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Future Hydrocarbon Potential of Kazakhstan [1]

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Abstract

Most of Kazakhstan's oil and gas reserves have not been developed. Many areas remain under or unexplored. It is anticipated that a considerable portion of Kazakhstan's potential oil and gas reserves will be located offshore in the Caspian Sea. Future reserves will be discovered and developed utilizing international technology that was unavailable to the nation during the Soviet period and as commercially justified with better access to world markets.

To date some 250 oil and gas accumulations have been identified in Kazakhstan of which approximately 110 have been developed. Four basins/provinces, considered to have the most potential for undiscovered reserves, are reviewed. These are listed in order of descending potential.

1. North Caspian (Peri-Caspian) Basin, also referred to as Pri- or Pre-Caspian
2. Middle Caspian Basin-Mangyshlak Province
3. South Turgay Basin
4. North Ustyurt Basin

Kazakhstan's cumulative oil production is estimated to be 3.8 billion barrels with approximately 13.2 billion barrels in identified reserves. Probabilistic estimates of undiscovered oil/condensate are in the 14 billion-barrel (P_{95}) to 89 billion-barrel (P_5) range with the mode (most likely) at 26 billion barrels. Potential gas reserves are equally impressive with identified reserves at 83 trillion cubic feet.

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Figure 1 – Kazakhstan: Location map.

Probabilistic estimates of undiscovered gas are in the 66 trillion cubic feet (P95) to 495 trillion cubic feet (P5) range with the mode (most likely) at 124 trillion cubic feet. The bulk of undiscovered oil/condensate and gas reserves are estimated to be attributable to Kazakhstan's portion of the North Caspian (Peri-Caspian) Basin.

Introduction

Kazakhstan, as other Former Soviet Union nations in the Caspian region, Azerbaijan, Russia, Turkmenistan, and Uzbekistan, are already major energy producers, and production will likely increase with additional investment, technology, and the development of new export outlets **(Figure 1)**.

Most of the oil and gas reserves in Kazakhstan and the region have not been developed, and many areas remain under or unexplored. A sizeable portion of Kazakhstan's resources will be likely located in the Caspian offshore utilizing international state of the art technology, some of which was unavailable to the nation during the Soviet period (Effimoff, 1999).

Oil and gas basins/ provinces and regions of Kazakhstan are depicted in **figure 2.** It should be noted that provinces and regions are administrative divisions but generally reflect geology or type of production associated within an area.

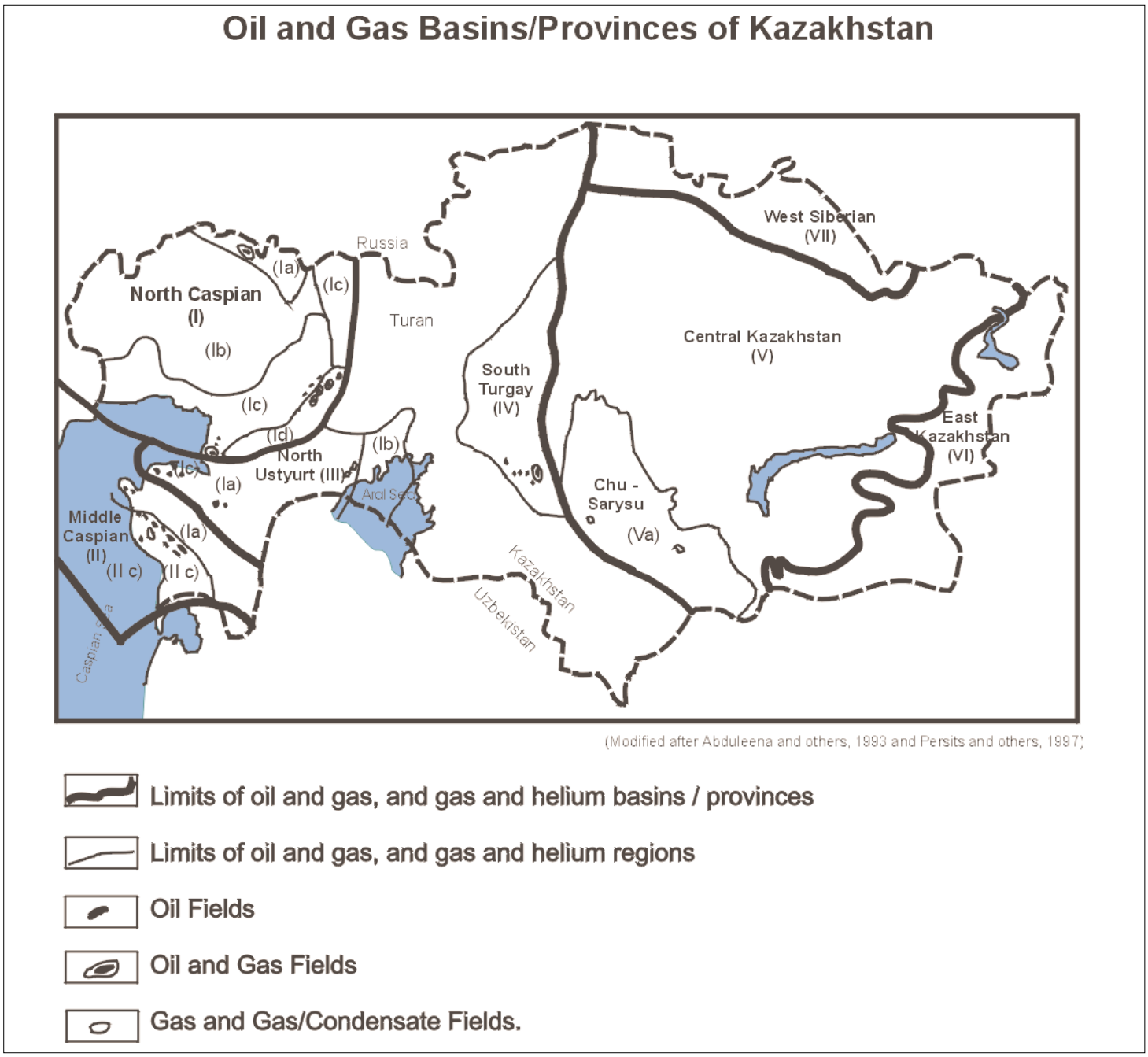

Figure 2 – Oil and gas basins / provinces of Kazakhstan (modified after Abduleena and others, 1993, and Persits and others, 1997).

I. North Caspian (Peri-Caspian) basin and oil and gas province: (a.) Northwest oil and gas region, (b.) Central oil and gas region, (c.) Astrakhan-Aktubinsk oil and gas region, (d.) South Emba oil and gas region, and (e.) Ural foredeep oil and gas region.

II. Middle Caspian basin-Mangyshlak province: (a.) Mangyshlak oil and gas region, (b.) South Mangyshlak oil and gas region, and (c.) Middle Caspian oil and gas region.

III. North Ustyurt Basin (part of Turan oil and gas province): (a.) North Ustyurt oil and gas region, (b.) Central Aral oil and gas region, and (c.) Buzachi oil and gas region.

IV. South Turgay Basin (part of Turan oil and gas province).

V. Central gas and helium province: (a.) Chu-Sarysu basin, and gas- helium region.

VI. East Kazakhstan gas and helium province.

VII. West Siberian oil and gas province.

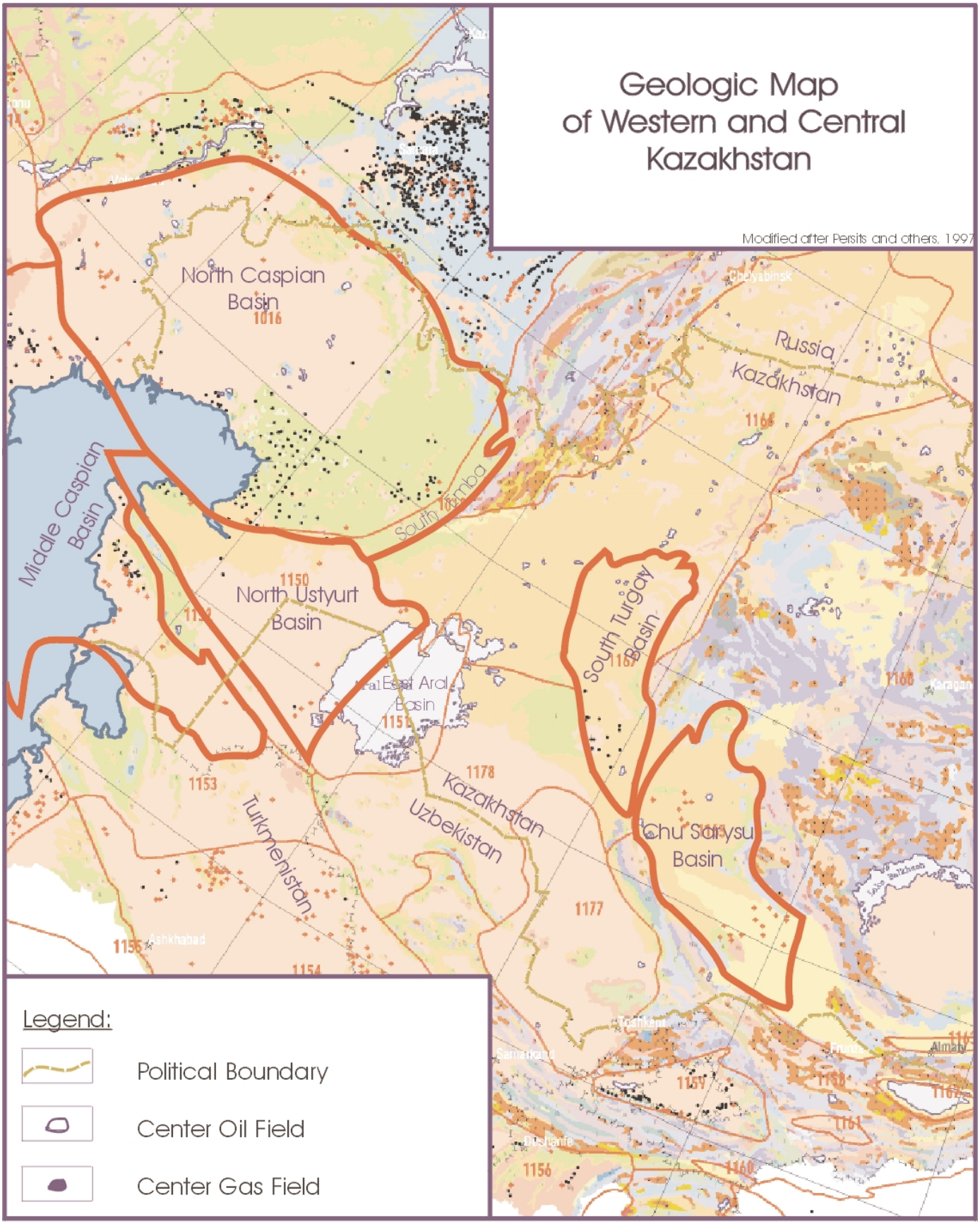

Figure 3 – Geologic map of western and central Kazakhstan. Basins discussed are highlighted.

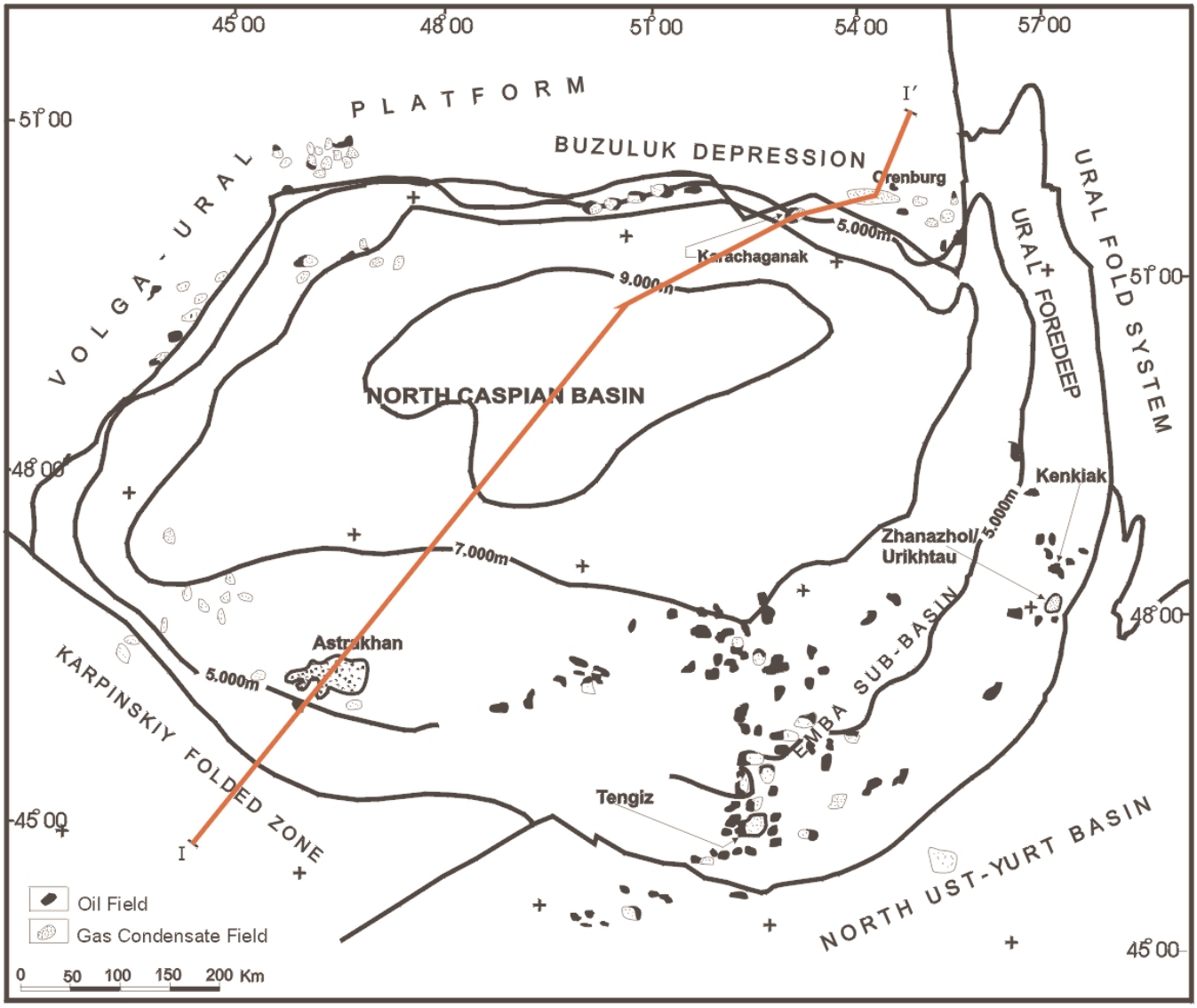

Figure 4 – North Caspian Basin: structure map on top of pre-Kungurian (sub-salt) section showing oil and gas fields. Major fields noted.

History, Oil and Gas Reserves and Production

Oil in Kazakhstan has been known anecdotally for centuries as evidenced by many localities near the Caspian incorporating the word “munai” in their name. “Munai” is the Kazakh word for oil. A. Bekovitch-Cherkasky, the head of a military expedition sent by Peter the Great to Khiva, provides some of the earliest written documentation of oil deposits in present day Kazakhstan. In 1717, the expedition crossed the border of Guryev Province and compiled geographical information including data on local oil seeps. Drilling for oil commenced in the 1890s with first commercial oil production being established in 1911 from a depth of 225 meters in the Dossor area (Myzaprova, 1998).

To date some 250 oil and gas accumulations have been identified in Kazakhstan of which 107 have been developed (Myzaprova, 1998). Cumulative oil production is about 3 billion barrels with approximately 17 billion barrels in identified reserves. Probabilistic estimates of undiscovered oil are

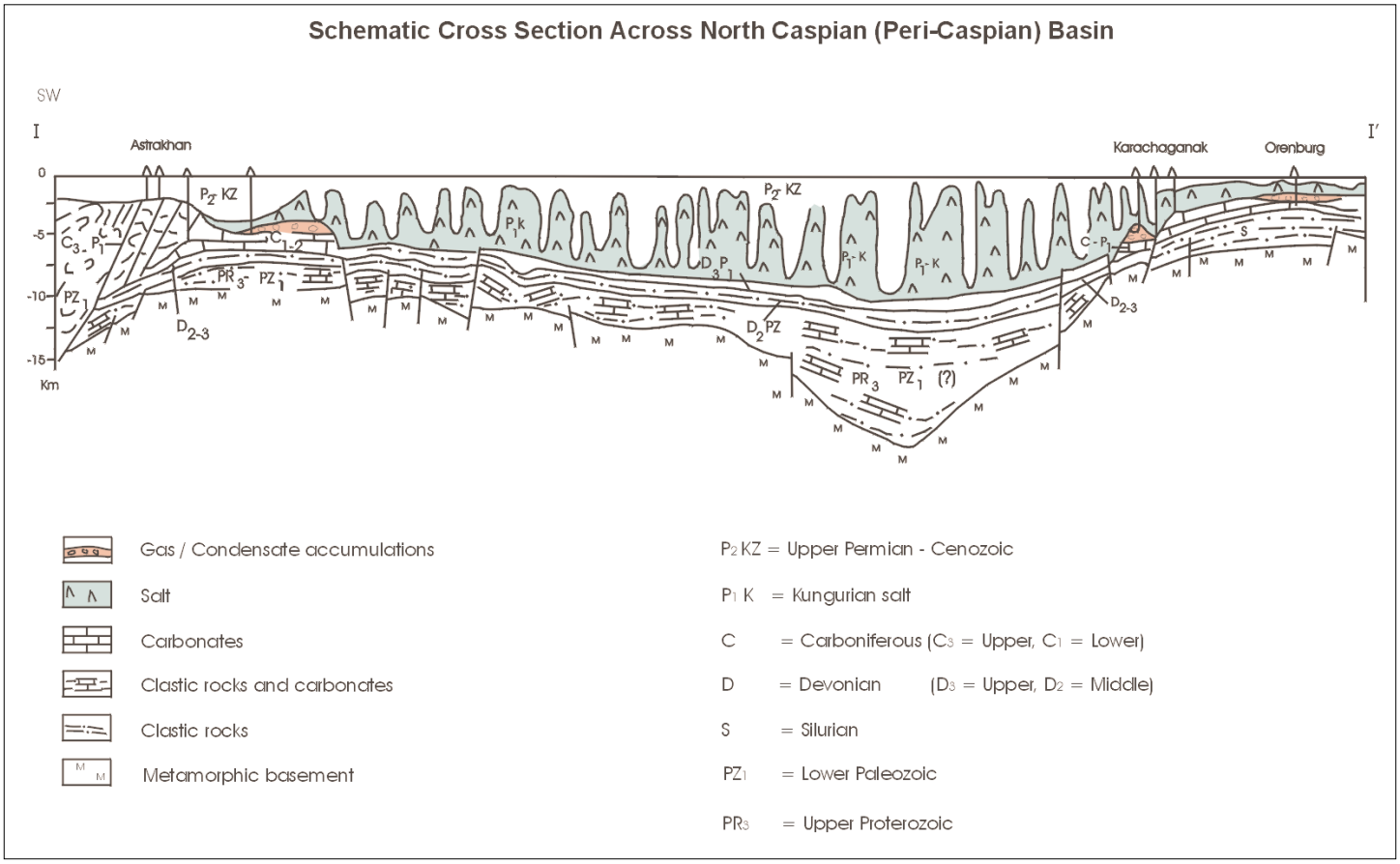

Figure 5 – Schematic cross section across North Caspian (peri-Caspian) Basin.

in the 14 billion (P95) to 89 billion (P5) range. The mode (most likely) is at 26 billion barrels with the bulk of oil reserves attributable to the Kazakh portion of the North Caspian (Peri-Caspian) Basin. The Basin is also referred to as the Pri or Pre Caspian Basin in the literature. Potential gas reserves are equally impressive with identified reserves at 83 TCF, with probabilistic estimates of undiscovered gas in the 66 TCF (P95) to 495 TCF (P5) range. The mode (most likely) is at 124 TCF. Again the majority of potential gas reserves are anticipated to be derived from the North Caspian Basin (Ulmishek and Masters, 1993, and EIA b, c, d, 1999).

Kazakhstan is the second largest oil producer among the former Soviet republics after Russia. In 1997 Kazakhstan produced 521 million BOPD, down from 530 MMBOPD in 1992 but up from 414 MMBOPD in 1995. Gas production in 1997 was 605 MMCF/D, down from 795 MMCF/D in 1992 but up from 410 MMCF/D in 1996 (EIA, 1999).

Almost half of Kazakhstan's oil production comes from three large onshore fields- Tengiz, Uzen, and Karachaganak. In 1993, Chevron concluded a $20 billion joint venture (Tengizchevroil) to develop the Tengiz oil field, with 6-9 billion barrels of estimated recoverable oil reserves. Tengizchevroil exports about 170,000 bbl/d of crude oil through the Russian pipeline system; by barge and rail to the Baltic; and by ship, pipeline, and rail to the Black Sea. Given adequate export outlets, Chevron believes it can reach peak production of 750,000 b/d from the field by 2010. The Caspian Pipeline Consortium (CPC) will export Tengiz oil to world markets via a 900-mile, $2.3 billion oil export pipeline connecting to the Russian Black Sea port of Novorosiisk.

Table 1 Petroleum Resources of Kazakhstan

Oil
Billion Barrels

Basin/ Province	Cumulative Production	Identified Reserves	Undiscovered Resources			
			95%	Mode	5%	Mean
North Caspian (Peri-Caspian)	0.8	12.8	10	23	80	36
Middle Caspian-Mangyshlak	2.1	1.6	2	1	2	2
South Turgay	0	0.7	1	1	5	3
North Ustyurt	0.3	1.8	1	1	2	1
Chu-Sarysu	0.0	0.0	0	0	0	0
Total	**3.2**	**16.9**	**14**	**26**	**89**	**42**

Natural Gas
Trillions of Cubic Feet

Basin/ Province	Cumulative Production	Identified Reserves	Undiscovered Resources			
			95%	Mode	5%	Mean
North Caspian (Peri-Caspian)		80.0	63	118	480	209
Middle Caspian-Mangyshlak	6.5	1.3	1	2	8	5
South Turgay	0	negligible	0	1	1	1
North Ustyurt	0.6	0.4	1	1	2	1
Chu-Sarysu	0.0	2.0	1	2	4	2
Total	**7.1**	**83.7**	**66**	**124**	**495**	**218**

Modified after Ulmishek and Masters, 1993

Kazakhstan has undertaken a number of reforms in order to develop its potential, including privatizing a number of existing energy concerns, however Kazakhstan needs to resolve two major issues in order for it to further increase oil production. Development of the offshore potential of Kazakhstan in the Caspian Sea has been slowed by a dispute over ownership rights. This disagreement ties in with a broader debate between Caspian Sea Region states over how the Caspian Sea should be treated under international law. The other major issue is the development of export routes to bring Kazakhstan's oil to world markets. Under the former Soviet Union, all of Kazakhstan's oil was exported through the Russian pipeline system. Kazakhstan still views Russia as a viable export option, and the existing export pipeline to Russia will be expanded by 1999. In addition, the CPC pipeline will also pass through Russia en route to the Black Sea. Other oil export pipeline options from the Caspian Sea region are also being explored.

More than 40% of Kazakhstan's 83 Tcf of identified natural gas reserves are located in the giant Karachaganak field in its northwest area, on trend with Russia's Orenburg field. Liquids production from the field is expected to exceed 300,000 bbl/d by 2006, with the output to be exported using the CPC pipeline, and gas output should reach over 883 billion cubic feet (Bcf) annually.

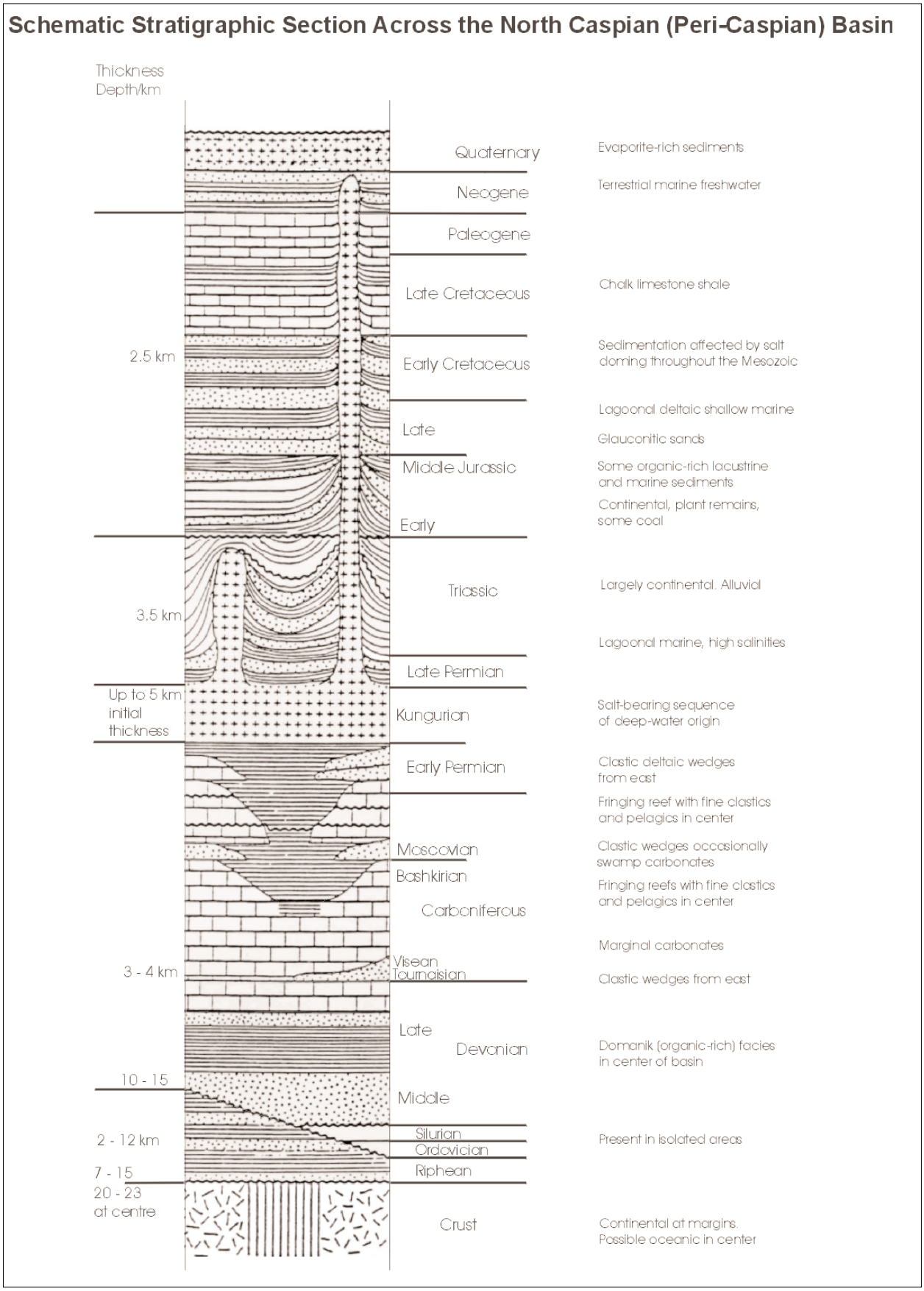

Figure 6 – Schematic stratigraphic section across the North Caspian (Peri-Caspian) basin.

Kazakhstan's other significant gas production comes from Tengiz, Zhanazhol, and Urikhtau fields. Associated gas production at the Tengiz field rose to over 50 Bcf in 1997, and the field will become the second largest producer of gas in Kazakhstan. The undeveloped offshore areas are also believed to hold large amounts of gas. While some of these fields are near the Russian gas pipeline system, they are not currently linked to it, and Russia's Gazprom is a potential competitor with Central Asian gas on world markets. Kazakhstan must either negotiate to connect its fields with the existing Russian gas pipeline system, or develop new ways of getting gas to markets.

In general, the Kazakh gas sector faces a lack of infrastructure, especially pipelines. Although six gas pipelines connect Kazakhstan to other Central Asian republics and Russia, gas-producing areas within Kazakhstan in the west are not connected to consuming areas such as the populous southeast and industrial north. Construction of an internal pipeline is under consideration to transport gas from Kazakhstan's western field to all oblasts in Kazakhstan (EIA a, 1999).

Assessment of Undiscovered Reserves

Ulmishek and Masters (1993) provide an excellent assessment of undiscovered oil and gas resources in countries of the Former Soviet Union (FSU) including Kazakhstan. The assessments were made by participants of the World Energy Resources Program of the U.S. Geological Survey utilizing a modified Delphi (subjective) method and based on multi-year studies of the geology of FSU basins and exploration results (Masters and others, 1998). Kazakhstan's reserves and undiscovered resources are allocated on a basin by basin basis and are presented in **Table 1.**

Four of Kazakhstan's basins / provinces are considered to have the most potential. These are listed in descending order of potential, based primarily on propensity for oil and secondarily for natural gas:

1. North Caspian (Peri-Caspian Basin) , also referred to as Pri-Caspian or Pre-Caspian
2. Middle Caspian Basin-Mangyshlak Province
3. South Turgay Basin
4. North Ustyurt Basin

In view of the significance of the oil and gas potential of the North Caspian Basin, as depicted in Table 1, the following discussion will focus on the North Caspian (Peri-Caspian) Basin, with shorter discussion on the next three Basins / Provinces. The Chu-Sarysu Basin in touched upon for completeness. Mentioned basins are depicted on the geologic map of western and central Kazakhstan **(Figure 3)**.

North Caspian (Peri-Caspian) Basin

The North Caspian Basin possesses the most significant potential for the discovery of oil and gas in Kazakhstan. Russia and Kazakhstan share the basin on an approximately 20%-80% basis, respectively. The Basin covers approximately 550,000 square kilometers and represents a deeply subsided portion of the Russian Platform that is bound on all sides by deep seated regional faults, which accommodated Paleozoic and Mesozoic subsidence. Basement faulting is documented throughout the basin but is most prevalent along the southern and eastern margins **(Figure 4)**. Although, basin formation can be inferred to have commenced during the Riphean (Proterozoic), subsidence can be documented to have been initiated in the Devonian.

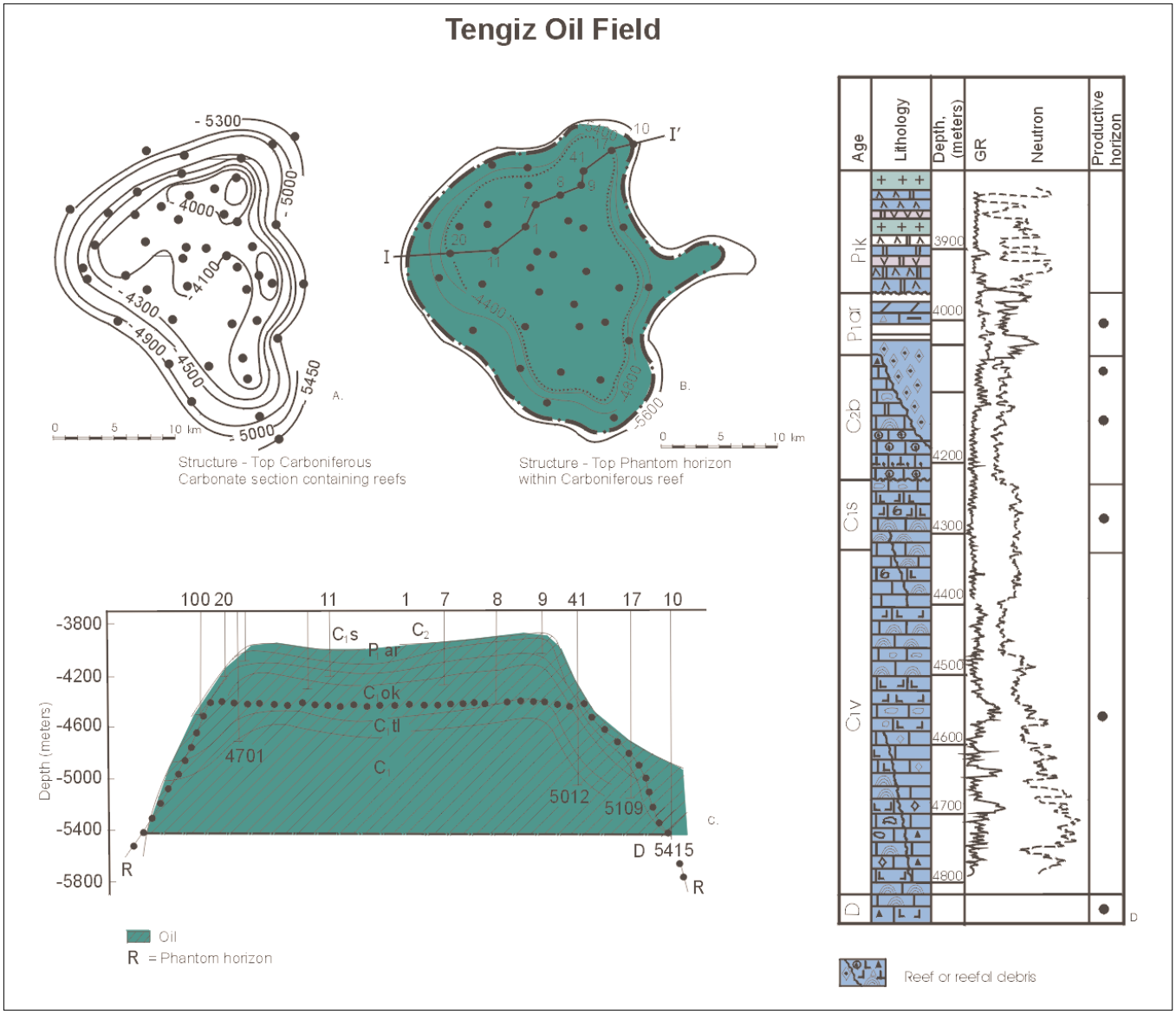

Figure 7 – Tengiz oil field (modified after Abduleena and others, 1993): (a.) Structure map on top of Carboniferous carbonate section containing reefs. (b.) Structural map on a phantom horizon within the Carboniferous reef section with oil-water contact indicated. (c.) Composite stratigraphic section for Tengiz field: (Permian): P1k=Kungurian, P1ar= Artinskia; (Carboniferous): C2b= Bashkirian, C1s= Serpukhovian, C1v= Visean; and (Devonian): D

The Permian (Kungurian) salt section divides the basin's hydrocarbon systems and stratigraphy into a pre-salt and a post-salt section. Pre-salt hydrocarbon accumulations are localized primarily in Devonian to Permian carbonates in stratigraphic and/or basement related structural traps. Hydrocarbons in the post-salt section are located in Mesozoic clastic reservoirs, generally in structural traps, that often have a strong stratigraphic component, and are formed by the movement of the Permian salt **(Figure 5)** (Dongaryan, 1990, Ponchva and Savvinova, 1980).

The basin may contain more than 20 kilometers of sediments at its center ranging in age from the Riphean to the Quaternary **(Figure 6**). It is thought that an oceanic crust may underlie the center of the basin. Clastics prevail in the section from Riphean to late Devonian time. The organic rich facies

of the Domanik formation, representing the main source rock package for production from Paleozoic reservoirs, was deposited at the center of the basin during the middle Devonian. This early clastic sequence is followed, from the late Devonian through the early Permian primarily by carbonates, with incursions of clastics along the basin margins, sourced mainly from the east/southeast and secondarily from the northwest. Most of the large fields in the basin occur in reefs and/or carbonate debris of Carboniferous to Permian age that ring the basin, as well as associated facies. Associated facies include high-energy fringing reefs and banks, low energy platform interior facies and bank slope deposits. Production is usually associated with zones that have been enhanced by fracturing and/or the development of Karst. Examples of such fields are Tengiz **(Figures 7 a, b, c),** Karachaganak **(Figures 8 a, b)** and Zhanazhol **(Figures 9 a, b, c)**. There is some production from Carboniferous clastic facies. A lower to middle Permian (Kungurian) salt bearing sequence is believed to be of deep water origin and up to 2500-3000 meters in thickness at the time of deposition. This salt is diapric and therefore varies greatly in thickness. Post-salt stratigraphy consists primarily of continental and lacustrine facies from late Permian through the early Jurassic grading into shallow marine clastics in the early Cretaceous. Middle Jurassic shales accumulating in anoxic environments are considered to be source rocks generating oil and gas for accumulations in the post-salt sequence. Chalks, limes and shales dominate from the late Cretaceous to the Neogene, followed by a mixed stratigraphy of continental and shallow marine sequence in the Neogene. The Quaternary consists of evaporite rich sediments. It should be noted that post-salt stratigraphy, particularly during the Mesozoic, is influenced by movement of the Kungurian salt. Post-salt reservoirs are mid to late Jurrasic and lower Cretaceous sandstones such as at the Kenkiak field **(Figures 10 a, b, c)** (Arabadzhi and others, 1993, Bagrintseva and Belozerova, 1987, Dalyan and Posadskaya, 1972, Demidov, 1992, Demidov, 1996, Ivanov, 1988, Kochariyants and others, 1979, Shlygin, 1997, Tarkanov and Bezborodova, 19 , Trochimenko, 1987, Vladimirova and Maltseva, 1990, Zamarenov and others, 1986).

The Basin has a relatively low thermal gradient in the eastern half of the basin with gradients of 1-2 degrees centigrade/100 meters increasing to 2-3 degrees centigrade/100 meters in the western half and to southwest. The highest thermal gradients are in the southwestern most portion, immediately west of Atyrau on the Caspian Sea reaching 4.5-4.8 degrees centigrade/100 meters. Generally, onset of hydrocarbon generation for pre-salt source rocks is considered to be late Permian/Triassic, and for post-salt, late Cretaceous/Paleogene (Egorova, 1979, Kalinko and others, 1993, Kiryukhin and others, 1984, Medvedeva and others, 1993, Svetlakova, 1987).

During the past two decades years, several supergiant oil and gas condensate fields (Tengiz-1979, Karachaganak-1979 and Zhanazhol-1984) and a number of smaller, but significant, fields were discovered in rocks beneath the thick Permian salt of the Basin. The Basin is still in an immature stage of exploration because of great depths to potential reservoirs, high reservoir pressures, and high sulfur content in the gas. The potential of the basin remains high for the pre-salt Paleozoic carbonate rocks and associated reefs and clastic fans on the margins. Carboniferous and Lower Permian clastic fans are widespread along the eastern and southern margins of the Basin. A shallow, Mesozoic, post-salt salt-dome play has been explored for many years, and still possesses a significant petroleum potential.

Middle Caspian Basin-Mangyshlak Province

The Middle Caspian Basin-Mangyshlak Province of Kazakhstan covers about 75,000 square kilo-

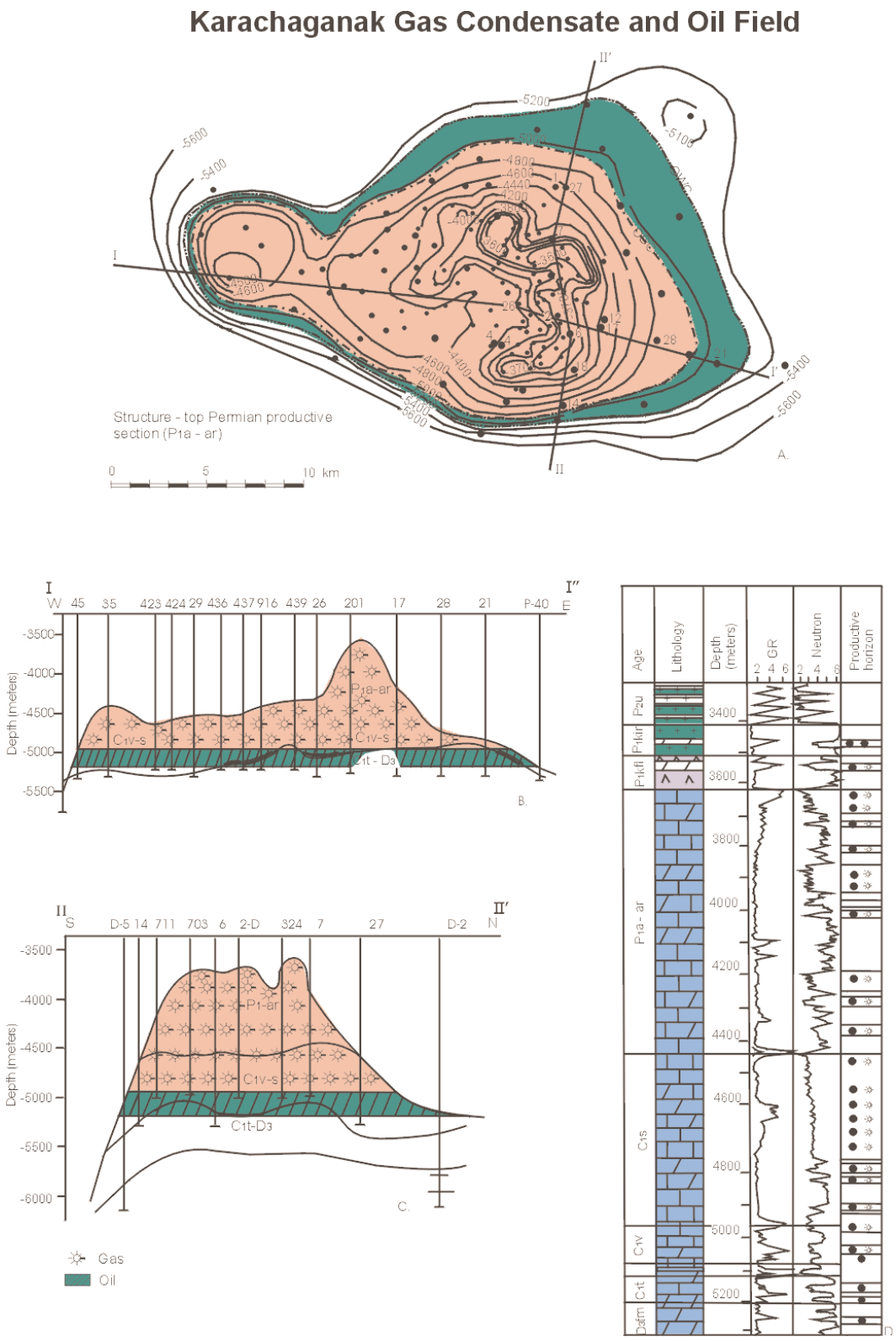

Figure 8 – Karachaganak gas condensate and oil field (modified after Abduleena and others, 1993): (a.) Structural map on top of Permian productive section; top and base of oil rim outlined. (b.) Composite stratigraphic section for Karachaganak field: (Permian): P2u= Ufimian, P1k= Kungurian, P1a-ar= Asselian – Artinskian; (Carboniferous): C1s= Serpukhovian, C1v= Visean, C1t= Tournaisian; (Devonian): D3fm=Famennian.

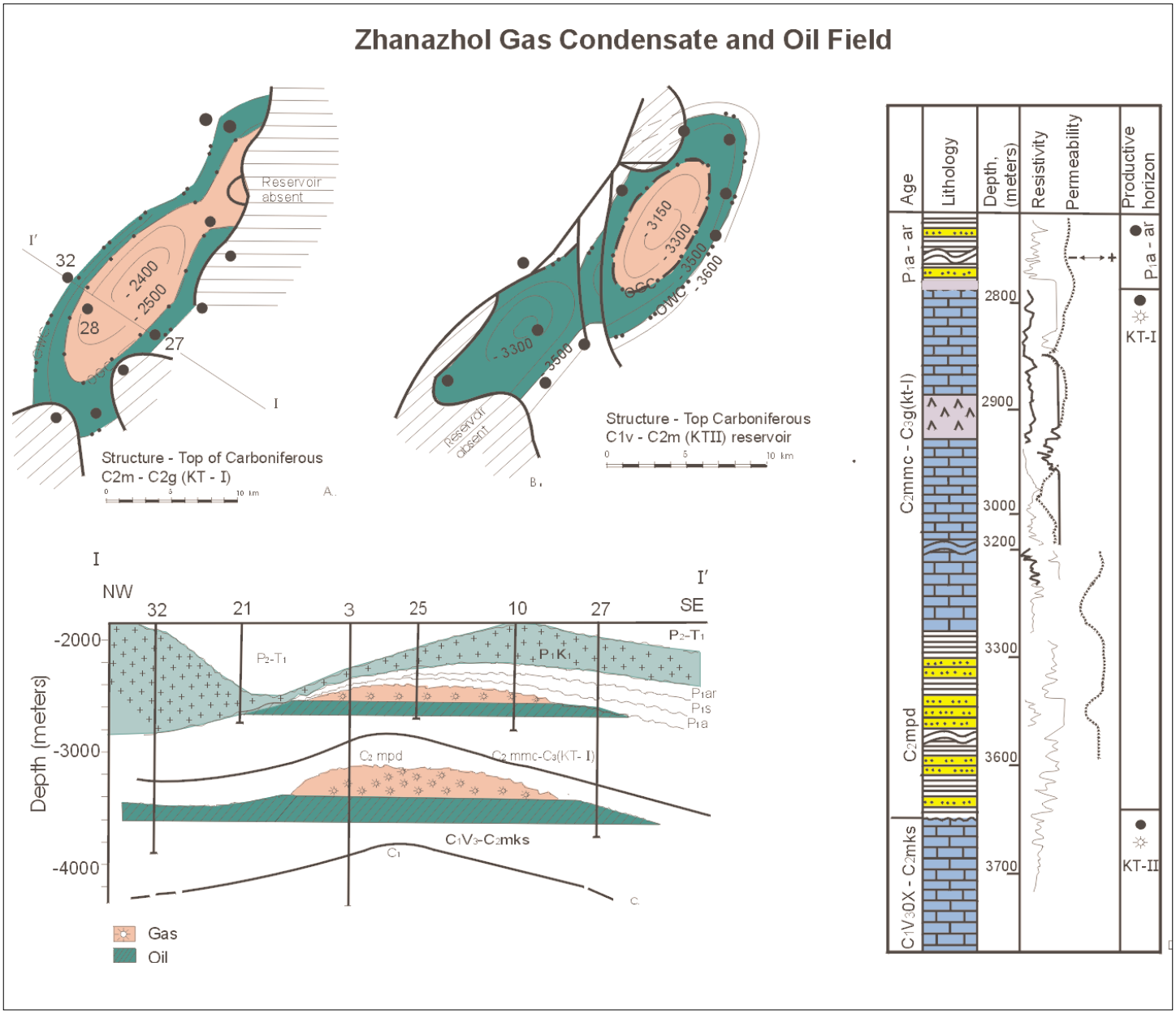

Figure 9 – Zhanazhol gas condensate and oil field (modified after Abduleena and others, 1993): (a.) Structural map on top of Carboniferous C2m-C2g (Moscovian to Gzelian carbonate reservoir (KT-1). (b.) Structural map on top of Carboniferous C1v-C2m (Visean – Moscovian) sandstone reservoir (KT-II), (c.) Composite stratigraphic section for Zhanazol field: (Permian): P1a= Artinskian, (Carboniferous): C2mmc-C3g= Moscovian (Myachkovskian)-Gzelian, C2mpd= Moscovian (Poldoskian), C1v3ox-C2mks= Visean (Okskian-Kashirian).

meters (about 35,000 square kilometers is onshore and about 40,000 square kilometers is offshore). It is part of the North Caucasus-Mangyshlak petroleum province, which extends from the Azov-Kuban basin, in Russia, eastward across the middle of the Caspian Sea onto the onshore Mangyshlak Trough in western Kazakhstan. The onshore areas of the province have been extensively explored; gas dominates in the Azov-Kuban basin, whereas most of the Middle Caspian Basin-Mangyshlak Trough is oil-prone.

The principal part of undiscovered resources for the Middle Caspian Basin-Mangyshlak Province is

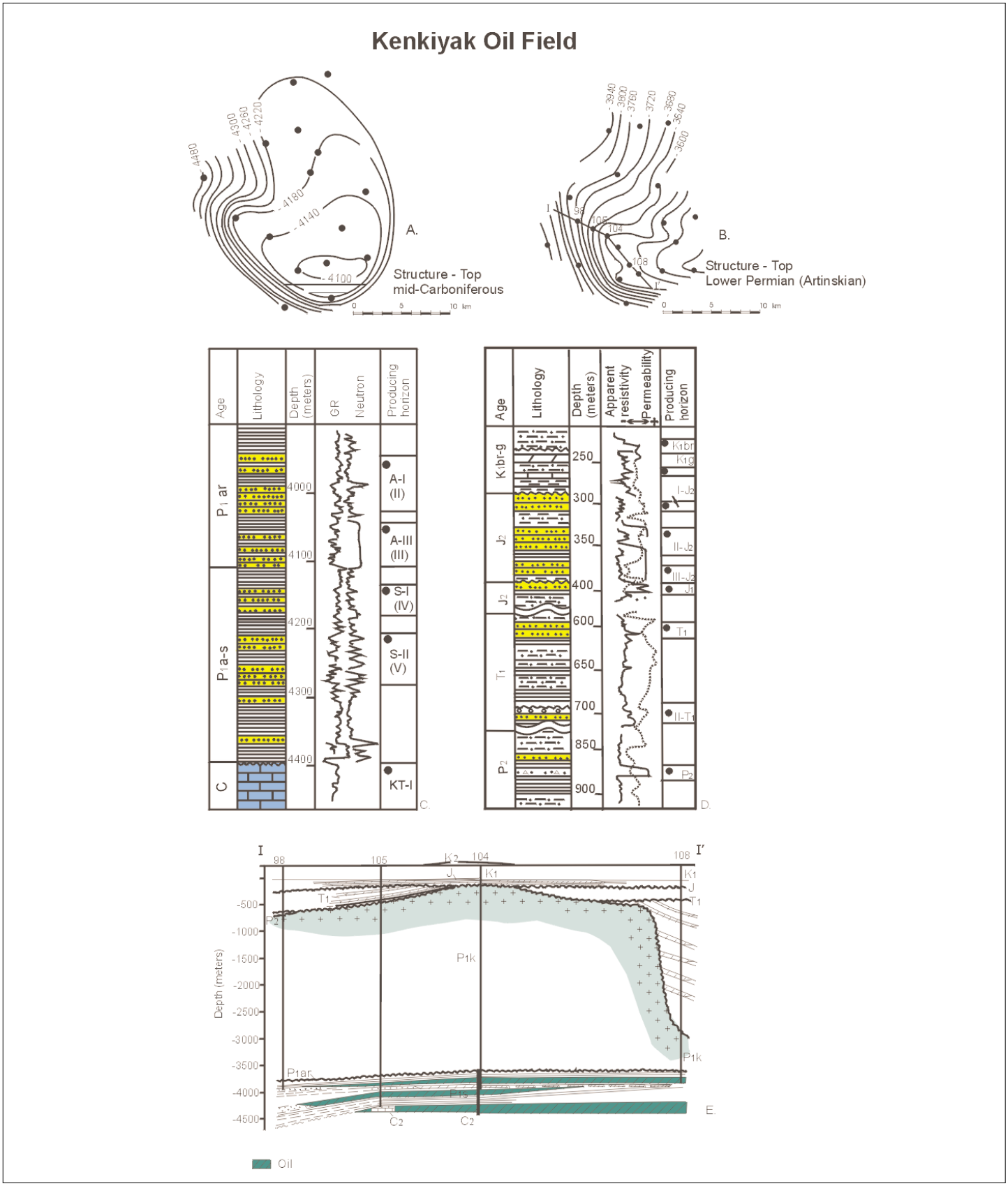

Figure 10 – Kenkiyak oil field (modified after Abduleena and others, 1993): (a.) Structural map on top of the mid Carboniferous, (b.) Structural map on top of the lower Permian (Artinskian) reservoir , (c.) Composite stratigraphic section for Kenkiyak field: (Cretaceous): K1br-g= Barremian, (Jurassic): J1= Dogger, J2= Lias, (Triassic): T1= Scythian, (Permian): P2= Upper Permian, P1ar= Artinskian, P1a-s= Asselian-Sakmarian, and (Carboniferous): C.

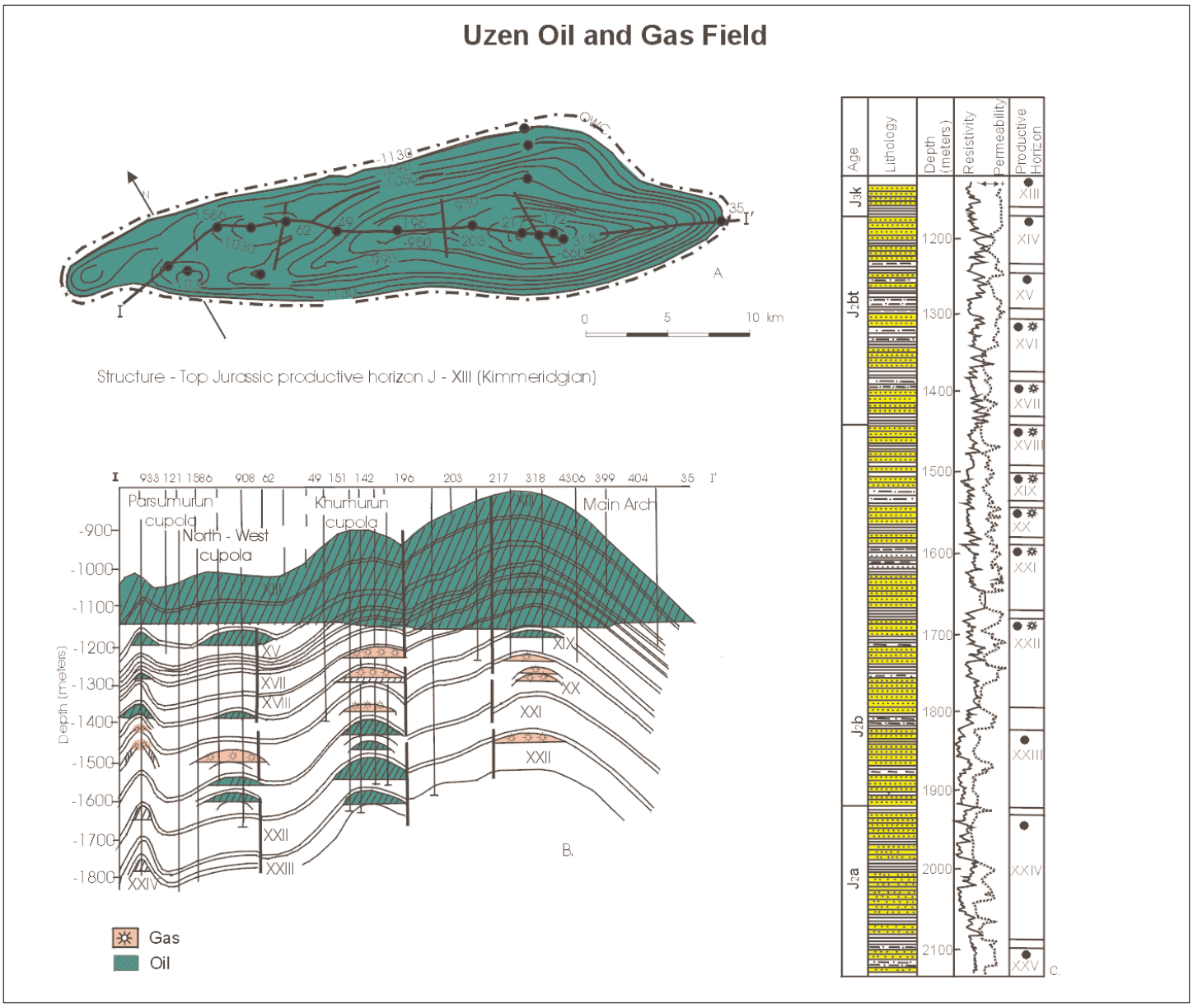

Figure 11 – Uzen oil and gas field -Jurassic pays (modified after Abduleena and others, 1993): (a.)Structural map on top of Jurassic productive horizon J-XIII (Kimmeridgian). Oil pool outline indicated, (b.) Cross section through Uzen field showing pays and culminations (cupolas) along strike at the Jurassic level, (c.) Composite stratigraphic section for the Jurassic producing section: (Jurassic): J3k3=Kimmeridgian, J2bt=Bathonian, J2b= Bojacian, J2a= Aalenian.

located offshore in the unexplored central Caspian Sea of the Middle Caspian basin where Jurassic and Lower Cretaceous clastic rocks in structural traps are the prime exploration targets. Uzen **(Figures 11 a, b, c, d, e, f)** and Zhetybay are two onshore giant fields, which produce from middle Jurassic through lower upper Cretaceous fluvial to deltaic clastics and would serve as analogs for the offshore (Abduleena and others, 1993 and Maximova, 1987). The main reservoirs are middle and upper Jurassic shallow marine to non-marine sandstones. Traps are drapes over Permo-Triassic asymmetric horst features. These features are modified by strike-slip faulting and attendant anticline development (Ulmishek and Masters, 1993).

Source rocks in the area are possibly Permian shales, the Middle Triassic Olenek shale and lower

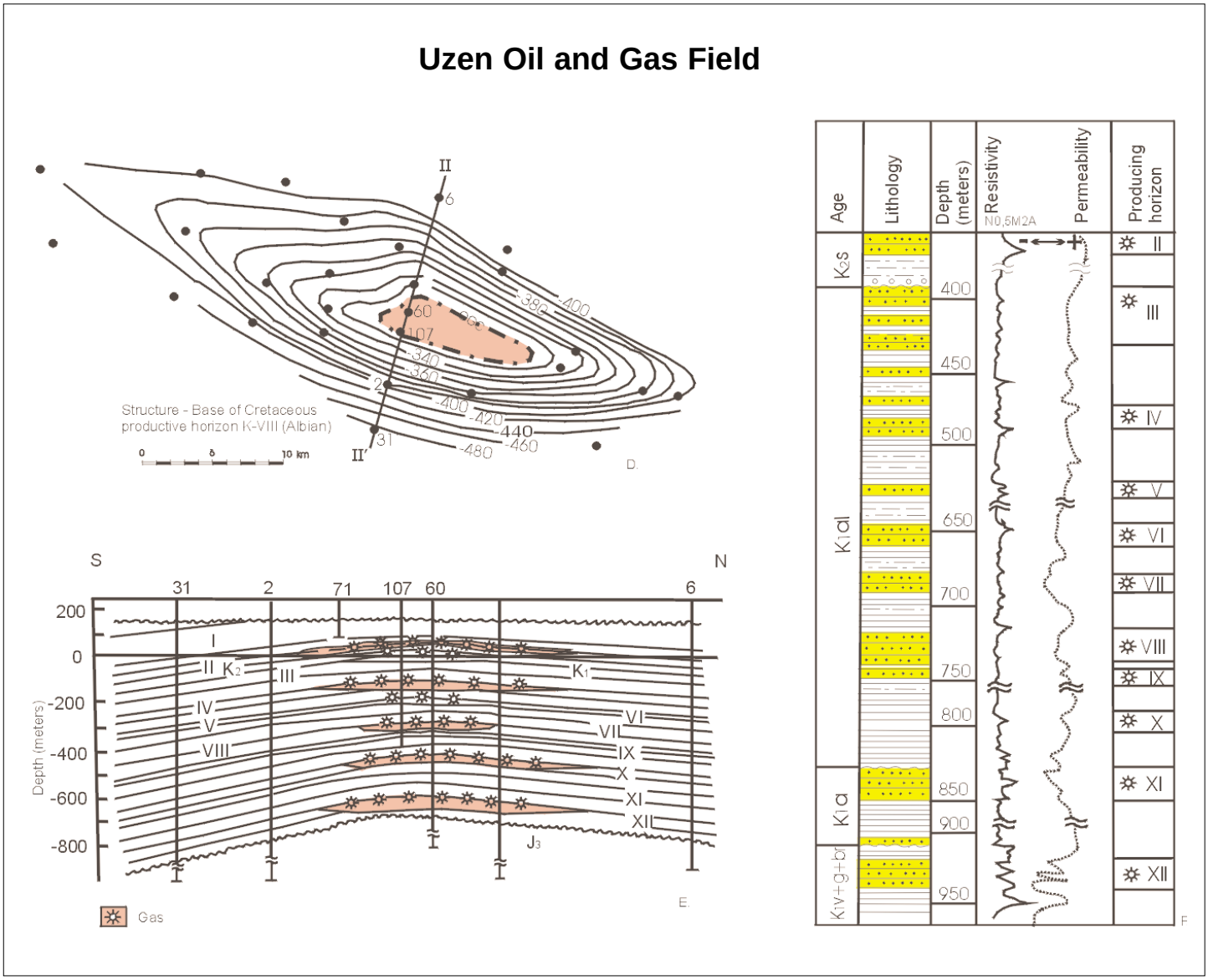

Figure 12 – Uzen oil and gas field - Cretaceous pays (modified after Abduleena and others, 1993): (d.) Structural map at the base of Cretaceous productive horizon K-VIII (Albian). Gas pool outline is indicated, (e.) Cross section through Uzen field showing Cretaceous pays, (f.) Composite stratigraphic section for the Cretaceous producing section: (Cretaceous): K2S= Senonian, K1at= Albian, K1a= Aptian, K1v+g+br= Neocomian.

Jurassic black shales. Generation is likely to have commenced in Cretaceous time. Some oils are highly paraffinic and gas is often sour.

South Turgay

The Turgay Basin covers 160,000 square kilometers and lies entirely in Kazakhstan. Exploration began in the early 1980's and revealed flat-lying Tertiary and Cretaceous rocks underlain by a Lower-Middle Jurassic rift system. About a dozen oil and gas fields have been discovered, but most reserves are concentrated in Upper Jurassic and Cretaceous (Neocomian) clastic rocks in the large Kumkol field with 50-100 MMBOE in reserves **(Figure 12 a, b, c, d)** (Abduleena and others, 1993 and Maximova, 1987).

The basin is lightly explored, with the northern half essentially undrilled. However drilling of a number of structures, similar to Kumkol field, have not resulted in significant discoveries. Much of the remaining potential is probably in stratigraphic and structural traps in the lower-middle Jurassic to lower Cretaceous clastic sequences on north-south oriented horsts in the rift that developed prior to migration. Migration is considered to have commenced in Cretaceous to early Tertiary time. Middle to upper Jurassic shales have high total organic content exceeding 10% in 10-meter zones and are good source rocks for oil. Triassic and Jurassic coal measures up to 50 meters thick serve as gas source rocks. A more speculative play might be in the Lower Carboniferous carbonates on the basin's margin and on tilted horst blocks in the basin (Ulmishek and Masters, 1993).

North Ustyurt

The North Ustyurt basin covers about 145,000 square kilometers of which about the eastern 20% lies in Uzbekistan. The basin occupies a microcontinent in the Hercynian accreted terrain. Thick Triassic and Jurassic through Tertiary clastic sediments overlie a carbonate platform of the microcontinent. Most of discovered reserves are heavy oil with high sulfur content (up to 2.6%) in Jurassic and Cretaceous (Neocomian) rocks, at shallow depths on the Buzachi Peninsula, which is located on the extreme western side of the basin. Karazhanbas field **(Figure 13 a, b, c, d)** is the basin's largest field discovered to date, with about 500 million barrels of oil in recoverable reserves. Elsewhere in the basin several rather small oil fields in Jurassic clastics and a few gas fields, of possible biogenic origin, in Eocene sandstones have been discovered (Abduleena and others, 1993 and Maximova, 1987).

Oil source rocks are not well documented and possibly the oil discovered has migrated from the North Caspian Basin where it was generated from Devonian to Permian shales.

The Jurassic to Tertiary sequence is moderately explored and its potential for undiscovered reserves is deemed relatively low. Future discoveries are likely to be analogous to accumulations discovered to date, also located in anticlines, often fault bound. There is a possibility of yet to be documented stratigraphic pinch out traps along the flanks of the Buzachi Arch on the shore of the Caspian Sea. The deep Paleozoic section has been penetrated only in a few locations. Seismic data in the eastern part of the basin suggests the presence of reefs and basinal facies perhaps containing source rocks. The assessment of undiscovered resources for the basin is conservative and highly uncertain (Ulmishek and Masters, 1993).

Chu-Sarysu

Several hydrocarbon fields have been discovered in Carboniferous and Devonian rocks in the Chu-Sarysu Basin. Pridorozhnoye gas field is a typical example **(Figure 14 a, b, c, d)**. Suspected source rocks in the Devonian to Carboniferous (Tournaisian) section are strongly over-mature and all discoveries have been gas. Gas in the Lower Permian reservoirs, below a salt cap, is dominantly nitrogen with high helium content. The undiscovered potential of the basin is rather low and related to the virtually unexplored Devonian section below the upper Devonian salt seal (Ulmishek and Masters, 1993, Abduleena and others, 1993 and Maximova, 1987).

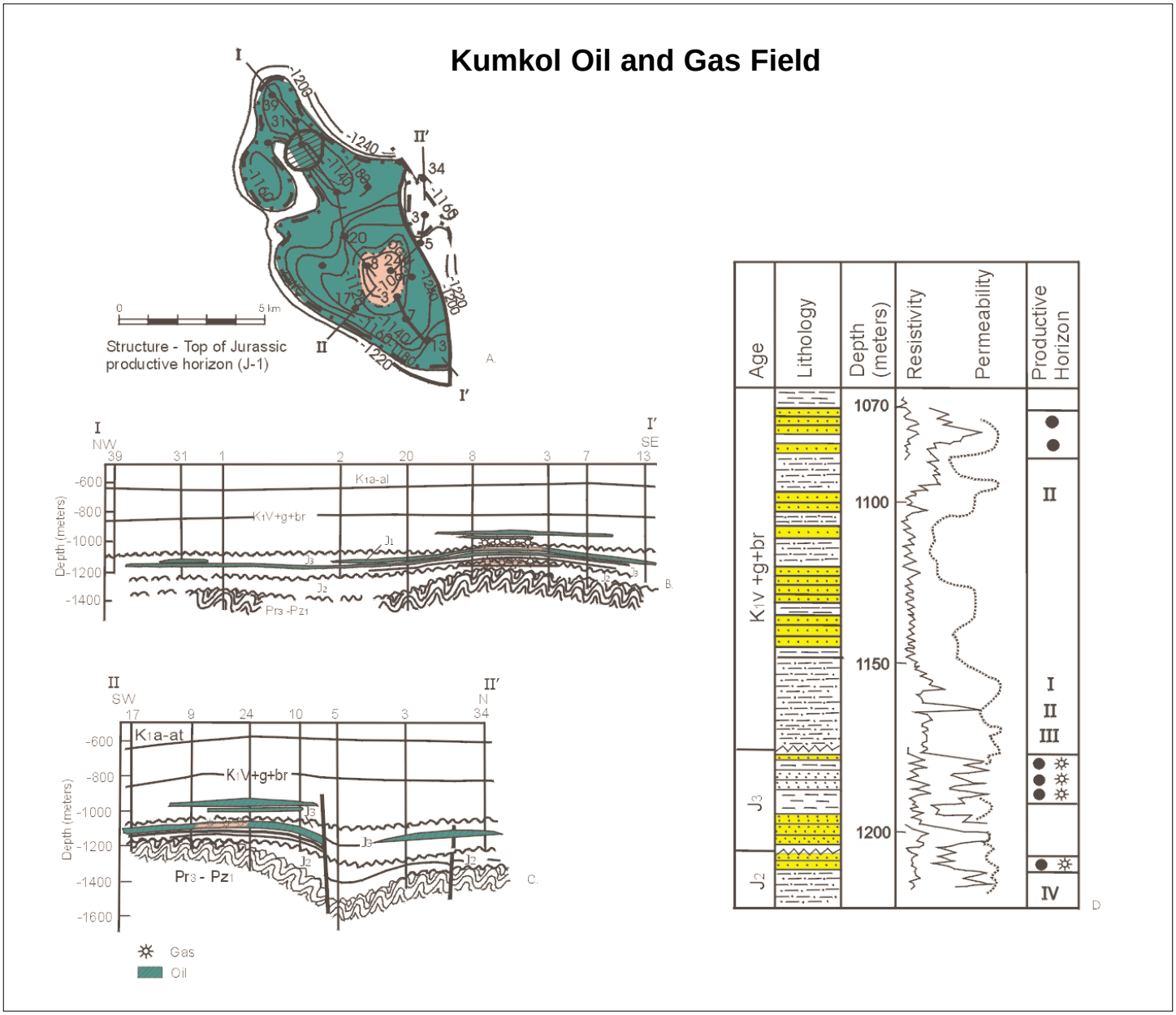

Figure 13 – Kumkol oil and gas field (modified after Abduleena and others, 1993): (a.) Structural map on top of Jurassic productive horizon (J-1). Outlines of oil gas contact and oil water contact are indicated, (b.) Cross section through Kumkol field I-I', (c.) Cross section through Kumkol field II-II', (d.) Composite stratigraphic section for the field: (Cretaceous): K1v+g+br= Valanginian, Hauterivian, Barremian, (Jurassic): J3= Malm, J2= Dogger.

Conclusions

Most of Kazakhstan's oil and gas reserves have not been developed. Many areas remain under or unexplored. It is anticipated that a considerable portion of Kazakhstan's potential oil and gas reserves will be located offshore in the Caspian Sea. Future reserves will be discovered and developed utilizing international technology that was unavailable to the nation during the Soviet period and as commercially justified with better access to world markets and improved infrastructure.

To date some 250 oil and gas accumulations have been identified in Kazakhstan of which approxi-

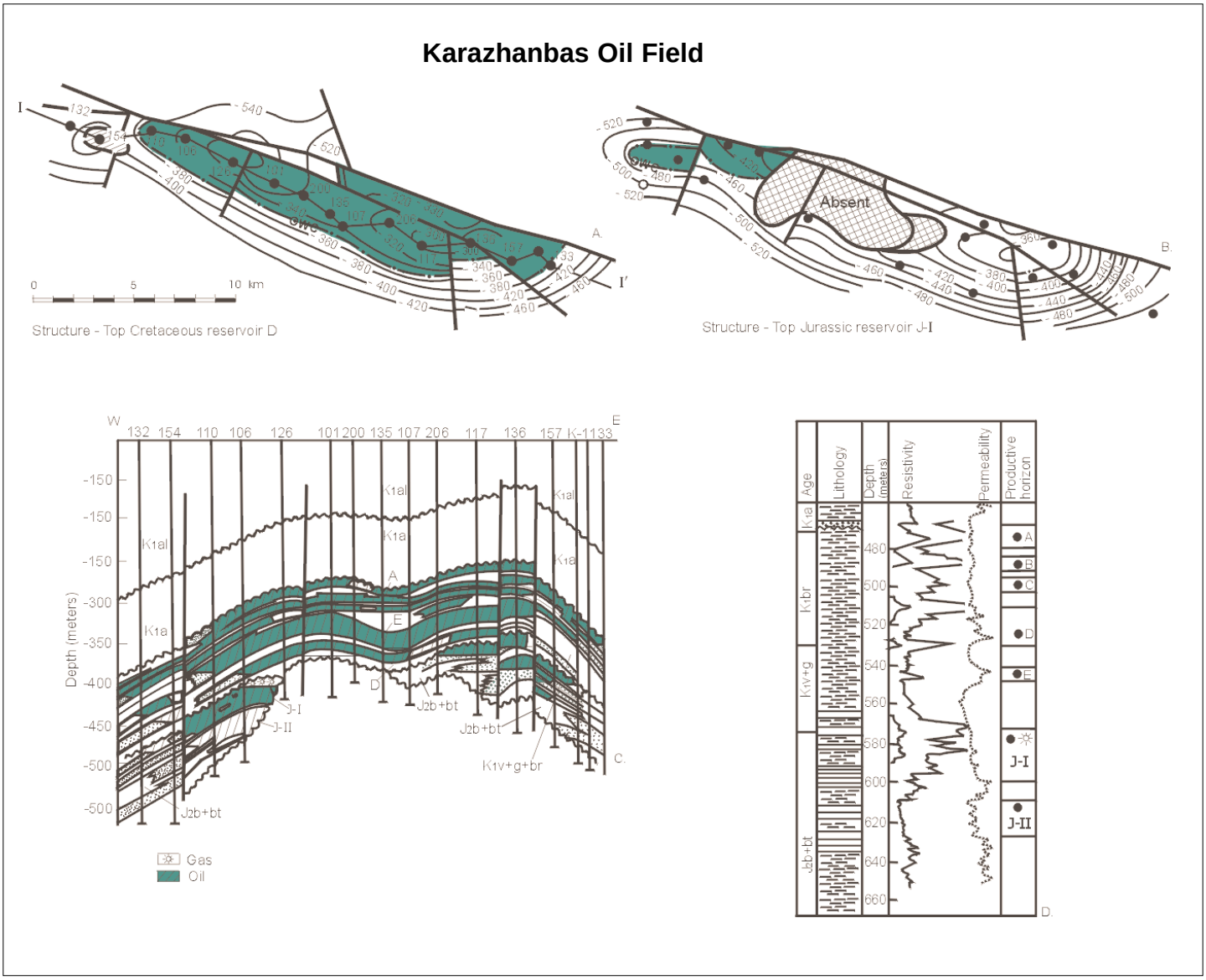

Figure 14 – Karazhanbas oil field (modified after Abduleena and others, 1993): (a.) Structural map on top of Cretaceous reservoir D, (b.) Structural map on top of Jurassic reservoir J-1, (c.) Cross section through Karazhanbas field, (d.) Composite stratigraphic section for the field: (Cretaceous): K1a= Aptian, K1br= Barremian, K1v+g= Valanginian, Hauterivian, (Jurassic): J2b+bt= Bajocian, Bathonian.

mately 110 have been developed. Four basins / provinces, considered having the most potential for undiscovered reserves. These are listed in order of descending potential.

1. North Caspian (Peri-Caspian) Basin
2. Middle Caspian Basin-Mangyshlak Province
3. South Turgay Basin
4. North Ustyurt Basin

Estimates of most likely volumes of undiscovered oil / condensate and natural gas are 26 billion barrels and 124 trillion cubic feet, respectively. The bulk of undiscovered oil / condensate and gas

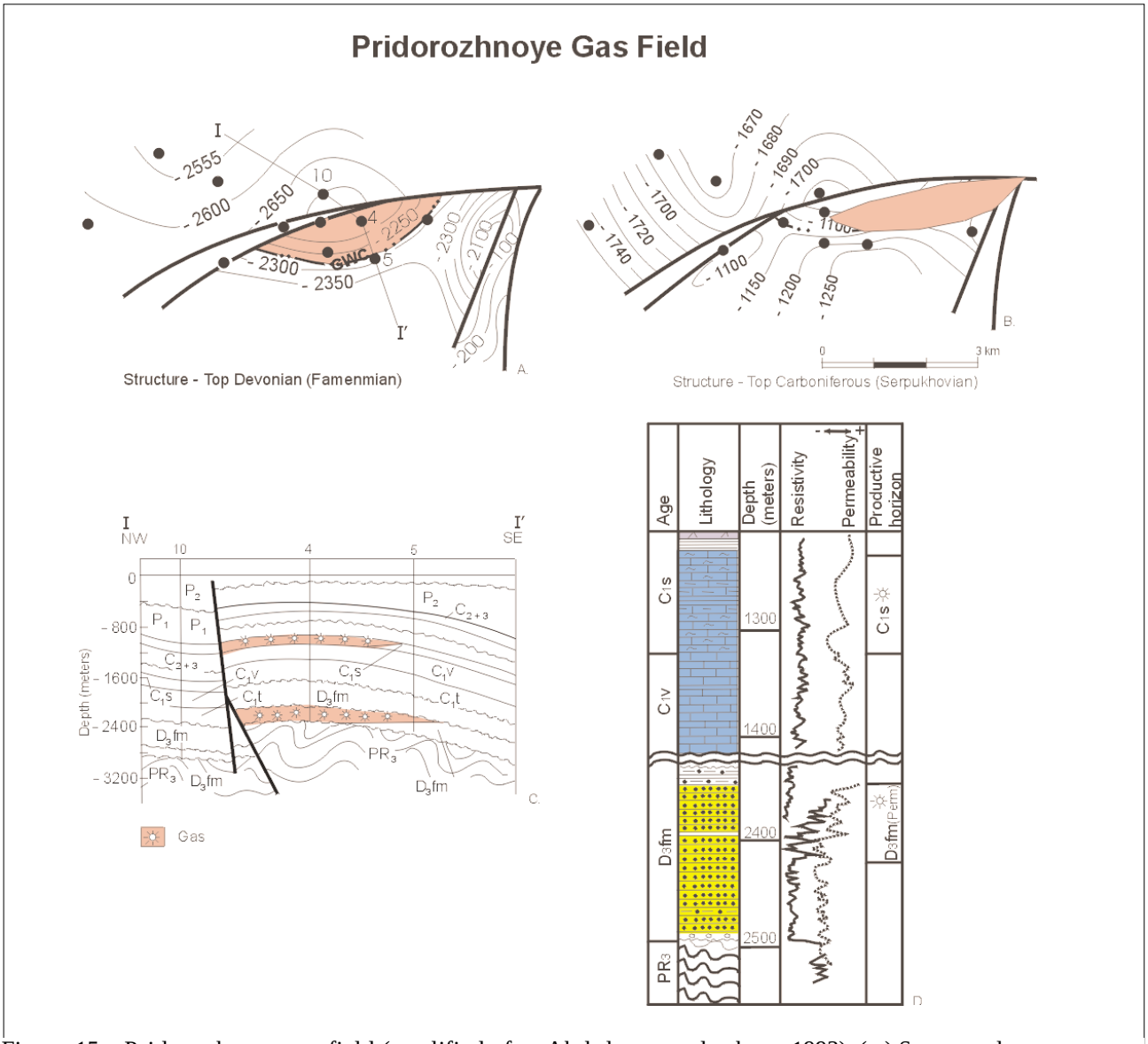

Figure 15 – Pridorozhnoye gas field (modified after Abduleena and others, 1993): (a.) Structural map on top of the Devonian (Famennian) reservoir. Gas water contact is indicated, (b.) Structural map on top of the Carboniferous (Serpukhovian) reservoir, (c.) Cross section across Pridorozhnoye field, (d.) Composite stratigraphic section for the field: (Carboniferous): C1s= Serpukhovian, C1v= Visean, (Devonian): D3fm= Famennian, (Pre Cambrian): PR3= Riphean.

reserves are estimated to be attributable to Kazakhstan's portion of the North Caspian (Peri-Caspian) Basin.

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