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Lithofacies and Sedimentary Environments of Aghajari Formation in Dehsheikh Mountain, West of Shiraz, Iran

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Abstract: Aghajari Formation, known as Upper Fars Group, is developed throughout the Folded Zagros Zone and has a thickness of 2966 m in its type section in SW of Iran and 1473 m in the study area, located 20 km west of Shiraz. Aghajari Formation, in this area, consists of three major facies associations. These are "fine", "medium" and "coarse" grained terrigenous sediments, usually interpreted as channel deposits. Fine member deposits, mainly siltstone and mudstone, are the most abundant facies at lower part of Aghajari Formation. These deposits belong to inter-channel areas which receive sediment during floods. Medium member deposits consist a variety of Lithofacies: sharp-sided sandstone beds, cross-bedded sandstones, trough cross-bedded sandstones, cross-laminated sandstones, parallel-laminated sandstones and lateral accretion (epsilon) cross-bedding. These features reflect the episodic and decelerating nature of the responsible flows. Coarse member deposits consist of micro-and macro-conglomerates. Micro-conglomerates generally occur as thin beds, only a few clasts thick and interbedded with sandstones and mudstones. Macro-conglomerates, with tightly packed clast supported frameworks, are the main facies that commonly grade through stratified pebbly sandstones into variously bedded sandstones. Bed thicknesses together with clasts sizes, vary from bottom to the top and usually increase upward. In lower parts of the sequence (small scale), bed thickness and clast size vary randomly; the conglomerates are commonly separated by fines, but in many cases these are scarce. In upper parts of the sequence (large scale), coarsening upward trends occur at the scale of tens of meters, recognized on the basis of maximum clast size. These conglomerates are interpreted as channel lags. The clasts of the conglomerates are extra-formational and derived from the erosion of neibouring or farther uplands. Upward coarsening in units of a few meters thick is attributed to the gradual reactivation of a channel after an interval of temporary abandonment in the braided complex. At the larger scale, the grain-size changes may be accompanied by changes in the relative abundance of constituent facies. Changes at this scale are commonly attributed to tectonic causes. There are also three minor facies associations. These are "gypsum", "marl" and "algal limestone", interpreted as playa lake and shallow lake sediments.

Key words: Lithofacies · Sedimentary environments · Aghajari formation · Folded Zagros zone · Iran

INTRODUCTION

The Aghajari Formation was studied in detail and formally defined by James and Wynd [1] and was checked again by Setudenia [2]. It is equivalent to Dibdiba Formation in south of Iraq, Upper Fars in north of Iraq and Syria and Hofuf Formation in Kuwait & Saudi Arabia [3]. The Aghajari Formation includes Lahbari Clastic Member at its upper part. The above-mentioned studies focused primarily on oil producing areas (south-western of Iran). Sedimentology, sedimentary environment and morphotectonical evolution of Aghajari and Bakhtyari Formations [4] as well as this study were conducted on the outcrops of the Internal Fars Province.

The Aghajari Formation is present throughout the Zagros Basin, but, because of its gradual subsidence during deposition, it is best developed in Dezful Embayment (about 3000 m) and probably increases in the synclines of this region. In its type section (N 30°48'42" and E49°47'29"), Aghajari Formation consists of 2966 m alternation layers of brown to gray calcareous sandstones and red marls with gypsum interlayers and red siltstones [3]. Aghajari Formation in Zagros Zone (Fig. 1) is characterized with two lithofacies groups that each

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develops in Internal Fars and northwestern of Dezful Embayment. The first is mostly continental clastic sediments (mudstone, sandstone and conglomerate), but the second one, that spreads in Coastal Fars, has a marine characteristics (marl with gypsum inter-layers).

Deposition of the Aghajari Formation took place during the Late Miocene-Early Pliocene, but it doesn't have unity in age and becomes younger from northwestern to south-eastern and from northeastern to south-western. In the type section, the lower contact with Mishan Formation is dominantly gradual and sometimes abrupt. The upper contact with Bakhtyari Formation is sometimes gradual and conformable and occasionally abrupt and unconformable. In the study area, the lower contact with Gachsaran Formation and the upper contact with Bakhtyari Formation are gradual

STUDY AREA AND METHODOLOGY

The study area is located about 20 km west of Shiraz in the Folded Zagros (Fig. 1 and 2). Geographically, this area is part of Fars Province. Field work was concentrated at the southwestern flank of the Dehsheikh Syncline in NW vicinity of Dehsheikh village. A section was measured in detail crossing the trend of the syncline (Fig. 3-5). Tectonically the area is part of a foreland basin filled dominantly with a thick sedimentary sequence of clastic compositions [6]. The thickness of the Aghajari Formation in the study area is 1473 m. Samples were taken almost every 10 meters and in addition to that, sampling was based on facies variations. Approximately 80 thin sections of medium member deposits (sandstones) were studied, in order to identify relevant microfacies, although the greater part of the study was based on field work.

Lithofacies: Three major facies associations are distinguished in the study area. These are "fine", "medium" and "coarse" grained sediments members, usually interpreted as channel deposits. These are the typical mollasse deposits of many mountain belt foreland basins. There are also three minor facies associations. These are "gypsum", "marl" and "algal limestone", interpreted as playa lake or shallow lake sediments.

Major Facies Associations

Fine Member Deposits (Siltstones and Mudstones): These are the most abundant facies at lower part of Aghajari Formation and are generally horizontally laminated. In some cases, the fine member units show small-scale coarsening upward units which pass from muds to siltstones and occasionally to fine sandstones. The fine member deposits are red in colour and usually show a more intense development of red pigment compared with associated sandstones.

Interpretation: This facies records the deposition of fine material from suspension. Such deposition is most common in inter-channel areas which receive sediment during floods. The areas may be floodplains which are predominantly subaerially exposed. Small-scale upward coarsening units probably record the infilling of shallow floodplain lakes by small deltas [7]. Deposits of subaerially exposed floodplains are more likely to develop a red coloration.

Medium Member Deposits: Following lithofacies can be distinguished in this member (Fig. 6-8):

Sharp-sided sandstone beds that commonly occur interbedded with fine member deposits (siltstones and mudstones) and are usually thin, seldom more than a few tens of centimeters and exceptionally 1 meter thick. These sandstones are somewhat restricted laterally and sometimes closely spaced. In some cases, they are more extensive and parallel sided.

In some red, fine member sequences there are *cross-bedded sandstones.* These sandstones are commonly well sorted and the grains are well rounded.

Trough cross-bedded sandstones that encompass a wide range of grain sizes from pebbly sandstone down to fine sandstone in sets up to a few tens of centimeters thick.

Cross-laminated sandstones that usually occur towards the top of the medium member deposits and involve finer grained sand. This facies shows ripple-drift.

Parallel-laminated sandstones are usually fine-grained sandstones with primary current (parting) lineation on bedding planes. These are most common towards the top, but also occur at all levels.

Lateral accretion (epsilon) cross-bedding is an important feature of the medium member. It is low angle cross-bedding which extends as a single set over the substantial part of the medium member deposits. The inclined layers are defined by fluctuations in grain size, generally in the very coarse to very fine sandstone range and there is commonly a tendency for them to be an overall upward fining so that very coarse sandstones taper out upwards into very fine sandstones. Members

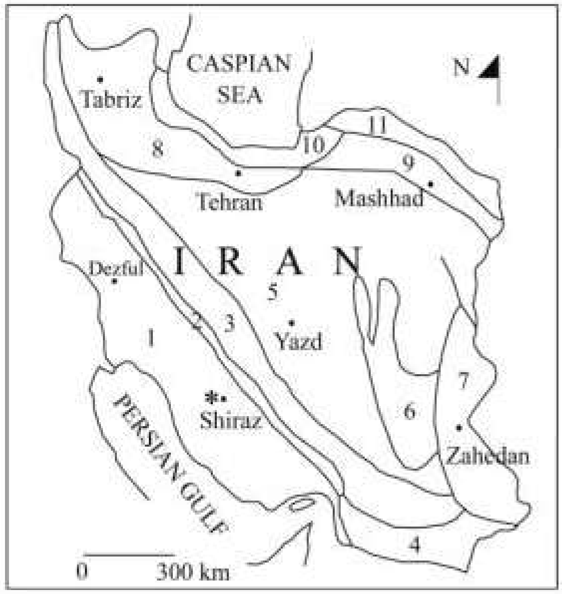

Fig. 1: Tectono-sedimentary provinces of Iran [5] and the location of the study area. 1-Folded Zagros, 2-High Zagros, 3-Esfandaghe-Marivan, 4-Makran, 5-Central Iran, 6-Lut Block, 7-Nehbandan-Khash, 8-Alborz-Azarbayejan, 9-Binalud, 10-Gorgan-Rasht, 11-Hezarmasjed-Kopedagh, * study area

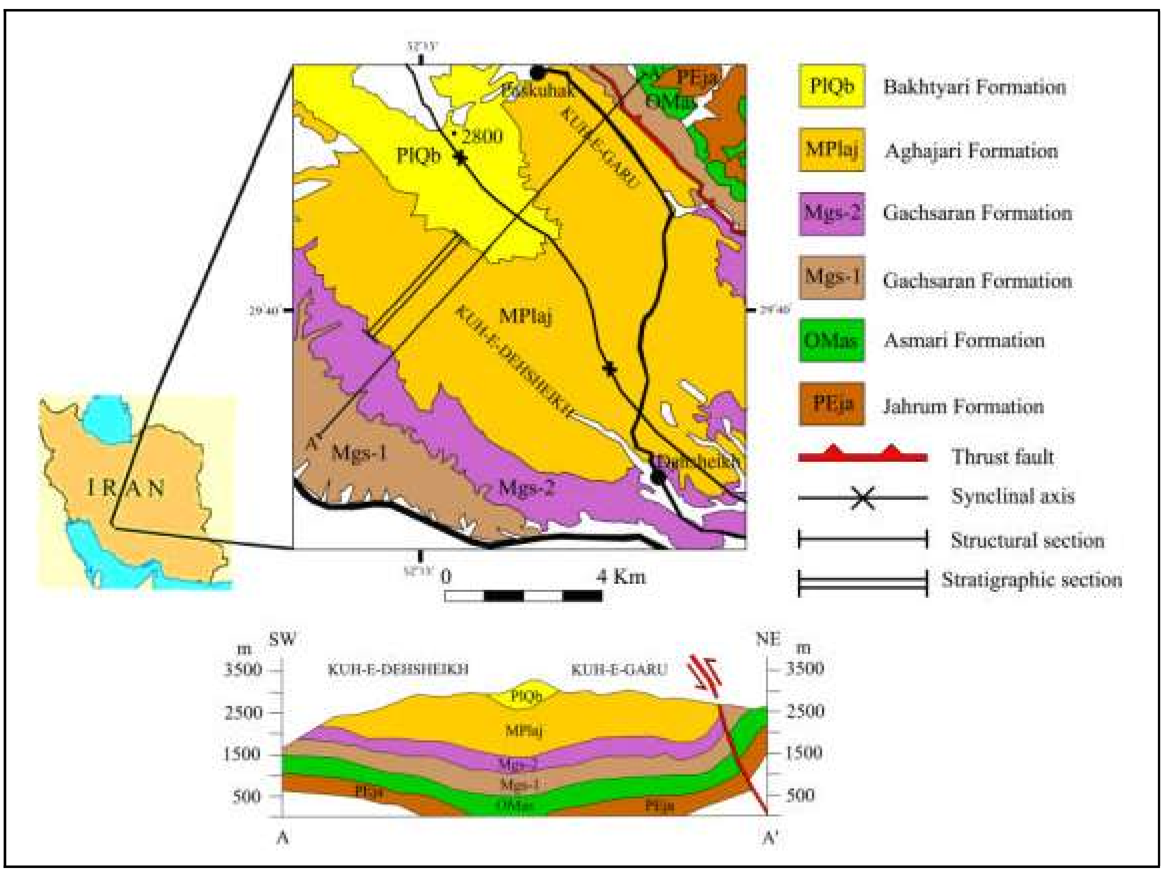

Fig. 2: Geological map of the area and a section crossing through AA´

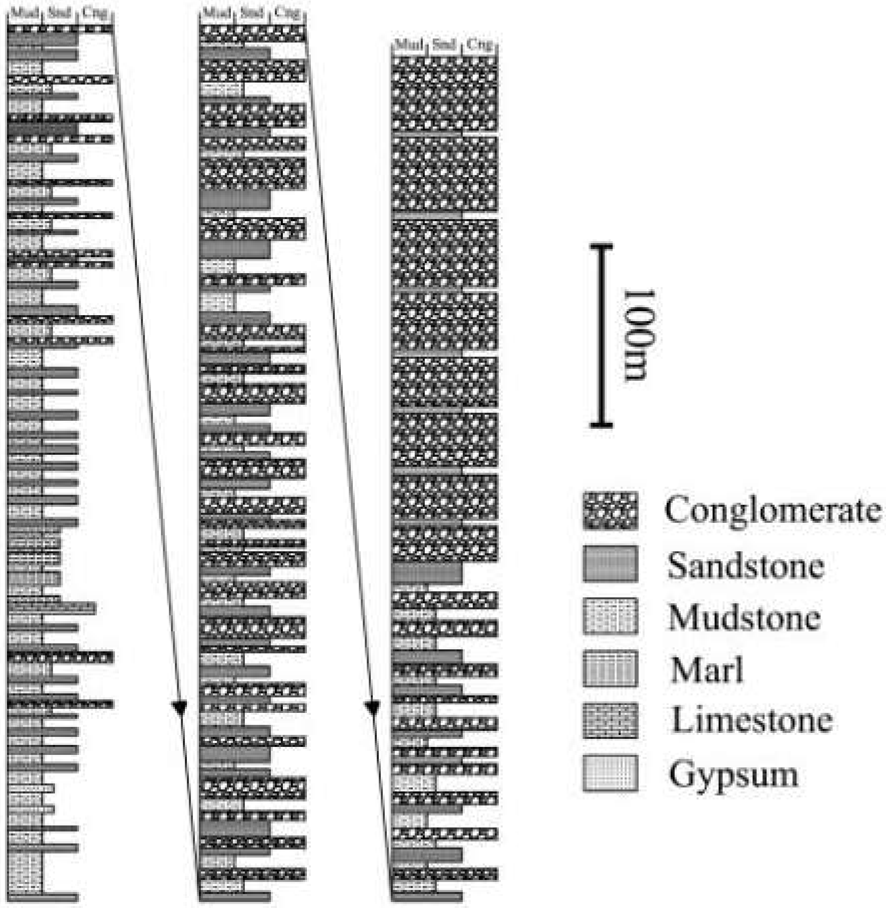

Fig. 3: Stratigraphic section (lithologic log) of the study area. Location of the section is shown in Fig. 2

Fig. 4: A south-west view of Dehsheikh synclinal Mountain (Lower part of Aghajari Formation; the line shows crossing section)

Fig. 5: A north-east view of Dehsheikh synclinal Mountain (Upper part of Aghajari Formation; the line shows crossing section)

Fig. 6: Ripple drift in a sandstone bed

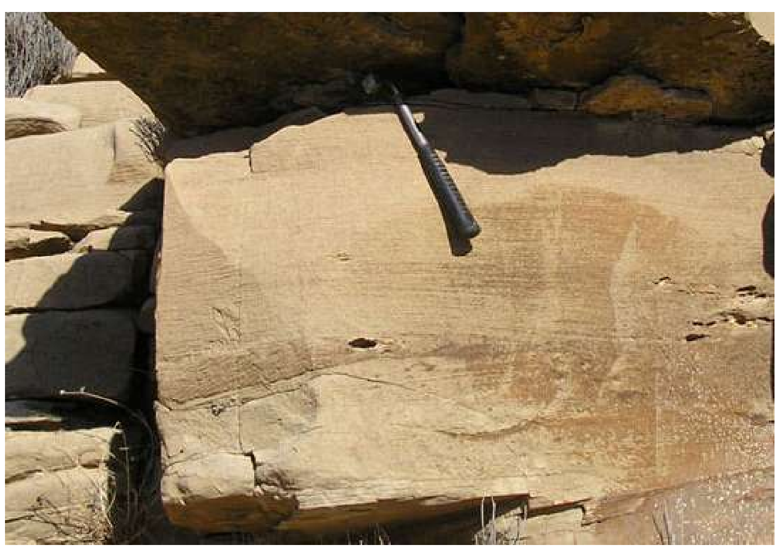

Fig. 7: Parallel-laminated sandstones

with epsilon cross-bedding range in thickness up to about 5 m and sets may commonly be traced laterally over tens of meters.

Microfacies: Micritic to bio-microsparitic calclithite (70%) and radiolaritic chertarenite (30%) are the main composition seen under the microscope. These sandstones are somewhat hematitic and texturally moderately-well sorted and fine-grained to coarse-grained. Known fossils are Rotalia sp. and Cibicides sp., none of them can be used for age definition (Fig. 9).

Interpretation: These features reflect the episodic and decelerating nature of the responsible flows. Where the sandstones are somewhat restricted laterally they are probably crevasse splay deposits and where closely spaced they may represent a levee [8]. Where they are more extensive and parallel sided, they are probably the deposits of sheet floods on the distal parts of a fan [9, 10]. The cross-bedded well sorted sandstones are interpreted as the products of aeolian dunes which migrated in the inter-channel areas. Trough cross-bedding is attributed to the migration of dunes with crest lines or sandwaves with a more three-dimensional, commonly linguoid form.The cross-laminated sandstones record the migration of small ripples. Where ripple-drift occurs, it demonstrates a high rate of vertical bed accretion. The parallel-laminated sandstones are interpreted as the product of upper phase plane bed transportation. Lateral accretion (epsilon) cross-bedding is interpreted as the product of lateral accretion on an inclined surface which is usually taken to be a point bar of a meandering channel, but which may also occur as a local element in a more braided system [11]. The fluctuation in grain size reflects stage fluctuation in the channel concerned [12]. Stage fluctuation is also implied by the presence of erosion surfaces within the epsilon cross-bedding. There is a greater tendency for epsilon cross-bedding to show up in medium member laid down by channels which had a suspended load [13].

Coarse Member Deposits: Two principal facies can be distinguished: Micro-conglomerates and macro-conglomerates.

Micro-conglomerates: These conglomerates generally occur as thin beds, only a few clasts thick (Fig. 10). These conglomerates are commonly associated with major erosion surfaces. When the bulk of the medium member is pebbly sandstone (trough cross bedded sandstone), these conglomerates are widespread and overlie local scours such as the base of trough cross-bedded sets.

Macro-conglomerates: Conglomerates with clast supported frameworks (Fig. 11) are the main facies that commonly grade through stratified pebbly sandstones into variously bedded sandstones. They are often unstratified but sometimes horizontally stratified with clast imbrications. The clasts are subrounded to rounded coarse pebble size at lower parts and cobble size at upper parts. Litologically the composition of clasts is dominantly limestone and chert, but rare sandstone and microconglomerate are also found. Genetically these clasts belong to Crataceous and Tertiary Systems cropped out to the NW of the study area. Bed thicknesses, vary from bottom to the top, usually increase upward (as is seen in clast sizes). There is usually a correlation between bed thickness and clast size (Fig. 12). The clast-matrix ratio is high and clasts are tightly packed in a framework. These conglomerates have a sheet-like structure and are interbedded with finer sediments (sandstone and mudstone).

Within wedges of these conglomerates both facies and thickness change laterally but the rate of change, since depends on the scale of the system and the nature of the dominant processes, varies from bottom to the top of the sequence. It is often possible to demonstrate lateral changes in these deposits because of exceptional exposures, exist in the study area. There are sometimes flat bases and convex upwards tops in units of framework conglomerates. The units are elongated and are flanked by cross-bedded pebbly sandstones.

In lower parts of the sequence (small scale), bed thickness and clast size vary randomly. The conglomerates are commonly separated by fines, but in many cases these are scarce. When only a small portion of sand is available, most or all of it is absorbed into the spaces of the gravel framework rather than giving fine interbeds. Elements of both upward fining and upward coarsening occur in the small scale sequence. In upper parts of the sequence (large scale) coarsening upward trends occur at the scale of tens of meters, recognized on the basis of maximum clast size.

Interpretation: Whilst conglomerates make up a large proportion of ancient coarse alluvial successions it is unusual for sandstones and siltstones to be entirely absent and most sequences show a range of facies. When pebble size conglomerates are associated with major erosion surfaces they are interpreted as channel lags. The clasts of these conglomerates are extra-formational and are derived from the erosion of neibouring or farther uplands. Conglomerates with clast-supported frameworks and pebbly sandstones with clear stratification are the

Fig. 8: Fluctuation in grain size which causes upward fining (very coarse to very fine sandstone).

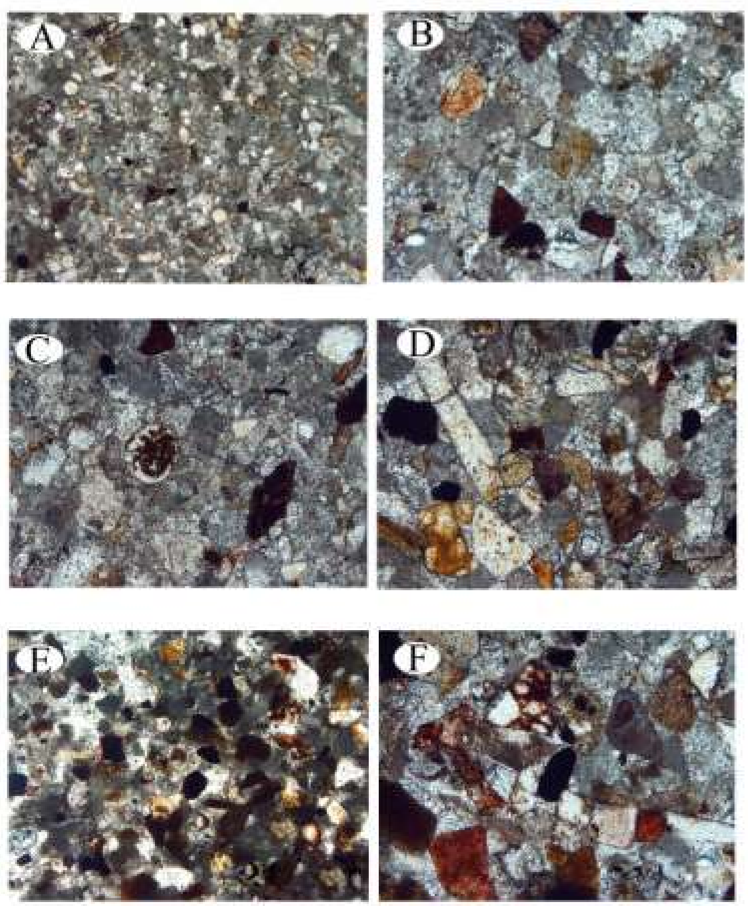

Fig. 9: Main microfacies seen in sandstones: Calclithite (A, B and C) and chertarenite (D, E and F). X40.

Fig. 10: A bed of conglomerate inter-bedded with sandstones, at lower part of Aghajari Formation

Fig. 11: A bed of conglomerate at upper part of Aghajari Formation

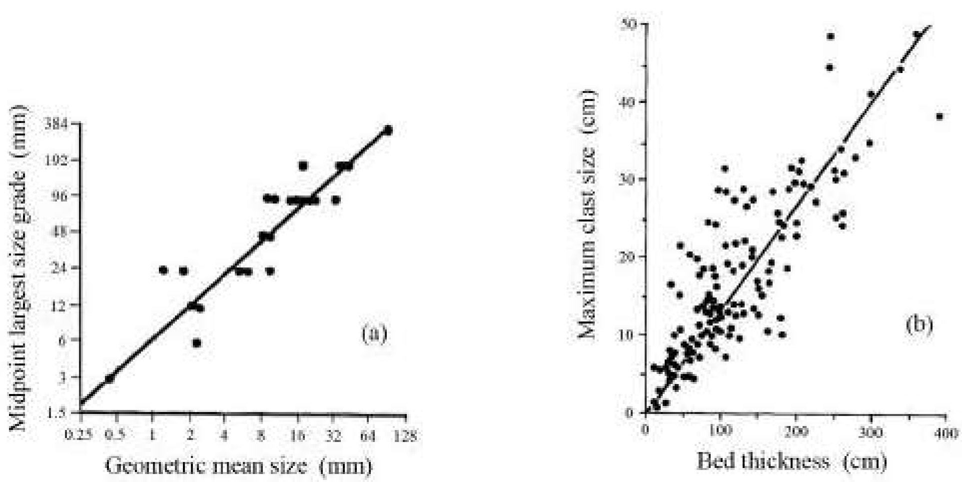

Fig. 12: Graphs showing the relationships between (a) maximum clast size and average clast size and (b) maximum clast size and bed thickness in clast supported conglomerate

Fig. 13: A bed of limestone at lower part of Aghajari Formation

Fig. 14: Algal grainstone of the limestone facies

result of bed load deposition. Horizontally stratified or unstratified conglomerates with clast imbrication record deposition on a flat bed with vigorous grain transport such as might occur on the top of a longitudinal bar or on a channel floor and textural variation may relate to water stage changes [14]. Where conglomerates have sheet-like form and are interbedded with finer sediment (sand or silt) they probably result from sheet-floods. The framework conglomerates with flat bases and convex upwards tops record the dominance of longitudinal gravel bars. Where bed thickness and clast size vary randomly, which occur in lower parts of Aghajari Formation, may be due to the episodic sedimentation in the form of debris flows and sheet floods. The scarcity of fines between episodic depositional structures may be due to their removal by subsequent scour or to a inherent lack of fines in the sediment supply. Upward fining may be related to either channel abandonment or the lateral accretion [15]. Upward coarsening in units of a few meters thick is attributed to the gradual reactivation of a channel after an interval of temporary abandonment in the braided complex. At the larger scale, the grain-size changes may be accompanied by changes in the relative abundance of constituent facies. Changes at this scale are commonly attributed to tectonic causes. Coarsening-and fining-upward sequences may result respectively from tectonic uplift of the source area or from their subsequent wearing down during a quiescent phase.

Minor Facies Associations

As Mentioned above Three Minor Facies Exist: The gypsum facies is seen in two intervals each of them about 3 meters thick which commonly rest on and underlie by laminated to thin-bedded silty mudstones. The beds can be traced for hundreds of meters. The environment proposed is an exposed playa in a dry period covered by sheet floods which introduced the silt and mud [16].

The marl facies, made up of gray silty marl, is also seen in three intervals, each of them about 5-6 meters thick, which can be traced for distances greater than 1 km. This facies records more humid conditions. The gray coloration suggests that reducing conditions occurred within the sediment soon after deposition. The environment proposed is a stratified lake [17].

The limestone facies with a thickness of 6 meters is dominated by algal grainstone (Fig. 13 and 14). The abundance of algal grainstone suggests that the facies was deposited in a lake margin carbonate flat environment [18].

CONCLUSION

To simplify discussion, two types of alluvial sequences were recognized in the Aghajari Formation, one dominated by sandstones and finer sediments with relatively little conglomerate at lower parts of the sequence and the other dominated by sandstones and conglomerates with little fine grained sediments at upper parts. The first group may be compared with deposits of present-day suspended-load streams, commonly meandering streams. The second groups find modern analogues in bed-load streams, both sandy and gravelly. Thick sequences of gravelly alluvium are generated and preserved where there is topographic relief and this commonly implies tectonic activity during or immediately prior to deposition. In foreland molasse basins, the deposits are commonly very widespread and dominated by stream deposits as a result of larger catchments areas and lower slopes.

REFERENCES

1. James, G.A. and J.G. Wynd, 1965. Stratigraphic nomenclature of Iranian oil consortium agreement Area, AAPG Bull., 49: 2182-2245.
2. Setudehnia, A., 1972. Lexique Stratigraphique International ASIE, V.III, Fascicule 9 b z, Iran du Quest.
3. Motiei, H., 1994. Geology of Iran; Zagros Stratigraphy. GSI Publications, pp: 630.
4. Bahrami, M., 1997. Sedimentology and morphotectonical evolution of Aghajari and Bakhtyari Formations in north-western of Shiraz, Islamic Azad University, J. Sci., 8(No. 27and 28): 1995-2010.
5. Nabavi, M.H., 1976. An introduction to the Geology of Iran,Geological Survey of Iran, In Farsi, pp: 110.
6. Alavi, M., 1994. Tectonics of the Zagros Orogenic belt of Iran: New data interpretations. Tectonophysics, 229: 211-238.
7. Scott, A.C., 1978. Sedimentological and ecological control of Westphalian B plant assemblages from West Yorkshire. Proc. Yorks. Geol. Soc., 41: 461-508.
8. Leeder, M.R., 1974. Lower Border Group (Tournaisian) fluvio_deltaic sedimentation and paleogeography of the Northumberland Basin. Proc. Yorks. Geol. Soc., 40: 129-180.
9. Tunbridge, I.P., 1981. Sandy high-energy flood sedimentation-some criteria for recognition, with an example from the Devonian of S.W. England. Sedim. Geol., 28: 79-95.
10. Hubert, J.F. and M.G. Hyde, 1983. Sheet flow deposits of graded beds and mudstones on an alluvial sandflat-playa system: Upper Triassic Blomidon redbeds, St. Mary's Bay, Nova Scotia. Sedimentology, 29: 457-474.
11. Allen, P.A., L. Cabrera, F. Colombo and A. Matter, 1983. Variations in fluvial style on the Eocene-Oligocene alluvial fan of the Scala Dei Group, SE Ebro Basin, Spain. J. Geol. Soc., 140: 133-146.
12. Stewart, D.J., 1983. Possible suspended-load channel deposits from the Wealden Group (Lower Cretaceous) of Southern England. In:Modern and Ancient Fluvial Systems. J.D. Collinson and J.Lewin (Eds.), Spec. Publ. int. Assoc. Sediment., 6: 369-384.
13. Collinson, J.D., 1986. Alluvial Sediments, In: Sedimentary Environments and Facies. H.G. Reading (Ed.), 2nd Edn., Blackwell, Oxford, pp: 20-62.
14. Steel, R.J. and D.B. Thompson, 1983. Structures and textures in Triassic braided stream conglomerates ('Bunter' Pebble Beds) in the Sher-wood Sandstone Group, North Staffordshir, England. Sedimentology, 30: 341-367.
15. Ramos, A. and A. Sopena, 1983. Gravel bars in low sinuosity streams (Permian and Triassic, Central Spain). In: Modern and Ancient Fluvial Systems. J.D. Collinson and J. Lewin (Eds.), Spec. Publ. Int. Ass. Sediment, pp: 301-312.
16. Smoot, J.P., 1983. Depositional subenvironments in an arid closed basin; the Wilkins Peak Member of the Green River Formation (Eocene), Wyoming, U.S.A. Sedimentology, 30: 801-828.
17. Desborough, G.A., 1978. A biogenic-chemical stratified lake model for the origin of oil shale of the Green River Formation: An alternative to the playa-lake model. Bull. Geol. Soc. Am., 89: 961-971.
18. Eugster, H.P. and R.C. Surdam, 1973. Depositional environment of the Green River Formation of Wyoming: A preliminary report. Bull. Geol. Soc. Am., 84: 1115-1120.