# Tectonostratigraphy of Sarvak Formation in Zagros Mountain Ranges; South West of Iran

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## Abstract

*In this study four geologic sections which are perpendicular to Zagros mountain range have been chosen.*

*Each geologic section is composed of many stations(stratigraphic columns). Sarvak formation as petroleum reservoir rock is studied in the field of lithostratigraphic and syndepositional tectonic activities.*

*Different tectonic activities in the sedimentary basin during Cenomanian, causes various aggregation pattern of Sarvak formation in each station.*

*Finally tectonic movements confirm variation of lithostratigraphic limit of Sarvak Formation in the sub division of Zagros.*

**Key words:** *Sarvak Formation, Lithostratigraphic, Tectonic activities, Zagros*

## Introduction

Sarvak Formation is a thick carbonated unit that is deposited in "Neotethys Southern Margin of Zagros" area. In the past this rock unit was called Hipporite limestone, Rudist limestone and Leshtegan limestone, but with sectional measurement in Sarvak rock unit at Bangestan mountain, Sarvak Formation substituted former names. Based on identified fossils, the age of the Sarvak Formation is Upper Albin to Touronian. This formation includes mostly carbonate in lithology and was composed from sequence of thin to medium-bedded limestone and massive limestone.

Also Sarvak Formation is one of the most important hydrocarbon resources production horizon in Iran (Afshar Harb, 2001). Laboratory and field observation lead to recognition of four facies environments: open marine, shale, lagoon in Coastal area of Fars, Khuzestan and Lurestan. The lower lithostratigraphic limit of Sarvak Formation which is conformable and gradational overlies the Kazhdumi Formation in type section. Upper lithostratigraphic limit of that is secant with Gurpi Formation.

## History of Previous Research

At first, James and Wynd (1965) studied Sarvak Formation and consequently the researches have been done on Zagros bio-stratum such as Bangestan group and the result of these researches shows that the age of Sarvak Formation is Cenomanian. Fonouni (1994) in studies on Sarvak Formation in Bangestan and Jahrum mountains reached new findings in biostratigraphy of it and reported new aperture in Sarvak Formation.

Motiee (1994) has explained the reduction of Bangestan group to Bangestan Formation and reasons that justify this matter. He believes that 1) Sarvak Formation type section is not a complete stratigraphic section and 2) in Dezfool Embyment, Ilam and Sarvak Formations that have similar lithofacies and are shallow, altogether form an oil reservoir. Lasmi and Kavoosi (2005) specified four sedimentary sequences stratigraphy for Sarvak Formation in Lurestan area and recognized that the age of Sarvak Formation is Cenomanian to Touronian in this area.

By studying stratigraphy and sedimentary enviroment of Ilam and Sarvak Formations in Abteymoor oil field, Ghabishavi et al (2006) concluded that Ilam and Sarvak Formations have deposited in a carbonate ramp area and by compairing core analysis data, they indicated that Oligostegina facies, which is from external and middle ramp usual facies, is productive part of Bangestan reservoir.

Al Ali et al (2006) studied Sarvak Formation with regard to sequence stratigraphy. By studies on sedimentary environment and diagensis Sarvak Formation in Karnge oil field Sadat feyznia and Amirzade (2005) found that the sedimentation of Sarvak Formation has occurred in four sedimentary environments:

Open marine, shale, lagoon and tidal flat. In the most recent studied on Sarvak Formation, Afghah and Dehghanian (2007) quantitavely and qualitatively studied microfasis of Sarvak Formation in Kuh-e Shahneshin and Khaneh-kat sections and specified that the age of Sarvak Formation is Cenomanian in these sections.

**Stratigraphy**

Considering the studied stratigraphic sections and places where Sarvak Formation has been reported, four geologic sections are selected which are perpendicular the Zagros trend (the sections position is presented in figure 1).

Each section includes several stations which are pointed out here after. The information of stratigraphic column of the selected stations has been obtained based on stratigraphic columns presented in reports 5 and 6 (Kalantari, 1994) by National Iranian Oil Company. Stratigraphic columns and geology sections prepared by Motiee (1994) have been also used:

Section 1: Khaneh kat; Sarvestan; Narau-1; Kuh-e Surmeh; Dalan-1; Kuh-e Siah-1; Mond (Table-1).

Section 2: Kuh-e Qanun banish; Kuh-e Dinar; Gulkhari; Binak (Table-2).

Section 3: Par-e Siah; Kuh-e Manghasht; Khaviz-1; Gachsaran; Rag-e safid; Hendijan (Table 3).

Section 4: Lab-e safid; Lali; Masjed solayman; Ahwaz; Darikhun; Shadegan (Table-4).

Based on the available data, stratigraphic correlation diagram of each of these sections have been prepared .Then changes in thickness and settlement of sedimentary basin floor, facies changes and disconformity of stratigraphy sections of Sarvak Formation is interpreted and studied .

## Latter Cretaceous incident

Local – chronological stratigraphic study and also the study of Cretaceous metamorphosis are signs of frequent tectonic unrest that is sometimes local and sometimes general, in a way that it seems that incidents comparable with middle Alp had remarkable effects on Iran. In the

most regions of Iran, there is a clear angular unconformity between lower and upper Cretaceous rocks that is preminent with detrital rows including much glauconitic. Erosive period after Tournian has cofirmed sedimentary disconformity between Ilam and Sarvak Formations in Zagros Mountains that is accompanied by generating latrit and lens. Cenomanian and erosive phase has caused the division of Sarvak Formation in two lithostratigraphic parts: Cenomanian and Tournian in Zagros Mountains.

Enough proofs in upper most of Sarvak Formation is confirmatory of a hiatus in Dezfool and Fars Embyment. This course begins from Cenomanian to Tournian and sometimes till Maastrichtian local. This phenomenon has reported in Hejaz by Steineke , Bramkamp and Sander (1958), in Kuwait by Owen and Nasr (1958) and in Iraq by Dunnington (1958) Am Shif by Elder (1963).

Gurpi (Santonin Marl) Formation overlies on Lower Cenomanian of Sarvak Madoud member in Bandar Abbas that is determined by Orbitolina – Trocholina assemblage zone. Gurpi Formation Maastrichtian Marl overlies on Sarvak Limestone with the Cenomanian – Tournian age in Bangestan Mountain.

In the most parts of Fars and Dezfool embayment regions , Sarvak Formation observable with Oligostegina, Alveolinid, Nezzazata biofacies overlies on Ilam or Gurpi Formation with Cenomanian age. This erosive disconformity is clear in oil field of white lode. In this field lower Sarvak is not seen which may be destroyed under erosion or has not been deposited at all in well 1 of Kharg oil field and well 2 of Kornegan oil field in southeast of Gachsaran oil field, lower Sarvak is detected as a very thin layer and also Ilam Formation has been vanished. In some regions of Lurestan like Kabir- kuhe, upper layers of Sarvak Formation which belongs to Tournian, there is regression iron oxide nodule. These conditions resulting from the fact that being apparent from water has accomplished before sedimentation of shale of Surgah Formation.

**Stratigraphy**

Middle Cretaceous sedimentation in Fars and Dezfool embayment is started with a new progress the result of which is limy and shale sediments of Albian Kazhdumi Formation .

In most parts of Fars Platform, Albian shale overlies on shallow limestone of Aptian(Dariyan Formation) with disconformity. This epeirogenic movement has caused the vanishment of parts deletion of Aptian limestone and rising at the time of sedimentation of Albian shales has caused the decrease of thickness in coastal regions of Fars. Shaly of Kazhdumi Formation can be observed in Fars and Khuzeston but in Lurestan region Kazhdumi has limy facies. Aptin Dariyan Formation is an important reservoir rock in Khami group.

Also Kazhdumi Formation is an important source rock in Zagros sedimentary basin (Motiee,1994).

Regression during Late Albian to Cenomanian caused sedimentation of a lot of shallow limestone of Sarvak Formation in spread area of Zagros basin. Falling of the sea level of Late Cenomanian has caused erosion of upper parts of deposited limestone during that storey especially in Fars and Bandar Abbas platform zones. The signs of this erosive disconformity is almost seen in all areas of Fars and Dezfool embayment as iron nodules. Fars area and Dezfool embayment start to deposit during Tournian again, but this settlement has been to the

extent of making shallow and coastal environments and has caused depositing upper carbonate of Sarvak Formation.

At the end of Tournian regional head up has been made and has caused a hiatus in parts or all sediments that belong to this area. After Asmari reservoir rock, Sarvak Formation is considereal as the most important reservoir rock of Zagros basin. Generally, lateral change in Upper contact of the Sarvak Formation is related to paleo sedimentary bathymetric conditions. However Madoud shaly member is recognizable only in Khouzestan region. (However, there is sea level fluctuation in this area during sedimentation of the Sarvak which is related to local tectonic activity in this time. Surgah shale Formation from Sarvak reservoir rock (Aghanabati, 1997)

Under the penetration of limy mud in the middle of Maastrichtian, a unit of clay limestone is identified inside Gurpi Formation that is called Emam Hasan limestone section (Motiee, 1994). Although lower limit of Gurpi is gradual with Ilam Formation surface and it can be a sign of low disconformity.

In places where Ilam deos not exist, Gurpi has overlied Sarvak and in this case, its sedimentary disconformity is more obvious. Upper lithostratigraphic limit of Gurpi Formation with purple shale of Pabede Formation is seen with evidence of erosive disconformity that this disconformity is a result of last Cretaceous phase movements, Laramid. In section one (Fiqure-2), thickness of Gurpi shale Formation is increased gradually from Khaneh-kat to Narau-1, so it has the least thickness (100 meter) in Kuh-e Surmeh and in continuation toward Mond it gets a relative increasing trend with regard to thickness.

In Sarvestan and Khaneh-Kat sections, the thickness of Sarvak limy Formation is about 400/430 meters, but its thickness is decreased in Narau-1 and reaches to 180 meters. Then it follows a relative increase trend of thickness up to Mond. The thickness of Kazhdumi Formation and Dariyan Formation is increased as we go to Sarvestan and in continuation, its thickness is decreased.

These thickness changes are because of sedimentary basin subsidence during deposition. At the beginning of this trend in Sarvestan and Khaneh Kat, the settlement of basin bottom is more and therefore the thickness of sediments is more.

In this section, shales of Kazhdumi Formation are the sign of high depth of the sedimentary basin and transgression of the sea level. In this section we can also see Kuh-e Surmeh, Dallan-1, Kuh-e siah-1, limy inter bed in Kazhdumi'shale which indicates that the basin depth has been decreased and sea level had regression.

In this section, except for Dallan-1 and Kuh-e Surmeh sections, Sarvak has observed like Neritic shallow limy facies that is the sign of regression of sea.

In Dallan -1 and Kuh-e Surmeh, shaly middle layers are seen among Sarvak Limestone which is an indicator of Benthonic facies change to Pelagic and the increase of the depth of basin lateraly. From Narau-1till Mond, basin depth has been shallow limestone of Ilam have been overlied Sarvak and then transgression of the sea caused deep shale of Gurpi Formation to be deposited. In Sarvestan and Khaneh-Kat, deep shale of Gurpi have been directly deposited on shallow limestone of Sarvak. This situation shows that change in sedimentary conditions of basin depth after Sarvak limestone deposit has increased in Sarvestan and Khaneh-Kat sections and the sea has transgressed and deep shale of Gurpi has directly settled on Sarvak Formation, but in continuation of this trend, despite disconformity that is seen in the upper

most of Sarvak Formation, the basin depth has been also shallow limestones of Ilam have been covered on surface of Sarvak Formation which has disconformity.

Then sea has progressed and Gurpi deep shales have been deposited on shallow limestone of Ilam.

In section two (Figure-3), the thickness of Gurpi Shaly Formation is high in Kuh-e Qanun-banish and Kuh-e Dinar and as we get closer to Kuh-e Dinar it is increased. In Gulkhari, the thickness has been very low, and then as we go to Binak it is increased. Also Dariyan Formation thickness has additive trend in this section. The thickness of Kazhdumi Formation was not so thick at the beginning but as we progress it increase from Kuh-e Dinar to Gulkhari. In Kuh-e Qanun-banish, at first basin depth has been high and Kazhdumi shale was deposited with evaporative layers, but after that, sea has regressed and Benthonic limestones of Sarvak were deposited in continuation, basin depth has increased and Gurpi is like shaly and evaporative layers.

In Kuh-e Dinar, benthonic limestone was deposited on Kazhdumi evaporates. In continuation, basin depth has decreased relatively at the time of Gurpi sedimentation and they are seen among deep shale of Gurpi.

Along section two, Sarvak has been deposited like shallow limestone. Sharp change in thickness decrease of Gurpi Formation from Kuh-e Dinar to Gulkhari is the result of Kazerun Fault function. Also along this section in Kuh-e Qanun banish sections, Kuh-e Dinar and Gulkari, Gurpi deep shale are seen on Sarvak with disconformity which indicate regression of sea. Generally in sections one and two, towards High Zagros that is in Saravestan, Khaneh Kat Kuh-e Qanun banish, Kuh-e Dinar and Gulkhari sections, sea has progressed after deposition of shallow limestones of Sarvak and basin depth has been increased. In a way that there is no sign of Ilam shallow limestone. In section three (Figure-4), thickness of Gurpi shaly Formation has been increased from Par-e Siah to Kuh-e Manghasht and Khaviz-1, but in continuation to Hendijan, its thickness has been decreased in a way that it is vanished in white lode (Rag-e Safid). Ilam Formation is seen with a trend of thickness increase in Par-e Siah , Kuh-e Manghasht, the thickness of Sarvak Limestone Formation has been increased from the beginning of section till Khaviz-1 and is decreased in continuation.

Its thickness increase is in Rag-e Safid. The thickness of Kazhdumi Formation has been increased gradually up to Khaviz-1 till reaches 900 meters in Khaviz -1. Its thickness has been decreased from Khaviz-1 to Gachsaran and at the end of section, its thickness was increased.

In continuation of this section, Sarvak Formation is seen like Benthonic limestone that it is a sign of sea regression and shallow basin. Then Par-e Siah and Kuh-e Manghasht has exited from sea level and in its upper most has created a disconformity.

After that sea has progressed, these sections have been entered to the basin but basin depth has been shallow and Ilam limestone has been deposited. Then with the transgression of the sea, deep shale of Gurpi have been deposited. After sediment of Sarvak shallow limestones in Khaviz-1 basin, occurrence of a transgression and clay limestone of Surgah Formation has been deposited. Then, falling of the sea level, this area has come from water and in top of Surgah Formation a disconformity is seen. Again a transgression in Khaviz-1section cuases sedimentation processes, but its depth has been shallow and Ilam limestones have been deposited on Surgah. In continuation, sea progressed, basin depth has been increased and deep

shale of Gurpi Formation has been deposited. A regression in this area cuases depth of the sedimentary basin has been shallow and Gurpi Formation was changed to limy facies.

In section four (Figure-1), Sarvak Formation is so thick. Its thickness from Lab-e Safid to Masjed solayman is increased and reaches 2800 meters in Masjed Soleiman. Then its thickness was decreased from Masjed Soleiman to Ahwaz, but it is high in that manner. At first basin depth has been high, the transgression of the sea cuases the Kazhdumi Shales Formation have been deposited. Then sea regressed and basin depth has been low and Sarvak limestone Formation has been overlied the Kahzdumi Formation.

In Masjed Soleiman, shaly interbed among Sarvak shallow layers as an indicator of deep marine environment are seen that is a sign boundary from Benthonic to Pelagic faceis of the Sarvak. In Lab-e Safid, shallow water environment has been continued and there is no sign of Kazhdumi shale Formation and Sarvak shallow limestone have been deposited on Dariyan shallow limestone Formation.

In strata of this section at the upper lithostratigraphic limit of Sarvak Formation, there is some evidences of coming out of water and then sedimentation. Transgression of the after Cenomanian and shallow water basin is a proof for deposition of the Ilam Formation in this area. In Masjed Soleiman, sea progressed, basin depth was increase and Surgah limestone Formation has been deposited.

Again there is a phase when it comes out from water with disconformity. In continuation sea progressed, basin depth has been increased gradually. Ilam limestone Formation and Gurpi deep shale Formation have been deposited.

**Conclusion**

Generally, Sarvak Formation lithostratigraphic limits have been controlled by tectonic activities of Australian movement. But it is necessary to note that variation aggradations pattern of Sarvak Formation is depended on rate of subsidence in the sedimentary basin (Figure-6).

Also different action of the Austrian movement in Zagros subdivision causes that upper lithostratigraphic limit of Sarvak Formation appears as different lithofacies (Gurpi, Ilam Formation). (Figures 7,8,9)

But, lower lithostratigraphic limit of Sarvak Formation overlies the Kazhdumi Formation gradationally in all of student stratigraphic sections (Figure-10) .

Actually the boundary between Kazhdumi and Sarvak Formation is changed in aggradations.

Pattern that occurs in the boundary of Albina – Cenomanian

Generally Sarvak Formation is started with Benthic facies (with orbitolina taxa) based on previous microfacies studies (Afghah & Dehghanian, 2007).

There is a transgression in Sarvak Formation which is detectable in the middle Sravak Formation.

Gradationally, pelagic facies in Sarvak Formation changes to the benthic facies, which relates to Austrian movement (figure-6).

Finally, disconformity between Sarvak and overlies Formation, indicates some part of middle Cretaceous epirogenic activity in the Zagros .

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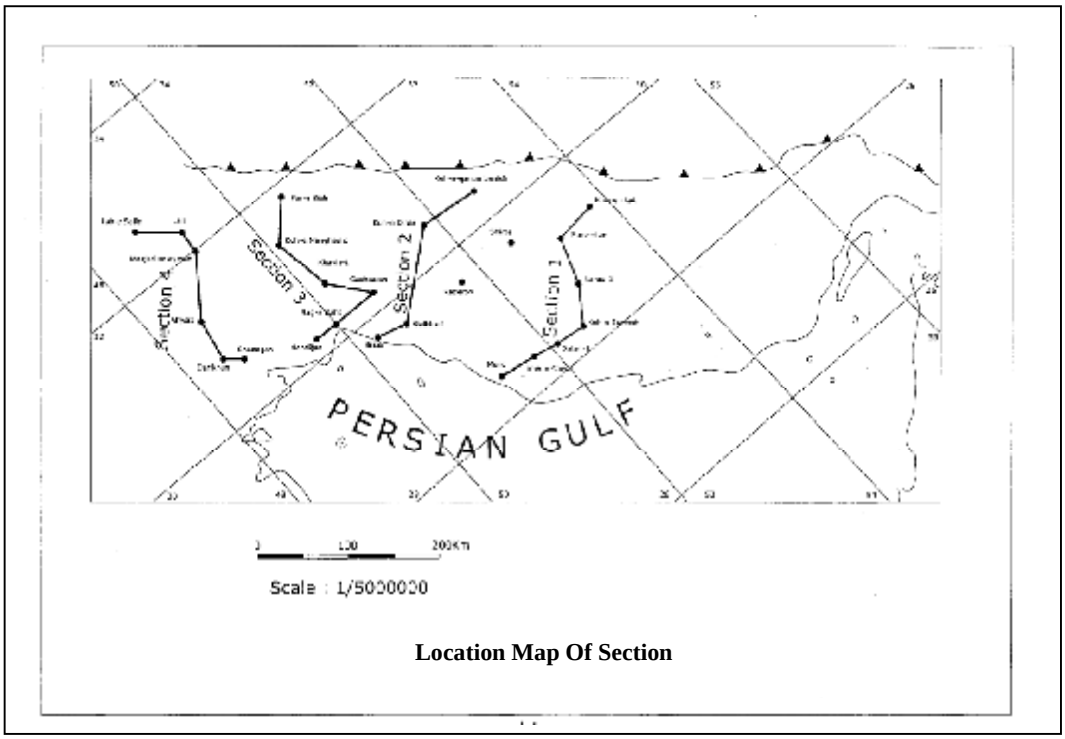
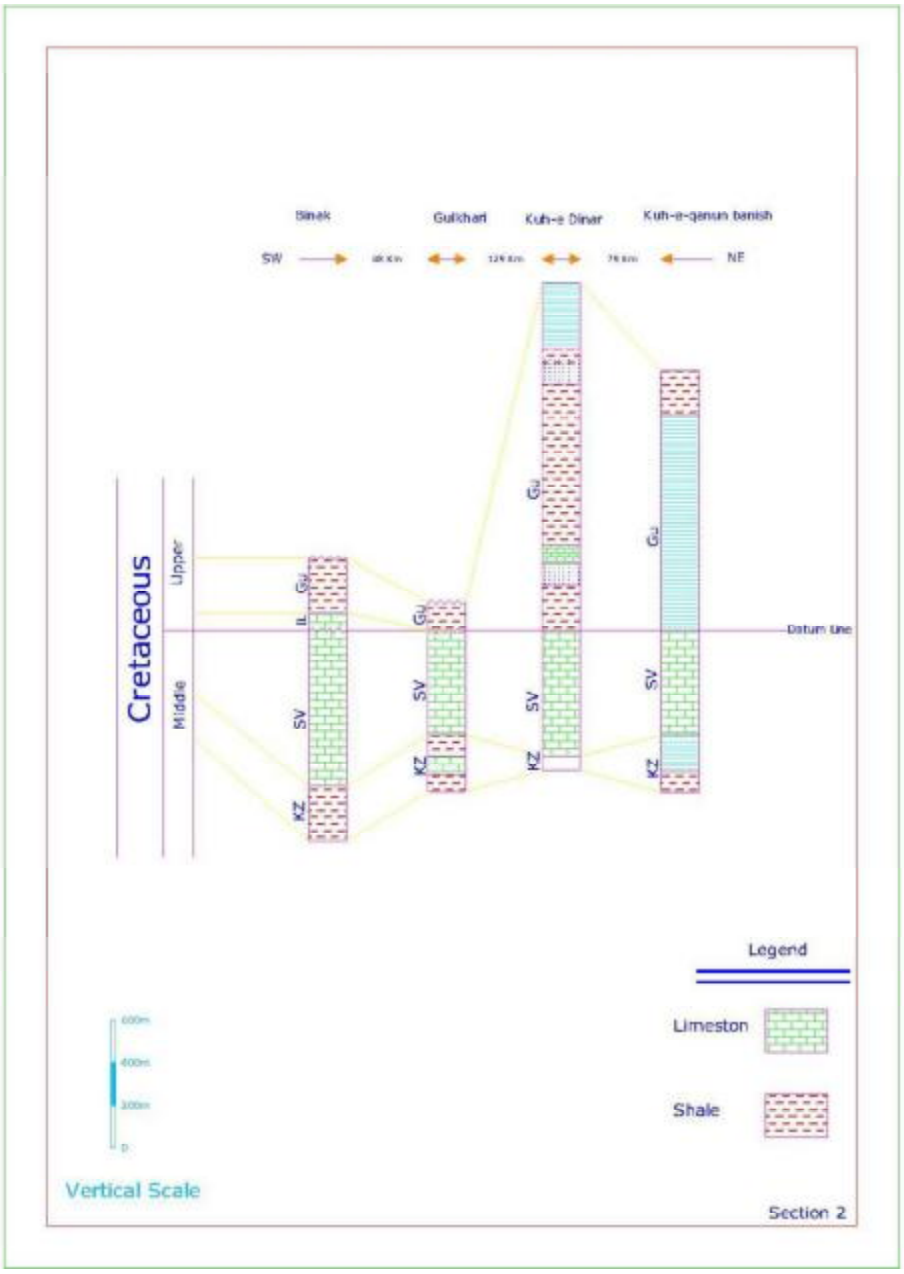



**Figure-1: (Zamani, Afghah, Esmaelpoor)**


**Figure -2 (Zamani, Afghah, Esmaelpoor)**

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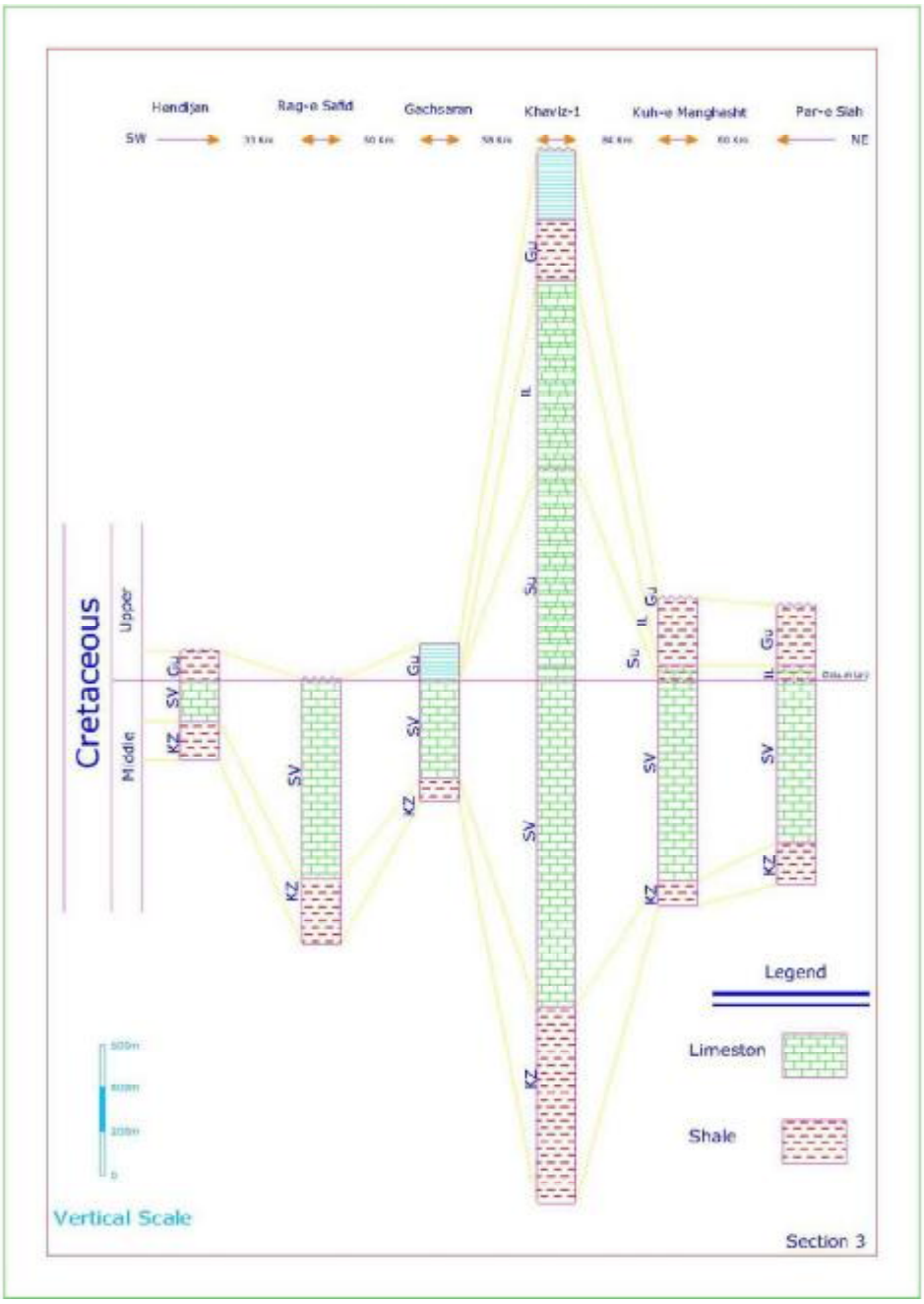


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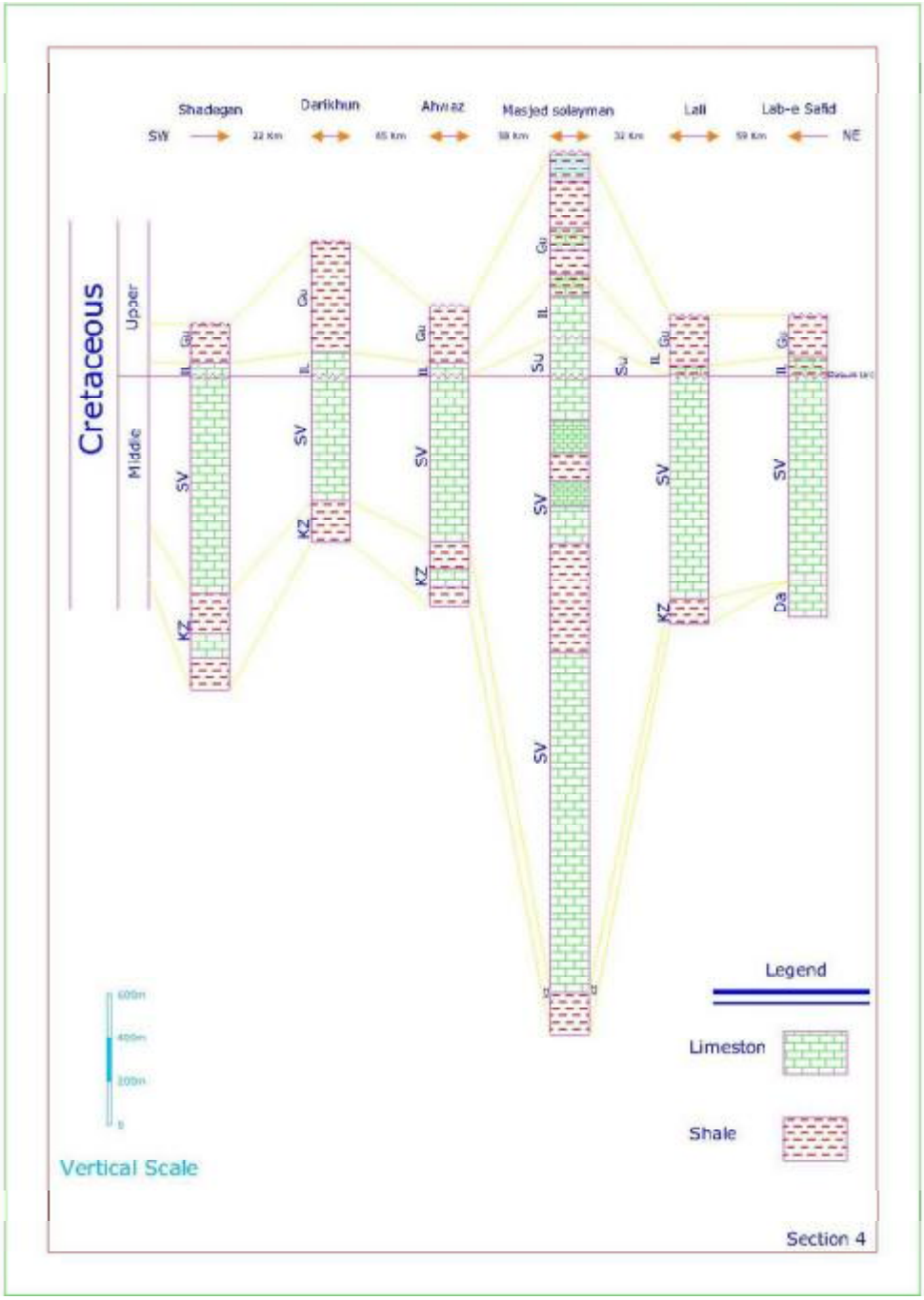


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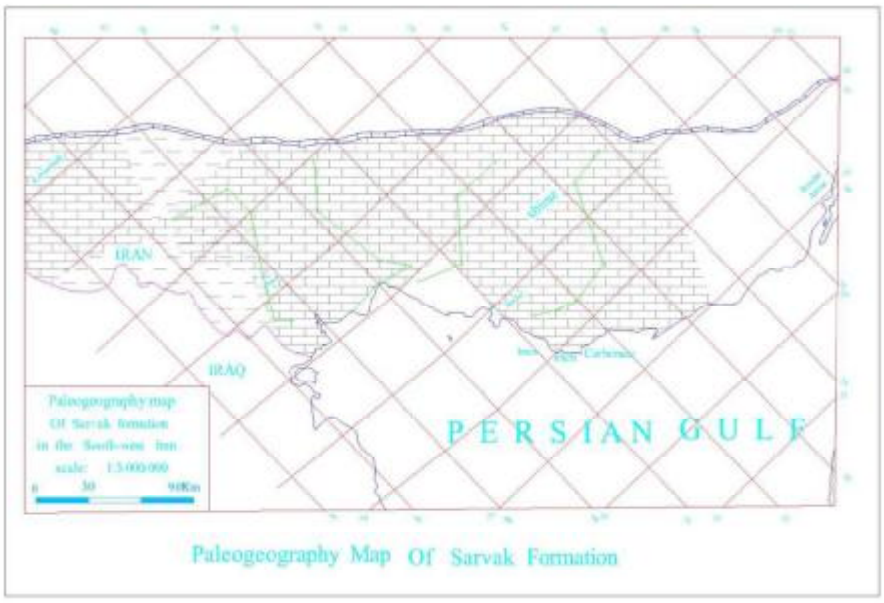


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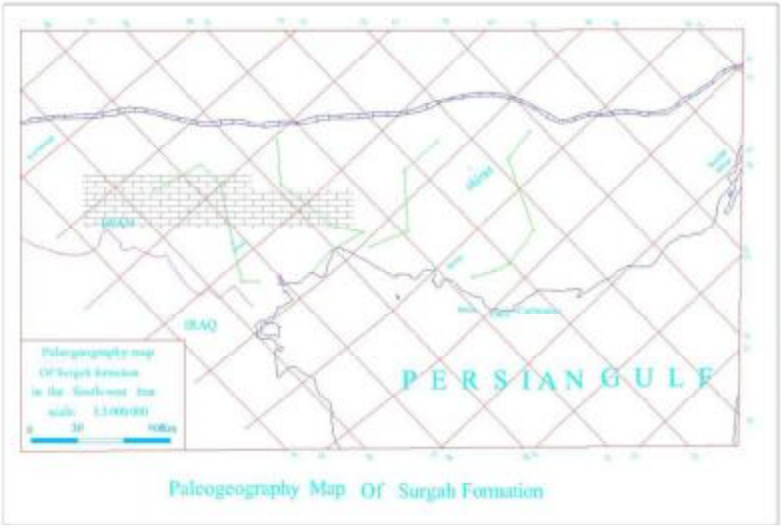


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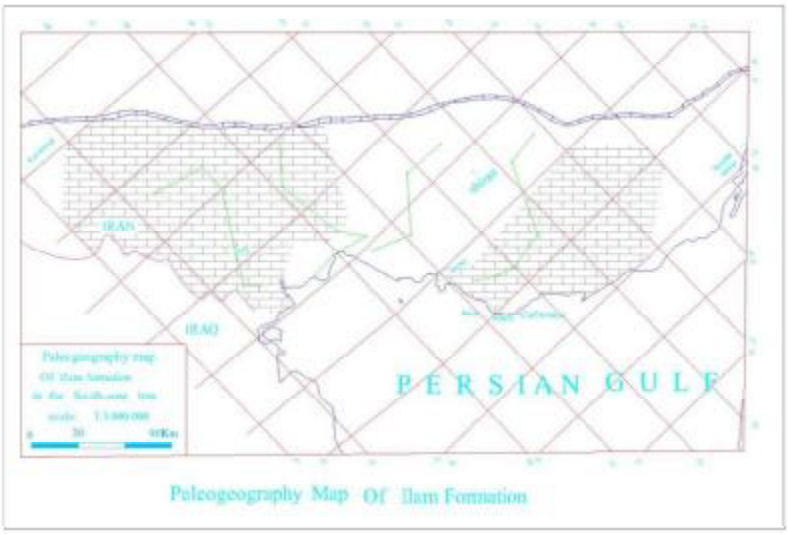


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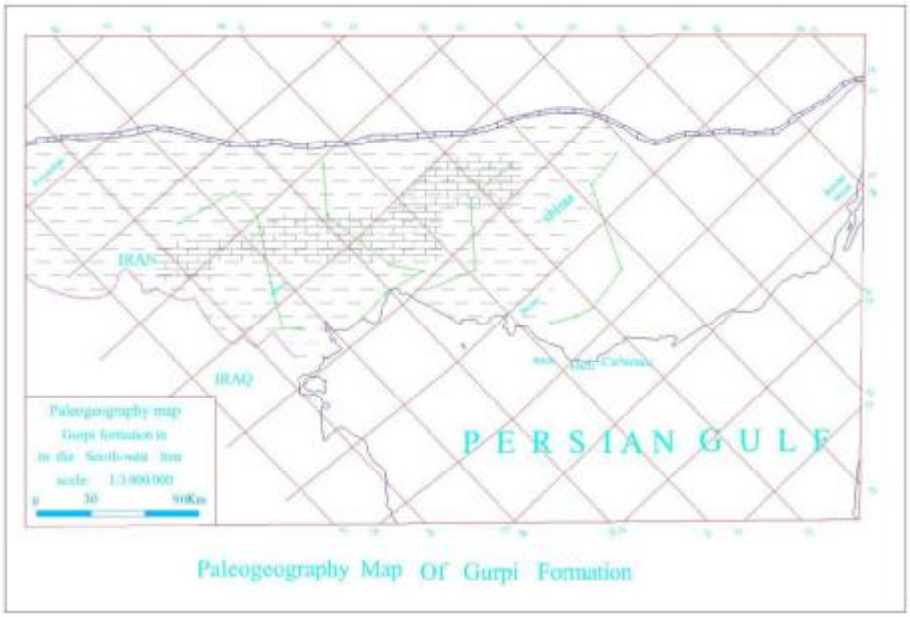


**Figure 9 (Zamani, Afghah, Esmaelpoor)**

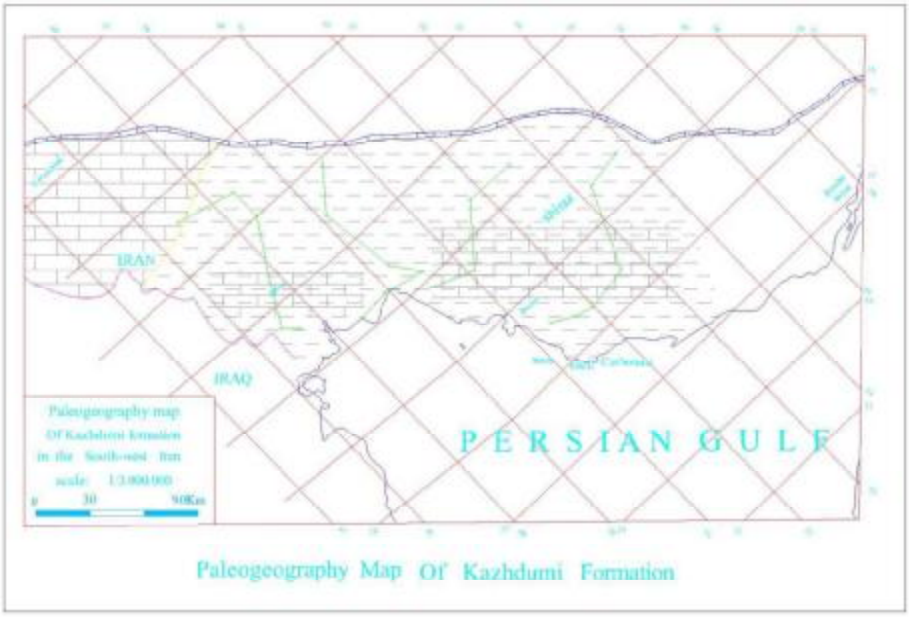


**Figure 10 (Zamani, Afghah, Esmaelpoor)**

**Table-1. (Zamani, Afghah, Esmaelpoor)**

| Location | Avrage | Lithology | Age | U.contact | L.contact |
|---|---|---|---|---|---|
| Khaneh kat | 400 m | Limestone | M.cretace(cenomanian) | Gurpi | Kagdumi |
| Sarvestan | 430 m | Limestone | M.cretace(cenomanian) | Gurpi | Kagdumi |
| Narau-1 | 150 m | Limestone | M.cretace | Ilam | Kagdumi |
| Kuh-e Surmeh | 600 m | Limestone with little shale and sandstone | M.cretace(cenomanian) | Ilam | Kagdumi |
| Dalan-1; | 150 m | Limestone interbeded shale | M.cretace(cenomanian) | Ilam | Kagdumi |
| Kuh-e Siah-1 | 100 m | Limestone | M.cretace(cenomanian) | Ilam | Kagdumi |
| Mond | 250 m | Limestone | M.cretace | Ilam | Kagdumi |

**Table-2. (Zamani, Afghah, Esmaelpoor)**

| Location | Avrage | Lithology | Age | U.contact | L.contact |
|---|---|---|---|---|---|
| Kuh-e Qanun banish | 500 m | Limestone | M.cretace | Gurpi | Kagdumi |
| Kuh-e Dinar | 600 m | Limestone | M.cretace | Gurpi | Kagdumi |
| Gulkhari | 500 m | Limestone | M.cretace | Gurpi | Kagdumi |
| Binak | 730 m | Limestone | M.cretace | Ilam | Kagdumi |

**Table-3. (Zamani, Afghah, Esmaelpoor)**

| Location | Avrage | Lithology | Age | U.contact | L.contact |
|---|---|---|---|---|---|
| Par-e Siah | 730 m | Limestone | M.cretace | Ilam | Kagdumi |
| Kuh-e Manghasht | 920 m | Limestone | M.cretace | Ilam | Kagdumi |
| Khaviz-1 | 1500 m | Limestone | M.U.cretace(albian-cenomanian) | Surgahe | Kagdumi |
| Gachsaran | 450m | Limestone | M.cretace | Gurpi | Kagdumi |
| Rag-e safid | 920 m | Limestone | M.cretace | ---------- | Kagdumi |
| Hendijan | 200 m | Limestone | M.cretace | Gurpi | Kagdumi |

**Table-4. (Zamani, Afghah, Esmaelpoor)**

| Location | Avrage | Lithology | Age | U.contact | L.contact |
|---|---|---|---|---|---|
| Lab-e safid | 920 m | Limestone | M.cretace | Ilam | Dariyan |
| Lali | 1000 m | Limestone | M.cretace | Ilam | Kagdumi |
| Masjed solayman | 2800m | Limestone interbeded shale | M.cretace(albian-cenomanian) | Surgahe | Kagdumi |
| Ahwaz | 730m | Limestone | M.cretace | Ilam | Kagdumi |
| Darikhun | 550 m | Limestone | M.cretace | Ilam | Kagdumi |
| Shadegan | 975 m | Limestone | M.cretace | Ilam | Kagdumi |