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Retraction Notice

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History

Expression of Concern:
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Correction:
☐ yes, date: yyyy-mm-dd
X no

Comment:

The paper does not meet the standards of "Open Journal of Geology".

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Uprising Mechanism and Its Effects on the Evolution of Structural-Stratigraphic in the Mangerak Salt Dome (Firuzabad Fars-Iran)

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Abstract

Mangarek salt diapir is exposed in the South West of Firuz Abad in Fars province in southern Iran and in terms of structure is exposed in the Zagros simply folded belt of Kohzad. This diaper is located in a transtentional zone between the overlapping parts of the Korebas fault zone. The origin of diapers is evaporative series of Hormuz from the beginning of the Cambrian—to the end of the Precambrian age. The wall geometry of the diapir suggests long-term activity of salt before the Zagros orogenic by downbuilding phenomenon, in which there is a shallow drape folding and simultaneously with the deposition leads to the formation of thin folds and is rising near the diapir. Salt movement sequences (halokinetic sequences) near this diaper, on both sides of it, are completely different in terms of geometry. This difference reflects the different interactions of salt rise-accumulation of sediment on both sides of the diapir. Mangarek salt diapir and its associated folds are limited from the two sides with a broad syncline with a thicker sedimentary cover than neighboring anticlines. These stalagmites have acted as a center of deposition for Mangarek rising diapir during pre-orogenic, so that with the accumulation of a significant volume of sediment, make the salt rise easier by the downbuilding mechanism. During the Neogene Zagros folds, thick sedimentary cover, within the syncline, resistant against folding and to some extent, complicates the ordinary transfer of tension locally. Therefore, this syncline prevents normal progress and regular development of anticlines, either longitudinal or transverse. The fold of the Zagros during the Neogene squeezes the salt diapir (squeezing) and intestifies the activities and moving part of salt out in the salt column structure. There are thick layers of salt in the formation of Hormuz and consequently, the emergence of a salt dome, in the area has a huge impact on the ancient deposition and sedimentary environment shape of the region. The rise in salt, on the one hand and subsidence of the sediment basin, on the other hand, will cause the balance in the sediment environment

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and as a result, drastic changes in sedimentary environments, near the salt dome. Changes range is a function of the depth of depositional environments and tectonic movements of the area, that there have been in the area during the Permian to recent times. During periods of progression and retrogression that have happened to the wide Zagros Basin, in rising salt dome place, these changes have a pronounced effect. Structural and stratigraphic studies, at different distances from the Mangarek salt dome, show that the salt dome above was raising at the time of late Cretaceous and Paleocene and had drastic changes, especially in the thickness of sediments and adjacent sedimentary zone facies. Dome rising rates are not the same in different time and therefore directly affect the surrounding sediment deposition. Of course, the dome was before the deformation of the Zagros Basin and probably it was exposed in Late Paleogene Sea and Neogene, as an Island (such as salt dome islands Persian Gulf today).

Keywords

Diapirism, Zagros, Mangarek Salt Domes, Downbuilding, Thinning, Kore Bas Fault

1. Introduction

Zagros fold-thrust belt that is in the middle of the Alpine-Himalayan belt is in the northeastern margin of the Arabic page [1]. Zagros fold-thrust belt is, because of opening and closing in New Tethys ocean basins and continuous convergence between the Arabic page and Iranian block belong to Eurasia [2]. The study area is located in the middle of the Zagros fold-thrust belt of Iran and in the Fars region (**Figure 1**). Mangarek salt diapir is located in 80 kilometers of south-west of Shiraz. This diaper is exposed along with the Korebas fault zone (**Figure 2**). Along with the Korebas fault zone, there are five salt diapirs exposed in order from north to south named Health, Migueli, Dadenjan, Mangarek and global with the origin of sedimentary series to the ending Precambrian—beginning Cambrian. Another diapir named Bahar is exposed along with a spring fault in parallel to the southern territory of the Korebas fault zone (**Figure 2**). These diapirs as young diapirs were considered simultaneously or after Zagros Orogeny [3]. Some researchers have related the activity of Zagros salt diapir number to Zagros pre-Neogene orogeny, but they did not present a documentary proof. In the meantime, [4] has proved that based on field evidence; the Khormoj diapir has reached the surface in line with Kazeroon fault zone during the Neocomian. The activity of the hidden salt dome in the Darang anticline core (near the southern end of the Kazeroon fault zone) in the time before Zagros orogeny is provable by using seismic lines. The formation and rise of salt due to the thin stretch of shell or shell thickness has attempted a group of researchers like [5] to relate the formation, rise and exiting diapirs in line with Korehbas and Kazeroon fault zones to pull-apart basin located between the overlapping parts of these fault zones [6]. Salt intrusion of these diapers is related to the creation empty spaces by basement block rotation around the vertical axis and they believe that the most important and perhaps the only factor in the rise and leave of the Hormuz salt in the Fars zone, is a lot of separate basement blocks that by rotation around the vertical axis, they have provided the necessary space to penetrate, rise and eventually the exit of salt to the surface and diapirs formation. According to [7], the salt movement existed in the central Zagros in time before Zagros folding that made up salt diapirs and concluded that pre-existing salt diapirs were squeezed by the next compression resulting from the Zagros Neogene orogeny and some of them have reached the surface. In addition, they have considered the importance of fault fold and unopened basins in line with Kazeroon and Korebas fault zones in the salt rise and leave and as a result, young diapirs formation [8]. They have used centrifugal analog Modeling Method to stimulate the salt diapirism in line with the strike-slip fault zones in the northwestern Fars. They suggested that the diapirs of this area of Zagros are because of the salt rise within open basins and damage zones. About the formation of such extensive areas, they expressed that movement in line with basement strike-slip faults (such as Kazeroon and Korebas) has induced the inclined slip in line with folds and faults of Zagros and has caused the open zone formation and folds and concluded that salt movement in this release curves and tension basins began when

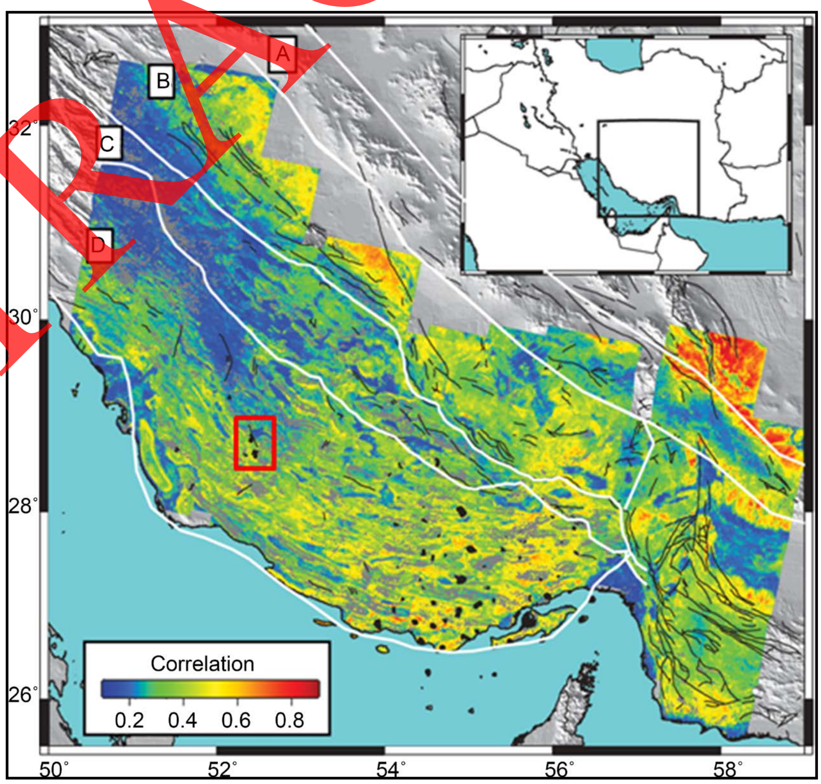

Figure 1. Map of Zagros orogenic belt tectonic states, where the study area is shown with a red rectangle. A: Girl Urmia volcanic Bar B: Sanandaj Sirjan zone C: High Zagros D: active Zagros fold-thrust belt. Black areas show the salt domes exposing, and black lines show faults with surface effects.

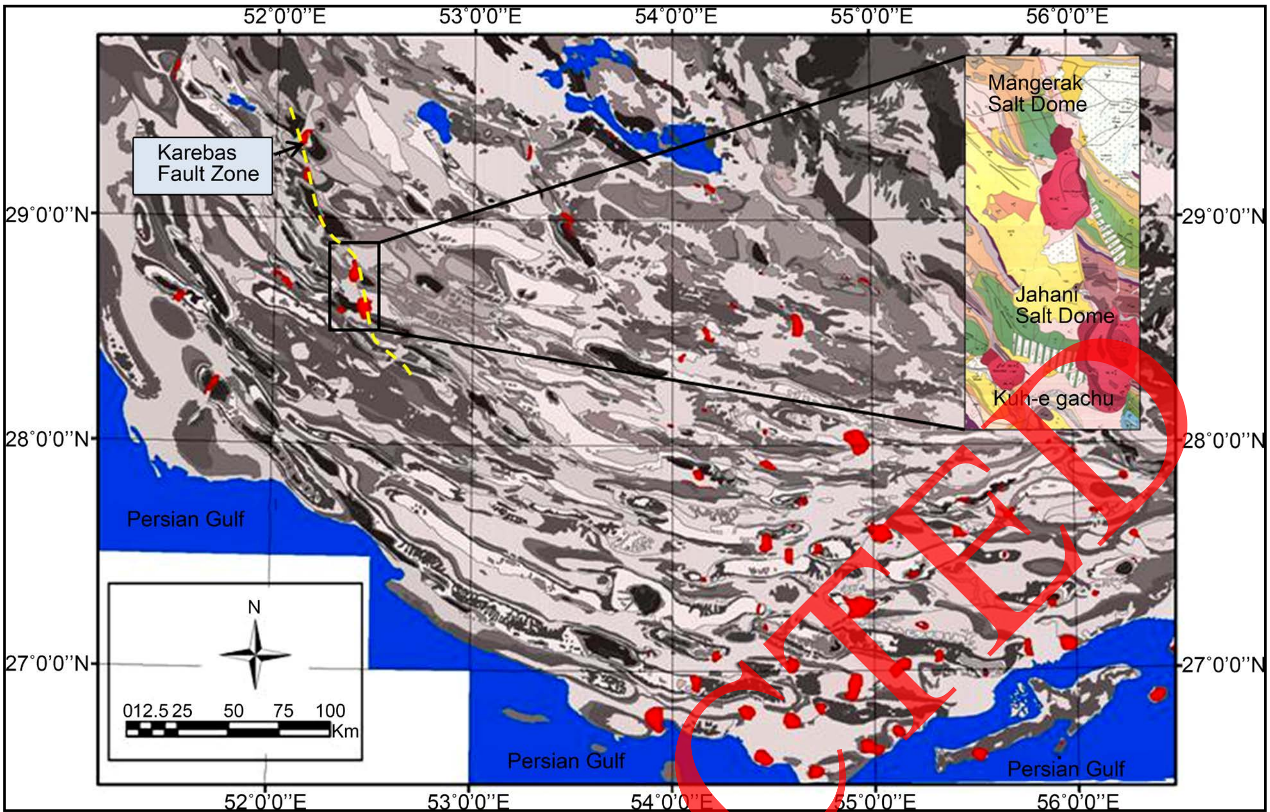

Figure 2. Map of Zagros folded structure (Part D in Figure 1). The red areas indicate exposed salt domes and yellow line indicates Korebas fault zone. Black rectangular of the study area and in the right side og geological map in the area includes Mangarek salt dome, a piece of Korebas fault and adjacent folds.

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the sedimentary cover was thin (Figure 3).

The aim of this study was to evaluate the activity and mechanism of salt diapir rise in Mangarek and its effect on the adjacent sedimentary environment, after its initial move and before Zagros folding. In this regard, the surface information and field observations are used.

2. The Tectonic Position

Based on time, Zagros salt diapirs are classified into three categories: before, during and after the Zagros deformation. East Fars domes that were previously active have exposed in the form of Islands in Paleogene Sea to Neogene, or they were buried domes that have been started at least from Permian [9].

During the Neo-Tethys Ocean thick in the Permian, Hormuz salt has been Liquefaction [10] and has reactivated diapirs in the North West-South East [11] and the last surviving Neo-Tethys Ocean, was closed along the Zagros suture zone. These domes have been reactivated with the next tectonic activity. At the beginning of Zagros folding in the Eocene, the Zagros simple folded belt began to spread from main Zagros thrust and has extended its Foreland basin to the South West and has created Mesopotamia and the Persian Gulf basin [12]. On this basis, a number of salt domes went out of their cover rocks by the high overhead pressure of sediments as well as pressure from the Zagros deformation

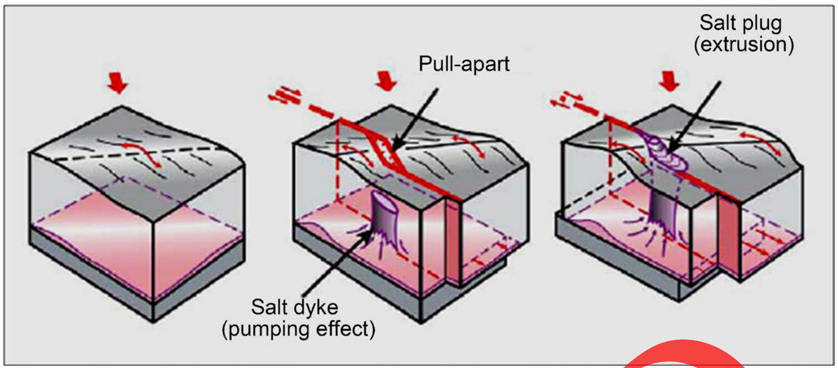

Figure 3. mechanism for growth and penetration of salt during tectonic structures in the transtentional zone.

front, and caused the exposing of salt dome Islands in the Persian Gulf or mountain-salt on the land. Zagros deformation forehead continuous migration to the south has created driving and sequentially anticlines and has caused simultaneous reactivation domes by the deformation of the Zagros. These domes reduced their age to the south. Their outcrop row is concurrent with older structures of the Zagros with the North-South trend that is skewed compared to the Zagros folds [13]. Zagros anticlines in the Fars region, where the thickness of the salt in the stratum series is more, they have more growth in a selective way. Probably the outcrop of rocks in the tank with potential, because of vertical uplift, was responsible for the lack of hydrocarbon cumulative in anticlines potential in the Fars region.

The master axis trend of folding in this area (such as Sayakh anticline) is as the master axis trend of northern Zagros West-Southeast folding that are cut by the oblique faults North-South (such as KoreBas fault). The failure trend of north-south in Korebas fault is considered basement and probably the salt exit control was before the Zagros deformation associated with this fault. Korebas fault or Mangerak fault system with trending north-south is in line with Kazeroon fault and is located 65 km east. This fault is divided into six separate pieces [2], and 5 large salt domes are exposed along it (Figure 2).

A part of fourth and fifth two pieces of this fault area expanded in the study area (Figure 4). Korebas fault pieces are in the form of right step toward each other and some areas are overlapped (Overlap) or under lapped. Sometimes these pieces attached together with transverse thrust fault. The fourth piece of Korebas fault (Narak fault) has become a multi-branch in its northern terminal, and possibly joins the third piece with a thrust fault, but in the southern end, it amortized toward the global salt dome. The fifth piece (Chartagh fault), also starts from the southern area of the Mangerak salt dome and joins some thrust strings in the Sormeh Mountains that is considered the compression stairs of this fault. Two pieces of Narak and Chartagh fault are in one direction together and one part creates a compression overlapping in the Middle. This zone with rising elevation, reverse faults, invert layers and fragmentation is indicative of this pressure. In the north and south of the study area, two compression zones

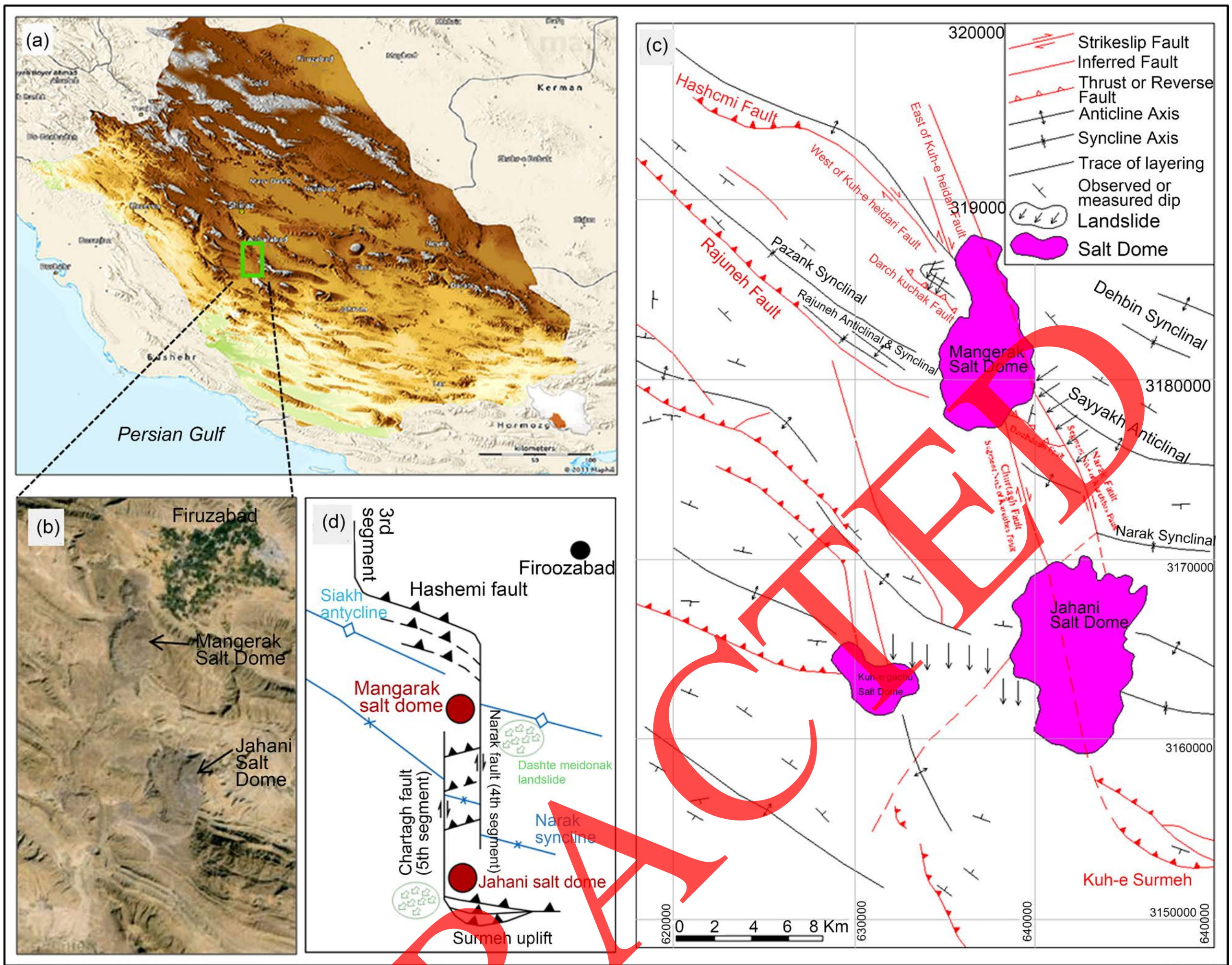

Figure 4. The structural map of the study area. (a): Map of unevenness in the Fars province and the study area. (b): ETM map of the study area where Mangarek salt dome is shown on it. (c): structural map of the study area and d: Schematic model of how structures relate in the study area and surrounding sections

and stretch have been created symmetrically. In the north and in the area of tension, they have caused landslide in a Meydoonak plain in the East of Narak fault, and in the area of compression, they have caused faulting and folding in the West of this fault. In the south and in the area of stretching causes landslide in the Kharto anticline ridge in the West of Chartagh fault and in the area of compression, causes drivings and rising of Sormeh Mountain in the East of the fault. Two global and Mangarek salt domes are surface exposed along these two faults that their birth explicitly in relation with the movement of these faults.

Some related the salt penetration to creating the vacant spaces or pull apart basin, due to the fault base stone blocks movement in the Korebas fault system [13] and [14]. Others believe that salt outcrops in exchange for this fault system have not the same strategy [2].

The Mangerak salt dome in the Sayakh anticline axis place has surfaced outcrops along Korebas fault. On the side of northwest dome, a dramatic reduction can be seen in the thickness of sediments. This thinning is further growing toward the dome that indicates its relationship with dome formation. Reducing the minimum thickness for formations after Asmari (Oligo-Miocene), would-be cited. Seismic data from the internal Zagros show that folding of some anticlines has started in the Miocene time [15]. To determine the age of folding, researchers have worked on the upper part of Aghajary formation, and in general, they have concluded that the start of folding was from 7.2 to 8.1 million years meaning the Late Miocene. Due to this, the dome was existed before the Zagros Basin deformation certainly and probably it has been exposed in Late Paleogene Sea and Neogene as an island (such as salt dome islands Persian Gulf today). On the other hand, the chimney location of the dome is located in the western block of Korebas fault and thinning the edge of the dome formations only appear in this section, that indicate the relationship of the birth of the dome with fault. As mentioned in the previous sections, the rupture of north-south in Korebas faults is considered the basement and probably, the salt exit control before the Zagros deformation has been associated with the fault.

In addition, Chakad Mountain in the world is at the fifth piece compression fault system stairs of Korebas fault [3] that indicates high pressure, salt burst and rising, in connection with the Korebas fault movement. The prominent chimney, salt walls and wide salt indicate the activity of the dome and therefore the activity of the faults. Figure 4 shows the schematic model of structures relation in the study area and surrounding sections.

3. Mangarek Salt Diapir

This twin dome has a length of 10 km and a width of 5 km. The northern part is much smaller than its southern part (Figure 5). The fourth piece of the Korebas fault system would separate right direction in Sayakh anticline axis (Figure 4). This fault piece cuts the Sayakh anticline and makes the salt in the core of the anticline reaches the surface. Then the north move toward the western block of the fault has caused part of the salt mass moved from its place, which has been an isolated salt mass separation feeder root. This made the twin salt and the lack of salt flux in the upper portion toward the main lower mass witness to this event. In the lower large part, the deep origin of salt flux is closed and the salt rate will be more than the rate of fed salt that a flat parabolic profile similar to the water droplet mechanism is formed. In general, this dome in accordance with the classification, is considered in line with salt flux and without the chimney that is still in operation.

4. Possible Activity Age of Salt Rise on Mangarek Diapir

The origin of Mangarek salt diapir is the series of Hormuz. According to [16], the starting age of salt movement in Mangarek diapir, similar to other Zagros and Persian Gulf diapirs, is considered a late Paleozoic, but in conjunction with the thrust movement of salt movement in this diapir, there is no information. So, checking the activities and the continuous rise of salt diapers, diapir rise mechanism after its initial formation and the implications of these activities will

Figure 5. Close look of the Mangerak salt dome-see the East side.

be dealt.

The oldest rocky outcrop at the edge of Mangarek diapir relates to the Cretaceous (Figure 6), but in the vicinity of the global salt dome that in terms of travel time is similar to Mnagarek dome, older formations can be seen from the early Triassic. The lack of occurrences older than late Jurassic, make the activity tracking of this diaper during the Paleozoic impossible. Field evidence represents diapir activity in Pazank stalagmites is well visible. In this place, the oldest stratum unit that has happened is Sarvak-Ilam Formation and it is the closest unit to diapir (Figure 6). With increasing distance from the diapir, the slope of layering changes regularly.

In terms of stratigraphic, they are on the Sarvak-Ilam formations, Paydeh-Gurpi formations, ASMARI, Gachsaran formation, Mishan formation and Aghajari formation. Bakhtiari conglomerate Formation in the form of unconformity is located on all units. This unconformity may be as a result of salt diapir activity or folding. The stratum geometry of this sedimentary series represents the continuous activity of Mangarek salt diapir from the Late Cretaceous to Neogene. In other words, this diapir existed before Zagros Neogene orogeny and it was active.

Another evidence that shows Mangerak salt diapir activity during before orogeny is many small fractures that are expanded in Ilam-Sarvak unit and cannot be seen in the adjacent formations (Figure 7). They may be related their formation into the salt diapir activity at the time of disposition Sarvak -Ilam formations. However, there are several reasons that make the formation and the rise of this salt diaper impossible due to the right fault zone performance and local transtentional related to its overlapping parts: 1) the Korebas fault zone was young and it is a simultaneous structure with folding, while the Mangarek salt diapir exist before the fault zone formation and it is older than strike-slip regime of this area and it was existed at the beginning of Zagros folding, thick sequence and dense of rocks in the late Paleozoic, Mesozoic and Cenozoic, so, based on the salt movement mechanics and diapirism process, in this case the diapir formation from a salt layer will be almost impossible horizontally within the local transtentional basin, 3) even if the thickness overburden makes the local congestion zone thin by transtentional fault performance, the subsidence of these dense

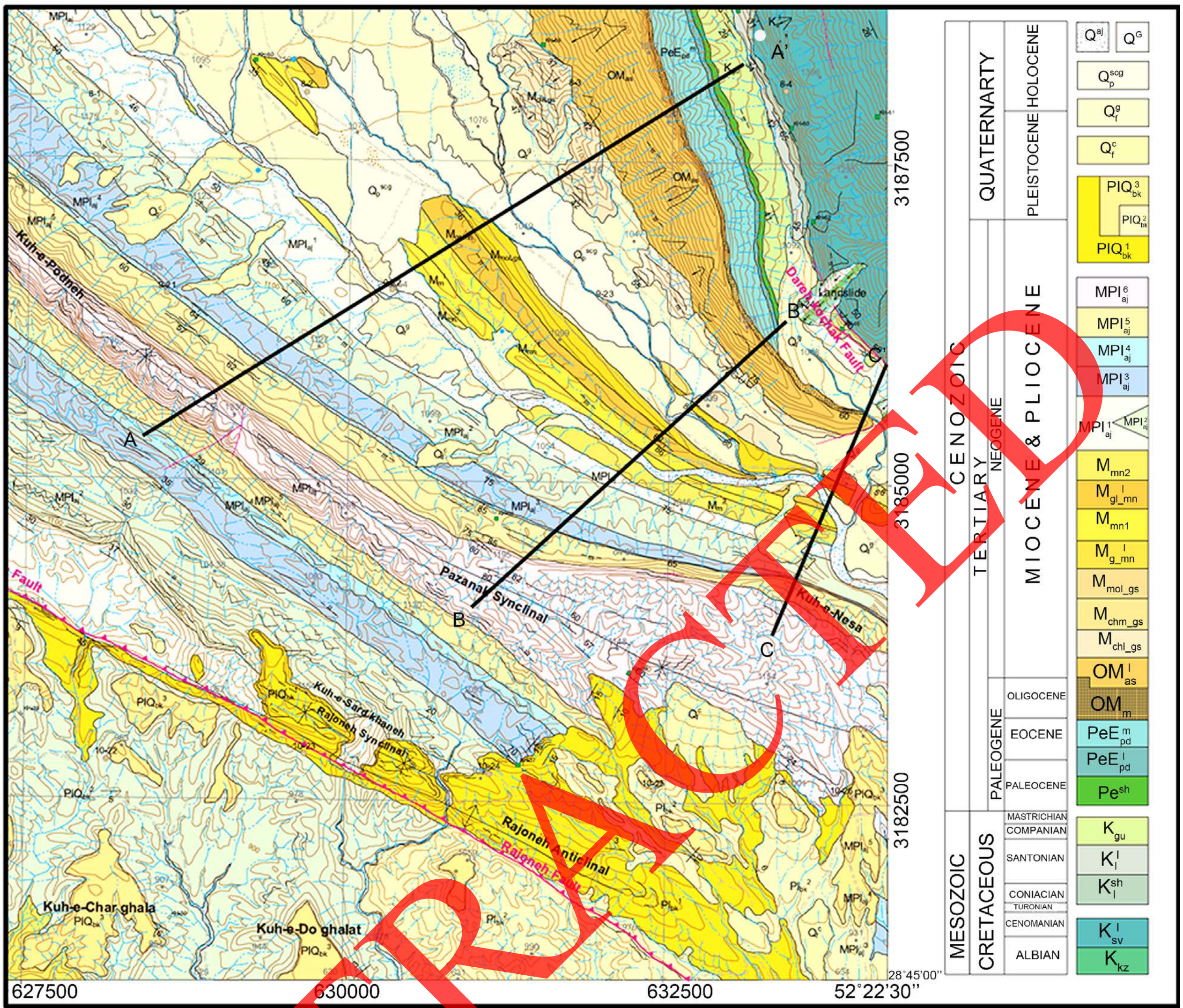

Figure 6. Geological Map of the NW of Mangarek salt and the location of harvested profiles in the picture.

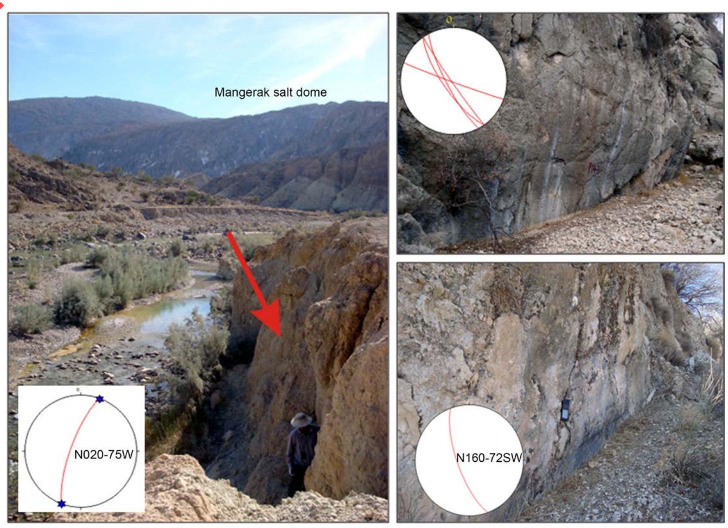

Figure 7. Relationship between stratigraphic formations and a number of small faults in Sarvak-Ilam stratigraphic units in the east of Mangarek diapir

blocks along thinning salt layer will be due to a major obstacle tension for the formation and growth of diapirs in transtentional position; 4) severe sedimentation simultaneously with orogeny (Gachsaran, Mishan and Aghajari formations) could strictly prevent the rise of salt.

Finally, only in certain circumstances that transtention may act as a mechanism with local performance for diapirism. These conditions include 1) transtentional regime before diapirism (while transtention is associated with Korebas fault zone components after the initial diapirism and Mangarek diapir formation), 2) Origin salt low layer depth (while in Zagros folding time, Hormuz salt layer was in high depth) and 3) lack of simultaneous sedimentation with diapirism within the transtentional zone (while, during transtentional zone performance, there is severe sedimentation simultaneously with the Zagros folding).

Therefore, Korebas fault zone performance is not the reason of Mangarek salt diapir formation and field evidence indicates another mechanism for diapirism. The geometry of foldings around this diaper suggests a long-term activity of salt before Zagros orogeny due to the downbuilding phenomenon of diapir margin small basins into the deep salt well, where low deep drape folding and simultaneous with the sedimentation lead to the formation of thin and rotated foldings near the rising diapir [12] [13] [14].

5. Down Building Phenomenon

Evidence shows that Mangarek salt diapir was rising in time before the Zagros folding, by downbuilding mechanism. Downbuilding is one of the most important mechanisms of salt rising and salt diapirs, in evaporative basins of the world. This type of diapirism will be done due to the differential loading and is a direct result rise of salt rising-accumulation of sediment. In other words, tectonic forces have no role in it. Downbuilding requires the rise of salt in a state that large amounts of sediments accumulate steadily diapir neighboring marginal syncline. The accumulation of sediment causes the salt to rise steadily compared to the foldings around, and this is while the growing diapir surface remains close to the ground (mostly sedimentary basin floor). In downbuilding phenomena, sediment deposited to sedimentary basin accumulated locally and thus increasing sediment loads caused local subsidence of the basin floor at that point into source salt layers [6] [7]. Therefore, the salt escape from the burden of large deposits (marginal syncline) and move to areas with lower sediment load (near the salt diapir) and feed the diapirs. In general, the geometry of diapers largely depends on the rate of salt rise at the rate of sedimentation. Dominant nechanism downbuilding on the rise is more diapir salt structures in the history of Fergashtegan, so that the issue is likely in every place of tectonic. Diapirism that happens with the help of downbuilding phenomenon is stopped when the rise of the salt cannot move forward with sedimentation that two things may happen: a) increase the rate of deposition; b) when the drain of the salt layer creates a salt weld-denominated and in this case, diapir will be buried more due to the sedimentation [8].

Due to the rise of salt by downbuilding mechanisms, structures and various geometries form around diapir, which the set of them is called, salt halokinetic sequences. Salt halokinetic sequences, by definition, are continuous collections of thinned and rotated foldings that surrounds by local discontinuities. These structures and related geometries include onlap of deposits on diapir edges, tickness changes and sedimentary foldings thinning from marginal syncline to diapir peak, steeping and even inverting foldings near the diapir, especially in older units, local growth foldings, local discontinuities in line with the ridge of diapir, local conglomerate whitin the formation near the diapir, normal faulting parallel to the edge of the diapir and even perpendicular to it and recycled debris from diapir [9] [10]. What is obvious in downbuilding diapirism is the folding thickness change of the neighboring and layers tilting near the salt diapir. By closing the salt diapir, foldings become steep and thin. This type of diapirism longer will influence older layers and therefore the tilting and steep value is greater in older layers and even in many reversed cases, sedimentary layers will happen. In some cases, layers thickness increases toward diapir that relates to salt depletion and the migration of the sedimentation center to diapir stem. Finally, the overall geometry of salt halokinetic sequences depends on several factors, including size of salt diapir, speed ratio of diapir rise to sedimentation speed, the size of the sedimentation center near the diapir, type and amount of sediment in the center of sedimentation, rising salt pile form and slope of growing salt dome wall.

Downbuilding diapirism accompanied by deformation near salt diapir generally where neighbor foldings or under salt (in diapirs and salt tenon), will have folded and fault. Faulting may be perpendicular to the diapir boundry (radial faults), parallel to the diapir (faults with the same center) or very complex. Folding may be too small with little thinning in foldings around or significant with vertical or even reversed layers, local discontinuities and severe folding thinning [2] [4] [5].

At first, it was thought that, sedimentary foldings tilt in the vicinity of the diapir is related to the development of shear zones that come into existence the diapir with surrounding foldings, and is leading to dragging of sedimentary layers of rock [13] and therefore the foldings are called drag fold. A new study [14] shows that salt rising cannot lead to the development of shear zones in diapirstone and make foldings in stone; because, the resistance of salt is less than stone and in Geological time scales, it acts as a fluid. That is why diapir salt cannot create the drag foldings in deep rock. So, the spread of these foldings around diapirs, that now is known as drape fold, related to the loading subtraction in center of sedimentation—small basins around the downbuilding salt diapir, escape of salt into the diapir and therefore it is the rise of it [4] and in shallow place, it is formed simultaneously with the sedimentation formation (**Figure 8**).

Salt halokinetic sequences will be created by changes in net rate of diapir rise in the net rate of accumulation of local sediment. In general, two types of salt halokinetic sequences will be expanded around downbuilding diapirs, that each

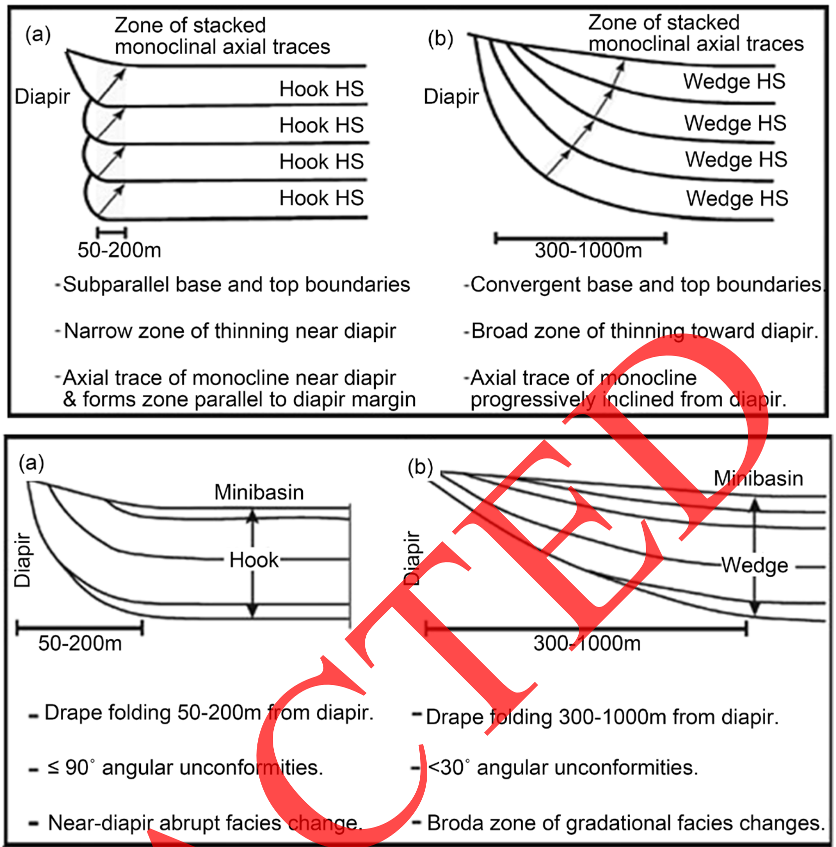

Figure 8. (up) two distinct types of salt halokinetic sequences that are as end-members. a) Hook halokinetic sequences of salt, b) wedge halokinetic sequences of salt. (down) two distinct types of combined halokinetic sequences of salt as end-members. a) board combined halokinetic sequence of salt, b) board combined halokinetic sequence of salt.

with have specific characteristics and geometry: 1) hook (hook); 2) wedge. The two sequences are specified based on field observations of folding geometry in salt basins of Mexico and seismic profiles from different basins (Figure 9). Hook and edge sequences are as ending members and there are complex and compound modes available. Salt halokinetic hook sequences have narrow deformation zones (50 to 200 meters), sharp angular discontinuities; diapirs recycled debris and sudden facies changes (Figure 8). Salt halokinetic wedge sequences have large deformation zones (300 to 1,000 meters), discontinuities and low slope cuttings and gradual facies changes (Figure 8). Hook sequences are stacked in the form of tabular; that they have semi-horizontal boundaries, thin ceilings and local deformations and their accumulation leads to tabular combined halokinetic salt sequence expand (Figure 8). Wedge sequences are stacked in the form of tapered that leads to tapered combined halokinetic salt sequence formation (Figure 8). These sequences have converged foldings boundaries, more thickness ceilings and extensive zones of deformation. The type of salt halokinetic sequence will be determined by the sediment accumulation rate to the rate of rise in diapir. Low ratios lead to tabular sequences (or hooked) and high ratios lead to tapered sequences (or wedge). These two criteria are measured

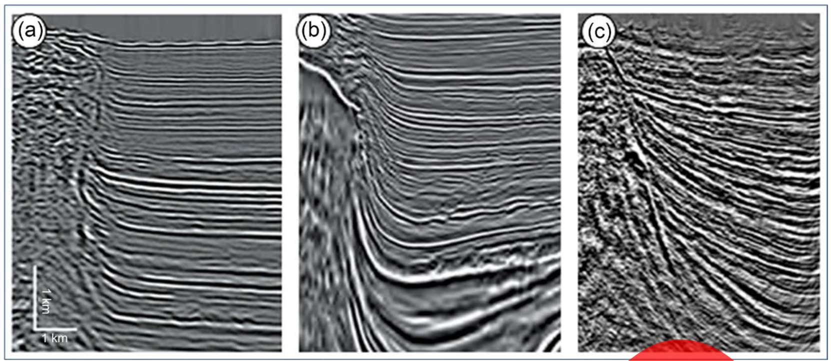

Figure 9. seismic profiling of secondary diapirs types and strata close to it. a) Folded sequence Panetta salt compound movement of the timber in the northern part of the Gulf of Mexico (Giles & Rowan, 2012) b) hook movement sequences of salt in Denmark c) wedge movement sequences of salt in the Persian Gulf.

relative to each other and absolute values are not considered [14] [15] [16].

Diapirs tend to evolute over time from the widescreen mode with low relief (salt pillows) to the slender diapirs. Therefore, folding and thinning in the small-scale basin, in typical is the characteristic of older and deeper sections of small basins. On the contrary, local salt halokinetic deformation is prevailing in low deep and vertical sections of diapirs.

6. Mangarek Salt Diapir Rise

Sarvak and younger layers in the northwest and southeast of Mangarek salt diapir shows downbuilding evidence. The increase slope of layers is due to reverse folding to older units due to continuous performing of downbuilding phenomenon because older layers were exposed longer to this mechanism. Because the downbuilding phenomenon has caused the rise of a constantly diapir downbuilding, so the turnover of older layers from Sarvak-Ilam within the same sequence of salt-movement is greater but because, the lack of occurrences, this turnover cannot be observed. Along the ridge of syncline, by awaying from diapir, they vertically appear and then return to normal (**Figure 5(a)** and **Figure 5(b)**). This geometry of foldings shows that the Mangarek salt diapir has risen with downbuilding mechanism. The situation in the Dadanjan salt dome that is located in North of Mnagarek diapir has also been reported [7] [8] [13]. Stratigraphic pattern indicates that Mangarek salt diapir activity was relatively severe through downbuilding mechanism during the late Cretaceous-middle Miocene. Steep slope can be seen and concluded in sedimentary layers adjacent of diaper. Of course, the conclusion is the combination of two former diapirism and the latter folding factors and is not merely a result of downbuilding phenomenon. Therefore, the detecting how much the slope layers have created by downbuilding before folding is not possible. However, with an average value of 40-degree gradient of layers on the part of the anticline, which is far from the diapir, we can find out a bit of a slope that is created by hanging folding before Zagros orogeny per folding unit [17] [18].

In conjunction with the formation of several faults in the Ilam and Sarvak unit adjacent to the Mnagarek diapir and the lack of them in other units (Papdeh-Gurpi and Asmari) there are two possibilities. The first possibility is that these faults were because of Zagros orogeny Neogene shortening and there is no relation to former diapirism and therefore may not undergo any rotation. The second possibility is that the initial formation of these faults is associated with the former diapirism and occurs before younger units' sedimentation of Sarvak and Ilam. Downbuilding diapirs typically have a thin celiengs. While the rising diapir and small neighboring basins subsidence, thin roof suffered from drape folding progressively. This type of roof folding can lead to the formation of normal faults with the same center (with a slope towards the diapir and vice versa), radial and even irregular due to outer arc tension in fold [6] [15] [16]. This type of fault can help the thin roof rupture of diapers and debris deposit formation that were carried into the adjacent basins and formed recycled debris from diapirs. This type of faulting and expanding recycled debris is more in salt halokinetic hook sequences and tabular salt halokinetic sequences. Therefore, it can be suggested that small fractures in the limestone units of Sarvak- Ilam in fact, were normal faults that are formed by drape folding of downbuilding at the time of this unit sedimentation in the Late Cretaceous. These fractures were reactive due to Zagros Neogene folding and underwent changes in the amount and movement mechanism. The current oblique slip movement of the faults is due to their placement in the current tectonic regime of the area. The reason that these faults have not right lateral strike slip mechanism is that they are now within or in the border of transtentional zone between two or three overlapping pieces of Korebas fault zones. Mangarek salt diapir is now within the transtentional deformation zone [1] [8] [13].

7. Evaluation of Structural-Stratigraphic Deformation

Seismic data of the internal Zagros show that the folding of some of anticlines has started in the Miocene [15] [16]. To determine the age of folding, researchers have worked on the upper part of Aghajari formation, and generally, they have concluded that folding started from 7.2 to 8.1 million years, meaning from the Late Miocene. Due to this, the Mangerak dome certainly was before Zagros Basin deformation and likely, at least, it was exposed in the Late Paleogene Sea and Neogene as an island (such as salt dome islands in the Persian Gulf today).

On the other hand, the chimney of the dome is located in the western block of Korebas fault and thinning the edge of the dome formations, apparently "only exists in this sector, which represents the relationship between the births of this dome with the fault.

The Mangarek salt dome has a surface outcrop in place along the Sayakh anticline axis and beside Korebas fault. On the northwest bank of Dome, a significant reduction in the layering condition and sediment thickness of participating formations can be seen in the anticline folds of Sayakh. This thinning is more pronounced toward the dome, which represents its relationship with dome formation. Reducing the minimum thickness for formations after Papdeh formation

(Paleocene), is invoked.

In order to better understanding of the mechanism, and the rise of Mangarek salt diapir, the geometrical relation of diapir with the adjacent strata and investigating the relationship between diapirism and folds in three profiles A, B, C, in line with almost perpendicular to the main folds of range (Figure 6) and by using the data field, geological map data and surface cutting of stratigraphic for NIOC, structural and stratigraphic interpretation were done and the cuts related to them were drawn (Figure 10). Sections A, B, C, respectively, were selected at a distance of 1.5, 3.5 and 6 km northwest of the Mangerak salt dome. Selecting the location of these profiles was made based on the best expose of adjacent strata. Harvest lines were perpendicular to the strata and along them, with the splitting of rock formations, the measure of their thickness and slope changes and layers, as well as facies changes were discussed.

Stratigraphic geometry, which is inferred near the diapir by using field observations and structural sections, is different. Changing the layered slope, near the diapir, represents different movement sequences of salt. Slope of layers, in some sections, is very steep (Figure 10). By field measuring, changes position of layering was studied. The layers inclination angle has increased by closing towards the salt dome, and in connection border of the dome, their slope is close to the vertical and at some point, and it is reversed. Thickness of the units in Papdeh, Asmari, Gachsaran, Mishan and Aghajari formations is very low near diapir.

8. Reviews of Thinning Layers Associated with Dome Formation

To determine the effect of rising Mangerak salt dome on the sedimentary environment of it, the investigation of the rock strata in the surrounding area was conducted. Initial investigations, clearly, revealed the thinning in sedimentary deposits around the dome above. Further investigations on this subject were considered in the form of harvesting three profiles at different distances from the dome. Profiles were chosen so that to show the thinning issue during the Paleocene to Pliocene (Figure 10). The results of these surveys show sedimentary deposits in 1.50 km of the Dome (line picked C), have thinning at a rate of 2.17 times. Table 1 shows the thickness of sediments in same stratigraphic units at 1.50, 3.50 and 6 kilometers away from the Mangerak dome.

Results of Table 1 also show the lack of similarity in thinning in the different time that indicates the change in speed of uplift dome. Most of thinning in Aghajary formation (rock unit MPl3a) is the equivalent of 14 times. Thinning intensity in time of Middle-Late Miocene coincide with a depost of Mishan formation has increased dramatically that can be because of the performance movements of tectonic phases in Austrian and Pasadenian. This issue in adjacent to the global salt diapir that is located in south of the Mangarek salt dome, have been reported by Edalat Nia and colleagues. In the northeast of diapers, the gradual thinning and removal of a unit in Mishan formation with closing to this

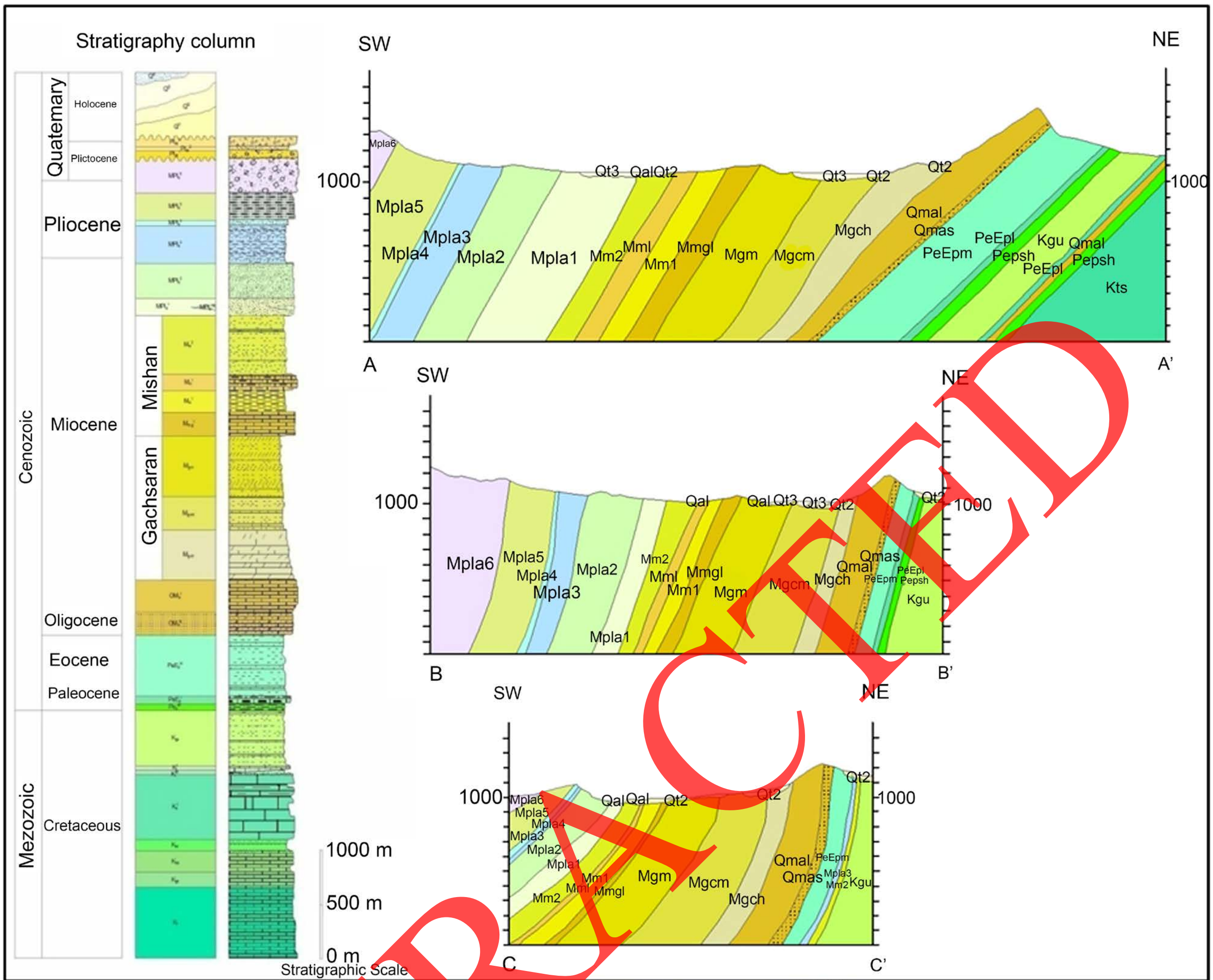

Figure 10. Three sections of Stratigraphy in Figure 6 and the stratigraphic column of the units in the region AA': 6 kilometers from the dome, BB': the 3.50 kilometers distance away from the Dome and CC': the distance 1.50 kilometers from Mangarek dome.

Table 1. Table of thinning the thickness of stone deposits, during the Paleocene to Pliocene in North West of Mangarek salt dome.

NO.	Age	Formation	Sub Unit	Thickness in section(m)			Shorting Rate
				AA'	BB'	CC'	
1			MPL5	406	353	127	3.20
2			MPL4	24.5	23	21	1.17
3	Mio-Pliocene	Aghajari	MPL3	225	187	16	14.06
4			MPL2	337	323	188	1.79
5			MPL1	451	154	82	5.50
6			Mm2	189	156	87	2.17
7		Mishan	Mml	124	62	23	5.39
8			Mm1	152	111	88	1.73
9	Miocene		Mm.g1	137	103	22	6.23
10			Mg.m	378	326	303	1.25
11		Gachsaran	Mg.cm	362	312	306	1.18
12			Mg.ch	387	131	124	3.12

Continued

13	Eoc-Olig.	Asmari	OMl	227	205	202	1.12
14			OMls	25	23	22.5	1.11
15	Paleocene	Papdeh	PeEpm	326	113	108	3.02
16			PeEpl	31	27	23	1.35
17			PePsh	77	51	37.5	2.05
	Total			**3858.5**	**2660**	**1780**	**2.17**

diaper represents similar conditions of the two adjacent diapir sedimentary basins (Figure 11).

It seems, orogenic movements has caused downbuilding increase in the salt dome, reduced the depth of the basin and further reduced of the thickness in sediments around it.

9. Checking Facies Changes during Dome Formation

In addition to thinning in the thickness of the sediments around the salt dome above, sedimentary facies has little changed toward the dome and has become more continental facies (Table 2). The facies changes have a direct link with the thinning, *i.e.*, by increasing the amount of thinning, more continent sediments are deposited that shows the dome uplift and reduces the depth of the sea. Coarse-grained sediments, such as conglomerate show coast to continental facies, by approaching the dome. It seems that the rise of the dome has caused the sedimentary basin floor rise and in addition to reduce the thickness of sediments (thinning), has caused sediments with continental facies (Figure 12).

Thinning sediments and changes in sedimentary facies toward the dome show that the Mangarek salt dome has cropped as an island (like today's salt dome Persian Gulf islands), has reduced from the depth of the sediment basin toward it, and thus has caused the reduction of sediment deposit.

10. Conclusions

Field evidences indicate that the Mangarek salt dome was existed pre-deformation of Zagros Basin and possibly, it was exposed at least in the late Paleogene and Neogene Sea as an island (such as salt dome islands Persian Gulf today).

The main mechanism of action, which has caused constantly diapir rise, is the downbuilding phenomenon in the center of local sedimentation around the diapir. These evidences will prove the start of Mangarek salt diapir activity, at least since the Late Cretaceous. This is the minimum age that can be inferred from surface data.

Strike-slip performance range and transtentional zone (Korebas fault zone) and creating weak tension atmosphere along with the fault, triggers diapirism, but it was not involved in the uprising, because, the possible rise and growth of diapirs, in transtentional basins, need very limited circumstances that, the area has not been provided. Downbuilding was the continuing compressional tension

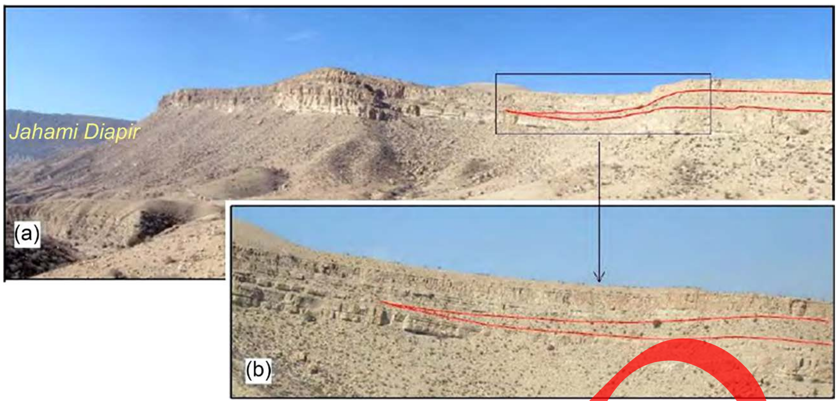

Figure 11. thinning and the gradual elimination of Mishan formation by approaching the World diapir. Southwestern look. The thickness change refers to the downbuilding phenomenon.

Table 2. Change in sedimentary facies rock, from the Paleocene to Pliocene in North West of Mangarek salt dome.

NO.	Age	Formation	Sub Unit	Profile AA'	Profile CC'
1			MPL5	Medium to thick bedded sandstone with interbedded siltstone and conglomrate	Medium to thick bedded sandstone with interbedded siltstone and conglomrate
2	Mio-Pliocene	Aghajari	MPL4	Thick bedded conglomrate and medium bedded sandstone	Thick bedded conglomrate and medium bedded sandstone
3			MPL3	Gypsiferous marl, claystone, siltstone with conglomrate and sandstone	Gypsiferous marl, claystone, siltstone with conglomrate and sandstone
4			MPL2	Sandstone and conglomrate	Sandstone and conglomrate
5			MPL1	Red sandstone, siltstone and marl	Red sandstone, siltstone and marl
6			Mm2	Gray to light blue marl with intercalation of argillic limestone	Gray to light blue marl and siltstone with intercalation of sandy limestone
7		Mishan	Mml	Thick and well bedded fossiliferous limestone with interbedded of marl	Thick and well bedded fossiliferous limestone with interbedded of marl and siltstone
8			Mm1	Gray and green marl with intercalation of limestone beds	Gray and green marl with intercalation of limy sandstone and conglomrate beds
9	Miocene		Mm.g1	Medium bedded limestone with interbedded gray and green marl	Medium bedded limestone and sandy limestone with interbedded marl and siltstone
10			Mg.m	Medium to thich bedded, white to greenish-gray gypsum, red and green marl	Medium to thich bedded, white to greenish-gray gypsum, red and green marl and siltstone
11		Gaghsaran	Mg.cm	Intercalation of gypsum, marl with interbedded of sandy argillic limestone	Intercalation of gypsum, red and green marl, siltstone with interbedded of sandy limestone
12			Mg.ch	Thin to medium bedded dolomitic limestone and marl with interbedded of gypsum	Thin to medium bedded dolomitic limestone and marl with interbedded of gypsum
13			OMl	Thin bedded, nummulitic limestone and dolomitic limestone	Thin bedded, nummulitic sandy limestone and dolomitic limestone
14	Eoc-Olig.	Asmari	OMls	Thin bedded, white to cream colour, sandy limestone and argillieous limestone	Thin bedded, white to cream colour, sandy limestone and some sandy conglomrate
15			PeEpm	medium bedded marl, calcareous marl and argillieous limestone	medium bedded marl, marl, siltstone and sandy limestone
16	Paleocene	Papdeh	PeEpl	Thin to medium bedded cherty argillieous limestone and intercalation of thin marl	Thin to medium bedded cherty sandylimestone and intercalation of thin marl and siltstone
17			PePsh	Red shale with interbedded green marl and argillieous limestone	Red shale with interbedded green marl , Sandy limestone and siltstone

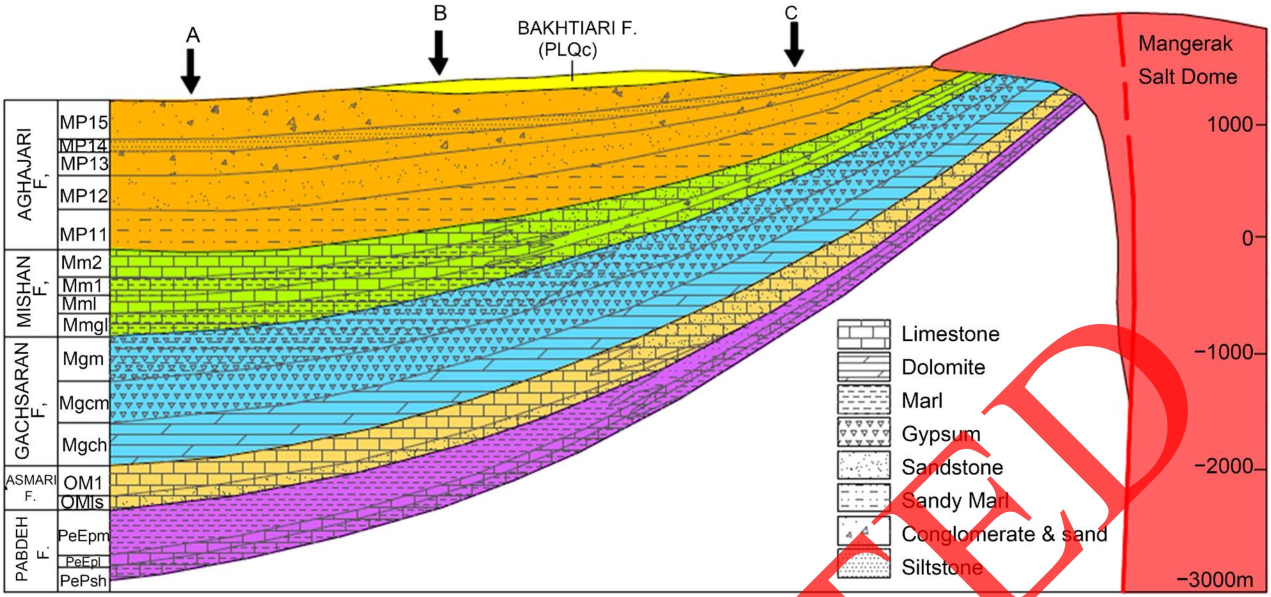

Figure 12. Geological profile of schematics before folding units, in the northwest of Mangarek diapir, that shows its relationship with the adjacent strata, in terms of thinning and facies changes. In the figure, the place of harvest lines A, B and C is shown

and buoyancy force due to continued diapers rise.

The geometry of the surface strata around salt diapir (field evidence) shows that, downbuilding in sedimentation centers around the salt diapir, has various functions in response to different rates of the salt rise—sediment deposits. These depositional centers have deposited a significant volume of sediment. During Zagros Neogene shortening, these deposition centers resist against folding and remain as broad synclines. This factor has made in addition to taking a considerable part of compression stress in pressing the salt diapir.

Mangarek diapir growth has caused a dramatic change in the adjacent sedimentary basin and its effects are evident as the change in thickness of rock units. That is, the thickness of the sediments around the dome has been reduced with closing to it and thinning. The degree of thinning is 2.17.

Thinning intensity during the Middle-Late Miocene time, which was coinciding with the Mishan Formation deposit, has significantly increased that can be influenced by the performance of the tectonic phase's movements in Austrian and Pasadenian. It seems that these gestures increase the movement and the uplift of the salt dome and further reduces sediment around it.

Changes in the sedimentary basin of Mangerak salt dome growth also have been associated with changes in facies. In addition to thinning, sediments will shift in terms of aggregation by approaching to the dome as well. Coarse-grained of sedimentary in rock units indicates a Mnagarek dome rise, reducing the depth of the adjacent sedimentary basins at different times, and as a result, adverse change in the surrounding rock facies.

The amount of thinning in the different times was not the same, which suggests a change in speed of uplift dome. Most of thinning in Aghajary formation (rock unit MPl3a) is equivalent to 14 times.

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