2-1-General Statement

The Zagros Mountains are parts of Alpine-Himalayan orogenic system. The Zagros Structural Belt is one the best exposed fold-thrust belts from geological point of view.

Geology of the Zagros Structural Belt was studied by Stocklin (1968). Falcon (1969) has divided the orogen into three structural zones, such as 1-An inner crystalline Zone of overthrusting, 2-An Imbricated Belt, and 3-Zone of Folding often referred to as the Simply Folded Belt.

Later the geology of the Zagros Structural Belt was studied by many other workers such as Berberian (1976), Colman-Sadd (1978), Darvishzadeh (1992), Rangzan (1993), Ali et al (2003). They divided the Zagros Structural Belt into four units which are as follows:

- Sanandaj-Sirjan Zone
- Imbricate Zone
- Zagros Fold Belt
- Molasse Cover Sequence, which are characterized by distinct geological and geophysical signatures.

Generalized stratigraphic (Fig 2-1) column for the Zagros Structural Belt (Cretaceous to Miocene) is grouped into four units according to their relative resistance to erosion as has been pointed out by Colman-Sadd (1978).
Stratigraphically the area consists of sediments from Precambrian to Cenozoic. Stratigraphic and geomorphic evidences indicate that deformation has propagated from northeast to southwest through time (Oberlander et al. 1965) and continues till present day. The exact timing of the onset of the most recent period of deformation, which apparently extends throughout much of Iran, is not well established.
Berberian and King (1981) estimated that deformation began about 5 Ma, which coincides with the start of a second phase of extension along the Red sea and Gulf of Aden. The inner portion of the orogen has been subjected to intermittent deformation extending at least as far back as the Late Paleozoic (Berberian et al. 1981). By contrast, the modern fold and thrust was a relatively quiescent region of sediment accumulation until the latest episode of shortening and uplift began in the late Miocene or Early Pliocene (James et al. 1965).

Further, the Zagros Structural Belt has been sub-grouped into four lithotectonic divisions in the study area, which comprises (Table-2-1) Sanandaj-Sirjan Zone, Imbricate Zone, Zagros Fold Belt and Molasse Cover Sequence.

An attempt has been made to establish the lithostratigraphy of the study area using satellite data and existing geological map applying remote sensing and GIS techniques.

The geological map was digitized over satellite image. The digital geological map (Fig 2-3) was calibrated to Landsat image and then extracted in GIS environment. The 3-D Landsat ETM image (FCC) reveals that the study area has different lithotectonic divisions (Fig. 2-5).

Email: moshaver1380@yahoo.co.uk
# Litho-tectonic division of the ZSB

<table>
<thead>
<tr>
<th>Geological Time</th>
<th>MCS</th>
<th>ZFB</th>
<th>IZ</th>
<th>SSZ</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>Bk.Fm., Recent Alluv.</td>
<td>Bakhtiary Fm.</td>
<td>Bakhtiary Fm.</td>
<td>Unconformity</td>
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<tr>
<td>Pliocene</td>
<td>Ag.Fm.</td>
<td>Aghajari Fm.</td>
<td></td>
<td></td>
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<tr>
<td>Miocene</td>
<td></td>
<td>Gachsaran Fm.</td>
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<tr>
<td>E</td>
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<td>Oligocene</td>
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<tr>
<td>Eocene</td>
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<td>Palaeocene</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>O</td>
<td></td>
<td>Shahbazan Fm.</td>
<td>Shabbazan Fm.</td>
<td>Alveonia</td>
</tr>
<tr>
<td>Z</td>
<td></td>
<td>Kashkan Fm.</td>
<td></td>
<td>Limestone</td>
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<tr>
<td>O</td>
<td></td>
<td>Tale Zang Fm.</td>
<td></td>
<td>Kashkan Fm.</td>
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<tr>
<td>I</td>
<td></td>
<td>Amiran Fm.</td>
<td></td>
<td>Amiran Fm. &amp; Limestone</td>
</tr>
<tr>
<td>C</td>
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<tr>
<td></td>
<td>M</td>
<td>Gurpi Fm.</td>
<td>Gurpi Fm.</td>
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<tr>
<td>E</td>
<td>Upper</td>
<td>Bangestan Gr.</td>
<td>L.St., Radiolite, Spillite</td>
<td></td>
</tr>
<tr>
<td>S</td>
<td>Cretaceous</td>
<td>Sugah Fm.</td>
<td>Sarvak Fm.</td>
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<tr>
<td></td>
<td></td>
<td>Kazdumi Fm.</td>
<td>Garau Fm.</td>
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<tr>
<td>O</td>
<td>Lower</td>
<td>Khami Group</td>
<td>Intusive, granite, Granodiorite, Quartzite</td>
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<tr>
<td>Z</td>
<td>Jurassic</td>
<td>Daryain Fm.</td>
<td>Dark grey to grey Limestone marl Limestone</td>
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<td></td>
<td></td>
<td>Gadvan Fm.</td>
<td>Jurassic-Cretaceous undivided</td>
<td></td>
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<tr>
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<td>Fahlian Fm.</td>
<td>Surmeh Fm. Limestone</td>
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<td></td>
<td></td>
<td>Hith Fm.</td>
<td>With Limestone &amp; volcanic</td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>Jurassic</td>
<td>Surmeh Fm.</td>
<td>Shale, Limestone</td>
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</tr>
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<td>Khanekat upper dolomite M. Fm.</td>
<td>Metavolcanic, marble, slate</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Middle dolomite</td>
<td>Dolomite, shaly dolomite</td>
<td></td>
</tr>
<tr>
<td>P</td>
<td>Permian</td>
<td>Grey dolomite</td>
<td>Marble</td>
<td></td>
</tr>
<tr>
<td>A</td>
<td>Devonian</td>
<td>Dalan Fm.</td>
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<tr>
<td>L</td>
<td>Silurian</td>
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<td>E</td>
<td>Ordovician</td>
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<tr>
<td>O</td>
<td>Cambrian</td>
<td>Mila Fm.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>Pre-Cambrian</td>
<td>Arabian Basement</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>Arabian Basement</td>
<td>Arabian Basement</td>
<td>Arabian Basement</td>
<td></td>
</tr>
</tbody>
</table>

Email: moshaver1380@yahoo.co.uk
2-2-Geological Setting

2-2-1- Molasse Cover Sequence

It forms the youngest geomorphic unit, structurally occurring as thrust sheet over the Zagros Folded Belt. Lithologically it comprises clastics of Aghajari and conglomerate of Bakhtiary formations of Mio-Pliocene age. The Molasse Cover sequence comprises cuesta topography and fans. Clastics are hard and resistant in nature. This gives rise to synclinal hills and cuesta flanks, which at places rise up to 100-500 meters above the valley floor. The Karkheh and Dez are two main rivers, which drain the area from north to south. The Dez river has morphotectonic expression of the neo-tectonism in the study area.

2-2-2- Zagros Fold Belt

The Zagros Fold Belt consists of different lithological units (Fig. 2-2) ranging in age from Cretaceous to Sub-recent and Recent (Table 2.1). The present study area is mostly dominated by Cretaceous calcareous rocks, dolomite, limestone, shale, silt and loamy shale, red and gray marls in northern part and the southern part exhibits conglomerates, evaporate rock units such as gypsum and anhydrite and Recent alluvium. The Recent alluvium has covered about 7.23 % perimeter of the study area. (Fig 2-3).
Fig. 2-2) Different lithology of the ZSB, Khurramabad, SW Iran

Kn = Kashakan Formation  
As = Asmari Formation  
Tz = Tale-Zang Formation  
Sb = Shahbazan Formation  
Am = Amiran Formation

The geological map of the Zagros Structural Belt southwest Iran was modified and digitally prepared in GIS format in present study (Fig 2-3).

Fig. 2-3) Geological map of the ZSB, SW Iran

Email: moshaver1380@yahoo.co.uk
2-2-3- Imbricate Zone

The Imbricate Zone, as a morphotectonic unit, has been separated from the Sanandaj-Sirjan Zone in the northeast on the basis of relief variation and from Zagros Fold Belt in the southwest on the basis of the penetrative NW-SE structural grain of the Zagros Fold Belt with which the geomorphic elements of the Imbricate Zone exhibit structural discordance. Hogbacks, cuestas, structural hills and structural valleys are developed in the Imbricate Zone.

The Imbricate Zone consists of different lithounits from Pleistocene to Cambrian. It comprises conglomerate of Bakhtiary Formation and marls, sandstone, limestone, radiolite, spilite, dark to medium grey limestone and marls, white limestone, volcanics, shale, laterite-volcanic and dolomite. The volcanics covered (0.24%) about 40588.360 meters (perimeter) of the study area. The calculation of the lithological percentages within the GIS environment suggested that about 42046.661 meters perimeter that is (0.25%) of the area is covered by radiolite and spilite.

2-2-4- Sanandaj-Sirjan Zone

Geologically the Sanandaj-Sirjan Zone is older than Zagros Structural Belt. The Sanandaj-Sirjan Zone is the metamorphic and meta-igneous core of the Zagros orogen of southwestern Iran. The Sanandaj-Sirjan Zone appears to have been formed during the Neo-Tethys due to collision of Arabian and Iranian plates in Late Cretaceous.

Email: moshaver1380@yahoo.co.uk
Berberian (1976) suggested that Sanandaj Sirjan Zone was uplifted and separated from Imbricate Zone and Zagros Fold Belt (Fig. 2-4) due to the collision between Arabian and Iranian plates. In this study a sharp contact between these two zones (i.e. ZSB & SSZ) has been reported from Chalanchoolan station in Lorestan province, 25 km south west of Brojerd.

The Sanandaj Sirjan Zone is dominated by different lithology such as schist, marble, quartzite where the metamorphism is high. The igneous bodies such as granite, granodiorite are commonly intruded within the metamorphic rocks. About 107575.748 meters perimeter which is 0.64% of the study area is covered by metamorphic rocks of Jurassic period. Granite, granodiorite, quartzite and diorite of the Jurassic-Triassic periods developed (0.417%) about 69582.822 meters (perimeter) of the study area. A sharp contact in the area (i.e. Chalanchoolan station) between highly metamorphic rock formation and of Cretaceous calcareous formation which covering 0.32% about (54253.279 meters, perimeter) of the area show the break in sequence of the geological formations in different time scale.

The Main Zagros Thrust lies at the contact of Sanadaj-Sirjan Zone with the Imbricate Zone in the Chalanchoolan area. It is observed that the break in sequence of the formations in the area is caused due to tectonic activities, high erosion, geomorphic processes and uplifting in Triassic and Late Cretaceous periods. The Zagros Structural Belt is not only affected by tectonic activities but also by geomorphic processes, which shows the changes in topography.

Email: moshaver1380@yahoo.co.uk
Fig. 2-4) Showing the Sanandaj-Sirjan Zone trend of the Chalanchoolan plain, the limitation of Imbricate Zone and Sanandaj-Sirjan Zone.

2-3- Digital Geological Mapping

Preparation of the digital geological map (Fig. 2-3) of the study area is parts of the spatial analysis in GIS. Remote sensing and GIS techniques were used in order to analyze the lithostratigraphy of the study area. Georeferencing of the image was carried out in ER-Mapper software on the base of the digital topography map. About 100 ground control points were introduced in the software to register the Landsat image. Digital image processing was carried out using 2% linear enhancement and sharpen filtering within the environmental visualization image (ENVI) version 3.6 software.

Interpretation of the digital Landsat imagery for the lithostratigraphy was carried out using image interpretation elements such as tone, texture, erosion and drainage patterns. In order to identify various lithotypes, the following methods were applied:

Email: moshaver1380@yahoo.co.uk
Level-1)

Identification of rocks in terms of igneous, sedimentary and metamorphic. In this level the banded tone on the Landsat image was used as a key to identify sedimentary rocks. Bedding recognized on the image was also marked for sedimentary rocks. Igneous rocks were identified on the basis of tone and absence of bedding plane, whereas metamorphic rocks were demarcated observing tone and presence of foliation plane.

Level-2)

The identification keys for level-2 are comprised of resistance to erosion, drainage, tone and vegetation. In this level mechanically and chemically formed sedimentary rocks were identified on the basis of resistance to erosion, drainage density and type of the drainage pattern.

Level-3)

A GPS was used in this level during ground truth checking for about 50 locations in the study area to identify various lithological contacts.

Landsat data were calibrated by field data and then combined with geological map derived to prepare a digital geological map of the area in GIS environment, which provides an easy assessment of information. Lithological units were digitally processed within the ENVI software to generate geological map of the area. The digital lithological units were introduced to ArcInfo software to produce topological
relationships. Further, the topological data were converted to the shape file format and introduced to Arcview software to create a geological map.

Finally, queries like “What is the length of Main Zagros Thrust?” “What is the lithology of the area?” etc, can be assessed within the GIS environment in a few seconds. This type of analysis would be much preferable than traditional research.

2-4- Stratigraphy

The generalized stratigraphical sequence (Colman-sadd, 1978) of the Zagros Structural Belt of southwest Iran (Fig 2-1) reveal that the regional stratigraphy can be divided into four physiographically effective units (excluding post-Miocene synorogenic sediments). From younger to oldest, these are: (1) Erodible evaporates, shales and marls of Miocene Gachsaran Formation; (2) Highly resistant Oligocene Asmari limestone, which forms hogback around cored fold; (3) A series of erodible late Cretaceous through Eocene flysch deposits and (4) A thick sequence of resistant Mesozoic carbonates.

The area was digitally analyzed within the GIS environment and each lithological unit covered the area was calculated in percentage. The GIS analysis suggest that the sum of lithological perimeter is about 16656505.233 meters in which about 4.14 % is undifferentiated rocks and 1.33 % covered by Khami Group of Lower Cretaceous to Upper Jurassic rocks.
Fig. 2-5) 3D, FCC 4-3-2, dated 2002 shows the Zagros Mountains in the study area, SW Iran. Approximate Scale 1: 440,000

2-4-1- Tertiary Sequence

The Tertiary sequence of southwest Iran represents a more or less continuous record of Palaeocene, Eocene, Oligocene, Miocene and Pliocene sediments. Economically these sediments are most important depository of oil in petroliferous basin in the Zagros Structural Belt.

2-4-2- Neogene Sequence

The Neogene sequence of Miocene age and Pliocene age is represented by Gachsaran, Aghajari and Bakhtiyari Formations in the Zagros Structural Belt. Towards the end of Oligocene the tectonic setting of the Zagros Structural Belt underwent a change from carbonate sedimentation to evaporate environment in which the

Email: moshaver1380@yahoo.co.uk
carbonate and marls co-existed with alternating anhydrite and salt beds from Gachsarn Formation of Miocene age.

Sandstone, siltstone and red marls in the Aghajari Formation suggest lacustrine and estuarine environment (James and Wynd 1965, Berberian 1976).

Coarse clastics of Bakhtiary Formation comprises sandstone, grit and conglomerate deposited in front of rising mountains in successor basins in the Zagros Structural Belt.

2-4-2-1-Bakhtiyari (Bakhtiary) Formation

Bakhtiyari Formation covers about 1.72% of total area is mainly formed around Dezful city. The name of this formation is taken from Bakhtiyari Group. The conglomerates being hard and resistant form prominent ridges overlooking the undulatory plains in southwest of Iran. The age of this formation is reported to be upper Paleocene. No fossil assemblages have been recorded from the rocks of Bakhtiyari Formation.

The lithology of this formation mainly consists of medium to coarse grained conglomerate, coarse-grained grit and sandstone. It has graded into cobbles and boulders of Oligocene age. The clastogenic assemblage of conglomerates and sandstones resting with an unconformity over the Aghajari sediments have been included under the Bakhtiyari Formation (Pilgrim 1908; James & Wynd, 1965; Stockline & Steusetudehnia, 1977).

Email: moshaver1380@yahoo.co.uk
2-4-2-2 -Aghajari Formation

The major tectonic event is the tectonic evolution of the Zagros Structural Belt during Miocene resulted in the regression of the sea and the formation of lacustrine and estuarine environment (James and Wynd 1965, berberian 1976). The clastics were brought from uplands in the northeast to depositional basin of the Aghajari Formation.

The transitional graduated layers of southern Khuzestan and Lorestan which are called “Graduate Transitional Sediment” (GTS) are considered as Aghajari Formation (Jalali 1986).

Lahbari section of Aghajari Formation consists same type of sediments that normally found in lower Bakhtiary Formation. The thickness of Aghajari Formation ranges in between 2000-10000 feet (Jalali 1986).

The lithology of Aghajari Formation mainly includes brown and grey layers of resistant calcareous, sandstone with gypsum in low concentration, marls and siltstones. About 816987.177 meters of perimeter of the study area is covered by Aghajari Formation (4.90%). The marl beds are of few centimeters to about a meter thick. It exhibits the layers of soft gypsum in abundance. The sandstone exhibits trough type cross-bedding. Aghajari Formation is gradually intercalated in Mishan Formation and overlain by Bakhtiary Formation. The sandstone shows graded bedding at places.

The Aghajari Formation normally consists of microfossils such as Ostracods, Charophytes, Elphidium haurinum, Rotaloa beccarii, R.beccarii var, Dentatus,

Email.moshaver1380@yahoo.co.uk
R. Stachi, R. Takanabensis, Nonion Incisum and Ostracods Trascyleberis Exanathemata, Cytheridea Sp. and Bairdiocypsis Sp. (Jalali 1986). Megafossils such as Crassostrea Gryphoides Var Cuneata have been reported by (Jalali 1986). The age of Aghajari Formation is reported from Miocene to Pliocene.

2-4-2-3-Gachsaran Formation

The Gachsaran Formation forms a cap rock over the petroliferous rocks of Asmari Formation (Fig 2-6). It covers about 17.77% of the study area. In Khuzestan province the boundary between Gachsaran – Asmari Formation is clearly discernible. In the Zagros Structural Belt the Asmari formation is followed by Gachsaran Formation, whereas in the Imbricate Zone the Gachsaran Formation is absent. Watson in 1960 and later James and Wund in 1965 divided this formation into seven members as follows:

![Fig.2-6) Shows Gachsaran Formation with light blue in color in Landsat imagery](image_url)

Email: moshaver1380@yahoo.co.uk
Member 1

It consists of thin layers of calcareous and bituminous shale. The thickness of anhydrite varies in the area whereas its minimum thickness was recorded as 130 feet (Jalali, 1986).

This member was formed by anhydrite layers with different thickness of salty units within it.

Anhydrite beds with subordinate salt in lower part followed by anhydrite, thin-bedded limestone with marl in upper parts.

Different thickness of salty layers and numbers of marl beds are present within it with grey colour limestone and anhydrite.

Marly anhydrite combined with limestone and red to grey colour marl.

Anhydrite with red to grey color marl and alternating layers of salt and anhydrite are present in this member.

Email: moshaver1380@yahoo.co.uk
Alternating layers of anhydrite and marl are present. Here Mishan Formation is overlain by Gachsaran Formation.

Gachsaran Formation in Khuzestan province is clearly dominated with fossils such as Ostracods, Bryozoa, Rotalids. The thin calcareous bed is also dominated with Miogypsina, and Charophta fossils. These fossils are also found in Gachsaran Formation of Lorestan province. The marls and calcareous rocks in Gachsaran Formation consists of the microfossils such as *Taberina malabarica*, *Sphaergypsina sp.*, *Peneroplis farsensis*, *Dendritina rangi*, *Miogypsina sp.*, *Flosculinella sp.*, *Neocalveoline (Borelis) melo*, *Elphidium sp.*, *Rotalids*, *Bryozoa* (Jalali, 1986). The age of Gachsaran Formation is reported as Lower Miocene.

2-4-3- Palaeogene Sequence

The Palaeogene sequence is developed in the Imbricate Zone and Zagros Fold Belt. The tectonic collision and magmatism signatures recorded from Sanandaj Sirjan Zone depicted from the field data and possibly represents the Palaeogene history in the Brojerd complex. The rocks for Palaeogene in the Imbricate Zone and Zagros Fold Belt are Pabdeh and Asmari Formations, which are recorded in Palaeocene to Miocene age.

The Palaeogene sediments in the shadow of the Iranian craton have been described as Amiran, Tal-e-Zang, Kashkan and Asmari formations. These formations are described as follows.
2-4-3-1- Asmari Formation

The Asmari Formation is the most pervasive in the area and is developed in the Imbricate Zone and Zagros Fold Belt as chemogenic sequence of Oligocene limestone which acts as reservoir of major oil fields in south west Iran. It covers about 16.71% of the total study area. These rocks probably suggest same environment of deposition both in Imbricate Zone and Zagros Fold Belt. The Asmari rocks are widely developed and are seen in Shahneshin-kuh and Tang-e-Fani areas. The equivalent of Asmari Formation (Fig 2-7) are Euphrate limestones, Kalhur limestones and Khamir limestones. The lower Asmari in Khuzestan consists of calcareous and anhydrite which although belongs to Papdeh Formation but are generally considered as parts of Asmari Formation. The Asmari formation is divided as follows:

- Asmari sandstone.
- Kalhur anhydrite of Lorestan

![Fig 2-7) Field photograph showing anticlinal fold in Asmari-Gachsaran Formation,](image-url)
2-4-3-1-1- Sandstone Asmari Member

The petroliferous regions of lower Asmari Formation composed of limestones and sandy limestones, which is also known as Ahwaz sandstone. This member is not reported from the study area.

2-4-3-1-2- The Kalhur Member

Asmari Formation also contain Anhydrite Kalhur or Gypsum Kalhur. The Kalhur member consists of marls and calcareous marls. About 1.55 % of the area is covered by marls and limestone. Kalhur member conformably lies over the marls of Papdeh Formation and limestone of Asmari Formation.

2-4-3-2- Papdeh Formation

Pabdeh Formations of Paleocene, Eocene and Oligocene ages were named as Globigerian marls or Dezak marls (Jalali 1987). The equivalents of these formations are Upper Eocene marls, the Eocene blue and purple shales, Middle Eocene limestones and Lower Eocene marls in their parts of the Iranian Peninsula.

Pabdeh Formation is dominated by shales, calcareous and marly shales. Papdeh Formation conformable over lies the Gurpi Formation, whereas the upper part of it is transitional Asmari limestone. This formation shows magenta color around the Lorestan and Khuzestan provinces. This formation is seen in lower end of the Kabirkooh anticline.

Email: moshaver1380@yahoo.co.uk
Papdeh Formation in all of its oil fields contains the planktonic fauna. In Khuzestan province, the magenta coloured sandstone contains fossils like *Globorotalia Velascoensis* and *Globorotalia Pseudomenardii*. These fossils whereas overlie sandstone the Gurpi Formation. In Lorestan province however the Papdeh Formation does not contain any fossil. In all the regions of Papdeh Formation of Eocene age contains microfossils like Glta.palmera. The age of the Papdeh Formation in Khuzestan province is Palaeocene to Oligocene and in Lorestan province reported to Upper Palaeocene to Miocene (Jalali 1987).

2-4-3-3- Shahbazan Formation

Shahbazan Formation dominated by Barren limestone equivalent to Shahbazan Formation. At the Tang-e-2, which is about 5 Km of Tal-e-Zang station in north east of Andimeshk city, is covered by different layers of weathered dolomitic calcareous. Shahbazan Formation has been seen in the northeast of the Lorestan province. Shahbazan Formation can be differentiated from Asmari Formation by weathered sediment conglomerates within the layers and variation in lithology from calcareous of Asmari Formation to dolomite of Shahbazan Formation. It is very difficult to differentiate these two formations in the field visit. Shahbazan formation covers about 0.88% of the study area on the satellite image.

In the south and southwest of the Lorestan province in the study area Shahbazan Formation is mixed with marls of Pabdeh Formation and towards the northeast of Lorestan, it is replaced by Kashkan Formation. The sharp contact between two formations of Kashkan and Shahbazan has been shown in figure 2-8. Kashkan formation shown consists of red coloured marls with low resistance.
Fig. 2-8) Showing the contact between Shahbazan Formation with dolomite in white colour and Kashkan Formation with red colour marls.

Shahbazan Formation contains fossils like Oblonga, Alvenolina and Num.cf.beaumonti (Jalali, 1987) in calcareous dolomite. The age of this formation is Middle Eocene to Upper Miocene.

2-4-3-4- Kashkan Formation

Kashkan Formation consists of red slit, sand and conglomerates. About 2.05 % of total study area on the Landsat image is covered by Kashkan Formation. About 13.68 % of the area is also covered by inseparable formations of Tale-Zang and Kashkan. The conglomerates are coarse grained. Towards southwest, the Kashkan Formation is faced by Pabdeh Formation whereas in the southeast it continues into Khuzestan province. In field visits it is observed that the thickness of the Kashkan Formation is reducing from northeast to southwest. Jalali (1987) has reported that the age of Shahbazan Formation is from Palaeocene to Eocene.
2-4-3-5- Tale-Zang Formation

At Tang-e- 2, which is about 5 km of southwest of Tale-Zang station, the grey coloured calcareous rocks are observed. Here, Amiran Formation is overlain by Tale-Zang Formation, whereas the Kashkan red sandstone and conglomerates are underlained by Tale-Zang formation.

Tale-Zang Formation mainly is seen in the northeast of Lorestan province. The thickness of Tale-Zang Formation varies because of gradual mixing of Amiran and Kashkan Formations. The age of Tale-Zang is reported to be Palaeocene-Middel Eocene.

2-4-3-6- Amiran Formation

The Amiran Formation is followed by Tale-Zang Formation, which comprises grey to brownish limestone and flysch (mixture of sedimentary rocks like sandstone, marls and mud) (Fig. 2-9). It also comprises weathered sandstone (Fig. 2-9) of olive to brown in color with cherty conglomerates (Fig 2-9) and calcareous rocks. The limestones are well bedded and massive in appearance. It has covered a perimeter of about 198609.923 meters (1.192 %). The Amiran Formation with alluvial has been queried in GIS environment. It covers about 7.53 % of alluvial exist in the area. At Ma-amulan village the Amiran Formation is encountered where the Kashkan river is passing. The contact between Amiran Formation and Gurpi Formation with grey marls is gradational. The thickness of Amiran Formation increases from southwest to northeast. Amiran Formation contains fossils like Omphalocyclus SP (Jalali 1987).
central Lorestan, the Amiran Formation is reported to be from Eocene to Palaeocene in age.

Fig.2-9) Amiran Formation at the top with red chert, conglomerate and sandstone at the bottom of the picture.

2-4-4- Upper Cretaceous

The upper Cretaceous rocks in the Zagros Structural Belt, are represented by Bangestan Group and Gurpi Formations. The Bangestan Group exhibits most extensive development of the Upper Cretaceous rocks in the study area. It covers about 10.76% of the total study area on the geological map derived from Landsat image. The Bangestan Group represents a sequence of limestone with intercalation of argillites, characterized by fossils assemblage of Albian Companian age (James and Wynd, 1965). Bangestan Group is separated into Sarvak and Ilam formations in the study area.

Email: moshaver1380@yahoo.co.uk
2-4-4-1- Gurpi Formation

The previous name of Gurpi Formation was Dezak marls. Gurpi Formation is dominated by grey marls, calcareous marls and dark grey to grey limestone (Fig. 2-10). Gurpi formation is overlain by Ilam Formation which indicated by the weathered sediment deposits. In Khuzestan and Lorestan provinces weathered calcareous rocks, white in colour which is called as Emam Hasan section (Jalali 1987). Gurpi Formation covers a perimeter of about 780772.282 meters (4.68 %) of the geological map of the study area which is digitally drawn and obtained in GIS environment.

In all of the oil regions of the study area there have been lots of fossils like Glt.sigali and Glt.elevata (Jalali 1987). The age is Palaeocene to Upper Cretaceous.

Fig.2-10) The field photograph showing dark grey limestone in Gurpi Formation.
2-4-4-2- Sarvak Formation

The limestone sequence in the study area of the Sarvak Formation is grey in colour. It is fine grained and thinly bedded. The limestone overlies Ilam Formation. Ilam and Sarvak Formations cover about 1.26% of the total study area. The fossil assemblages of the Sarvak Formation are *Orbitolina Cancave Lamarck, Somiosphera Conoidea, Bonet and Stomiosphera Sphaerica*, which indicate netritic and pelagic environment during Albian to Turonian periods (James and Wynd, 1965).

2-4-4-3- Ilam Formation

The Ilam Formation consists of well-bedded grey to light grey, fine-grained argillaceous limestone in the study area. It is overlying the Sarvak Formation. The rocks of Ilam Formation are exposed in the eroded cores of anticlines in the area around Kuh Sultan and Kabir Kuh. The base of Ilam Formation is not well exposed in the study area. The rocks of Ilam Formation in the satellite ETM 3-D image (Fig. 2-5) (FCC) exhibit greenish-brownish hue, fine to medium texture, fine to medium sub-dendritic drainage pattern and high relief. The Lorestan province contains fossils like *Globotruncana Concavata*, whereas in Khuzestan province the fossils are *Ammobaculites SP.* and *G. elevata*.

2-4-4-4- Kazhdumi Formation

The shaley layers of the Kazhdumi (Cretaceous) and Pabdeh/Gurpi (Late Cretaceous/Early Tertiary) as well as Gachsaran (Late Miocene) and evaporitic layers could locally be seen. These formations act as secondary decollement in the study area.
2-4-5- Cretaceous Sequence

The Cretaceous period has been most significant in the geotectonic evolution of the Zagros Structural Belt. The Cretaceous rocks represent three different geotectonic environments in the Sanandaj-Sirjan Zone, Imbricate Zone and Zagros Fold Belt. The sedimentary sequence is mostly developed in the Zagros Fold Belt which could be separated into Lower and Upper Cretaceous. The ophiolite sequence mostly developed in Imbricate Zone and comprising red grey and greenish chert, red and green shales and basic and ultra basic igneous rocks. In the Sanandaj-Sirjan Zone the granite-granodiorite, quartz diorite and their associated volcanic phases represent the beginning of collision tectonics in the Zagros.

2-4-6- Jurassic Sequence

The Jurassic sequence comprises igneous-metamorphic rocks which are found in the Sanandaj-Sirjan-Zone. The sedimentation in Jurassic rocks of Sanandaj-Sirjan Zone, Imbricate Zone and Zagros Fold Belt are well developed. The Jurassic sediments in these three lithotectonic units exhibit variable lithology and sedimentation history.

2-4-7- Triassic Sequence

The carbonate sequence and the associated sediments (shale and sandstone) are developed in the Zagros Structural Belt. In the Sanandaj-Sirjan Zone the Triassic sequence includes marble intercalated with slates and metavolcanics. The Triassic rocks in the Sanandaj-Sirjan Zone comprises limestone, light colored calcitic marble,
quartzite which have been folded with associated metadiabase, serpentinite, tuffites and calcareous sandstone.

**2-4-8- Permian Sequence**

In north west of the Imbricate Zone in the Zagros Structural Belt inliers of Permian rocks have been recorded between Chenarestan and southeast of Kolider below the Triassic sequence. The Permian rocks of the Chenarestan area may be delineated into two lithostratigraphic units namely the lower limestone and the upper dolomite sequence. In the Sanandaj-Sirjan Zone the Permian rocks have been recorded from east of Kafshgiran and southeast of Amirabad townships. Marble out crops are found at some place in this area. In the Zagros Fold Belt this sequence is absent.

**2-4-9-Cambrian Sequence**

The sequence of the sandstone and shale with interstratified beds of dolomite and limestone resting over the Infra-Cambrian rocks of Hormoz series have been assigned as Cambrian rocks. This sequence is absent in both the Zagros Fold Belt and Molasse Cover Sequence.

**2-4-10- Palaeozoic Sequence**

The Palaeozoic sequence in the Zagros Structural Belt which has been reported from Imbricate Zone only referred as Cambrian and Permo-Carboniferous. In the study area Ordovician, Silurian and Devonian have been periods of break in the geology of the Zagros Structural Belt.

Email: moshaver1380@yahoo.co.uk
2-5-Discussions

Geologically the study area is divided into four lithostratigraphic units namely Sanandaj-Sirjan Zone, Imbricate Zone, Zagros Fold Belt and Molasse Cover Sequence. For lithological purposes the digital geological map (1:2^5) has been prepared using remote sensing and GIS techniques. The GIS is used to answer simple questions derived under the research work, which may be posed by user. These operations vary from simple and well defined queries like, “What is the length of Main Zagros Thrust?” “What is the lithology?” etc, can be assessed within the GIS environment within a few seconds. This type of analysis would be much preferred than traditional research. The topological relationships could implement the percentage of each lithology in the study area. The perimeter and percentage of lithology can further be used for structural and tectonic evaluation in the Zagros Structural Belt.

The sum of lithological perimeter is about 16656505.233 meters which contains about 1204327.322 m (7.23%) of alluvium, 287232.523 m (1.72%) of Bahktiary Formation, 816987.177 m (4.90%) of Aghajari Formation, 2960616.493 m (17.77%) of Gachsaran Formation, 2784345.118 m (16.71%) Asmari Formation, 1258969.672 m (7.53%) Amiran Formation with Recent alluvium, 198609.923 m (1.19%) of Amiran Formation, 1793634.734 m (10.76%) of Bangestan Group, 780772.282 m (4.68%) of Gurpi Formation, 210221.981 m (1.26%) of Ilam and Sarvak Formations, 2279652.526 m. (13.68%) of Kashkan with Tale-Zang Formations, 342586 m (2.05%) of Kashkan Formation, 221985.804 m (1.33%) of Khami Group, 147056.745 m (0.88%) of Shahbazan Formation which consists of marls, anhydrite, gypsum, 54253.279 m (0.32%) of Cretaceous calcareous, 42046.661 m (0.25%) of limestone

Email: moshaver1380@yahoo.co.uk
with radiolarite and spilite, 259674.394 m (1.55%) of marls and limestone, 92595.445 m (0.55%) of marls and limestone with sandy limestone, 107575.748 m (0.64%) of metamorphic rocks of Jurassic age, 69582.822 m (0.41%) of granite and granodiorite with quartzite and diorite of Sanandaj-Sirjan Zone of Triassic-Jurassic age, 40588.360 m (0.24%) of volcanics and 690559.4 m (4.1%) of the study area consists of undifferentiated rocks. These types of analysis within the GIS environment with litholgical percentages can be useful for further study like environmental and engineering geology.