800-3000 meter. The Productive Zones of the field have been investigated with the exploration wells.

In the cross section of SWG layers and horizons are described in the following sequence.

Kalin Suite (KaS) consists of sand and clay layers. KaS is divided into 3 parts: KaS-1, KaS-2, and KaS-3. The percentage of sand increases from top to the bottom part of the cross-section.

Sand layer is located in the cross section of Well №11. The thickness of this sand layer is 120 meters. Apparent Resistivity (AR) raises up 20 ohmmeters. This shows that the horizon contains low-density hydrocarbons (gases). Well test information about wells № 5, 11, 16 have approved this information.

The thickness of KaS is 290-340 meter and productive part of KaS is KaS-2 and KaS-3 KaS-1 mainly contain clays and productivity of this part are lower than KaS-2 and KaS-3.

The thickness of Pod-Kyrmaky Suite (PKS) is 75-100 m, it contains 70 percentage fine and coarse grained sand and sandstone with clay layers. This production suite has been opened by the wells №13 and 24. At the logs of PKS shows apparent resistance is 10-15 Ohmmeter and their differentiation of this layer is normal.

Kyrmaky Suite (KS) mainly consist of clay layers and contains fine-grained sand, sandstone, and aleurite. In the logs of KS, sediments are characterized by low apparent resistivity and abnormal differentiation. The thickness of KS is 200-270 meter.

Nad-Kyrmaky Sand Suite (NKSS) consist of coarse-grained sands and contains a major original surface separating coarse cross-bedded sandstones from fine-grained sandstones. Black and colorful conglomerates and rough rock sediments include to this production suite. These layers have opened in the 2900-3550-meter depth and the thickness of NKSS is 45-65 meter.

Nad-Kyrmaky Clay Suite (NKCS) consist of light gray clays and rarely contains with sand-aleurite sediments. The thickness of NKCS is 120-150 meter and depth interval is 2800-3550 meter.

Pereriva Suite (PS) is the most productive horizon of the Shallow Water Gunashli field. PS consists of coarse and medium grained sand-aleurite sediments with thinly layered clays. The cross-section of PS has a high apparent resistivity (up to 50 ohmmeters) and well differentiated collectors. The thickness of this suite is 110-150 meter (361-492 ft.) and it is located at the depth of 2700-3550 meter (8858-11647 ft.).

Balakhani Productive Series (BPS) has the sequence of sand-aleurite and clay rocks. In the cross-section of BPS V, VI, VII, VIII, IX and X horizons separate with the clay layers. Net to Gross (for the sand) is gradually increase toward the bottom part of the cross-section and equal to 50 percentages. The Diagram of logs indicates that the X-horizon is most productive and reservoir capability is higher than other horizons. The apparent resistivity reaches to 20 ohmmeters and more, spontaneous potential curve indicates normal differentiation. X-horizon is one of the most productive objectives as Pereriva Suite: its thickness is 60-80 meter (197-263 ft.), and the depth is 2000-3050 meter (6562-10007 ft). İn general BPS thickness is 610-750 m. (2001-2461 ft).

IX horizon of Balakhani Productive Series is also in industrial development: its thickness is 100-130m, N/G for sand gradually increases towards the bottom of the cross section. VIII, VII, VI and V horizons located above IX horizon and have different thicknesses, changes between 70-140 meter and has oil reservoirs according to geophysical data and tests in cross section.

Sabunchu Productive Series (SaPS) - consists of sand and clay rocks, cross sections include II, III and IV sand horizons, which are isolated with shale. The thickness of the formation is 320-440m and thickness of the layers is changed between 50 and 70 m.

Surakhani Productive Series (SuPS) - thickness is 950-150 m. Cross section consists of I, I1, DE and C horizons. Mainly contains clays with low thickness sand-aleurite layers.

Aghjagil layer (upper Paleocene) contains fine-grained sand and gray clays with volcanic ash, thickness is 65-110 m.

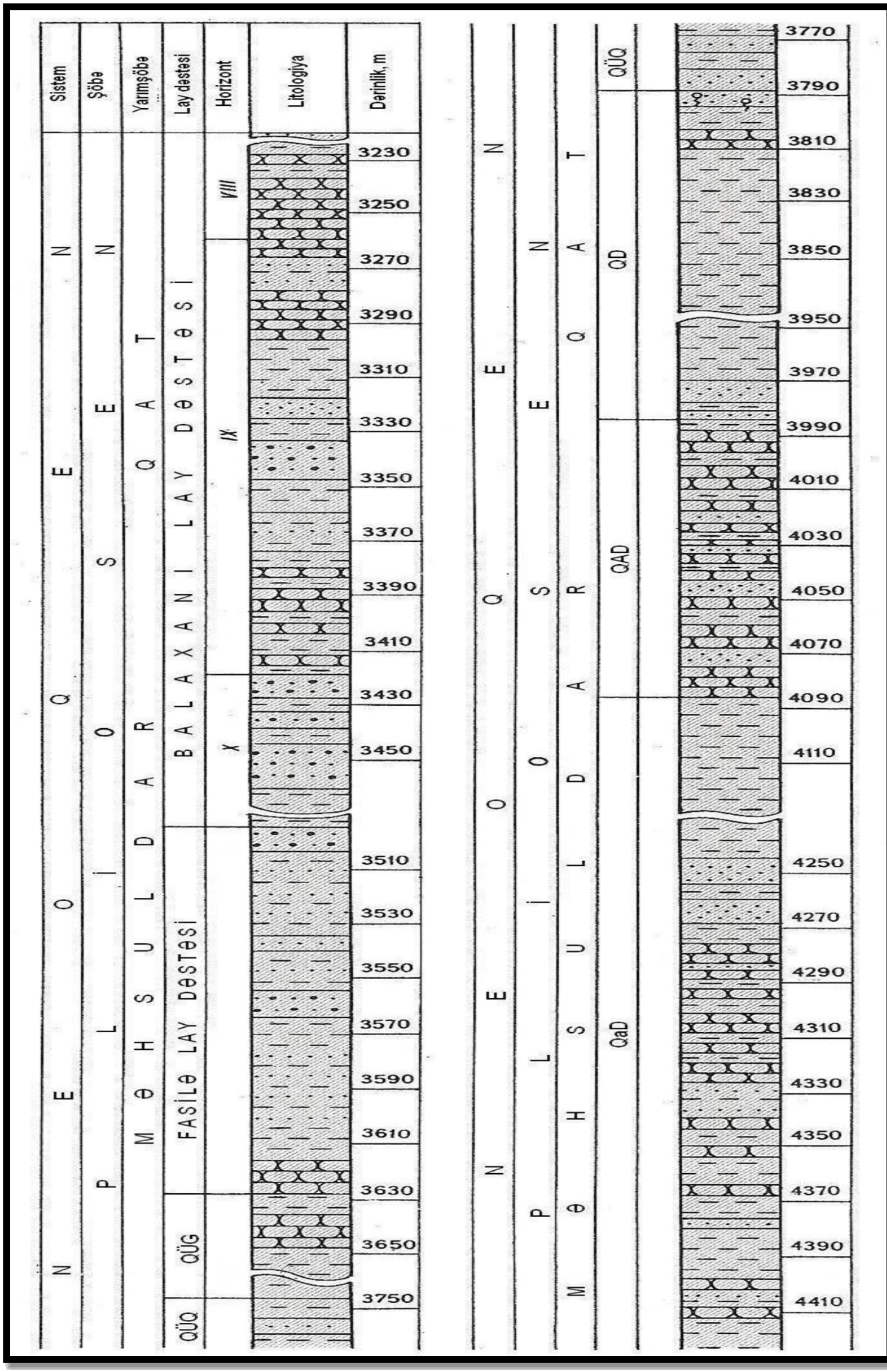

Figure 1.2.1 Stratigraphic Cross-Section of Gunashli field

Absheron layer has 250-320 meter thickness, consists of dark gray clays with sands.

Old Caspian sediments are represented with Baku layer, consists of dark gray clays. Fine-grained sand layers are met in class. Thickness is 60m.

Modern sediments contain shale seashell; rough-grained sand is met in some places.

Therefore, productive horizons and layers of Gunashli have been completely enclosed and studied by several exploration wells.

1.3 Lithology and reservoir propertiesof formation rocks

As we mentioned VII, VIII, IX, X, PS, NKCS, NKSS, PKS are productive horizons in Gunashli field. The thickness of these horizons are: VII-70/140 m,VIII-80/130 m, IX-100/130 m, X50/110 m, PS-105/150 m, NKCS-120/150 m, PKS-40/75 m,PKS-55-100m.

Rich hydrocarbon intervals of productive zones were studied with the data of well test and oil water and gas contours during result of complex geophysical researches. Average and effective thickness of productive horizons is given below:

Table 1.3.1Average and effective thickness of horizons

Horizons	Average thickness, m	Effective thickness, m
VII	104	27
VIII	106	22
IX	114	17
X	86	32
PS	129	73
NKCS	136	12
NKSS	56	28
PKS	78	32

Studying reservoir properties of productive zones is vital for effective calculation of oil and gas reserve calculation and development processes. Reservoir properties are determined from laboratory analysis of rock samples and geophysical research data of wells.(2)

Reservoir properties of productive zones Gunashli field were mainly investigated with result of analysis rock samples during drilling exploration wells. (Well No.1, 3, 4, 5, 6, 11, 14, 15, 16, 18, 21, 26).

Investigated rock samples was taken from 1700-3555 meter depth.

1200 analysis based on more than 285 samples were used to study reservoir properties of productive zones (porosity, permeability, carbonate concentration, shale concentration).

Rock samples from taken from well No.69 are from 3505-3605-meter interval; 31 samples were analysed from given interval. Porosity varies between 7.7-20.1%. Average porosity of formation not taken into account three clay samples (7.9-9.4 %) is 16.35 %. This number equals to 12.89 % in well No.80.

As it was mentioned before, rock samples were taken from newly drilled 3 wells (56, 69 and 80) since 2005 report. Rock sample was taken from 3965-3995 m in well 56, from 3500-3060 m from well 69, 3560-3585 m from well 80 and they all relates to KaS-2.(3)

Wells 56, 69, 80 situates in IX, X and IX horizons respectively.

According to log data inKaS cross section has 8-9 (number 56) and 10-12 (number 69 and 80) Ohmmeter. Spontaneous potential curves have good data with exception of well 56. Tests were conducted in KaS-2 well number 69 and 80 and formation water was collected from intervals 3596-3499 and 3596-3564 m. According to boundary of reservoir they were divided into productive and non-productive zones. Productive zone has porosity of 7.5-19.8 %, permeability of 0.24-331.09 mD. As it can be seen, Apparent Resistivity (AR) of KaS-2 productive zone changes between 8-12 Ohmmeter and probably, it is limited to boundary points.

Interconnected water in pores of productive zones were used to find hydrocarbon saturation.

Hydrocarbon saturationwas calculated after determining connected water in the pores. (Table1.3.2)

$$\mathbf{S_{hc} = 1 - S_w}$$

Table 1.3.2 Hydrocarbon saturation for the horizons

Horizons	İnterval hydrocarbon saturation
V	0,62-0,77
VI	0,61-0,71
VII	0,63-0,79
VIII	0,66-0,91
IX	0,68-0,78
X	0,66-0,91
PS	0,63-0,87
NKSS	0,65-0,77
PKS	0,63-0,79
KaS	0,63-0,76

Taking account boundary of reservoir of the rock samples taken during drilling they were divided into productive and non-productive zones. Boundary of parameters needs to be determined. It is obvious that, a single boundary value cannot be determined for all productive horizons because of difference in lithology-reservoirs parameters of rocks. As a result, 220rocksamples were added into productive, 80 rock samples were added into non-productive zones. Change interval of reservoir properties and average valueswere calculated according to PZ s and formation.

Taken account the difference in formation and lithology of horizons in cross section of PZ, they were divided in4 groups and condition value was applied for each rock group.

To find reservoir boundary values distribution curves were constructed for each rock group and relationship between them were studied.

Limit value of permeability is 0.001 mkm^2, diagrams have been madedependence of porosity and permeability with carbonate and shale coefficient, using all of this, was identified limit values of permeability, porosity, carbonate and shale coefficients. (table 1.3.3)

Table 1.3.3Limit values of reservoir parameters

Productive Series	Permeability,mkm^2 >	Porosity,% >	Carbonate,% <	Shale,% <
SuPS and SaPS	0,0012	11.2	20.9	44.7
BPS and PS	0,0013	9.1	23.2	41.9
NKCS, KS and KaS	0,0011	9.9	18.8	40.4
NKSS və PKS	0,0012	8.3	19.3	42.2

1.4 Tectonics

Gunashli field is located in anticlines zone of Absheron-Balakhani in the east of NeftDashlari. The zone where is east of Gunashli field joined to Chirag field is followed with mud volcanoes and disconformities

Schematic structure maps were established according to results of seismic works (until 1980) in Gunashli area. In 1983 according to the works of interpretation of seismic materials carried out new schematic structure maps were established.

In 1985, according to the carried-out exploration works by DEM and UDNM(1981-1984) and data of 30 wells drilled to 01.01.1985 seven structure maps (VI, IX, PS, NKSS,PKS və KaS) were established by Scientific –Research and Project Institute "Gipromorneftegaz"and "KHazarneftgazgeofizkashfiyyat" departments involving with calculation of oil and gas reserves of Gunashli field.

In 1992, due to calculating the reserves for the second time 8 accurated structure map of productive series (VI, IX, PS, NKSS,PKS, və KaS) were made and these were the main parts of calculation plans. These maps were established according to both seismic exploration data and well data of 163 number well.(1)

In 1998, due to calculating the oil gas reserves for the third time, using all geophysical information including 202 well materials detailed 8 structure maps and 5 geological profiles (4 lateral, 1 vertical) established due to VI, IX, PS, NKSS,PKS, və KaS antclines. Calculation of field reserves were carried out according to the indicated geological point of view.(3)

During calculating field reserves for the fourth time after drilling 40 additional wells 12 profiles and 8 structure maps (for top of I, V, VII, IX, PS, NKSS, PKS, KaS horizons and layers) were established. The establishment of profiles and maps were referred to both 242 well information and seismic materials.

Structure maps were detailed according the top of PKS layer. Beside of the structure maps indicated in report, profile was made covering 249, 312,427, and 97, 99,276, 280 numbered wells.(3)

Structure maps given in 2005's reports and presented involving new well data show there is not significant difference in tectonic structure. However, disconformities in VIII and IX blocks of structure can be shown by the following two directions.

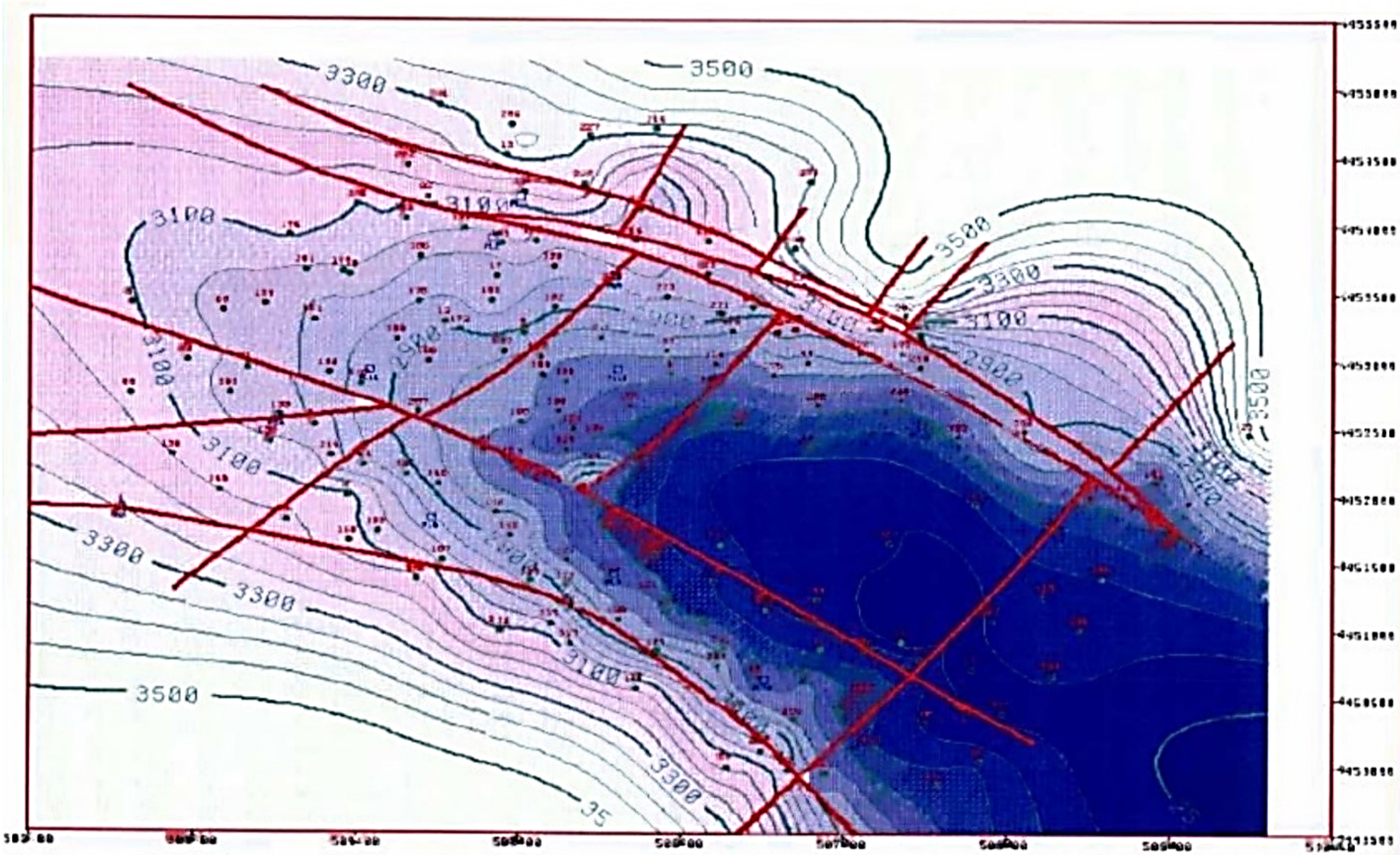

Figure1.4.1 Structural map of PS, Gunashli field

The unconformity which is inside of the VIII block divides it to $VIII_a$, $VIII_b$ və $VIII_s$ parts and continues until the VIII block. It pinches out in the direction to the bottom.

As the unconformity N1 is not lateral, it causes the expansion of the area VI block.

The tectonically structure of the Gunashli field is basically clarified with the structure map of PS.

The dimensions of the field are 12x4.5 km. It lays in the North West – South East direction. It is an asymmetric anticlinal trap. North-East part of the anticline is a little steep ($30\text{-}35^0$), and the South-West part is inclined ($20\text{-}25^0$). North-West percaline is a little wide bends towards Neft Dashlari ($10\text{-}12^o$), South East periclinal is not so wide, and it is separated from Chirag fold. Saddle measure of the fold was relatively increased approximately 450-500 meter than Neft Dashlari (Figure 1.4.1).

Gunashli fold is divided into 18 compartments by 10 laterals (5, 6, 7, 8, 9, 10, 11, 12, 13, 14) and 4 (1, 2, 3 and 4) vertical faults. Vertical faults divided the structure into 3 areas:

North section– this part is divided into 7 (I, II, III, IV, V, VI, VI_a) compartments by unconformities N^o 5, 6, 7 and 8.

Central section– this part is also divided into 4 (VII, VIII, IX və X) compartments by unconformities 9, 10, 11.

South section – this area is divided into 7 (XI, XI_a, XII, XIII, XIV_a, XIV and XV) compartments by unconformities N^0 12, 13, 14.

1.5 Oil, water and gas bearing zones of SWG

The distribution of the hydrocarbon and water in the layers of the Productive Zone is given from the bottom to the top.

Kalin Suite (KaS) is divided 3 parts: KaS-1, KaS-2, KaS-3. The total thickness changes between 233 and 324 m.

In the wells N^0 1, 3, 5, 11, 15 and etc. the entire layer has been drilled, however, wells N^0 24, 81, 83, 84, 93 only 40-140 m of the formation has been drilled. The sandiness of the layer increases towards the bottom.

There are sand layers at bottom of the KaS-3 formation. The thickness of the sands is about 60-140 m. In the shown direction, the resistance of the reservoir increases. The formation contains free gas. This information has been proved by the data ofwell No.5 and 11.

KaS-2 and KaS-1 mainly consist of clays, and but productive layers being is assumed based on log data of Well No.5, 11, 15, 18, 23, 28 at the lower part of Cross-section KaS-2. KaS-1 contains mainly clay layers, and this layer is not important.

Thickness of Pod-Kyrmaky Suite (PKS) varies between 55 - 100 meter. 49 wells have been drilled to PKS. 30 of them is gas condensate well, but one of them oil well (130ton /day).

Thus, hydrocarbon distribution of PKS is observed by the following regularity: Oil, gas condensate with oil content and gas condensate deposits have been found subsequently at North flank, central area and south flank of structure. Water produced from 4 wells (Well No. 11, 21, 275, 242) at marginal part of PKS.

Thickness of Nad-Kyrmaky Sandy Suite (NKSS) is varies between 40-75 meter. Large amount condensate produced from this suite.

69 wells were drilled toNad-KyrmakyClay Suite(NKCS), but 37 well is developed. In result, 16 of its areoil, 20 of its are gas condensate wells. Only from one

well (No.21) produced formation water. North flank of NKSS contains oil, central (VII block) and south (XIII and XIV block) area deposits gas condensate with oil content. VIII, IX and X blocks have gas condensate deposits.

Thickness of Pereriva Suite (PS) is varies between 105-150 meter. PS is most productive suite of Gunashli Field. 72.4% of initial recoverable oil reserves were produced. Operating wells is observed with high production rate (max. 500 tons per day).

X horizon is most productive horizon of Balakhani Productive Series (BPS).Thickness of X horizon varies between 3-5 meter. Net to Gross (N/G) for sand rise up 65%.

IX horizon has large contour like as X horizon and PS. 61 wells were drilled to this horizon. 23.2 % reserves were produced.

VIII horizon is test with well No.26. During testing noted high resistivity. Resistivity was 5.4 ohmmeter. There are some oil bearing layers in this horizon which is observed 20 ohmmeter resistivity. Daily oil production of VIII horizon wells was between 50-80 tons.

VII horizon is oil bearing horizon, upper part of cross section of VII horizon located VI, V, IV horizons which is contained gas condensate deposits.

Thus, the following industrial important and having rich oil and gas condensate horizons is detected based on well data in Gunashli field.

- Oil-bearing horizons (VII, VIII, IX, X, PS, NKCS),
- Gas condensate bearing horizons (IV, V, VI, KaS-3)
- Gas condensate bearing horizonswith oil content (NKSS, PKS).

Except following oil and gas condensate horizons, based on geophysical data of wells SuPS (C, D, and I^1) and SPS (II and III horizons) contain C_2 categoryhydrocarbon deposits.

1.6 Field development stages of SWG

It is known that the development process of the oil fields consists of the following stages:

1. Build-up
2. Plateau
3. Decline
4. Abandonment

The first stage (Build-up stage)of the field development is characterized by the drilling new wells which are includes main well stock. Exactly, significant industrial oil production was in this stage. In this period of development field operated with natural mechanisms.

The second stage (plateau stage) covers the years of oil production stability. And this phase is distinguished by falling production 10% of the maximum production rate. During this period, drilled the reserve well stock and various methods and measures are being taken to improve oil recovery in the field.

The third stage (decline stage)is characterized by a decreasing oil production.End of this phase is determined with 2% of the production rate. Wells is operated with artificial lift mechanisms. In this stage water flooding occur and some of wells is removed from production well stock.

The fourth stage (abandonment stage) is characterized by the production rate which less than 2%. At this stage, all possible measures is being used to prevent the decline of production rate.

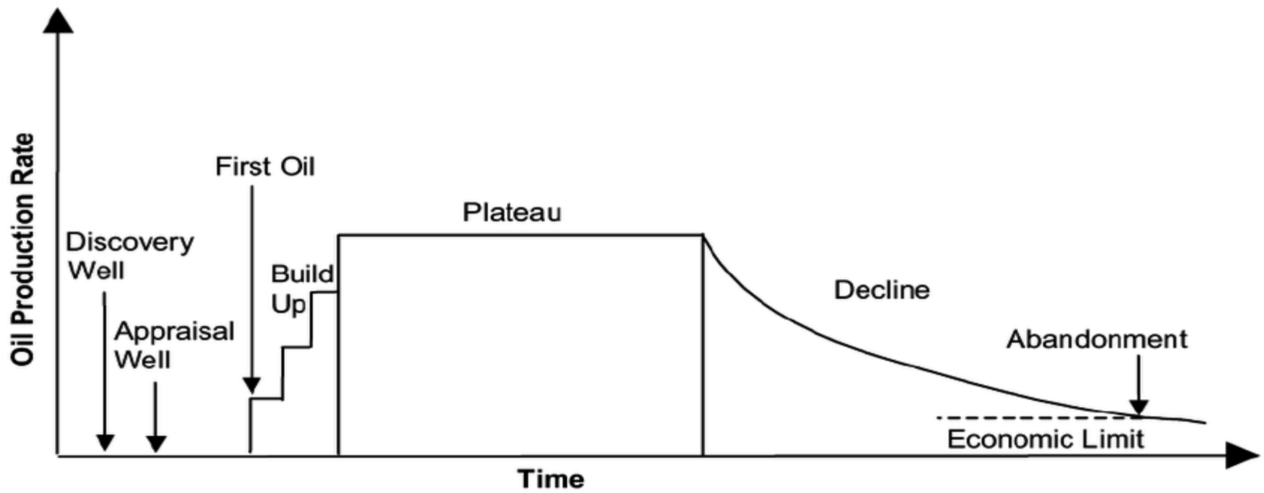

Figure 1.6.1 Theoretical production profile of an oil field, describing various stages of development in an idealized case. (4)

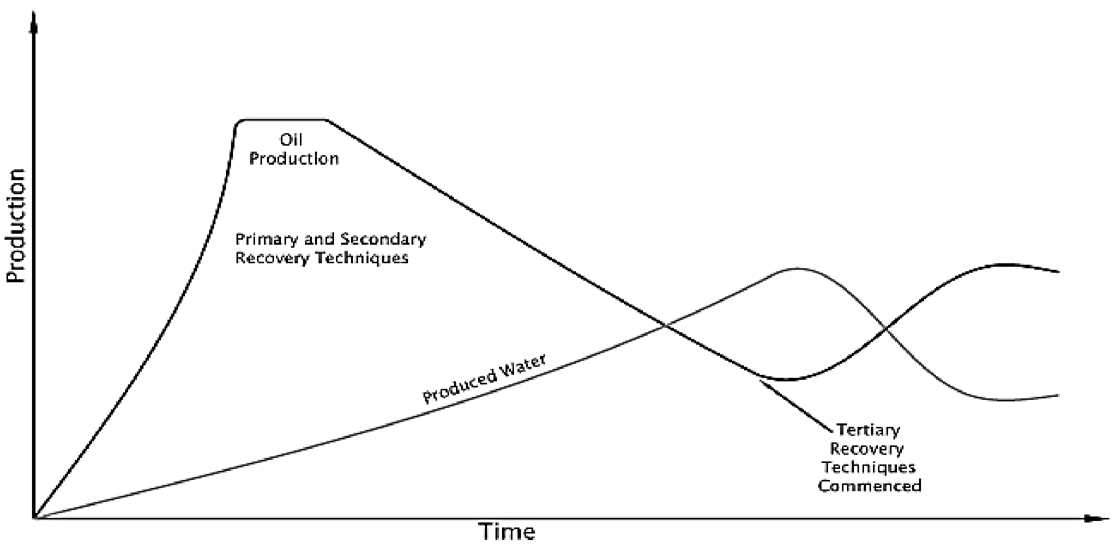

Figure 1.6.2. Typical oil reservoir recovery with secondary and tertiary enhanced recovery techniques(5)

The fifth stage of development was proposed by the professorB.A. Baghırov. The results of his extensive research show that, after the last stage of field development adding next stage is advisable. During the abandonment phase of field development production rate may be rise up more than 2% due to application of additional processes. And we called this period fifth stage. (Figure1.6.2 and 1.6.3)(6)

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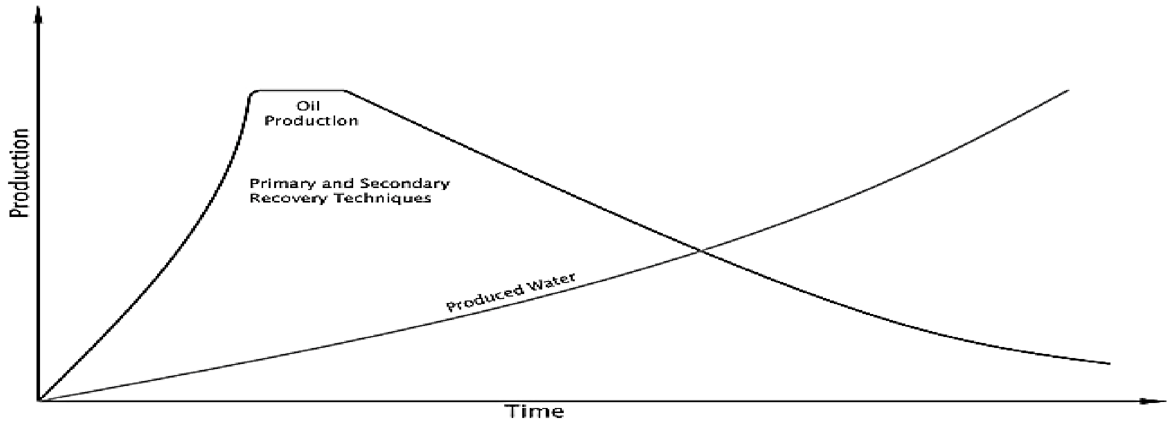

Figure 1.6.3. Typical reservoir performance profile

There are 18 oil and gas bearing horizons and production series at cross-section of Gunashli field. It has been identified from the drilling and geophysical surveys data. All of oil and gas-condensate layers were related formation and tectonically shielded type of facilities. And the Oil-Water contact (gas-water contact) has different absolute depths within the blocks

Productive oil-bearing layers is determined at the geological cross-section of the field. And this oil-bearing layers are divided the following horizons for the cost-effective field development:

- Oil-bearing horizons (VII, VIII, IX, X, PS, NKCS),
- Gas condensate bearing horizons (IV, V, VI, KaS-3)
- Gas condensate bearing horizons with oil content (NKSS, PKS) is horizons

The discovery of the Gunashli field in 1979 was related to the development of exploratory well No. 4. This well was drilled to X horizon of Balakhani Productive Series and perforation interval depth was between 3455-3423 meter.Duringwell testing identified that, production rate was 230 tons per day. Then, as a result of the testing at the exploratory well No.6 produced 320 tons per day in November of 1980.

Table 1.6.1 Dynamics of Field Development, Gunashli Field

Years	*The number of wells*	*Oil production, thousand tons*	*Gas production, mmscm*	*Natural gas, mmscm*	*Water production, thousand tons*	*Water injection, mscm*	Average oil production per well, tons	Development rate
1980	*2*	74	11,5				100,9	0,03
1981	2	220	33,9				301,0	0,10
1982	3	240,4	37,8				219,4	0,11
1983	8	782,7	88,1				268,1	0,37
1984	15	1622,2	182,2				295,5	0,77
1985	27	3105,3	372,0		0,5	0,0	315,1	1,47
1986	42	4035,7	571,7		38	55	291,0	1,91
1987	66	5031,6	795,1		141	173	233,6	2,38
1988	92	5792,3	1411,2		341	1146	205,5	2,74
1989	120	5933,2	1639,2		196	1863	180,6	2,81
1990	125	6560,7	1764,4		177	1078	168,0	3,10
1991	139	6699,8	1742,4		271	1115	161,0	3,17
1992	142	6578,8	1674,3		338	1447	160,5	3,11
1993	141	6190,3	1771,3		527	1474,9	137,9	2,93
1994	153	5807,1	1678,8		328	1471,0	123,3	2,75
1995	164	5732,8	1572,4		327	1494,7	117,2	2,71
1996	157	5838,3	1691,8	110,9	400	1460,8	117,3	2,76
1997	164	58210,3	1647,3	269,1	352	1440,4	113,9	2,75

Continued Table 1.6.2

Years	*The number of wells*	*Oil production, tons*	*Gas production, mmscm*	*Natural gas, mmscm*	*Water production, thousand tons*	*Water injection, mscm*	Average oil production per well, tons	Development rate
1998	162	5884,3	1536,2	270,8	367	1446,5	114,3	2,78
1999	172	5893,1	1548,1	240,0	353	1469,1	113	2,79
2000	174	5937,7	1551,3	307,1	515	1401,4	110	2,81
2001	181	5853,4	1552,3	384,9	566	1314,9	108	2,77
2002	185	5784,2	1865,0	446,1	597	1255,8	98,37	2,74
2003	192	5690,2	2030,7	511,3	835	1076,3	94,52	2,69
2004	193	5546,6	1967,4	666,9	862	696,3	89,72	2,62
2005	198	5464,5	1910,0	795,5	967	1227,1	87,71	2,58
2006	200	5261,8	1835,9	1359,8	966	851,2	90,3	2,49
2007	209	4990,4	1909,9	2880,8	916	536,9	89,5	2,36
2008	215	4886,2	1897,6	4704,1	915	908,6	83,5	2,31
2009	218	4842,3	1444,6	4552,1	960	1080,2	80,5	2,29
2010	230	4782,4	1421,0	4906,6	985	1528,4	82	2,26
2011	240	4634,8	1177,3	5163,0	1003	2248,8	76,6	2,19
2012	250	4669,2	1104,2	4949,9	1065	2770,0	75	2,21
2013	261	4633,5	1054,4	4732,7	1250	2812,8	71	2,19
2014	267	4618,5	1077,4	4326	1340	2769,3	70	2,18
2015	266	4525	1096	4282	1500	1955	68	2,14

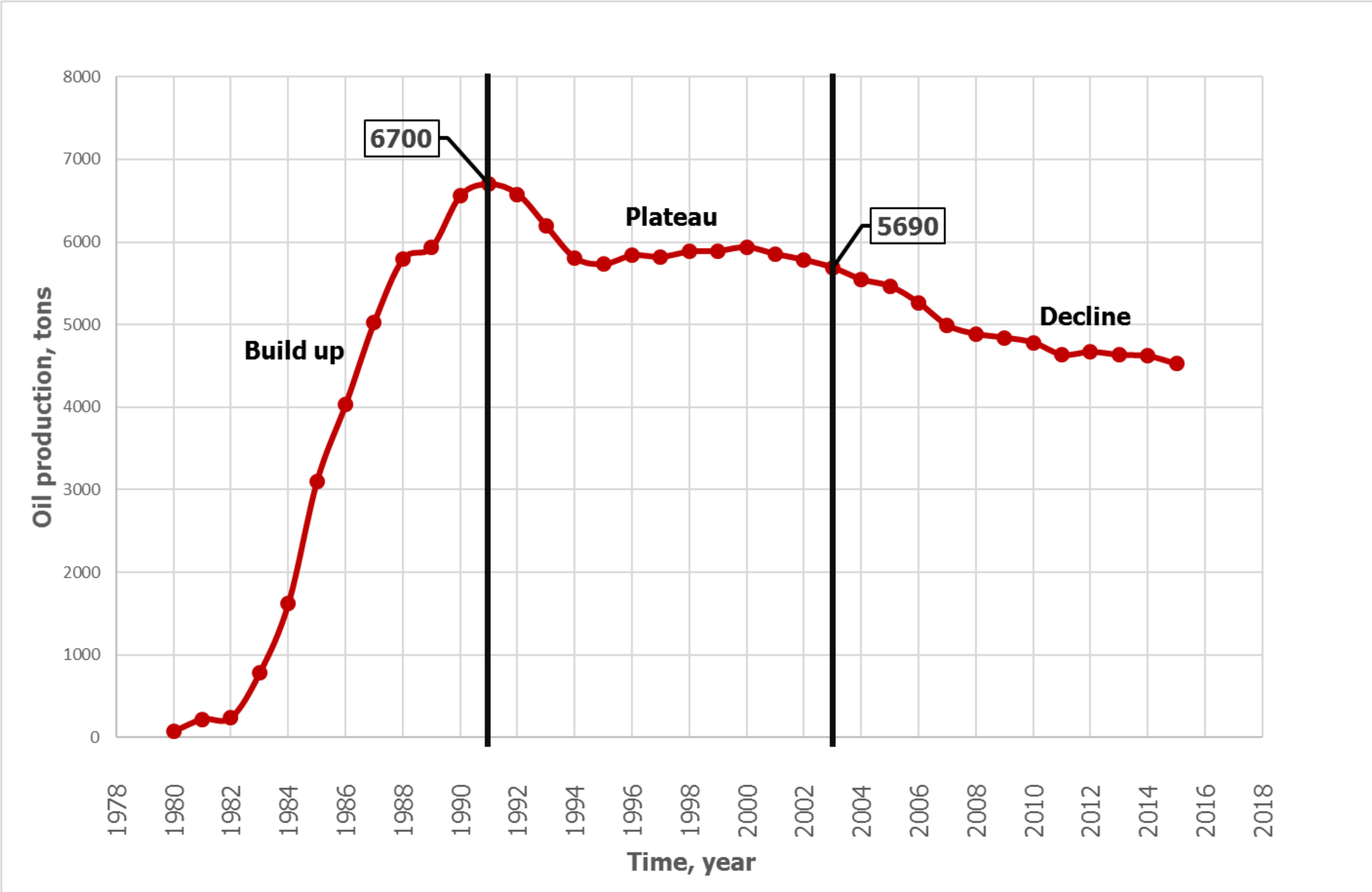

Figure 1.6.4.Dependence annual oil production on time

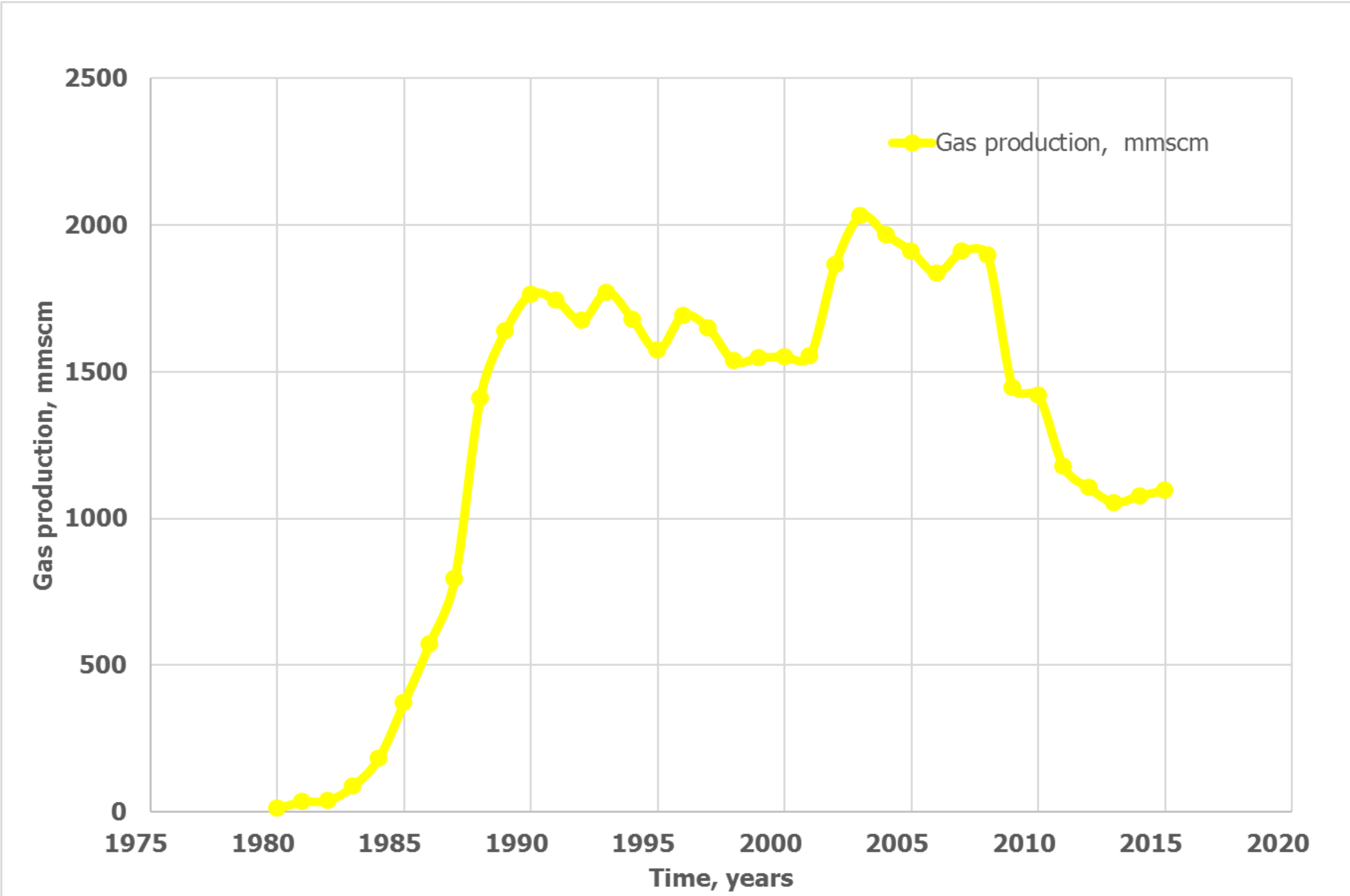

Figure 1.6.5. Dependence gas production on time

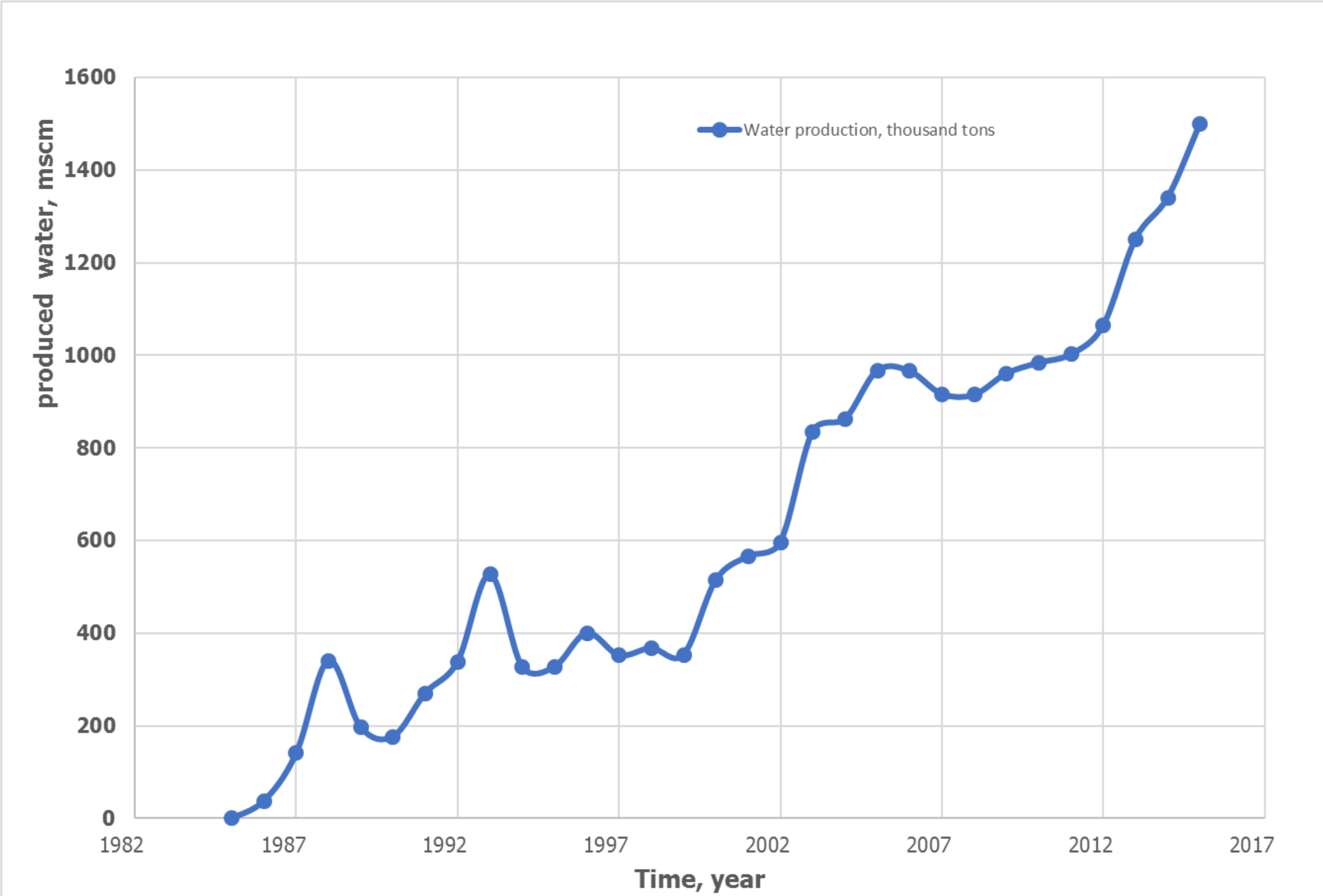

Figure 1.6.6.Dependence water production on time

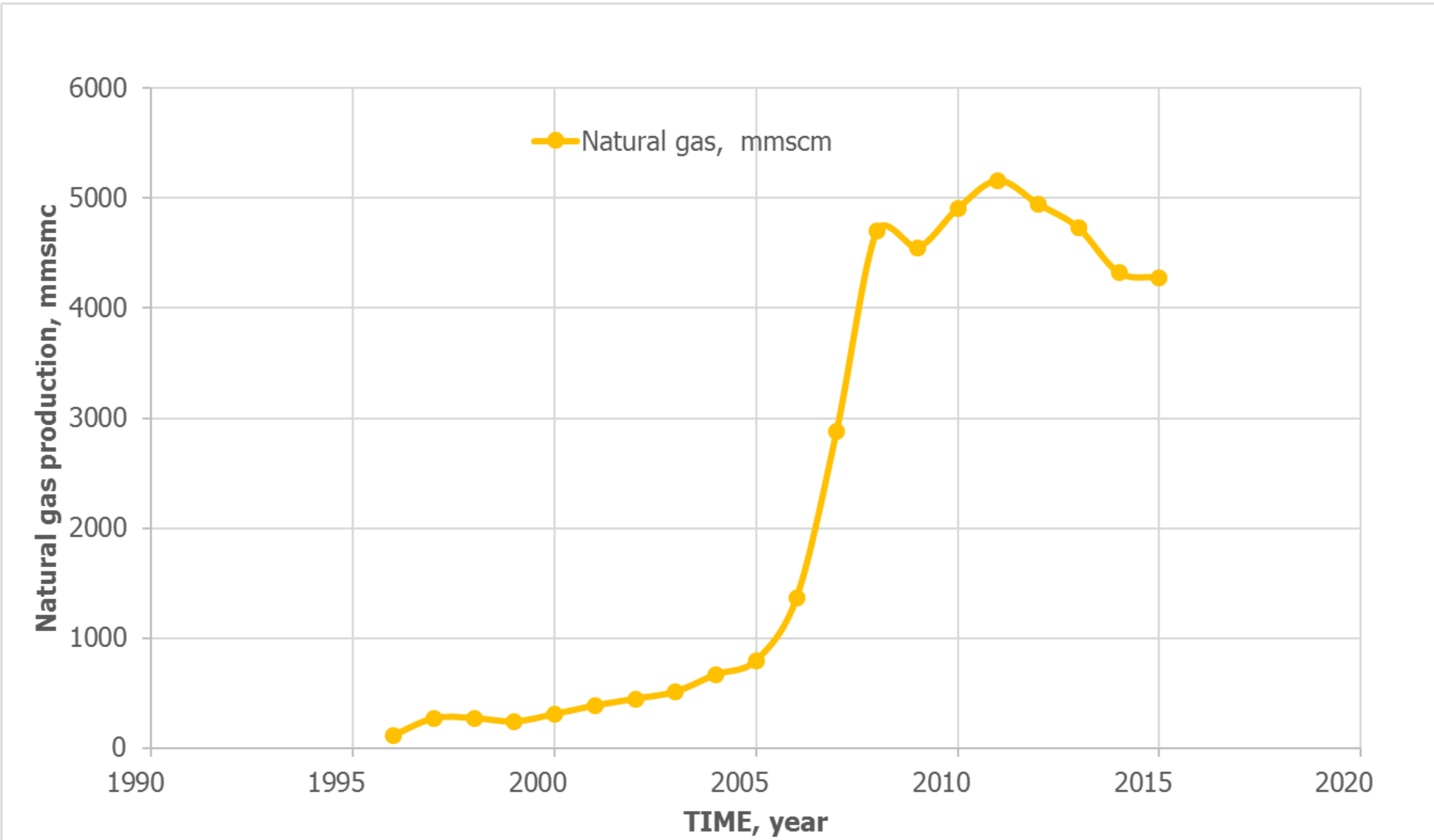

Figure 1.6.7.Dependence natural gas rate on time

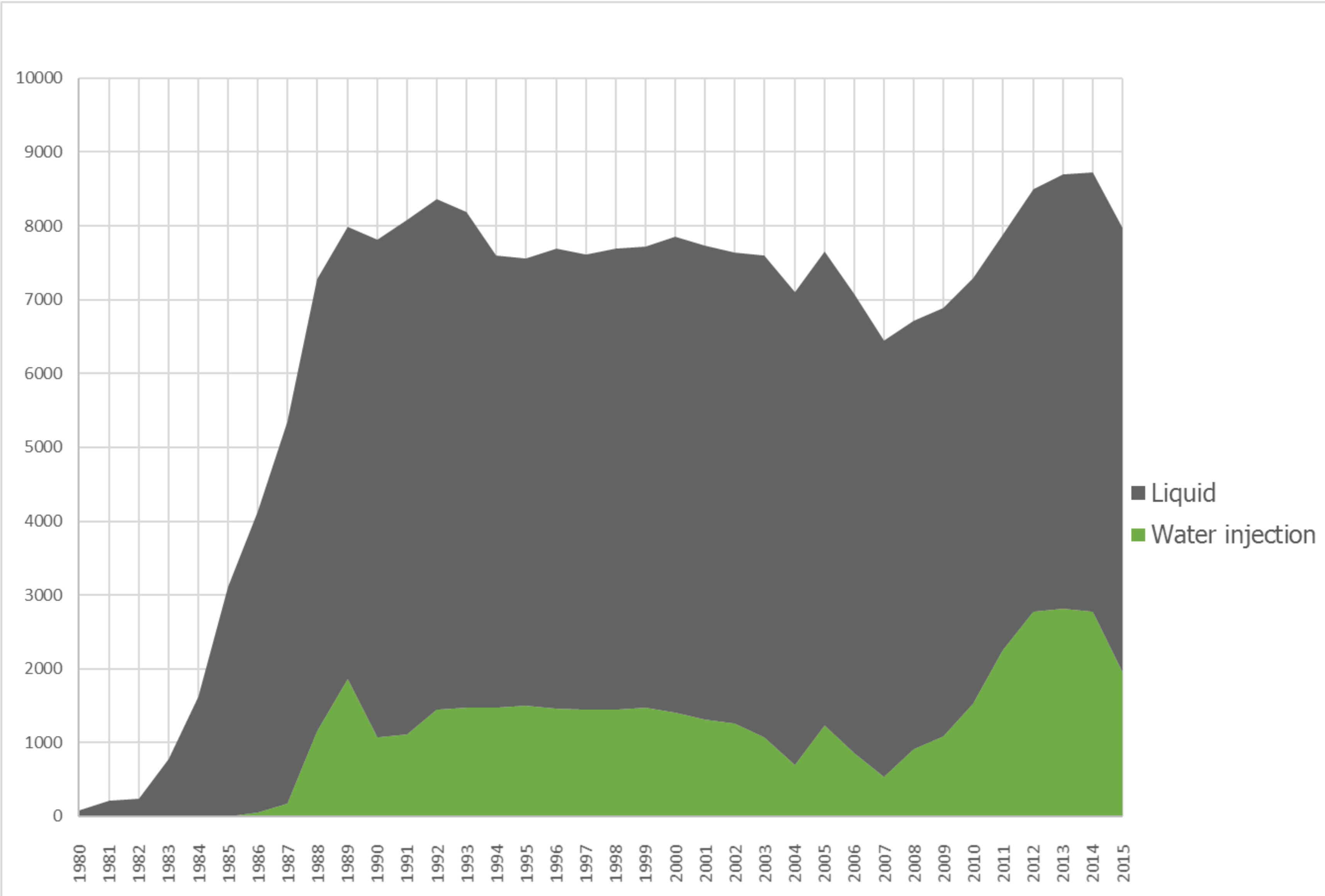

Figure 1.6.8Annually produced liquid and injected water over development period

Field development of Gunashli is started since 1980, and continued till current date. Although the field is under development for 36 years, removable residual oil reserves have been found at the different large exploitation facilities.

At present, residual oil deposits are concentrated for the facilities in the lower and upper sections of productive layer sediments. Large-scale geological and physical data collected, researched and systematized for analyzing field development of 9 operating facilities during the exploitation period. This information is collected on each individual operating facilities and on the bed was systematized in the form of tables. This information is collected on each individual operating facilities are systematized in the form of tables.(7)(6)

Table 1.6.2 Field development stages of Gunashli

Phases	Period	Characteristic of phases
I	1980-1991	Build-up
II	1991-2003	Plateau
III	2003-c/date	Decline

CHAPTER II. GEOLOGICAL CHARACTERISTICS AND OIL AND GAS BEARING OF THE PERERIVA SUITE

PS development started in 1980. In the first-time installation of production platformswere carried out comparatively shallow water area. In that area sea depth was 80-150meter.And the installation of production platformstakes a long time. Therefore, drilling of production wells havetaken more down-tempo, mainly in the north-east and south-western areas of the fold. The number of the completed drilling wells was around4 or 5 wells per year at the build-up period of development. Oil production rateof this wellswas in the range 350 - 450 tons per day. Gradually, oil and gas production of PSwas intensified. The annual oil production rate and initial recoverable reserve of PS increased up to 5-7%.

Since the beginning of development 120mlntons of oil, 130 mln tons of liquid, 30000mmscm of dissolved gas was produced from PS. In 2015, annual oil and liquid production ratewassubsequently 3130 and 3900 thousand tons. And annual dissolved gas production was 530mmscm. The average daily production of the well was 92.7 tons'oil, 115.3 tons' liquid. Flooding coefficientwas 18.6%. Annual production of the wells has decreased more than 50%. Average current gas factor was respectively 190 scm per ton.

155 production and 19 water injection wells were drilled at PS.Production wells contain 148 oil and 7 gas-condensate wells. Producing well stockincludes 84 wells, respectively 76wellsinclude operating well stock, 8 wellsinclude non-operatingwell stock, 2 wells expected liquidationuntil 01.01.2016.12 of operating wellsis flowing well and 64 of its are operated with the gas lift method. There are 7wells at water injection well stock of Pereriva Suite, 3 of these wells are in operating well stock and 4 wells are in the non-operating well stock. 4 wells of producing well stock and 3 wells of injection well stock have been eliminated from the well stock due to certain geological and technical reasons.170 wells took placeduring the operating of PS. (Figure 2.1.0)

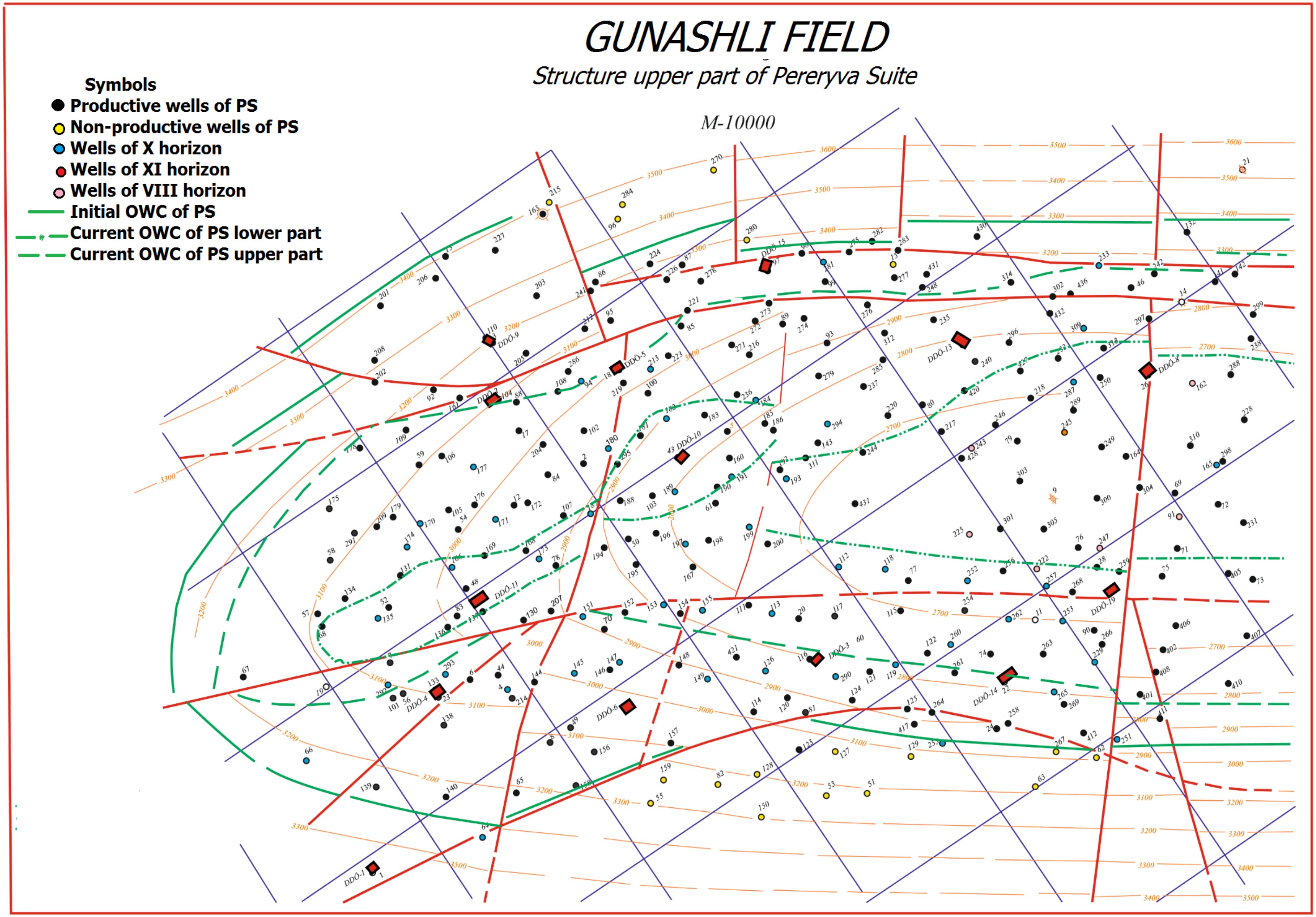

Figure 2.1.0. Development map of Gunashli field

From beginning of field development 169960 thousand tons of oil, 189357 thousand tons of liquid, 46664 MMSCM dissolved gas, 45659 MMSCM natural gas, 3691 thousand tons of condensate produced from the field (Figure 1.6.4, 1.6.5, 1.6.6, 1.6.7, 1.6.8, 1.6.9, 16.10, 1.6.11,). Cumulative production for the year are listed below. (Table 1.6.1).

2.1 Oil-bearing zone and productivethickness of PS

For the previous report about Pereriva Suite 45 wells was drilled over the last six years. Majority of these wells located inner initial oil-bearing contour at IX block and at X block. (Figure 2.1.1). For this reason, Oil-Water Contact (OWC) remains invariable inside the blocks. But after development well No.87 from II block produced oil. And this provides to change category of reserves from C_2 to C_1.

Water produced from well No.13 at I tectonic block of Pereriva Suite. Although, it is assumed that the oil-bearing layer. Considering this OWChave been accepted at 3349-meter absolute depth based on data of well No.203 and well No 208. (3) (8)

OWC is determined at 3492-meter depth for the II tectonic block based on data of well No.86, 87 and 270.

Oil produced from well No.282 at III tectonic block. Considering this info and data of well No.280 OWChave been accepted at 3445-meter depth.

Contour of C_1 category reserves was defined at 3378-meter depth for the IV tectonic block based on data of the wells No.430 and 233.

OWC have been adopted at 3320-meter depth, inside VI_atectonic block, based on data of the well No.202.

OWCwas calculated for VII tectonic block, but wells were not drilled in this direction of layer. The wells (No.134, 175, 291 and etc.), which is located near the oil-bearing contour, were put into operation since 1985 andlong-time (10-12 years) produced oil from this wells with fountain. At this wells did not happen water flooding for long time. It shows that, OWC away from this wells location and this case again confirm that, calculated OWC depth is right. OWC have been accepting for Neft Dashlari and Gunashli field in the middle of structure saddle.

Oil-bearing layers were surrounded with tectonic unconformity at VI, VIII, IX, X, XII, XIII blocks. And contour of oil-bearing layers has been accepted for this tectonic unconformities. (2)

OWC of XI tectonic block have been adopted from data of well No.66 at the 3288-meter depth.

OWC of XI_a tectonic block is defined exactly. So that, OWCis easily identified from the logging data of wells No.139 and 140, which is located at OWC area.

Depth of OWCat XV tectonic block has been accepted 3280 meter, from previous calculation.

At the XIV tectonic block depth of B category reserves contour maybe accepted approximately 2975 meter based on geophysical data of well No.411. ButOWC of XIV tectonic block was not defined exactly.

Thus, area of hydrocarbon deposits is calculated for each horizons and layers with the integrating instrument from the map and during calculation map scale is considered. Results given in the table 2.1.1

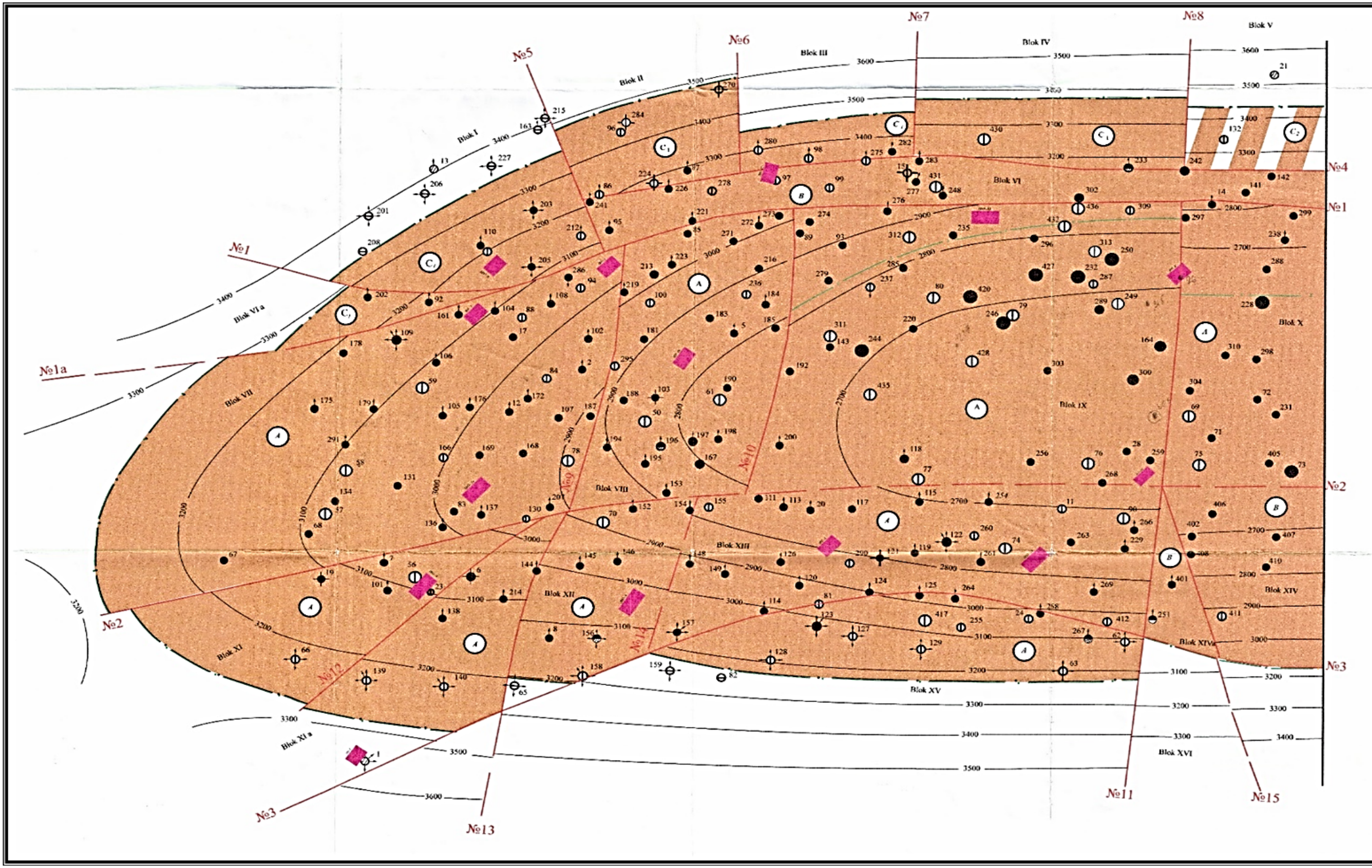

Figure 2.1.1. Reservoir estimation of PS for the categories.

Table 2.1.1Oil-bearing area and effective thickness of PS tectonic blocks

Horizon	Block	Category	Oil-bearing area, thousandscm	Effective thickness, M
PERERIVA SUITE	I	C_1	900	67
	II	C_1	600	63
	III	C_1	320	23
	IV	C_1	740	41
	V	C_2	350	25
	VI	B	1254	67
	VIa	C_1	220	50
	VII	A	4530	74
	VIII	A	1970	77
	IX	A	4600	78
	X	A	1750	83
	XI+XIa	A	2130	61
	XII	A	940	72
	XIII+XV	A	3810	75
	XIII+XIa	B	1200	71
Sum		A	19730	75
		B	2454	69
		C1	2780	53
		$A+B+C_1$	24964	72
		C_2	350	25
		$A+B+C_1+C_2$	25314	71

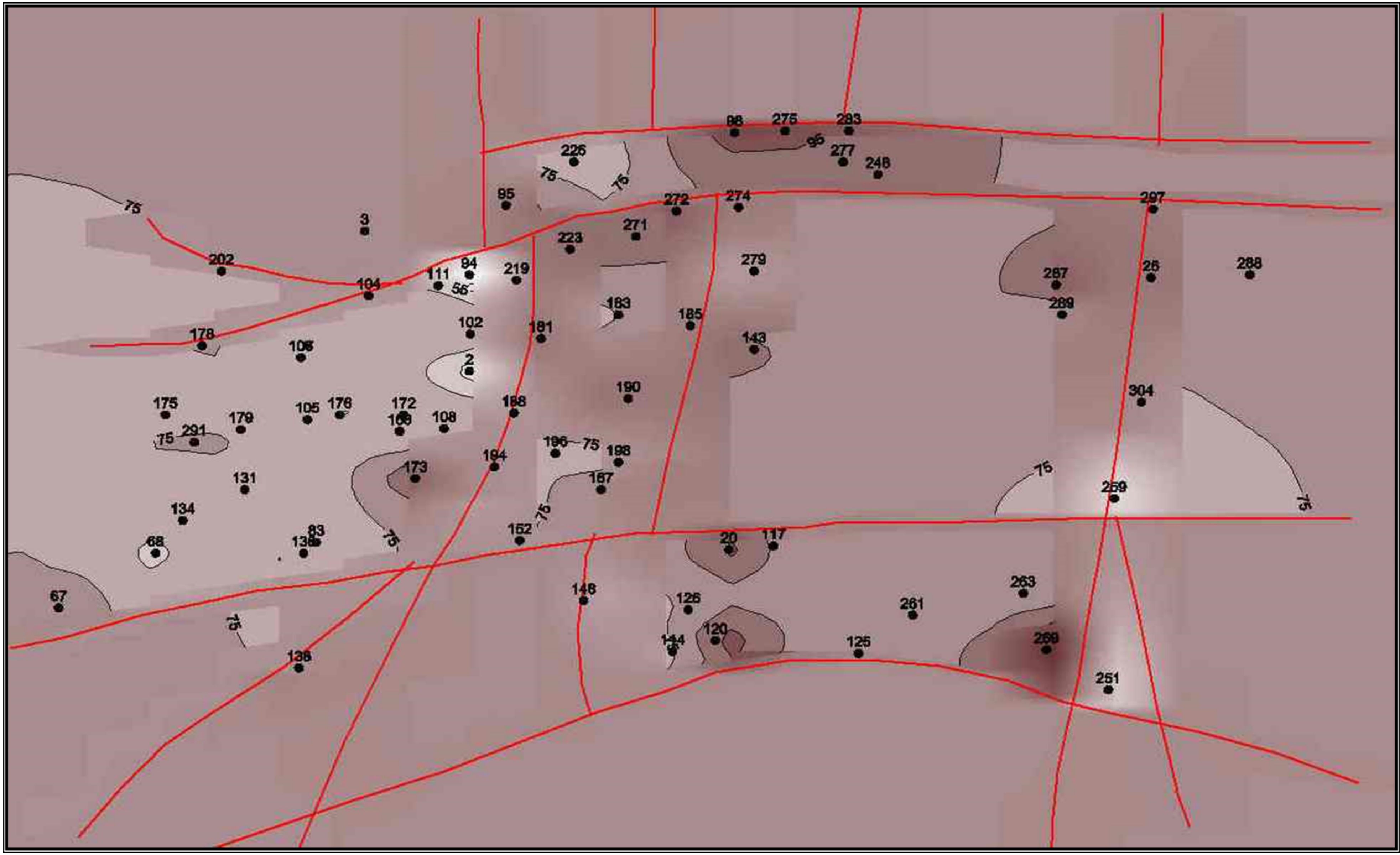

Figure 2.1.2 Map of effective thickness, Pereriva Suite, Gunashli **field**

2.2 Tectonic structure

Tectonic faults are one of the main indicators of the geological structure of the fields. These unconformities of the geological formations are also called disjunctive dislocations in the geological literature.

The role of disjunctive faults at distribution of fluids should be investigated. Thus, the majority of the oil fields have tectonic faults and these faults are characterized by different features. In this regard, the fields which is located at South section of Caspian Sea, is no exception. The fields are almost available disjunctive dislocations and they take place in the process of field development.

Disjunctive dislocations are divided mainly two types: normal fault and reverse faults. (Figure 2.2.1 and Figure 2.2.2).

As seen in figures, disjunctive unconformity depending on the type, different impact to stratification in cross-section of field: but this case does not meet at reverse fault, if each layers crossed twice with same well in cross section of the fields; in this condition each drilled well is cross layer one time.

To detection of faults is one of the most important issues of petroleum geology. Seismic exploration methods and wells data should be used to definition of disjunctive dislocations.Thus faults different affected to fluid distribution on the field. So, in case of they are violating the integrity of bed fluid flow field is affected in different. Regardless of the distance of displacement and dislocation amplitude some faults don't prevent the flow in the reservoir, others prevent flow. The first type is open or conductive, second type is closed or the screen type fault.

Therefore, stuck into the layer water was also observed in the field. Open (conductive) breaks sometimes can lead to difficulties cutting in the field of hydrodynamic conditions : layers in the process of development compared to the high-pressure injection of fluid flow above or below the low pressure conditions can cause sleeping. Such cases are found in Absheron fields developed for a long time. Screen (or closed) breaks the field of fluid flow from one area to another and prevents the formation of a layer. The following operations are performed sequentially Disjunctive faultsthe early stages of development:

- Are drawn to the structural map of the field;
- Disjunctive faults and the volatility observed in specified;
- Water-oil and gas-oil outlines of the plan;
- The size of the field (water and oil analysis, pressure, etc.). Systematized;
- Geological - Mining and Geological - mathematical methods in the areas of comparative analysis Tectonic Faults are fragmented.

As a result of the above transactions, the nature of faults are to be found. The algorithm is based on the use of the oil-field geology of the following hypothesis: in bed, his integrity has been violated as a result of the sharp tectonic processes; it several tectonic faults are divided into blocks; at the subsequent geologic periods, divided in accordance with the law hydrostatic for the field to the distribution of liquid savings. Therefore, the water-oil and gas-oil units in adjacent blocks of the same hypsometric levels. In such cases, does not play an important role in the distribution of fluid handling function disjunctive conductive fractures. When faults are screen type, in the adjacent tectonic blocks hypsometric depths are different contacts of water-oil .

The determination of the properties of tectonic faults in violation of the integrity of field just to study the condition of the water-oil and gas-oil contours are not limited: we must to use other methods for the reliability of the solution. First of all, in the field faults block water pressure and oil prices, a comparative analysis of physical and chemical parameters, and it allows the definition of the degree of similarity between adjacent tectonic blocks. Thus, the similarity of the mathematical parameters of complex formation if it disjunctive conductive disorders otherwise shows that the spoilage screen function.

Hydrodynamic methods are used to study the nature of faults. In order to apply the method of tectonic fault located in selected different two wells and one of them is under severe technological changes (increased or decreased production) and indicates that the changes in neighboring wells is considered to be breaking the conductive or vice versa.

Effective development of the field data collection process on disjunctive disorders is of great importance. If faults are type display, each block should be treated as a separate operation. They have a network of wells (including injection wells), operating methods, and etc. should be resolved separately. Disjunctive torn field space regardless of the number of faults in the field, in the case of conductive should be treated as a single operation and development process at all geological, technological, hydrodynamic and others. Issues in the field should include this feature.

Finally, it should be noted that a feature about faults. It is also possibility to change their function in the process of development: the screen has lost its function in the process of extracting breaking type, can be conductive or ce versa. This feature should be considered during the field development.

2.3 Lithology and reservoir properties

Net-to-gross (N/G) ratio (Sandstone factor) of Pereriva Suite varies between 0.39 and 0.64 for the sand. Thus, N/G for sand change between 0,40 and 0,55 in the south-west flank and increase in the south-east direction of the reservoir. Porosity of the reservoir varies between 0,18 and 0,30. And shale layer thickness varies between 3 and 12 meter and divided 13 parts.

Pereriva Suite layers are characterized by the apparrent resistivity which, varies between 4 and 65 ohmmeters. (Table 2.3.1). Amplitude of Spontaneus Potential rises up to 79 mV in several wells.Shale layers resistance varies between 2 and 5,5 ohmmeters. Value layers thickness increase up from 1,2 m to 22,8 m.

Table 2.3.1. Reservoir properties of Pererive Suite

Parameters	Value of parameters
Avarage depth, m	3200
Sedimentary rocks type	terrigenous
Avarage thickness of layer, m	125
Average thickness oil productive zone , m	70
Porosity, %	0,26
Average oil saturation, %	0,78
Permeability, mkm^2	0,188
N/G	0,60
Coefficient of stratificaton	7

It should be noted that, after 1985, the oil analysis (Pereriva Suite) parameters cannot be taken as a starting point, because of the formation pressure decreased and gas factor increased.

During Exploitation years of Pereriva Suite (well № 2, 6, 7, 12, 17, 19, 102, 103, 105, 106, 108, 131)initial parameters of oil-bearing layers are as follows: Initial formation pressure of PS 33.4 MPa, compressibility coefficient $1.2*10^{-4}$ 1/MPa, volumetric thermal expansion coefficient 1.329, gas factor 104 m^3/m^3.

Variation interval and average value of physical and hydrodynamical parameters of the reservoir are given on the table 2.3.2. These parameters value is varies for the depth, formation pressure and tempreture.

Table 2.3.2 Physical and thermodinamical features of PS

Parameters	Pereriva Suite	
	Variation interval	Average value
1	2	3
İnitial formation pressure, MPa	32,8-36,0	33,4
Formation tempreture, ^0C	61-63	62
Geothermal gradient$^0C/m$	0,017-0,021	0,0195
Current daily production well , t/day	12-351	136,8
Water flooding factor, %	0,06-0,81	0,52
Gas factor, m^3/t	95-1130	302
Special productivity , m^3/ day/MPa	0,01-5,72	2,86
Special injectivity, m^3/gün MPa	6,8-9,0	7,9
Hydrocunductivity , $10^{-12}m^3/Pa.s$	230-1117	749
Reduced radius, m	0,1	0,1
Permeability , $10^{-3}mkm^2$	8-650	188
Piezopermeability . $10^{-4}m^2/c$	1840-2700	2270

2.4Estimation hydrocarbon reserves of PS

Industrial importance of Oil reserves Gunashli field has been approved since 1985. Oil, gas and condensate reserves was estimated during development of the field in 1985, 1992, 1998, 2005, 2011.

For the first time oil, gas and condensate reserves was estimated base on initial date of 30 wells on shallow and deep water Gunashli field in 1985. Since 1985 reserves was estimated based on exploration and preliminary drilling data in 1992.

In 1999 reserves was estimated for the third time, unlike previous years, it covers only SWG.

From the previous report 40 wells were drilled in the field during last 7 years. In 01.01.2005 hydrocarbon reserves were estimated based on data of last drilled 40 wells and dynamics of the field development. In subsequent years,as a result of researches (geological, exploration, mining geophysics, drilling, development and etc.) hydrocarbon reserves were recalculated and distribution of hydrocarbon reserves for the horizons is given in table 2.4.1. As seen in the table 2.4.1. Initial balance reserves are$240x10^6$ tons ($1714x10^6$stb) which were estimatedfor the $A+B+C_1$ categories. And for this estimation, dissolved gas reserves are 42000 mmscm (1483220 mmscf), recoverable oil reserves are $142x10^6$ tons ($1014x10^6$stb), recoverable dissolved gas reserves 30000 mmscf (105940 mmscf). Initial and recoverable reserves for the C_2 category is calculated, respectively, 1 million tons ($7.14x10^6$stb) oil and 128 mmscm(4520 mmscf) gas.

In the thesis is used volumetric estimation method to calculate oil reserves.(9)

$$Q_{i.r} = \frac{A \cdot h_{ef} \cdot \varphi \cdot (1 - S_w) \cdot \rho_o \cdot 10^6}{B_0}, ton$$

Here,

$Q_{i.r}$ - Initial oil reserves, tons

A – Area of reservoir (m^2), calculated from map data

h_{ef} – effective thickness of productive layer, (m),

calculated fromand/or core data

φ – Porosity, %, defined from log and/or core data

S_w – Water saturation %, defined from log and/or core data (S_o= 1- S_w)

S_o - Oil saturation %, defined from log and/or core data

ρ_o– Oil density, q/sm^3

B_o- formation volume factor for oil at initial conditions)

Initial oil Reserves of Pereriva Suite Gunashli field is calculated by using volumetric method.

$$Q_{i.r} = \frac{25000 \cdot 80 \cdot 0.28 \cdot 0.78 \cdot 0.862 \cdot 10^3}{1.43} = 263300 \cdot 10^3, ton$$

Ultimate oil recovery factor is calculated 0.6. We can calculate initial recoverable reserves with this formula.

$$Q_{i.r.r} = Q_{i.r} \cdot RF_{i.}, 10^3 ton$$

$$Q_{i.r.r} = 263300 \cdot 10^6 \cdot 0.6 = 157980 \cdot 10^3 tons$$

Here, $Q_{i.r.r}$- initial recoverable reserves

$RF_{i.}$ – Recovery factor

It was revealed that, 120000*10^6tons' oil produced from Pereriva suite till current date. Then residual reserves calculate:

$$Q_{r.r} = Q_{i.r} - G_{cum.oil}$$

$$Q_{r.r.r} = Q_{i.r.r} - G_{cum.oil}$$

Where, $Q_{r.r}$– residual reserves, tons

$Q_{r.r.r}$– recoverable residual reserves, tons

$G_{cum.oil}$ – Cumulative produced oil, tons

Calculation Qr.randQ$_{r.r.r}$:

$$Q_{r.r} = (263300 - 120000) \cdot 10^3 = 143300 \cdot 10^3 \, tons$$

$$Q_{r.r.r} = (157980 - 120000) \cdot 10^3 = 37980 \cdot 10^3 \, tons$$

And current oil recovery factor:

$$RF_{cur.} = \frac{G_{cum.oil}}{Q_{r.r.r}}$$

Where, $RF_{cur.}$ – Current recovery factor

$$RF_{cur.} = \frac{120000 \cdot 10^3}{263300 \cdot 10^3} = 0.46$$

Estimation initial and current residual, recoverable reserves are shown on the table 2.4.1.

Table 2.4.1Estimation reserves, PS, Gunashli field

Horizon	$Q_{i.r.}$	$Q_{i.r.r.}$	$G_{cum.oil}$	$Q_{r.r}$	$Q_{r.r.r}$	RF	
	thousand tons					$RF_{i.}$	$RF_{cur.}$
PS	263300	157980	120000	143300	37980	0.6	0.46

As mentioned above, the following formation parameters are used for the calculation of oil reserves with the volumetric method: effective thickness of the layers, reservoir properties (porosity, permeability, oil and gas saturation factor), oil-bearing area, specific gravity of oil and formation volume factor.

These parameters are divided two groups – variable and constant parameters.

The first group parameters include effective thickness of layer, porosity oil saturation factors. The second group includes specific gravity (density) of oil and formation volume factor.

As regards to area of oil-bearing zone, of course, this parameter is subject to change. In that case, should use average value constant parameters and variable parameters which are obtained from the well data to estimation sectorial distribution of hydrocarbon reserves. (Table 2.4.1)Thus, values of parameters are obtained from the wells data and variation them on the field area carried out with the help of new methods - kriging analysis. The new methods are being implemented on the basis of specific algorithms and program reflects the following:

- Distribution of initial oil reserves taking into wells data;
- Distribution oil production from wells in operation throughout the area;
- Maps of sectorial distribution of residual oil reserves.

Sectorial distribution initial reserves map, initial recoverable reserves map, residual reserves map and cumulative production maps for the tectonic blocks has been established by using the method of statistical mapping krayqinq and using wells data of

Gunashli field Pereriva Suite, (Figure 2.4.1, figure 2.4.2, figure 2.4.3, figure 2.4.4).Initial reserves of Pereriva Suite are more concentrated on the tectonic blocks – VII (45.1 million tons), IX (48.2 million tons) XIII (38.4 million tons). VIII (20.4 million tons), X (19.5 million tons), XI (15.1 million tons) of tectonic blocks reserves is less than reserves ofthe central tectonic blocks. The reserves of tectonic blocks (II, III, IV, V), which is located in the north-east flank of thefieldis less than others and this is reflected on the map.

The distributed areas of initial recoverable reserves of the field are consistent with the distributed areas of the initial reserves. Figure 2.4.2.

As the map of the distribution cumulative production is consistent with the distribution map of initial reserves and initial recoverable reserves. Thus, main part of production of Pereriva Suite is obtained from the VII (29.1 million tons), IX (28.9 million tons) and XIII (20.7 million tons) tectonic blocks, but from. X XI and XIV tectonic blocks produced less production.

As for the analysis of maps of the distribution remaining reserves of the Pereriva Suite, VI (10.3 million tons), VIII (6.3 million tons) and X (5.7 million tons) tectonic blocks is important. Cumulative Production on the horizon more VII, IX and XIII, although the tectonic blocks of the remaining provisions prevail over other tectonic blocks. In accordance, this tectonic blocks reserves are 16, 19.3 and is 17.7 million tons.

Thus, in the thesis Reserves of Pereriva Suite, Gunashli field was estimated and differentiation reservesof Gunashli field have been implemented. Three prospective zones have been identified for the object. And it was being expedient to use above mentioned new methods for the reserves estimation.

Table 2.4.2Oil and dissolved gas reserves of PS

Horizon	Category	Provided oil and gas reserves			Reserves at balance			Difference
		Production from beginning development	Initial reserves	Residual reserves	Production from beginning development	Initial reserves	Residual reserves	
Oil, thousand tons								
FLD	A	84400	194602	110202	59262	124187	64925	45277
			116761	32361		67681	8419	23942
	B	10606	24687	14081	39823	88162	48339	-34258
			14812	4206		48048	8225	-4019
	C_1	7582	17027	9445	3491	8363	4872	4573
			10215	2633		4557	1066	1567
	$A+B+C_1$	102588	236316	133728	102576	220712	118136	15592
			141788	39200		120286	17710	21490
	C_2		141788	1015		2685	2685	-1670
			1015	609		1463	1463	-854

Continued (table 2.4.1)

Horizon	Category	Provided oil and gas reserves			Reserves at balance			Difference
		Production from beginning development	Initial reserves	Residual reserves	Production from beginning development	Initial reserves	Residual reserves	
Dissolved gas, mmscm								
	A	21726	34055,6	12329,6	15554	21732	6178	6151,6
			24534,8	2808,8		2571	2571	237,8
	B	2725	4320,3	1595,3	9928	15428	5500	-3904,7
			3094,9	369,9		12867	2939	-2569,1
	C_1	1888	2979,8	1091,8	749	1463	714	377,8
			2146,8	258,8		1220	471	-212,2
	$A+B+C_1$	26339	41355,7	15016,7	26231	38623	12392	2624,7
			29776,5	3437,5		32212	5981	-2543,5
	C_2		177,6	177,6		470	470	-292,4
			128	128		391	391	-263

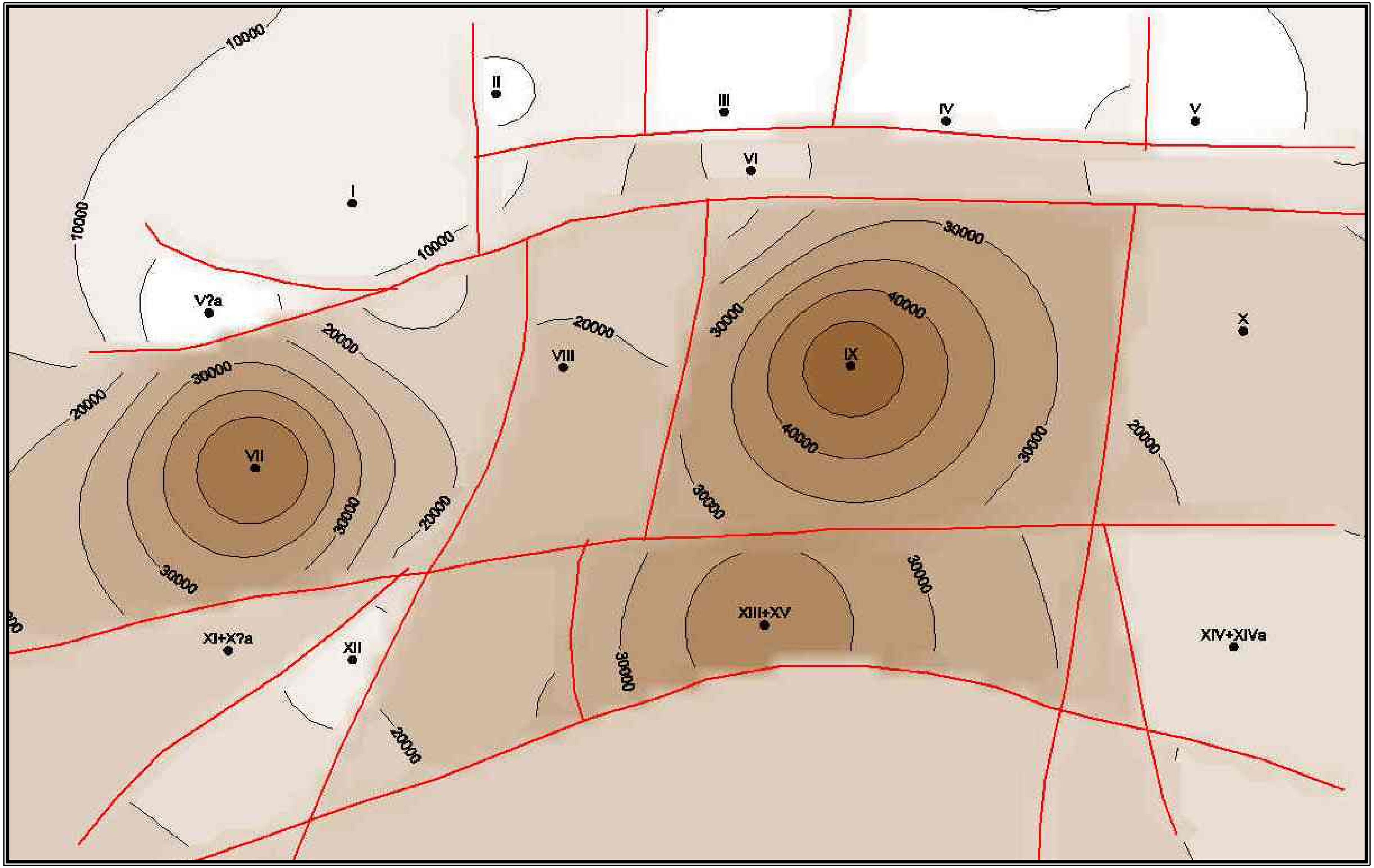

Figure 2.4.1 Sectorial distribution map of initial reserves of PS

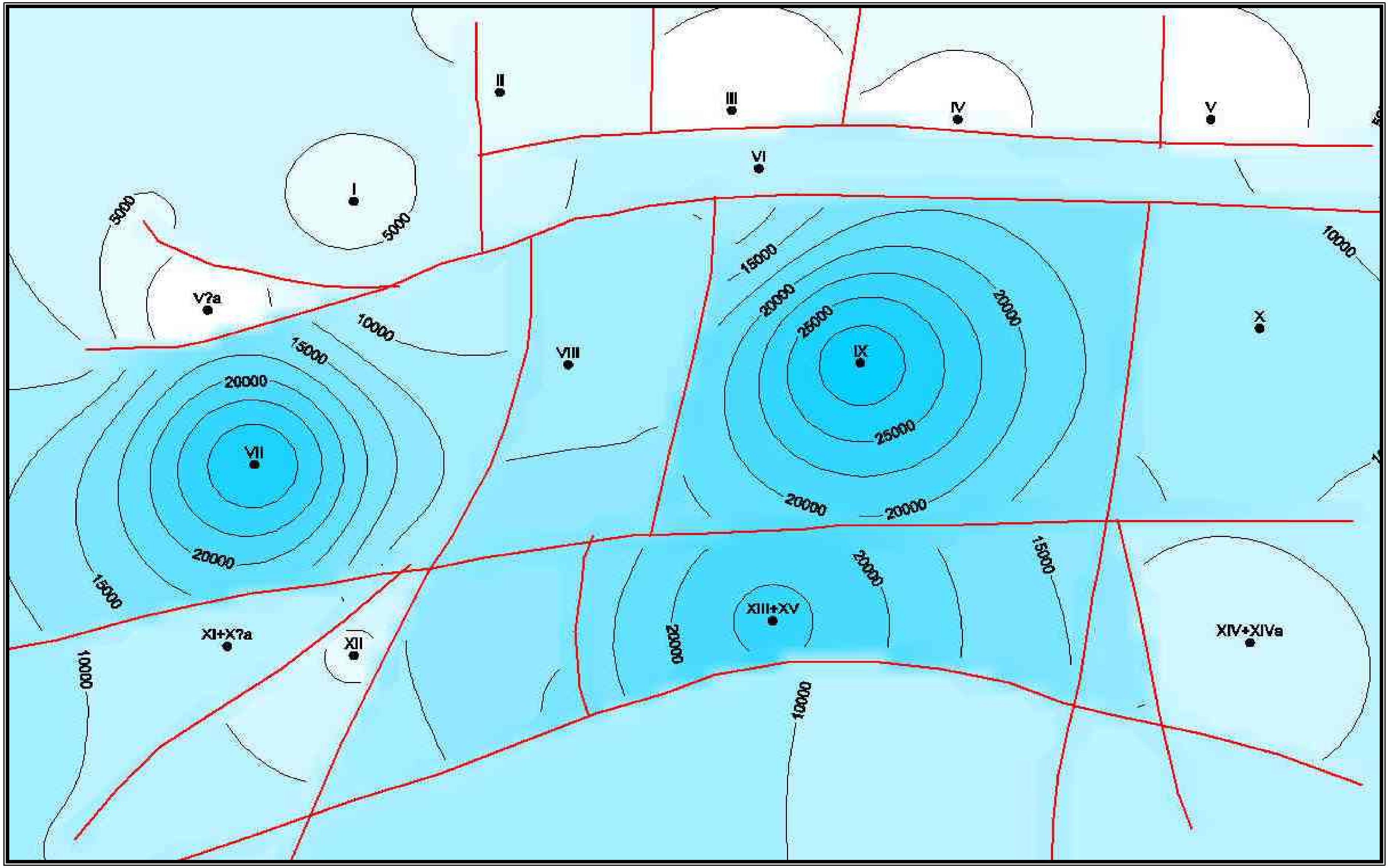

Figure 2.4.2 Sectorial distribution map of initial recoverable reserves of PS

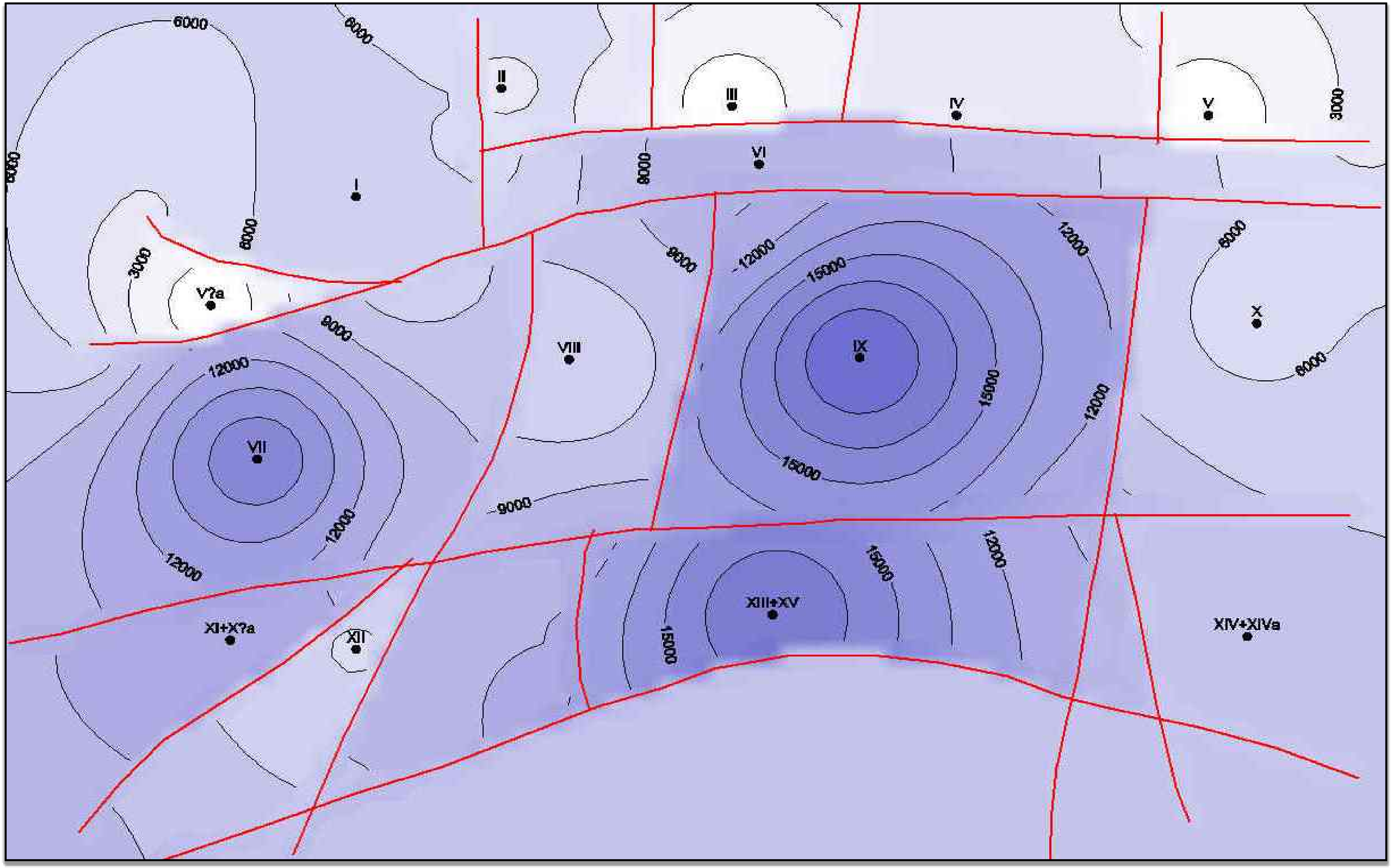

Figure 2.4.3 Sectorial distribution map of initial residual reserves of PS

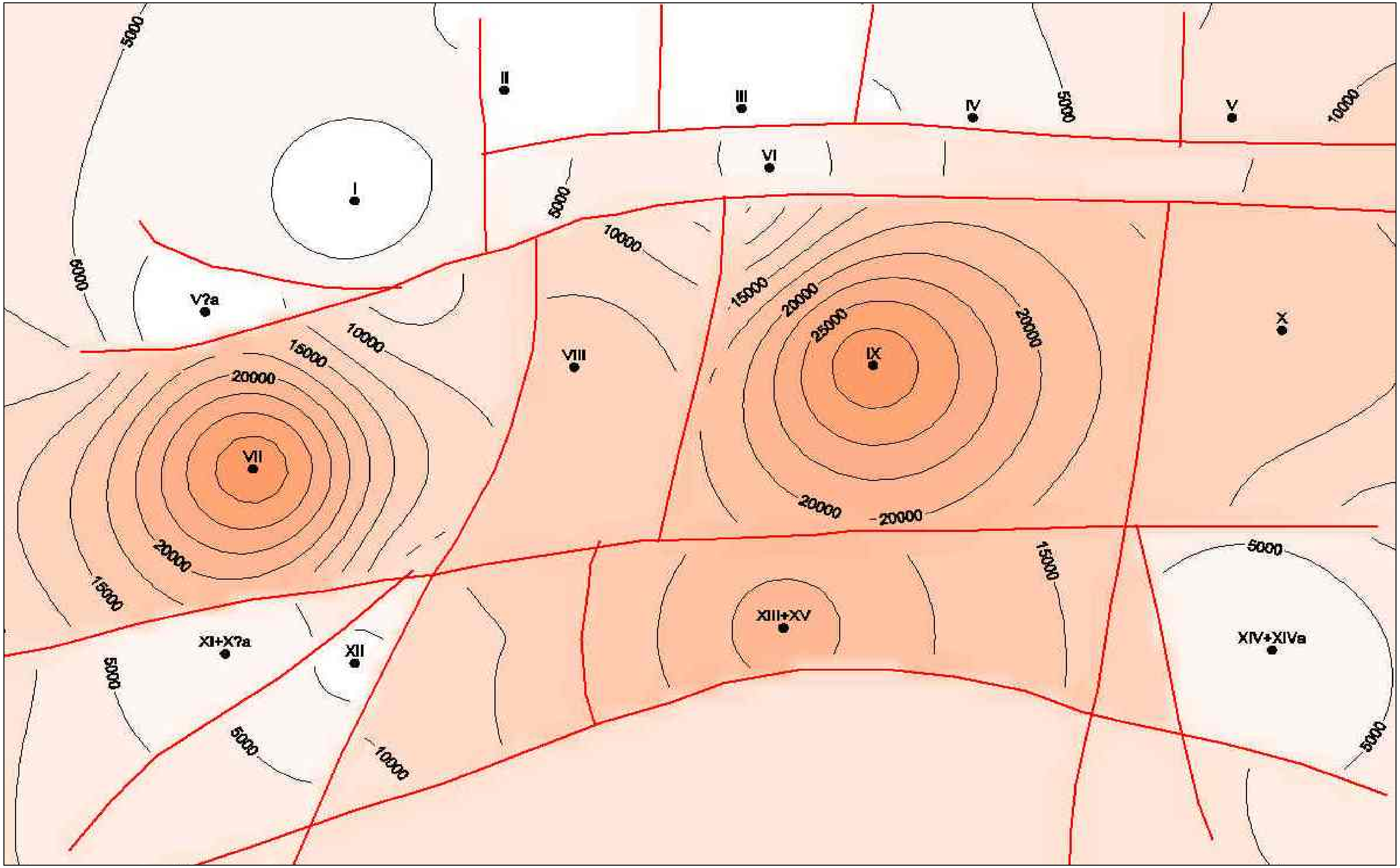

Figure 2.4.4 Sectorial distribution map of cumulative oil production of PS

2.5 Dynamics of development PS

As we mentioned, Pereriva Suite is most productive facility of Gunashli field. Main part of residual oil reserves is collected in PS.

Drilling operations started to PS in 1980. At the same year drilled only one well. İn 1981, cumulative oil production of this wells was 128000 ton.

Since 1982, new wells drilled. Oil production rate was increased from 146000 tons to 3939200 tons, between 1982 and 1987 years. 45 wells was operated in 1987. The maximum point of annual oil production have been in 1992. 72 well was operated and annual production was 4714000 tons' oil, 1047 mmsmc' disolved gas, 332000 tons' water in this year. Development temp was 3.3 %.Between 1992 and 1993 year annual oil production rate was stable. Since 1995, annual oil producton rate is decreased, although quantity of production wells increased.

Since 2005, annual oil production is decreased from 4000000 tons to 3233200 tons due to quantity of production wells is decrased.

Currently, operates 84 wells, which annual production is 3130.4 thousand tons' oil, production, 715.7 thousand smc water, 525.7 MMSMCs' of natural gas production. The current formation pressure is 18 MPa.

In general, quantity of wells increased, but development rate is decreased.Annual oil, liquid, water, accosiated gas production, injection water rate, number of operating wells, number of injection wells and flooding coefficent are given on Table 2.5.1, Curves of this parameters on time added to diagrams. (Figure2.5.1, 2.5.2, 2.5.3 and 2.5.4)

Table 2.5.1 Current technological parameters of PS

Years	Annual Production					Gas factor smc/ton	Cumullative production					Number of wells		Floodingco efficent, %	Average daily oil production, ton/day	Average daily liquid production, ton/day
	Oil, thousandton	Water, thousandton	Liquid, thousand ton	Gas, mmsmc	Waterinjection, mmsmc		Oil, thousandton	Water, thousandton	Liquid, thousandton	Gas, mmsmc	Waterinjection, mmsmc	oductionwells	Injectionwells			
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1980	13	0	13	4.1	0	315	12	0	12	4	0	1	0		34	34
1981	129	0	129	20.2	0	156	142	0	140	24	0	1	0		366	366
1982	145	0	145	24.1	0	164	290	0	286	48	0	2	0		209	209
1983	566	0	566	73.2	0	129	853	0	853	121	0	7	0		232	232
1984	1411	0	1411	160.1	0	113	2265	0	2265	281	0	14	0		288	288
1985	2741	0	2741	310.3	0	113	5005	0	5005	591	0	24	0		326	326
1986	3545	0	3545	536.1	50	151	8551	0	8551	1127	50	34	3		298	298
1987	3940	0	3940	654.2	173	166	12490	0	12490	1781	223	45	3		250	250
1988	3925	295	4220	917.1	1015	234	16417	296	16712	2698	1238	51	9	7	220	237
1989	3565	250	3815	1001.2	1308	281	19981	548	20528	3699	2546	53	8	7	192	206
1990	4275	245	4520	895.2	878	209	24258	788	25045	4594	3424	64	6	5	191	202
1991	4535	215	4750	978.1	870	216	28792	1004	29795	5572	4294	68	7	5	191	200
1992	4715	330	5045	1047.1	1125	222	33506	1336	34841	6619	5419	72	9	7	187	200
1993	4205	495	4700	1124.2	974	267	37709	1830	39539	7743	6393	73	5	11	165	184
1994	3710	280	3990	997.1	958	269	41418	2111	43529	8740	7351	73	6	7	145	156
1995	3640	251	3891	852.2	934	234	45059	2361	47420	9592	8285	77	9	6	135	144
1996	3725	326	4051	890.1	886	239	48786	2686	51472	10482	9171	79	7	8	135	147

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1997	3835	240	4075	959.2	931	250	52623	2927	55550	11441	10102	80	7	6	137	146
1998	3940	201	4141	951.6	986.6	241	56566	3128.3	59694	12392.5	11088.2	78	9	4.9	144.4	151.8
1999	3920	210	4130	976.7	732.2	249	60486	3337.3	63823	13369.3	11820.4	80	8	5.1	140	147.5
2000	3960	245	4205	1630.1	735.3	411	64450	3582.4	68032	14999.3	12555.7	78	7	5.8	145.2	154.2
2001	3888	257	4145	1107.2	732.2	285	68338	3840.1	72178	16106.3	13287.9	75	6	6.2	148.1	157.9
2002	3870	252	4122	1128.8	767.8	292	72208	4092.9	76301	17235.2	14055.7	76	6	6.1	145.5	155
2003	3917	321	4238	1063.7	561.4	272	76126	4414.9	80541	18299	14617.1	82	3	7.6	136.5	147.7
2004	3987	387	4374	1158.7	370.7	291	80113	4802.7	84916	19457.6	14987.8	87	2	8.9	130.9	143.7
2005	4000	540	4540	1185.2	368.5	296	84113	5343.2	89456	20642.7	15356.3	87	2	11.9	131.4	149.1
2006	3935	508	4443	1255.7	303.8	319	88049	5851.7	93901	21898.3	15660.1	80	2	11.4	140.6	158.7
2007	3835	538	4373	1383.5	312.8	361	91883	6389.9	98273	23281.7	15972.9	71	3	12.3	154.3	175.9
2008	3589	413	4002	1303.7	480.8	363	95472	6803.2	102276	24585.5	16453.7	70	2	10.3	146.5	163.4
2009	3579	456	4035	897.8	304.6	251	99052	7259.9	106312	25483.4	16758.3	69	3	11.3	148.2	167.1
2010	3525	545	4070	766.9	496.8	218	102577	7805	110382	26250.2	17255.1	67	3	13.4	150.3	173.6
2011	3357	577	3934	577.2	715.5	171.9	105934	8382.4	114317	26827.2	17970.6	71	3	14.7	135.1	158.3
2012	3372	572	3944	588.6	689.5	174.5	109307	8954.5	118261	27415.9	18660.1	76	3	14.5	126.8	148.3
2013	3300	634	3934	572.3	659.6	199.8	112608	9587.4	122195	27988.1	19319.7	79	2	16.1	119.4	142.3
2014	3233	655	3888	538.8	450.4	168.7	115840	10243	126083	28527	19770.1	83	2	16.8	104.9	126.3
2015	3130	715	3845	525.6	301.1	190	118971	10958	129929	29052.5	20071.2	84	2	18.6	92.7	115.3

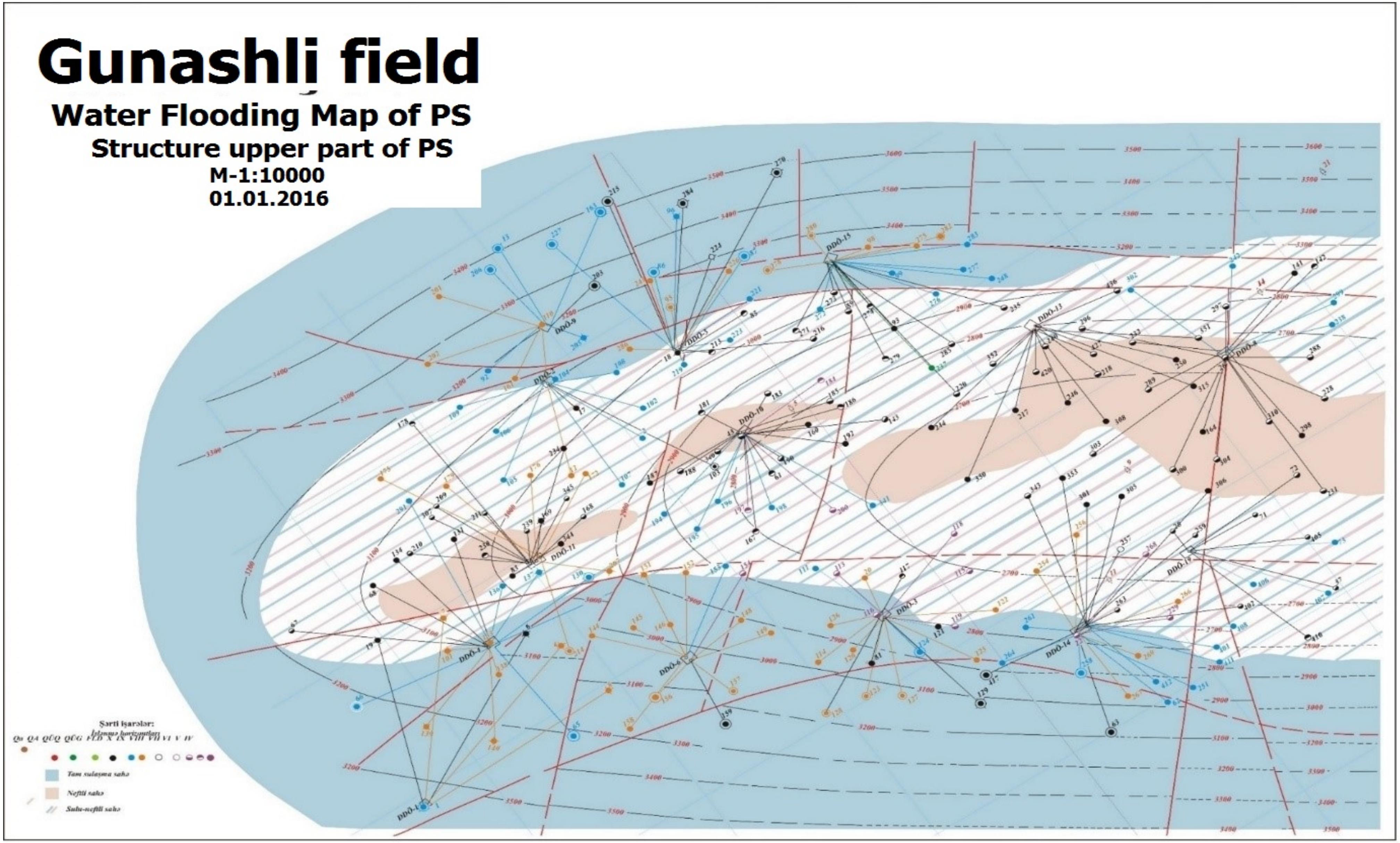

Figure 2.5.1 Water Flooding Map, Pereryva Suite, Gunashli Field

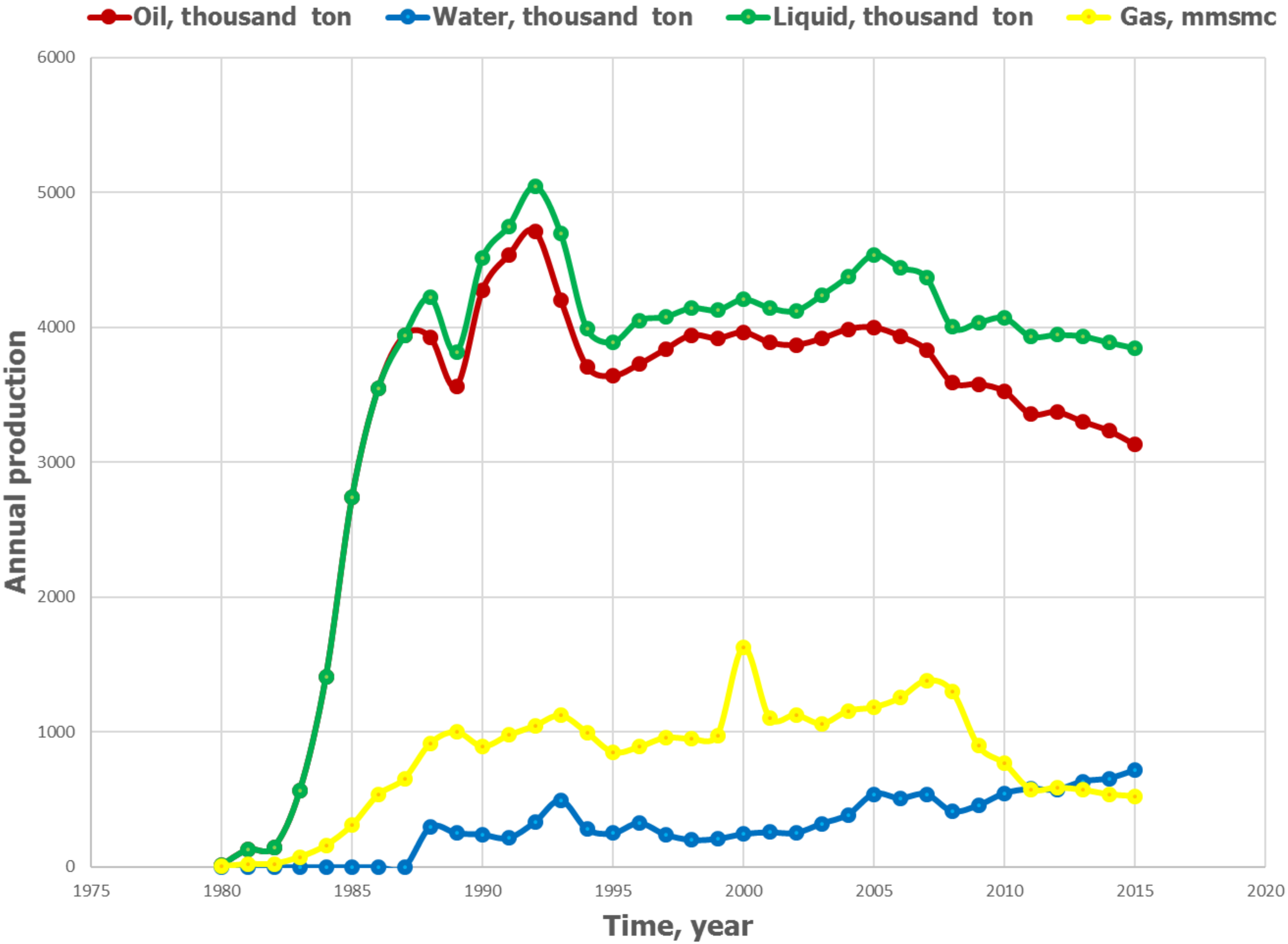

Figure 2.5.2 Annual production dependence on time

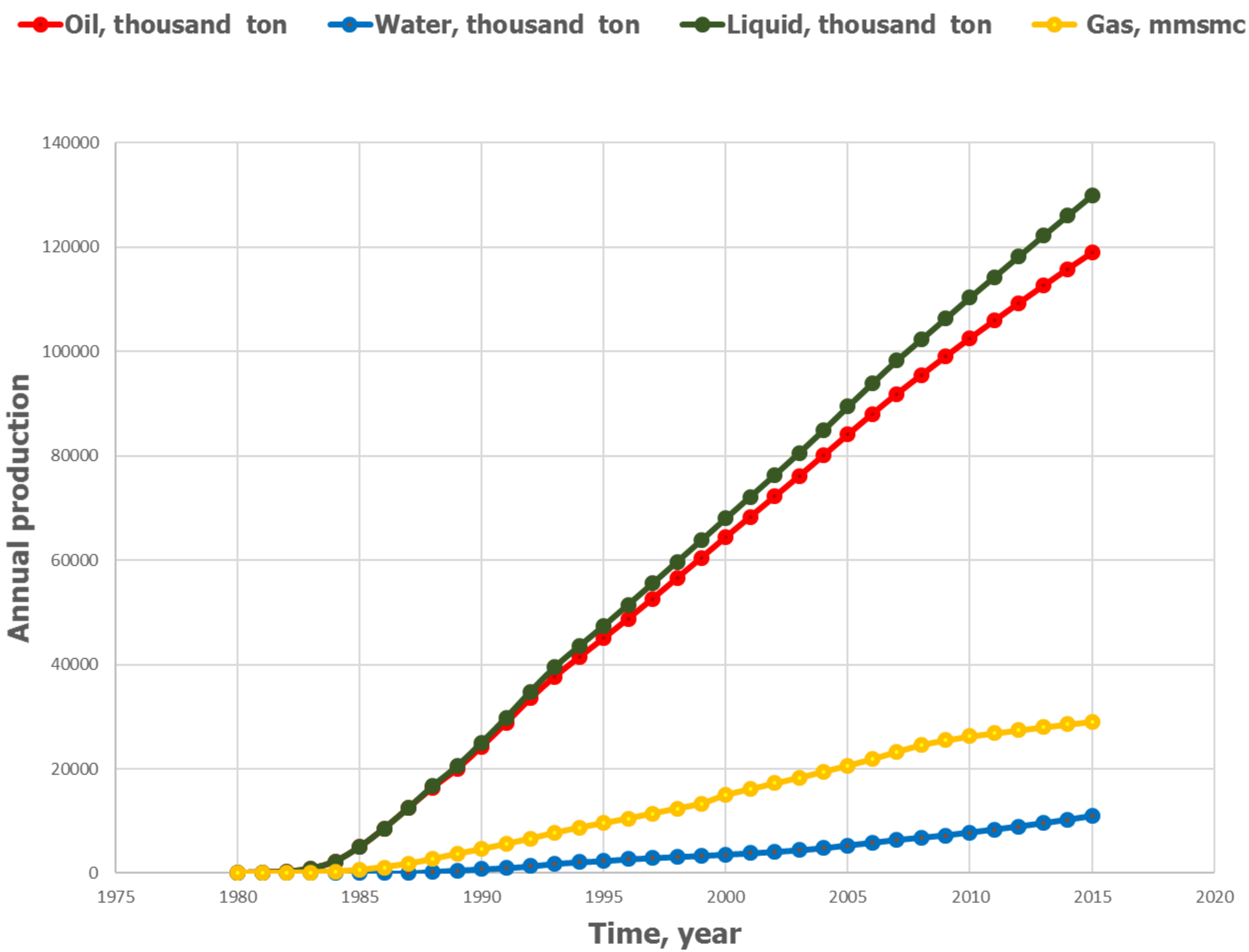

Figure 2.5.3 Cumulative production dependence on time

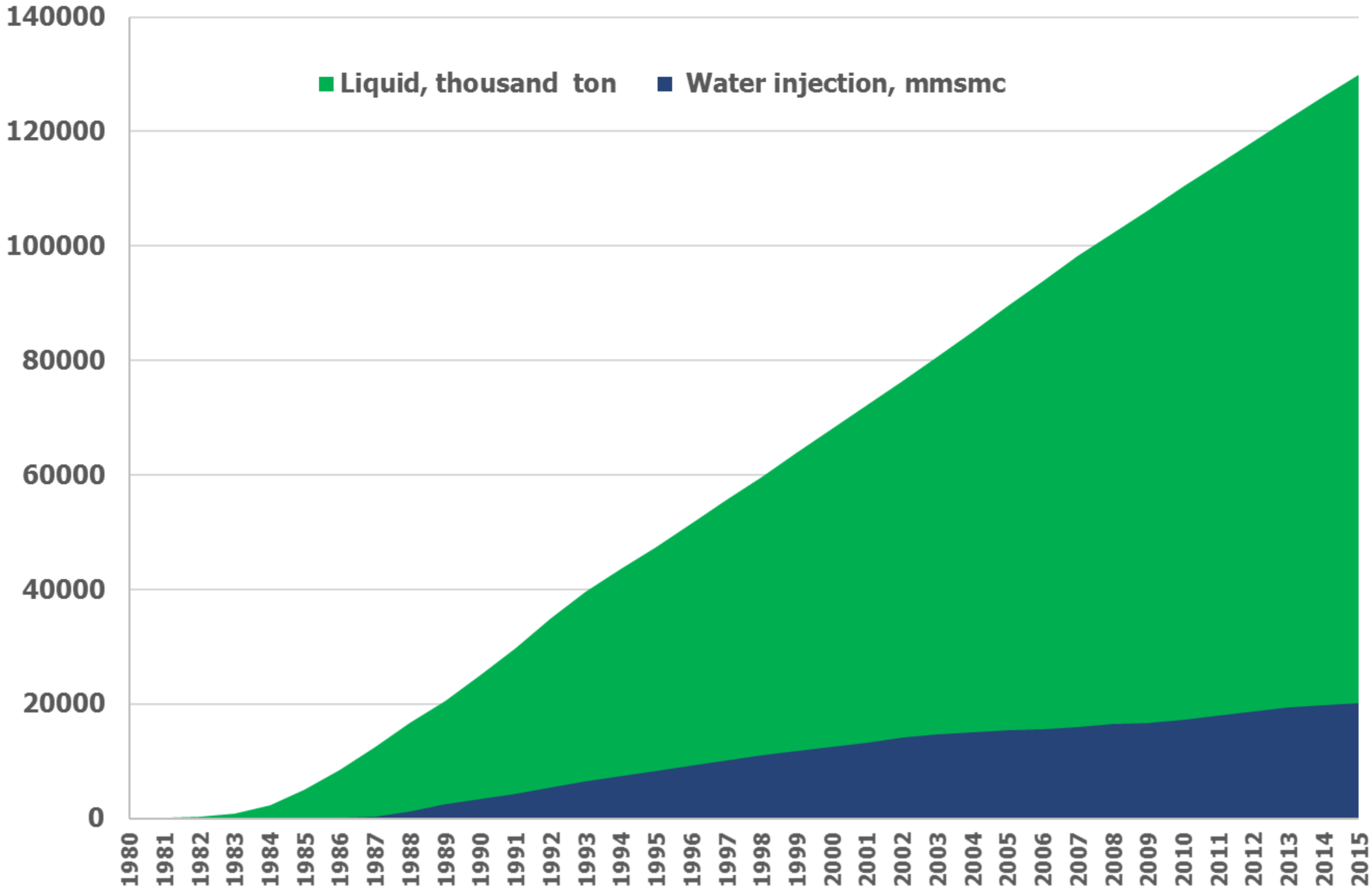

Figure2.5.4 Difference cumulative produced liquid and injected water on time

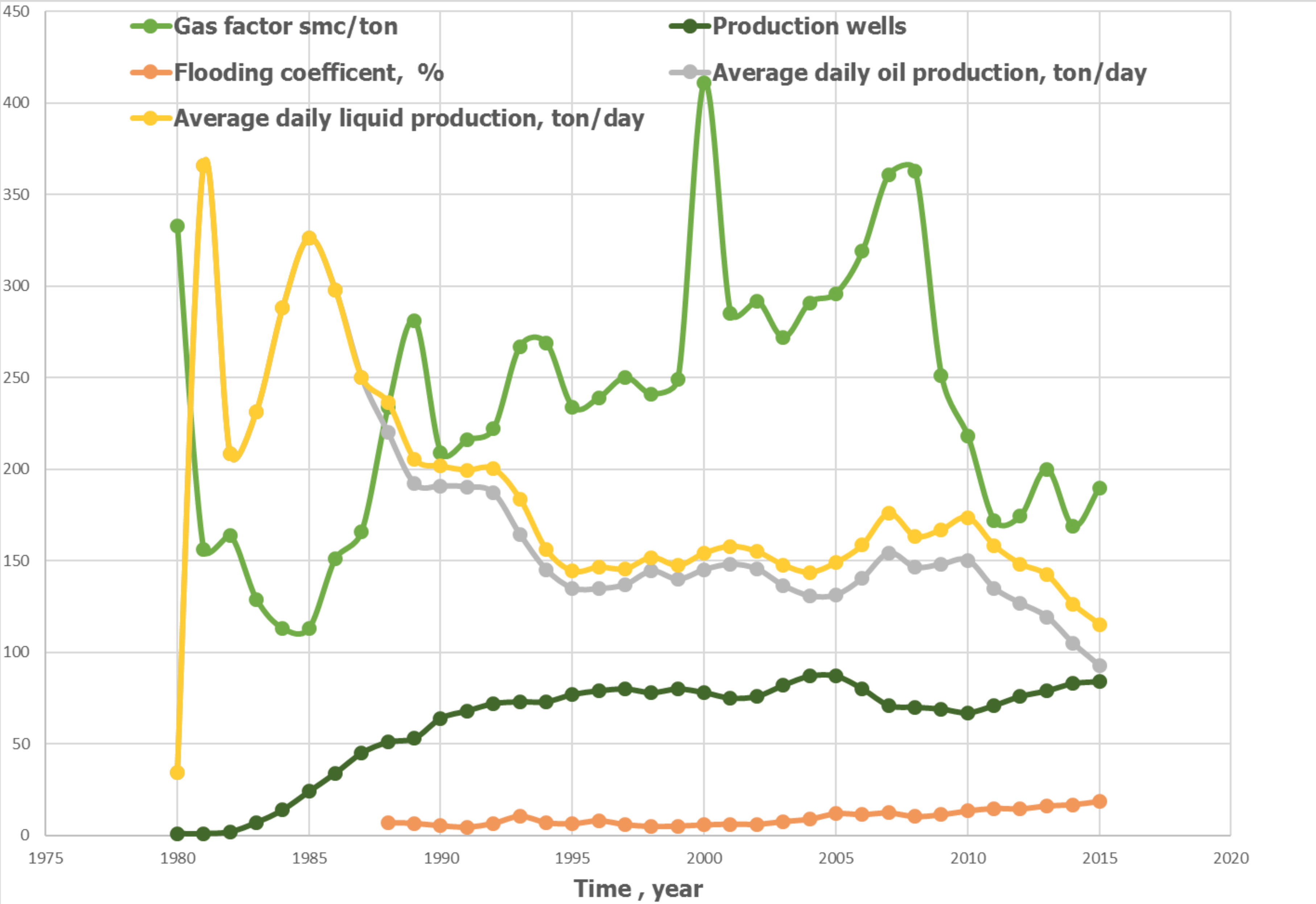

Figure 2.5.5 Dynamics of field development, Pereryva Suite, Gunashli field

CHAPTER III.EFFICIENCY WATER INJECTION PROCESSES IN PS

Current situation, there are 6 water injection wells of injection well stock at the Pereriva suite, which is 3 of them are still operating. Others suspended from various technical and technological reasons. Two of the existing injection wells are situated at the South-west, and one of injection well is in the north-east area. Currently, water injection rate is 2150 m^3/ per day and water is pumped through 3 wells into the Pereriva suite. From the beginning of development, total injected water was 41565900 m^3 to this horizon. Compensation of produced liquid with injected water is 9.5% from the beginning of the year, but from the beginning of development compensation is 12% and this percentage is very low. During this period formation pressure decline rate rapidly increased and productivity of wells decreased. Production wells which is situated in the center of the field gas factor increased due to low injection rate. It should be noted, that the main part of the injected water (approximately 70%) is pumped to the south-west part of field, and therefore, the current oil-water contact towards the center of the field has helped considerably. (5)(10)

It should be noted, that the remaining oil reserves covered areas of the bottom and top facilities of Pereriva Suite, approximately, estimated the plan overlap. With this in mind, the complete water injection process over thickness of Pereriva Suite (bottom and top part of Pereriva Suite) can be considered effective. The basis of this, the pressure of the bottom and top facilities of Pereriva Suite is relatively near. From the other side,distribution injected water amount for Pereriva Suite, may be provided to the current liquid production of the bottom and top facilities Pereriva Suite.(5)

Compensation of injected water to produced liquid is not enough and it caused decreasing formation energy at some of the blocks, in particular, at VII, VIII and IX blocks formation pressure is lower than bubble point pressure. At the result, the oil wells is which operated by high gas factor is decreased production rate. The main reason of this, is decreasing phase permeability for the oil at the well bottom, and phase permeability for gas has been increase. The wells of above-mentioned blocks wells located close to the northern tectonic unconformity and water zones effect to this wells very weak. But the blocks (X, XI, XII, XIII, XIV) which is located south-west zone of Pereriva Suite maintained a relatively high pressure, and it takes place under the influence of injected water and active contact waters in the reservoir. At the result of Oil-Water Contact (OWC) active movement over the first and second series of production wells and returned to operation upper productive horizons. Water flooding of the bottom zone of Pereriva Suite covered larger area than upper part of Pereriva Suite.(7)

However, the current development of Pereriva Suite shows that most of the increasing gas factor is observed IX and X blocks. Thus, these blocks were involved in relatively recent development. VII, VIII, XII and XIII blocks are working with relatively low gas factor in the field. The average gas factor for the blocks are 100 - 300 tons per cubic meter.

Despite the above-mentioned features of Pereriva Suite annual oil production has stabilized in recent years. The main reason of this is cost-effective exploitation of production well stock and the implementation of effective geological and technical measures cannot compensate production rate.(2)

The analysis carried out on the blocks of each layer that allows that, to determine the efficiency of the measures improving enhanced oil recovery
and to determine developing hydrodynamic relations between the blocks.

It is known that, the most of the oil reserves are extracted under partial water drive mechanism or as a result influence water injection during the water flooding period. This feature acutely indicates itself on the basis of layers which have great oil saturation thickness and stratification (like as Pereriva Suite) by cross-section of field.

If we accept the field as a single hydrodynamic system, then providing water injection along the whole perimeter of the field is important for discharging and simultaneous movement Oil-Water contact (OWC) of this hydrodynamic system at the same time.

From this aspect the selection and placement of subsequent water injection wells was carried out in accordance with this principle. Dynamics of development parameters of Pereriva Suite is given in the Table 3.1.0 and Figure 3.1.0

Calculation reaching date of injected water to production wells, water flooding area, water flooding radius.

Reaching date of injected water to production wells:

$$t_0 = \frac{(2L)^2 * m_{ef.} * h * \ln \frac{Q_{in.}}{Q_{pr.}}}{\pi * (Q_{in.} - Q_{pr.})}, \text{ day}$$

t_0 – reaching date of injected water to production well, day

2L – distance between injection and production wells, m

m_{ef} – effective porosity, %

Q_{in} – injection rate, m^3/d

Q_{pr}- production rate, m^3/d

h - average layer thickness, m

π =3.14

Effective porosity:

$$m_{ef} = \text{m} * \varphi, \ \%$$

Water flooding area:

$$S = \frac{Q_{in} * t_0}{h * m}, \text{ m}^2$$

Water flooding radius:

$$R = \left(\frac{S}{\pi}\right)^{0.5}, \text{ m}$$

Table 3.1.0 Dynamics water injection of Pereriva Suite

water injection wells №	Daily water injection rate ($Q_{inj.}$), m^3/d	Production wells №; (influence water injection)	Production rate ($Q_{pr.}$), m^3/d	Layer thickness (h), m			Porosity, (m)	Effective porosity, (m_1)	Distance between injection and production wells (2L), m	$Q_{inj.}/Q_{pr.}$	$\ln(Q_{inj.}/Q_{pr.})$	$(2L)^2$	$Q_{inj.} - Q_{pr.}$	Reaching date injected water to production wells		Water flooding area, m^2	Water flooding radius, m
				Injection	Production	Average, (h)								Day	year		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
67	1210	68	210	50	76	63	0.26	0.13	583.5	5.8	1.75	340472.3	992	1595	4.4	229874	271
	1210	134	198	50	82	66	0.26	0.13	799.7	6.1	1.81	639520.1	1003	3100	8.5	440284	374
	1210	209	100	50	28	39	0.26	0.13	1258.4	11.7	2.46	1583570.6	1097	5580	15.3	1354551	657
17	1210	178	45	65	15	40	0.26	0.13	994.4	26.1	3.26	988831.4	1154	4510	12.4	1068014	583
	1210	187	20	65	21	43	0.26	0.13	686	63.2	4.15	470596.0	1181	2910	8.0	631308	448
	1210	181	45	65	15	40	0.26	0.13	755.5	26.1	3.26	570780.3	1154	2670	7.3	616486	443
	1210	213	20	65	5	35	0.26	0.13	904.9	60,0	4.09	818844.0	1180	4240	11.6	1085813	588
111	720	117	65	45	9	27	0,26	0,13	538,5	10,4	2,35	289982,3	633	1290	3,5	239627	276
	720	167	40	45	17	31	0,26	0,13	423,2	17,9	2,89	179098,2	661	1055	2,9	174415	236
	720	61	50	45	13	29	0,26	0,13	672	13,7	2,62	451584,0	649	2265	6,2	406294	360
121	1220	263	80	50	8	29	0,26	0,13	717,9	15,2	2,72	515380,4	1121	1395	3,8	478017	390
	1220	301	160	50	24	37	0,26	0,13	893,4	7,5	2,02	798163,6	1041	2375	6,5	592238	434
	1220	305	135	50	32	41	0,26	0,13	1056,1	8,9	2,18	1115347,2	1065	3695	10,1	874428	528

CHAPTER IV. THE EFFECT OF EOR METHODS TO PRODUCTION

The experiment results show that is one of the effective solution of completion field development to use Enhanced Oil Recovery (EOR) methods. These methods include physical, chemical, thermal, thermodynamically, biological and etc. methods. These methods have been widely used in oil fields in the world, and they are high efficiency. The effective using of these methods were depend on geological and technological conditions for each of them. Therefore, the effective using of these methods geological and technological characteristics are listed on the figure 4.1.0(9)

Experiments show that, four parameters have important role at the application of these methods. These parameters are oil viscosity at reservoir conditions, the slope depth of exploitation object, permeability formation rocks and usage rate of reserves. Oil reserves classification model is created based on these parameters, which it also allows to define application area existing methods of EOR.(9)

1) oil viscosity at reservoir condition (A)

$$A_1<10 \text{ mPa*s (10 cP)}; A_2>10 \text{ mPa*s (10 cP)}$$

Here, A_1- at the reservoir condition, oil viscosity less than 10 cP, this oils are light, A_2 - at the reservoir condition, oil viscosity more than 10 cP, this oils are heavy.

These parameters are considered very important for the possibility of predetermined application physicochemical and thermal methods at the layers. Thus, application physicochemical methods at the oil fields, which have less oil viscosity, and the application thermal methods at the oil fields, which have high oil viscosity are more effective. In this regard, we may divide all facilities two groups which are in development (9): a) Objects, which physicochemical method is available, b) Objects, which thermal method is available

2) Slope depth of exploitation object (B)

$$B_1<2000 \text{ m}; B_2> 2000 \text{ m};$$

Here, B_1 and B_2, are slope depth of objects, which is respectively, more and less from 2000 m. depth.

It should be noted that, application of thermal method is more effective up to 2000 m depth in the fields. However, there are not slope depth limitations at the application of physicochemical methods. (9)

3) Permeability reservoir rocks (C)

$$C_1<0.1 \text{ mkm}^2; C_2> 0.1 \text{ mkm}^2;$$

Apparently, according to these parameters, development objects are divided two group: a) Objects, whichis available high reservoir properties, b) Objects, whichis available low reservoir properties, here, C_1 - permeability reservoir rocks less than 0.1 mkm^2, C_2 - permeability reservoir rocks more than 0.1 mkm^2

4) Usage rate of reserves (D).

The specified parameters are more important for the determining application series of enhanced oil recovery methods. For this reason, Usage rate of reserves are classified 3 groups:

$$D_1<20\%; 20\% <D_2<40\%; D_3> 40\%$$

Thus, classification model consists of 24 groups which, contains at all possible application conditions of EOR methods according selected four parameters. (9)

Value of relevant parameters of Pereriva Suite at Gunashli field is shown in Table 4.1. (9) (5)

It was revealed that, based on classification scheme the above-mentioned methods - physicochemical (surfactant–surface active agents, micellar) and physical-hydrodynamic (cyclic water injection) methods are more suitable to SWG. (Figure 4.1)

Forecast of additional oil production which expected from application of physicochemical (surfactant, micellar) and physic-hydrodynamic (cyclic water injection) methods was calculated on Table 4.1.0

Table 4.1.0 Forecast of additional oil production

Object	Oil viscosity, mPa*s,	Depth, m	Permeability reservoir rocks, mkm^2,	Usage rate of reserves, %	Class	Methods	Effectiveness of method, %	Forecast of additional oil production, tone
PS	0.978	2821	0.187	0.705	A1 B2 C2 D3	*Micellar*	8-15	3190-5980
						surfactant	3-5	1190-1990
						cyclic water injection	5-6	1990-2380

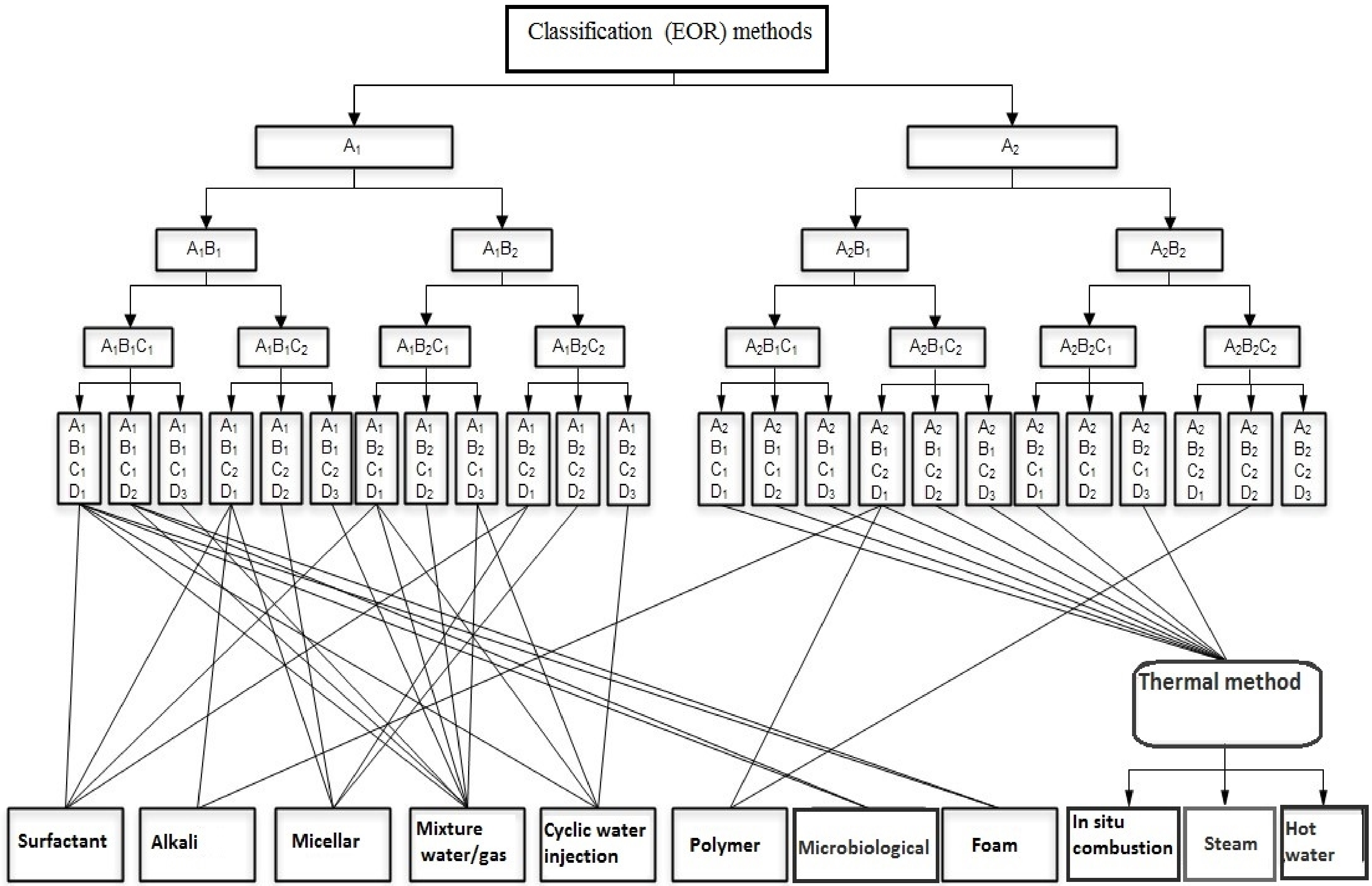

Figure 4.1.0 Classification model of Enhanced Oil Recovery (EOR) methods(9)

CONCLUSIONS AND RECOMENDATIONS

Conclusions

Result of field development analysis of SWG identifies that the main volume of obtained oil is produced from water flooded part (X horizon, lower and upper part of Pereriva Suite) of the field.

The rate of injected water volumes does not compensate produced liquid volumes. Therefore, the current oil recovery factor is approximately equal ultimate oil recovery factor and sometimes current oil recovery factor is more than ultimate recovery factor. Oil particular flows among the blocks, it is explained with the active natural water drive mechanism and good reservoir conditions of SWG.

Analysis formation water shows that its mineralization is decrease during development of field, it is sign of perimeter flooding waters with less minerals enter border of field. Signs of injected sea water mainly is not observed in the produced formation water.

Water injection wells locate far from production wells at south flank of Pereriva Suite that is why water injection process is less effective.

Recommendations

The following suggestions is proposed about providing rational development of Pereriva Suite, Gunashli field.

1. It should be noted that centralized water injection process, which using in order to artificially influence to layers, is not suitable in that kind of fields.
2. In future, water injection process should be carried out from III, V and VII zones by drilling new wells or converting current less productive oil wells.
3. In addition to water injection process, application of enhanced oil recovery methods (chemical, polymer water injection, steam injection, acoustic influence to layers and etc.) should be evaluated for the better oil recovery.
4. In order increasing acceptance of injection wells, accidazing filter zone of injection wells is an effective method.
5. Using surfactants is effective in order to increase permeability of rocks in the bottom hole of the wells. As surfactants, alkanes are suitable.
6. Collecting and analyzing geological, exploitation, drilling and logging data of reservoir are important for the mapping 3D, 4D reservoir models and doing reservoir simulation by using new software help us to clearly generate prediction of reservoir development.
7. In order increasing efficiency water injection processes, some flooded production wells should be used as injection well in future.

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