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Petroleum system analysis of the Paleozoic series in the Fars Platform of Iran

Majid Alipour [a,b,*], Bahram Alizadeh [a,c], Shohreh Mirzaie [d]

[a] Shahid Chamran University of Ahvaz, Faculty of Earth Sciences, Department of Petroleum Geology and Sedimentary Basins, Ahvaz, Iran
[b] Drilling Research Center (DRC), Shahid Chamran University of Ahvaz, Ahvaz, Iran
[c] Petroleum Geology and Geochemistry Research Center (PGGRC), Ahvaz, Iran
[d] Pars Petro Zagros Engineering & Services Co. (PPZ), Tehran, Iran

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ABSTRACT

The Paleozoic petroleum system of the Fars Platform of Iran is analyzed using 1D petroleum system models of 17 deep wells drilled in the study area. The main aim was to investigate the hitherto undocumented influence of salt tectonics on the essential elements and processes of this petroleum system. For the first time, a better understanding about the geohistory evolution of this prolific petroleum system is provided over the Fars Platform. Modeling results indicate that hydrocarbon generation from the Silurian source rock was associated with salt withdrawal synclines. Salt tectonics further controlled the entrapment styles and the geometric distribution of carrier/reservoir rocks and their overlying evaporitic seals. Our findings provide new insights for identifying the remaining exploration potential in the Paleozoic petroleum system of the Fars Platform and suggest that the role of salt tectonics should be considered in the future basin and petroleum system modeling studies in this area.

1. Introduction

Petroleum system analysis has become a critical part of hydrocarbon exploration portfolio in recent years (Allen and Allen, 2013; Alves et al., 2020; Lawson et al., 2018; Magoon and Dow, 1994). It helps exploration geologists to obtain a holistic understanding about the geohistory evolution of the petroleum systems in space and time and to study the complex interaction of many processes influencing the essential elements and processes of the petroleum systems (e.g., Fraser, 2010; Peters et al., 2017). In this study, a preliminary analysis of the Paleozoic petroleum system is conducted for the first time in the Fars Platform of the Iranian Zagros basin (Fig. 1).

The Fars Platform of the Zagros basin is an extremely prolific hydrocarbon province, with several giant and super-giant gas fields in the Paleozoic series (Bordenave, 2008, 2014; Esrafili-Dizaji and Rahimpour-Bonab, 2019). The Paleozoic petroleum system in the Fars Platform contains significant gas reserves in the Permo-Triassic carbonates (Dalan and Kangan formations) in numerous onshore and offshore fields (Esrafili-Dizaji and Rahimpour-Bonab, 2013, 2019; Ghazban, 2007; Kashfi, 1992) (Fig. 1). Notwithstanding the very old history of oil exploration in this basin (i.e. as early as 1900's), its various petroleum systems were not systematically studied until recent years. The Paleozoic system of this basin is especially less explored and little is known about its stratigraphy (Ghavidel-syooki, 1997; Ghavidel-syooki, 2003; Insalaco et al., 2006; Spina et al., 2018; Szabo and Kheradpir, 1978) and petroleum geology (Alipour et al., 2021; Bordenave, 2008; Esrafili-Dizaji and Rahimpour-Bonab, 2013, 2019; Motiei, 1993).

The main focus of this paper is to analyze the essential elements (i.e. the source rock, carrier, reservoir, and seal rock) and processes (i.e. hydrocarbon generation, migration, and entrapment) for the Paleozoic petroleum system of the Fars Platform. We highlight that the tectono-stratigraphic evolution of this area had a great impact on the spatial and temporal evolution of the Paleozoic petroleum system. Results from this study can provide essential input parameters for basin and petroleum system modeling studies in the future. In addition, a better understanding is obtained about the existing play fair-ways and remaining exploration potential in the Paleozoic petroleum system of the Fars Platform.

2. Tectono-stratigraphic evolution of the Zagros basin during the Paleozoic

Generally, the Zagros basin was influenced by three major tectonic phases during the Paleozoic times (Fig. 2): a) an old collision phase (i.e.

* Corresponding author. Shahid Chamran University of Ahvaz, Faculty of Earth Sciences, Department of Petroleum Geology and Sedimentary Basins, Ahvaz, Iran.
E-mail address: alipour@scu.ac.ir (M. Alipour).

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the Amar collision dating back to 640-620 Ma), b) a second thermo-tectonic event during Late Devonian and Carboniferous times (Tavakoli-Shirazi et al., 2013), and c) a final phase including the mobilization of the Hormuz salt, which is relatively little investigated in the studied area.

Following the first collisional event, various terranes were accreted to form the crystalline basement of the Arabian Plate (Sharland et al., 2001). In addition, prominent basement highs were formed (e.g., the Qatar-Fars Arch), which controlled the subsequent sedimentation of the evaporitic Hormuz Series (Perotti et al., 2011; Sharland et al., 2001; Stöcklin, 1968). These evaporites, in turn, controlled both the sedimentation patterns and the style of deformation in various parts of the Zagros basin (Callot et al., 2012; Jahani et al., 2009, 2017; Perotti et al., 2016; Sepehr and Cosgrove, 2004).

The second pre-Permian (Late Devonian and Carboniferous) extensional phase was followed by an Early Permian rifting phase (Ghasemi and Talbot, 2006; Madani-Kivi and Zulauf, 2015; Ruban et al., 2007; Sharland et al., 2001), which resulted in substantial crustal uplift and a major hiatus in the Zagros basin (Ghavidel-syooki, 1997; Tavakoli-Shirazi et al., 2013) (Fig. 2). These movements evolved into the Zagros Rift zone and separated Iranian continental assemblage from the Arabian Plate in the Middle Permian (Hassanzadeh and Wernicke, 2016; Ruban et al., 2007). Approximately along the present-day Zagros suture line, a regional NW-SE trending high was developed and more than 1100 m of Cambrian-Ordovician sediments were eroded down to the basement (Koop et al., 1982; Motiei, 1993) (Fig. 3a). Following this rifting event, the subsequent post-rift sequences included extensive carbonate-evaporite deposition (i.e. the Permo-Triassic Dalan-Kangan formations) in a restricted shelf along the eastern margin of the Arabian Plate (Insalaco et al., 2006; Motiei, 1993; Szabo and Kheradpir, 1978) (Fig. 3b).

The third phase of tectonic evolution in the Paleozoic series of the Fars Platform is relate to the mobilization of the Hormuz salt, which had a great influence on the evolution of the Paleozoic petroleum system. Adequate evidence is presented from the Zagros basin suggesting that the Hormuz salt movements began since at least Early Paleozoic (Hassanpour et al., 2018; Jahani et al., 2017; Motamedi and Gharabeigli, 2019). In this sense, the basal Hormuz Series in the Fars Platform can be considered as an example of a "pre-rift salt" (e.g., Lagabrielle et al., 2020). Similar findings about the early mobilization of the pre-rift salts have been reported from other parts of the world including Iberia (Lagabrielle et al., 2020; Saspiturry, 2020) and Pyrenees (Duretz et al., 2020; Jammes et al., 2010; Rowan, 2014). Therefore, the role of this pre-rift salt layer on the geometry and evolution of the rift system in the Fars Platform of Iran cannot be ignored, and additional studies are required to fully address its influence on the associated petroleum systems. In this study, we provide some evidence from the study to suggest that the influence of salt tectonics on the Paleozoic petroleum system can be far more important than previously thought.

The thick clastic wedge of up to 1000 m blanketing the faulted margin during the Carboniferous-Permian times (Fig. 3a), concurs with the view of early salt mobilization. Additionally, the presence of numerous faults on the basement of the Zagros basin would help trigger salt movement, since previous research has shown that salt diapirs preferentially form at the Intersection of basement faults (e.g., Edgell, 1992). The intersection of Qatar-Kazerun Lineament with NW-SE trending listric faults at the margin of the Zagros Rift zone could be such a favorable site for salt diapirism early in the geologic history of the studied area (Fig. 3c).

There are adequate information from the study area suggesting that withdrawal-synclines associated with salt activity were formed during Permian and Triassic times (Alipour et al., 2021). The pronounced depocenter-shifts previously reported for the Permian and Triassic intervals (Koop et al., 1982; Motiei, 1993; Szabo and Kheradpir, 1978) supports this conclusion (Fig. 4). These processes controlled not only the thickness and the depositional facies of the overlying Permo-Triassic carbonate reservoirs, but also defined the location of earliest hydrocarbon generation kitchens. Accordingly, the porous grainy facies were deposited towards the highs, while the low-porosity muddy facies were developed towards the synclinal lows. This agrees well with previous studies about regional porosity variations in the Permo-Triassic carbonates (Esrafili-Dizaji and Rahimpour-Bonab, 2013).

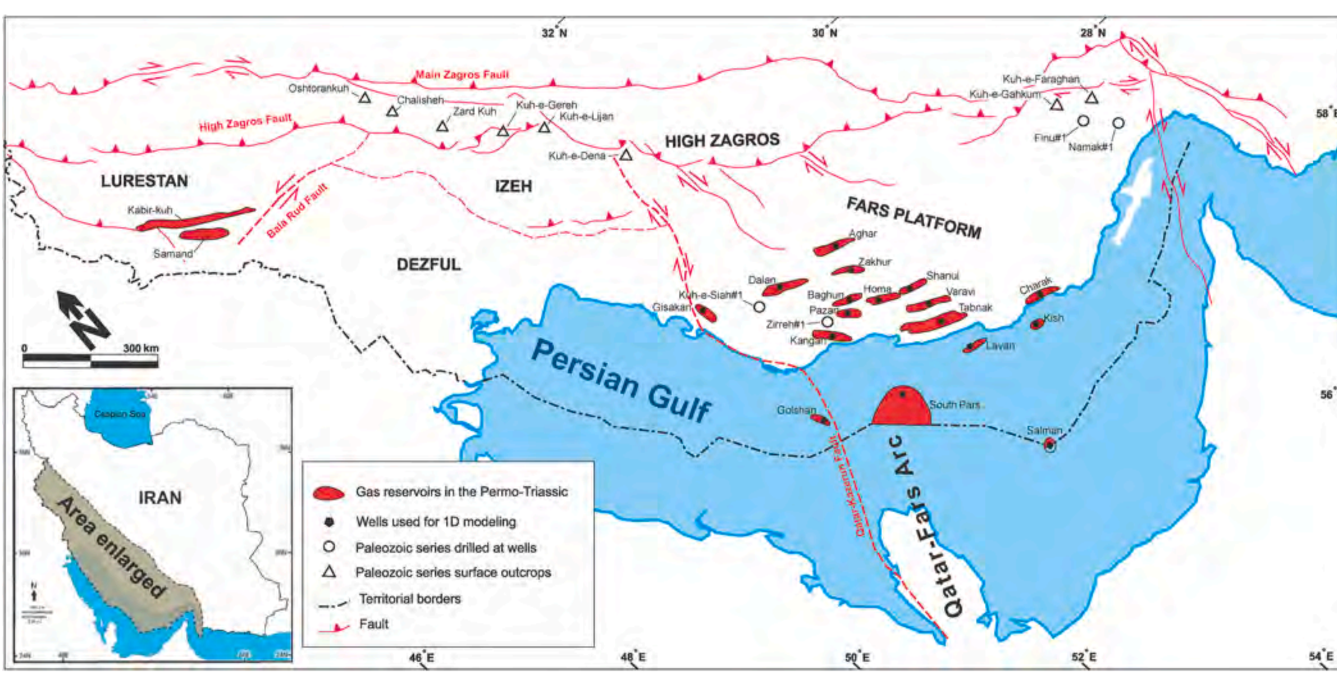

Fig. 1. Map showing the geographic distribution of hydrocarbon fields producing from Permo-Triassic carbonates (Dalan-Kangan formations). The deep wells used for 1D petroleum system modeling are shown with filled polygons. Open triangles show the location of several surface outcrops where Paleozoic rock have been studied in the literature.

3. Material and methods

For analyzing the Paleozoic petroleum system of the Fars Platform, in this study subsurface information coming from 17 wells were used for 1D petroleum system modeling (Fig. 1). These wells are among the deepest wells reaching the Paleozoic sediments in the study area and provide a relatively good understanding about the evolution of the associated petroleum system. Petromod® 1D software package was used for building the models. In addition, a comprehensive review of the literature existing on the Permo-Triassic sediments of the Fars Platform was made. Information about facies and thickness of the Permo-Triassic sediments were obtained from various sources and from our own modeling experience in the studied area (Bordenave, 2008; Koop et al., 1982; Motiei, 1993; Szabo and Kheradpir, 1978).

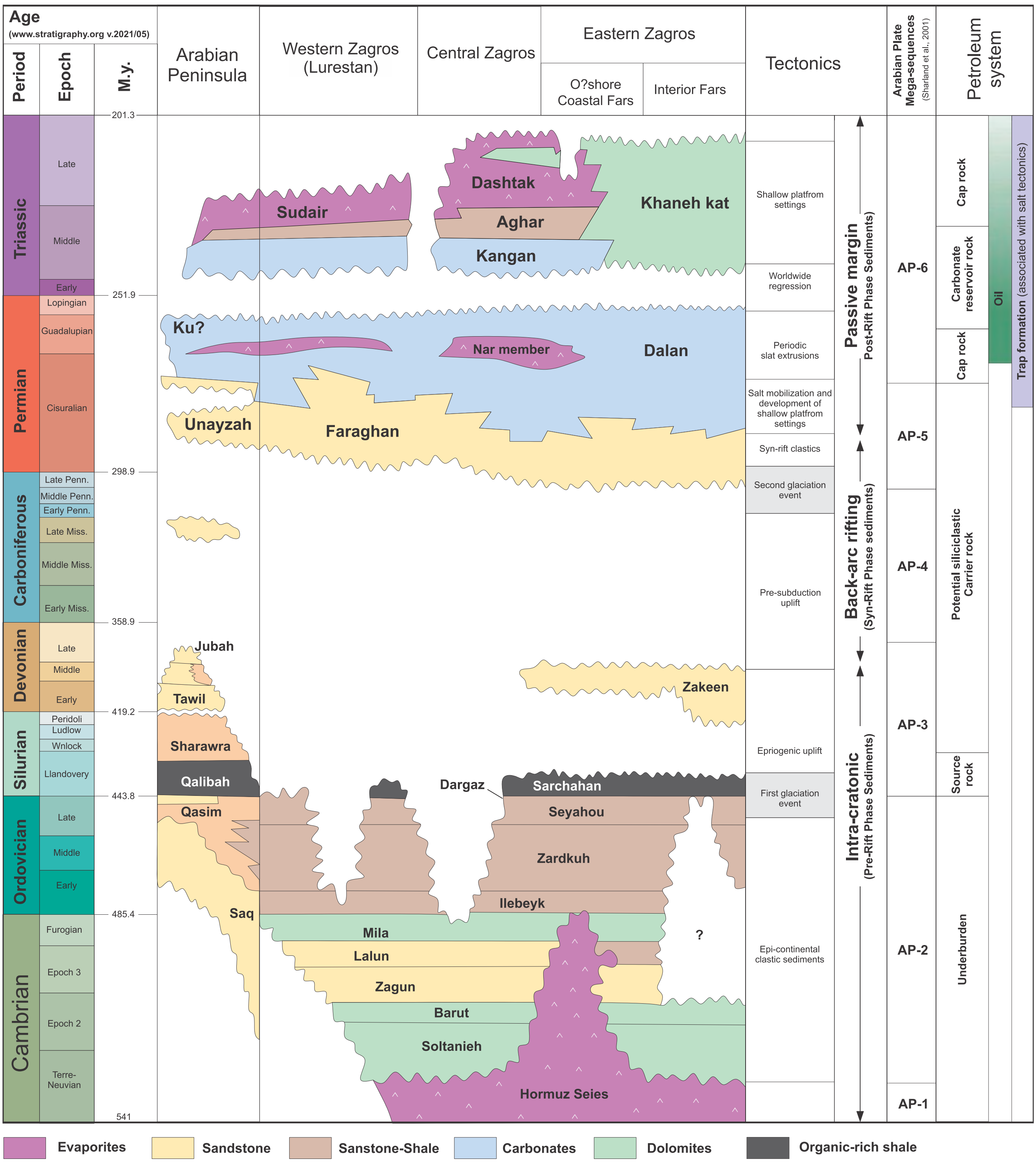

Fig. 2. Lithostratigraphic summary chart of the Paleozoic series in the Zagros basin (modified after Motiei, 1993). Major tectonic events along with the pre-rift, syn-rift and post-rift phases are distinguished and the petroleum systems elements and processes are highlighted.

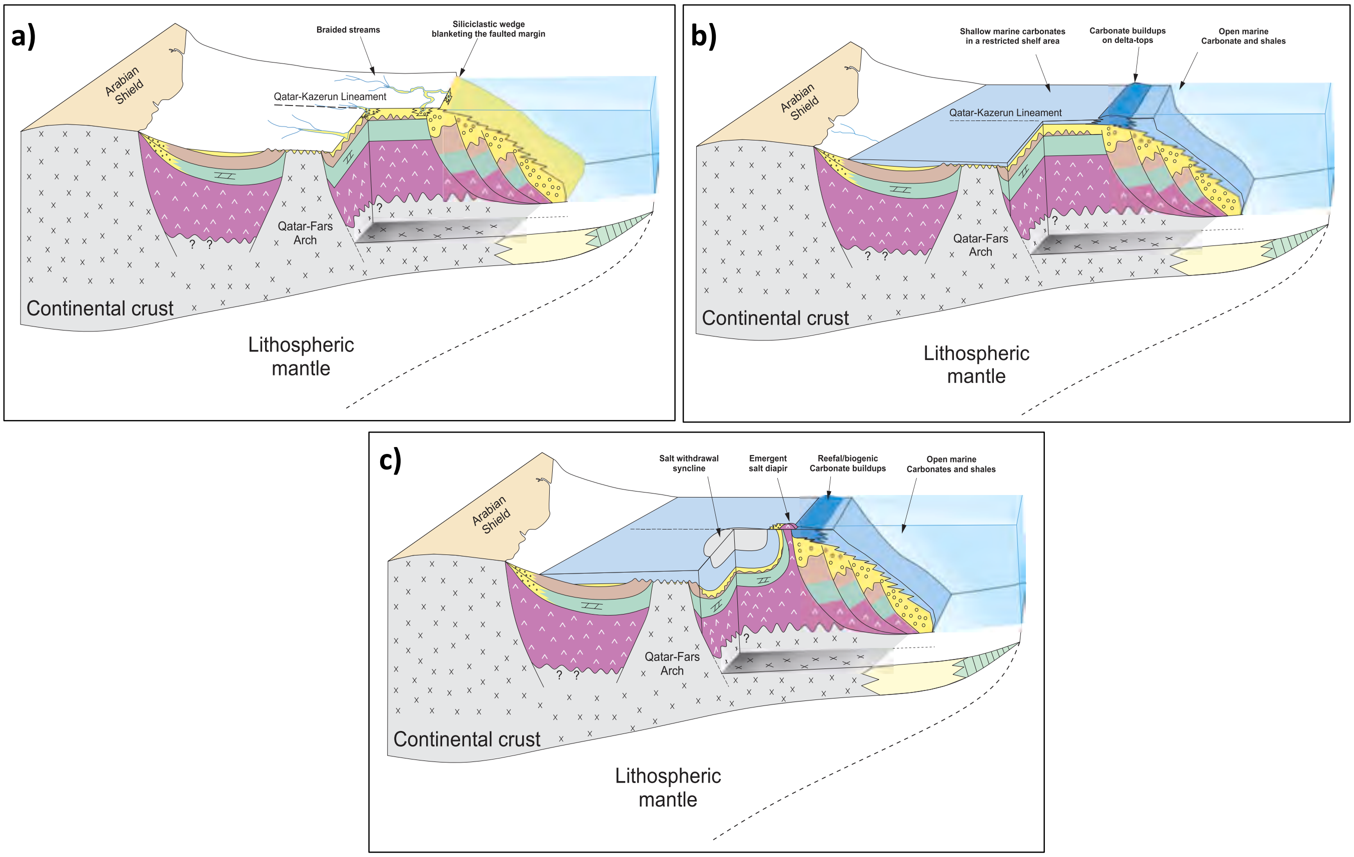

Fig. 3. 3D block diagrams of (a) the Carboniferous-Permian clastics showing the formation of a thick clastic wedge over the Neo-Tethys rift shoulder in the Fars Platform in the Zagros basin, (b) the sea-ward thickening prisms of the Permian post-rift sediments deposited in shallow marine shelf areas separated from open marine by reefal buildups where evaporite deposition could take place at times of sea level fall, and (c) the extrusion of salt diapirs into the restricted carbonate platform of the Triassic sediments, showing that the noticeable shift in depositional depocenter from Permian to Triassic times (see also Fig. 6) can be associated with salt withdrawal synclines.

4. Results and discussion

4.1. *Essential elements of the Paleozoic petroleum system*

The Paleozoic petroleum system of the Fars Platform of Iran mainly includes the Sarchahan-Dalan/Kangan system (Fig. 2), which is prolific in numerous gas fields onshore and offshore (Bordenave, 2008) (Fig. 1). Other potential Paleozoic petroleum systems could also be associated with the Zakeen and Faraghan clastics, which remain to be proven, although the equivalents of these clastic sediments are proven reservoirs in Saudi Arabia, UAE and Oman (Al-Johi and Al-Laboun, 2015; Arouri et al., 2010; Sharland et al., 2001; Taher et al., 2012).

4.1.1. *Source rock*

The most important source rock for the Paleozoic petroleum system of the Fars Platform is suggested to be the Silurian Sarchahan shales (Bordenave, 2008, 2014; Saberi et al., 2016). Organic geochemical evaluation of these shales has shown presence of basal hot shale intervals characterized by elevated Gamma Ray response and organic richness in Iran (Saberi et al., 2016) and Saudi Arabia (Cole et al., 1994; İnan et al., 2016; Jones and Stump, 1999; McGillivray and Husseini, 1992). These shales were deposited following the Hirnantian glaciation and succeeding sea level rise across the entire Arabian Plate (Jones and Stump, 1999; Lüning et al., 2000). The Silurian strata consists of a thick package of marine shales with several organic-rich hot shales intervals (Grabowski, 2005; Lüning et al., 2005). Leaner (warm) shales containing moderate amounts of gas-prone organic matter overlie the basal hot shales (Alipour, 2017; İnan et al., 2017; van Buchem et al., 2014). In the Zagros basin, these shale are identified with average TOC (≈5 wt%) and HI (≈70 mg HC/g TOC) values typical of type II/III organic matter (Table 1) with thermal maturity corresponding to the gas window (Khani et al., 2016; Saberi et al., 2016).

Tectono-stratigraphic evolution of the Zagros basin suggests that the Silurian shales could have been affected by at least two major erosion events corresponding to the pre-Zakeen and pre-Faraghan unconformities (Figs. 2 and 5). However, the eroded thickness is not precisely known due to the limited subsurface information in the study area. We believe that extensive erosion could have removed the entire thickness of the Silurian shales at some parts of the study area (Fig. 5), meaning that the erosion thickness is a major risk factor for the Paleozoic petroleum system. Nevertheless, due to the limited seismic and subsurface information from the study area, there is no general consensus on the approximate geographic extension of these shales.

4.1.2. *Carrier/reservoir rock*

Above the Sarchahan shales, the areally continuous clastic sediments of the Faraghan Formation could act as good carrier rocks to drain the generated hydrocarbons from the underlying shales.

Following a major unconformity between the Zakeen and Faraghan formations (Ghavidel-Syooki, 1998), variable thicknesses of the Cambrian-Devonian succession were removed (Tavakoli-Shirazi et al., 2013) and clastic sediments of the Faraghan Formation were accumulated (Spina et al., 2018; Tavakoli-Shirazi et al., 2013) (Fig. 2). These sediments are of continental origin and can be classified as early syn-rift deposits blanketing a faulted basement (Madani-Kivi and Zulauf, 2015) (Figs. 2 and 3a).

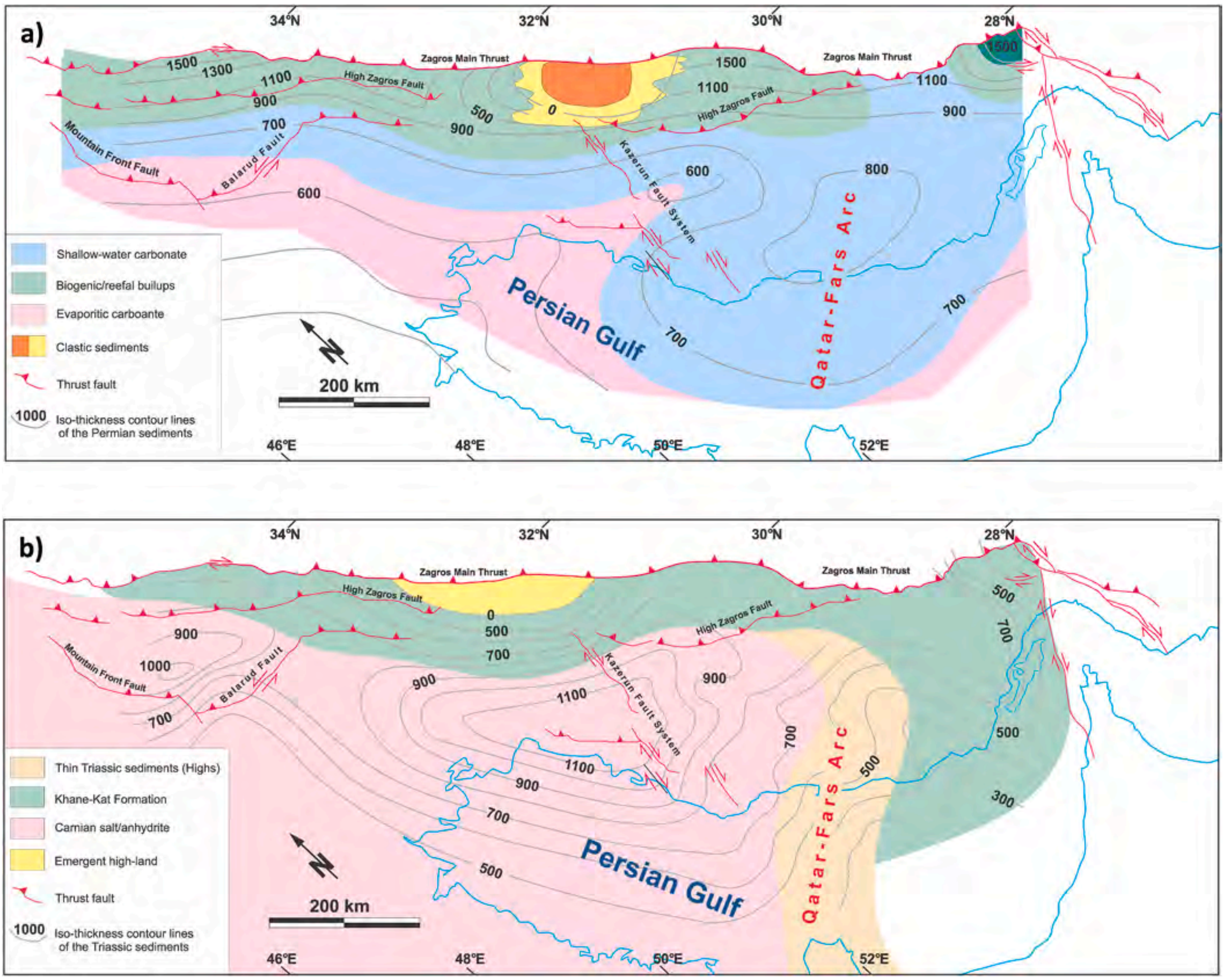

Fig. 4. Regional paleo-geographic maps showing the thickness variations in the of depositional units from Permian (a) through Triassic (b) (Motiei, 1993; Szabo and Kheradpir, 1978). The depocenter shift in the Permo-Triassic sediments can be explained by salt tectonics.

Table 1
Average rock-Eval 6 parameters for the Sarchahan Shale samples analyzed from wells and surface outcrops in the studied area (data from Saberi et al., 2016).

Location		S_1 (mg HC/g rock)	S_2 (mg HC/g rock)	PI	Tmax (°C)	S_3 (mg CO_2/g rock)	TOC (wt %)	HI(mg HC/g TOC)	OI(mg CO_2/g TOC)	MINC (%)
Outcrop	Well									
Kuh-e-Faraghan		0.48	5.47	0.11	459	0.16	5.29	154.30	4.20	0.74
Kuh-e-Faraghan		0.58	6.88	0.11	459	0.23	4	149.5	6.33	1.17
Kuh-e-Faraghan		0.04	0.13	0.33	423	0.37	0.37	77.27	163	0.15
	Golshan#3	0.27	0.21	0.54	429.14	1.66	0.26	83.14	687	0.79
	Zirreh#1	0.53	0.5	0.54	422	0.82	0.3	151	262	0.53
	Kuh-e-Siah#1	0.01	0.08	0.08	444	0.5	0.83	10	60	0.03

The siliciclastic sediments of the Faraghan Formation are gradually replaced with Permo-Triassic Dalan-Kangan formations (i.e. lithostratigraphic equivalents of the Khuff), which are important reservoir units of the Paleozoic petroleum system in the study area (Esrafili-Dizaji and Rahimpour-Bonab, 2013; Kashfi, 1992; Motiei, 1993; Szabo and Kheradpir, 1978). Therefore, the siliciclastic sediments of the Faraghan Formation could provide efficient conduits for hydrocarbon migration from the underlying Sarchahan kitchens to the overlying grain-dominated facies of Dalan-Kangan carbonates (Alipour et al., 2021) (Fig. 6a).

4.1.3. *Seal rocks*

Within the regionally extensive, poorly-circulated low-relief carbonate shelf of the Dalan and Kangan formations (Ehrenberg et al., 2007) several episodes of very fast evaporitic sedimentation are recorded (e.g., the Nar Member anhydrites), which act as Intra-formational

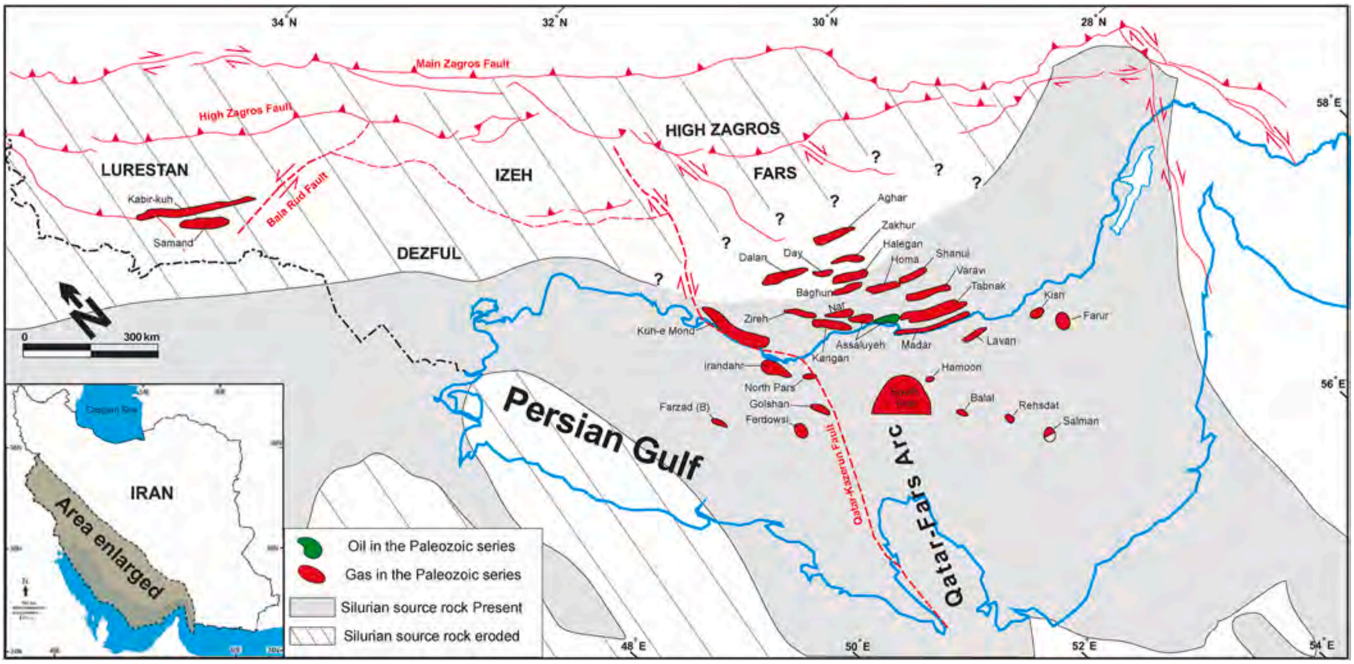

Fig. 5. Map showing the geographic distribution of the Silurian source rock (Grabowski, 2005). The Permian erosion event could remove the entire source rock facies in some areas.

seals for trapping hydrocarbons (Peyravi et al., 2010; Rahimpour-Bonab et al., 2010; Sharland et al., 2001; Warren, 2016). These evaporites have a widespread distribution across the Arabian Plate and in some cases (e.g., the South Pars Field) effectively separate the Lower Dalan reservoir from the Upper Dalan and Kangan reservoirs (Motiei, 1993).

Carbonates of the Dalan-Kangan formations are overlain by the Upper Triassic evaporites of the Dashtak Formation, which is the most important seal rock for the Paleozoic petroleum system in the Zagros basin (Kashfi, 1992; Szabo and Kheradpir, 1978) (Figs. 2 and 6a). Evaporite deposition during this time interval is reported to be a consequence of a very pronounced drop in seal level (Ziegler, 2001). However, we believe that the extrusion of Hormuz salt glaciers could also play a critical role in increasing brine salinity and deposition of massive evaporites (Fig. 3c). This agrees well with recent studies from the Zagros basin suggesting that the Hormuz salt movement could begin during the Early Paleozoic (Hassanpour et al., 2018; Jahani et al., 2017; Motamedi and Gharabeigli, 2019). Additional support for this interpretation comes from the paleo-geographic maps of the Permo-Triassic sediments in the study area (Fig. 4). These maps not only indicate noticeable shift of the depocenter northward in the Fars Platform but also they highlight presence of erosional highlands at the northeastern termination of the Qatar-Kazerun Lineament (Fig. 4). Therefore, we believe that Hormuz salt diapirism and associated withdrawal synclines had a great impact on the thickness/facies characteristics of Permo-Triassic sediments in the Fars Platform. Within these synclines thicker evaporite beds could be accommodated in a relatively short period of time (i.e. the depocenter shift), and hydrocarbon generation would be accelerated due to intensified burial (Alipour et al., 2021) (Fig. 6a).

Generally, the Dashtak Formation is thinner over the Qatar-Fars Arch and shows strong facies variation from evaporites to dolomites from SW to NE in the study area (Motiei, 1993). It is not surprising that the Dalan-Kangan reservoirs are barren in the northeastern parts of the Fars Platform since there is no effective seal to stop migrating hydrocarbons (Fig. 6a). Accordingly, this facies change can be an important risk factor for the Paleozoic petroleum system of the Fars Platform. Therefore, detailed mapping of the Dashtak evaporites edge can provide useful guidelines for future exploration of the Paleozoic petroleum system in the Fars Platform.

4.2. *Processes of the Paleozoic petroleum system*

4.2.1. *Hydrocarbon generation from the source rock*

1D petroleum system modeling results in the study area indicate that hydrocarbon generation from the Silurian shales started during the Late Jurassic (Fig. 7), which is in agreement with previous studies (Bordenave, 2008). Based on our modeling results, the earliest phases of hydrocarbon generation from the Silurian source rock began in salt withdrawal synclines (Figs. 7 and 4b). In these zones, the source rock would be buried to greater depths under a noticeably large thickness of contemporaneous sediments (e.g., larger thickness of the Dashtak evaporites on paleo-geographic maps, Fig. 4b).

However, we should note that hydrocarbon generation in the study area could be governed by a complex interaction of various processes. Basically, the organic matter contained in these shales is highly reactive with a narrow range of activation energy distribution (Abu-Ali et al., 2001; Alipour, 2017; Pietraszek-Mattner and Villa, 2009). In other words, the organic matter is expected to be highly sensitive to variations in the environmental factors during geological evolution of the basin. For example, the presence of salt at the base of the sedimentary column (i.e. the basal Hormuz Series) could have positively influenced the hydrocarbon generation by funneling more heat into the overlying strata. On the other hand, the negative influence of the Devonian-Carboniferous exhumation events on hydrocarbon generation processes cannot be ignored. Similarly, the heat flow increase associated with the Early Permian rifting event could intensify generation of hydrocarbons from the studied organic matter. Therefore, for better understanding of the hydrocarbon generation from the Silurian source rock in the Fars Platform, additional studies are needed to investigate the interrelations between the mentioned processes.

4.2.2. *Migration of generated hydrocarbon*

Our modeling results suggest that hydrocarbon generation in the Paleozoic petroleum system would initially begin in salt withdrawal synclines (Fig. 7). However, existing geological information suggests that migration of these hydrocarbons could not be vertical (Alipour

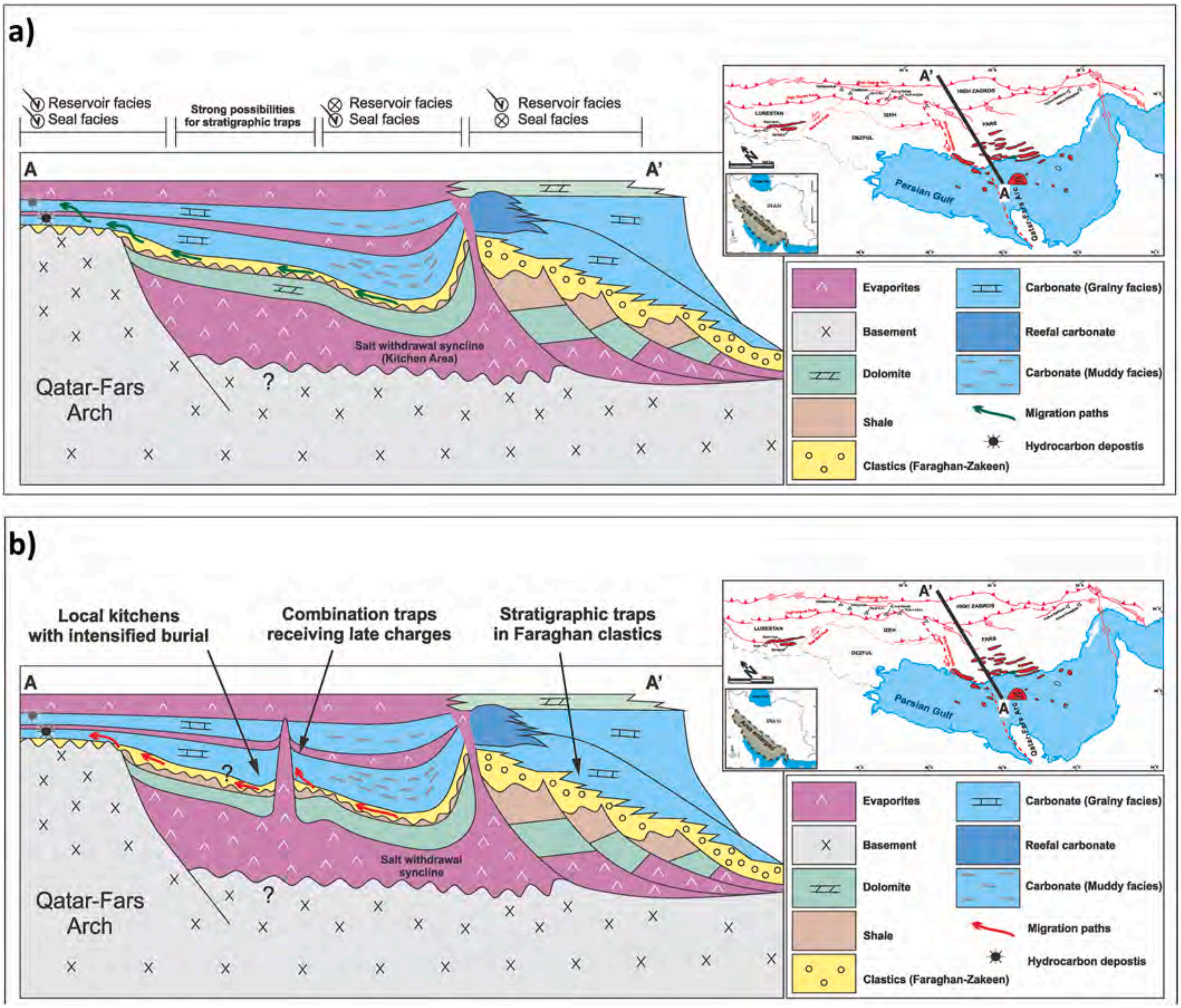

Fig. 6. Schematic diagrams showing (a) the generation of hydrocarbons in withdrawal synclines and their updip migration through overlying clastic rocks (i.e. Faraghan Formation) into the grain-dominated carbonate facies lying updip, and (b) the possible locations for the development of combination traps (stratigraphic and structural) along the migration pathways in the study area.

et al., 2021). The carbonate layers constitute a mud-dominated facies (with lower average porosity and permeability) in synclinal areas (Fig. 6a). However, they constitute grainy facies with elevated poro-perm characteristics towards structurally higher regions (Esrafili-Dizaji and Rahimpour-Bonab, 2013; Insalaco et al., 2006). Therefore, initial hydrocarbon charges would preferentially migrate updip through the Faraghan sandstones to accumulate within the grain-dominated facies of Dalan-Kangan reservoirs over structurally higher areas (Fig. 6a). A similar phenomenon has been previously described by other researchers to explain the formation of the so-called pre-Zagros accumulations (Bordenave, 2008; Rudkiewicz et al., 2007).

Based on the foregoing discussions, long-range lateral migration of hydrocarbons could have occurred from early Silurian kitchens (i.e. salt withdrawal synclines) towards structurally higher areas (Figs. 6a and 7). Additional subsurface information is required to define the approximate location of the earliest kitchens in the Zagros basin and to better understand the migration ranges and styles in the Paleozoic petroleum system.

4.2.3. *Trapping style*

Various types of trapping geometries could be present on the way of the migrating hydrocarbons. However, due to the strong halokinetic activities in the study area, salt-related traps could be the predominant types. Our 1D modeling results suggest that such traps were very likely present before hydrocarbon generation from the Silurian source rock, since structural geologists believe the salt mobilization began much earlier in the history of the basin. Based on our results, diapiric structures surrounding withdrawal synclines could be favorable trapping sites for the earliest hydrocarbon charges (Fig. 6b).

There is also strong potential for occurrence of stratigraphic traps of variable sizes and forms in the study area (Fig. 6 a,b). This is especially true where the grain-dominated carbonate facies of Dalan-Kangan reservoirs (i.e. at structurally higher areas) changes laterally to mud-dominated facies (i.e. towards withdrawal synclines) (Fig. 6 a,b). Additionally, we believe that a higher possibility exists in the mentioned areas for the development of combination traps as a result of subsequent diapirism and/or faulting (Fig. 6b).

Last but not least, some low-relief giant closures were formed above

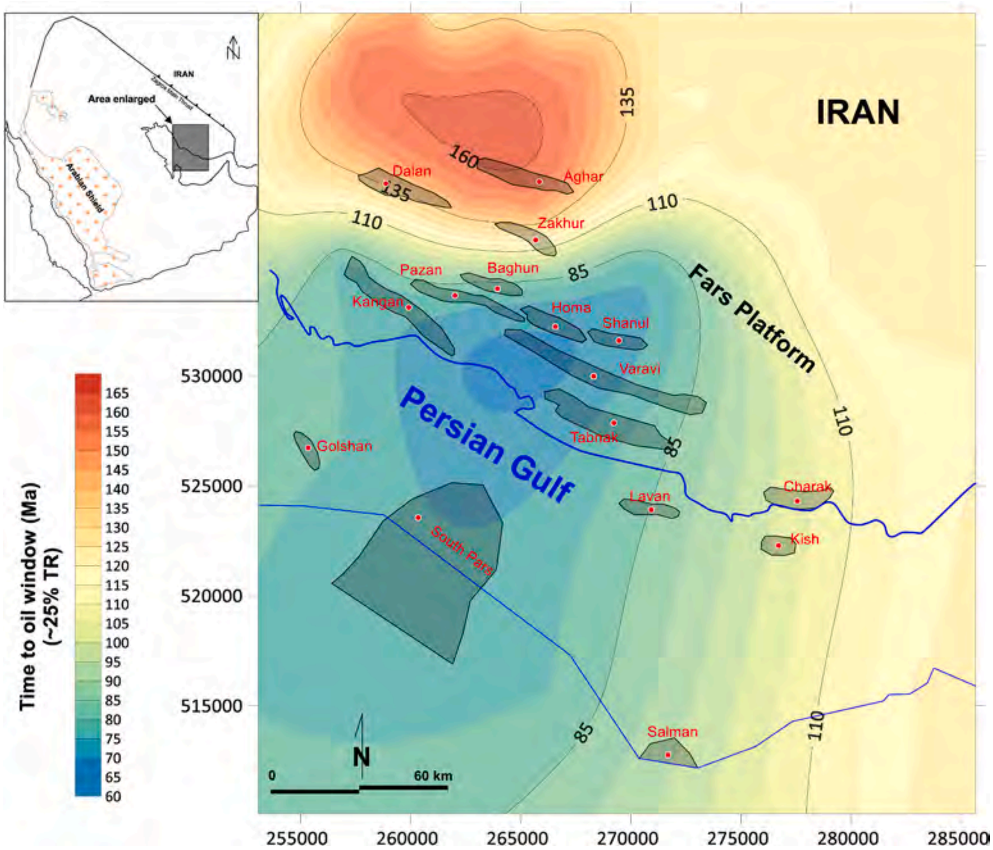

Fig. 7. Time of oil generation from the Silurian source rock constructed based on 1D petroleum system modeling results in the studied wells.

the basement highs in the study area. These trapping sites were characterized by improved porosity and permeability due to both syn-depositional and post-depositional (e.g., porosity enhancement during subarial exposure) processes. The super-giant South Pars Field is an examples of this category that rests above the Qatar-Fars Arch and holds huge gas reserves within the Dalan-Kangan reservoirs (Fig. 6 a,b and Fig. 7). Accordingly, we suggest that vast drainage areas could exist around this structure, thanks to the laterally continuous clastic carriers provided by the Faraghan Formation (Fig. 6a).

4.3. Implications for future exploration and production activities within the Paleozoic petroleum system

Results from this study have shown that significant potential still exist in the Paleozoic petroleum system of the Fars Platform for exploration of stratigraphic and combination traps within the Permo-Triassic carbonates (Fig. 6a). Similarly, considerable exploration potential can be associated with the siliciclastic sediments of the Faraghan Formation, where they inter-finger with distal shales or rest below the tight carbonates of the Dalan Formation (Fig. 6b). The latter targets are especially interesting in the NE parts of the Fars Platform, where the evaporitic facies of the Dashtak Formation changes to dolomites and the Permo-Triassic carbonates are barren (Fig. 6b).

Another implication of the results presented in this study is that syn-depositional salt tectonics could have a dominant control on the evolution of the Paleozoic petroleum system of the Fars Platform (Alipour et al., 2021) (Figs. 3c, 4 and 7). This new interpretation differs from previous studies that emphasized "the reactivation of Qatar-Fars Arch" as the sole factor controlling the thickness/facies variations in the Permo-Triassic carbonates (Esrafili-Dizaji and Rahimpour-Bonab, 2013). The latter interpretations are in contrast with the general geodynamic settings of the area, which generally include extensional regimes related to the opening of the Neo-Tethys Ocean. Furthermore, independent lines of evidence coming from previous structural studies (Perotti et al., 2011) indicate the reactivation mechanism is largely refuted by the N-NE orientation of the basement block system below the Qatar-Fars Arch. In contrast, the salt mobilization theory advocated in this paper suggests that regional warping of the overburden could occur above the Qatar-Fars Arch due to salt withdrawal. This is further supported by the previously published studies suggesting that regional warping of the succession above the Qatar-Fars Arch was directly controlled by salt withdrawal processes (e.g., Perotti et al., 2011). Therefore, we suggest that syn-sedimentary salt tectonics could greatly influence the tectono-stratigraphic evolution of the study area during the Paleozoic time. Accordingly, halokinesis controlled the spatial and temporal evolution of the essential elements and processes of the Paleozoic petroleum system.

5. Conclusions

In this study the essential elements and processes of the Paleozoic petroleum system are analyzed with special emphasize on their geological evolution throughout time. This was achieved by the application of 1D petroleum system modeling in 17 deep wells located on the Fars Platform. Our results indicate that the geohistory evolution of the Paleozoic petroleum system was largely controlled by the tectono-stratigraphic history of the study area. These results include:

- The geographic extension of the Silurian Sarchahan source rock is a major risk factor which is controlled by erosion events associated with Neo-Tethys opening,
- The thickness and facies of the Permo-Triassic carbonate reservoirs and the overlying evaporite seal rocks were largely controlled by the syn-sedimentary salt tectonics,

- The salt withdrawal synclines defined the timing and location of hydrocarbon generation from the Silurian source rock,
- Generated hydrocarbons could migrate at a regional scale towards structurally higher areas by means of lateral migration within the Faraghan clastic sediments, and
- Various kinds of trapping geometries (structural, stratigraphic, and combination traps) could exists around the withdrawal synclines and could be charged by migrating hydrocarbons.

These findings provide new insight about the spatial/temporal evolution of the Paleozoic petroleum system in the Fars Platform, and will help us build reliable basin and petroleum system models in the future. In addition, this analysis suggests that considerable exploration potential in the form of stratigraphic traps remains within the Paleozoic petroleum system of the Fars Platform, which require additional studies to be untapped.

Credit author statement

Majid Alipour provided the original hypothesis, prepared the text and figures used in the manuscript. Bahram Alizadeh prepared parts of the text and discussion. Shohreh Mirzaie provided well data and some of the information used in this paper.

Declaration of competing interest

The authors declare no conflict of interest.

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