The Study of The Cenozoic Conglomerate Outcrops in The Eastern and Western of The Zefreh Area, Northeast of Esfahan (Iran)

Abdolhosein Kangazian [1],Vahid Safaei[2] , Peiman Salehin[3]
1, 2& 3: Department of Geology, Islamic Azad University, Khorasgan Branch, Esfahan, Iran
kangazian@khuisf.ac.ir

Abstract:

Two successions of the Cenozoic conglomerate, located in the west of the Central Iran zone (W & E of the Zefreh village, 65 km of NE of Esfahan) were examined. One of these successions (ca. 360 m thick) is conformably laid on the Eocene Volcaniclastics, whereas the other (ca. 66 m thick) is unconformably laid on thick bedded limestones of the Eocene age. The distance between these two is approximately 4 km. Field evidences proposed that these rocks probably is time equivalent, and lateral extension of the shallow marine Qom Formation (Oligo-Miocene). Seven following lithofacies were distinguished: 1) crudely graded bedded, massive, matrix conglomerate (Gmm facies), 2) normal to inverse graded bedded, matrix conglomerate (Gmg facies), 3) inverse graded bedded, clast supported conglomerate (Gci facies), 4) massive clast supported conglomerate (Gcm facies), 5) crudely to well bedded, clast supported conglomerate (Gh facies), 6) trough crass bedded, clast supported conglomerate (Gt facies), and 7) lenticular, massive sandstone (Sm facies). Based on statistical data the Gmg, Gcm, and Gh facies are the main and the Gci, Gmm, and Sm are the minor facies in the first section. In the second

section the Gmg, Gcm, Gci facies are the main and the Gh, Gmm, and Sm are the minor facies. The main facies were originally deposited by debris flows, revealing that these rocks were occurred in a dry alluvial fan. Palaeocurrent directions could show that the fan was extended to the northeast (from the W section to E second) in the study area. Accorcing to sequence stratigraphy data, two 3^{rd} sequences, composed of HST, FSST, and LST system tracts, were recognized, which can be corresponded in the both successions fittingly.
Key word: Alluvial fan, Conglomerate, Sequence Stratigraphy, Centeral Iran Zone.

1-Introduction:

Conglomerate rocks, have a lot of evidence, can reveal climatic, tectonic, and depositional characteristics of their environments, especially if these data be matched with sequence stratigraphy information. This paper is a case study about occurrence and evaluation of the Oligocene/Miocene conglomerates in the Zefreh area (65 km of the northeast of Isfahan /central Iran). All the geological studies have been done in this area, until now, are about paleontology, lithostratigraphy and carbonate sedimentology (e.g.: Hairapetian 2009, Reuter et al. 2007, Gholamalian 2007, Jafarian & Brice 1973 and so on). But this study is the first investigation about the conglomerate and its sequence stratigraphy in the region. Consequently two outcrops, were located on the west and east side of the Zefreh village, were selected for inspecting. The positions of the bases of the west and the east sections are 32°53′57” N, 52°15′39” E and 32°53′64” N, 52°43′76” E, respectively.

2- Methodology:

The coarse clastic terrigenous rocks must be examined based on the field study. In this investigation, firstly, the pebble-type, texture, sedimentary structure, packing and the amount of the clasts and matrix of the rocks were studied-from the base toward the top of the sections. Secondly, the characteristics of the rock beds were checked vertically and laterally. Then the terrigenous rocks were classified based on the Petijohn (1975) and limestone was named according to Grabau's classification (1904). The lithofacies were recognized based on the Miall's method (2006). Based on the maximum grain size changes, along to the successions and by means of the Fisher's (1964) and Tucker's (2003) methods, the 3rd order sequences and their system trackts were determined. The sequence stratigraphy terms were extracted from Catuneanu (2006), and Coe et.al (2003).

3- Lithostratigrapy of the Successions:

The west succession, which conformably placed on the Eocene Volcaniclastic rocks (Radfar 2002), is composed of the following lithostratigraphic subdivisions:

Unit 1: It is composed of 33 m siliciclastics and Volcaniclastics rocks, including agglomerate and conglomerate, formed by various pebbles. Several tuff interbeds were also recorded.

Unit 2: The unit consists of the red, lens shaped peteromictic ortoconglomerates (ca. 209.6 m). The lenses are connected to each other without any lateral discontinuity. The contact with lower unit is sharp.

Unit 3: The unit is discriminated by its specific grey coloration from the underlying red unit 2. The lithostrata is also characterized by peteromictic orthoconglomerats and is made up of welded lenses such as previous unit. Sand lenses rarely are seen in this unit. Recent alluvial deposits covered upper part of this unit. Thickness of this unit is 119 meters.

The east succession conformably placed on the Eocene Volcaniclastic rocks, too. It can also be divided to three units which were explained in below:

Unit 1: this unit here, opposes the west succession, is thin (4 m) and composed of three limestone cycles (calcilutite to calcirudite). The unit conformably is located on the Volcaniclastic rocks.

Unit 2: a paleosol layer, about 0.3 to 1 m thickness, is the only component of this unit. Although it is an informal unit, but is very important in correlation of the both study successions (figure 3b).

Unit 3: like the west section, this unit was identified with its distinctive gray color conglomerates. This unit composed of lens shape conglomerate, and occasionally sandstone, layers which welded together and its thickness is 57.7 m. The conglomerate layers some time have erosional bases. This unit is covered by the recent alluvial sediments.

4- Petrography of the Successions:

Coarse grain siliciclastic rocks are composed of difference unstable detrital grains in these successions. They have a considerable extant and thicknesses and also composed of cobble to boulder size clasts. Consequently, according to Petijohn's classification (1975) and based on their matrix frequency, they can be called Orthoconglomerate. Based on point counting method data, it clears that the limestone, dolostone and sandstone clasts are abundant and Volcaniclastic, volcanic, and conglomerate clasts are scarce in these rocks. Consequently they were called Peteromictic Orthoconglomerate by means of Petijohns (1975). The rate of each clast-type changes from base to top of the sections. In the west succession, amount of the volcanic and Volcaniclastic fragments is abundant in the base (in unit 1) but in the upper portion (in units 2&3; chart 1) becomes rare, suddenly. The dolostone and limestone gravels are the most frequent gravels in unit 2 but their proportions are considerable in unit 3, too. Although amount of Sandstone clasts has an increasingly trend toward the top of the section and they are much more in unit 3, the carbonate gravels are the most abundance gravel in this unit, yet. It can't be done such comparison between the units of the east succession because units 1 and 2 are not terrigenous, here. However it can be stand that carbonate clasts are the most frequent clast in the unit 3 of this section, also. The decrease of the average size of the gravels and the increase of the sand lenses distribution are the most important differences between this section and the west one.

5- Lithofacies of the Successions:

According to the Mial's classification (2006) and based on the field study, 7 lithofacies, include of the 6 conglomerate and the1 sandstone lithofacies, as follow, were recognized:

5-1- Conglomerate lithofacies:

Gmm facies: all matrix supported conglomerats with crudly graded bedding refer to this facies . The facies has an eroding aspect in the field, because of the abundant matrix. A plastic debris flow has created this facies (Mial 2006) for the reason that it hasn't basal and lateral erosion boundaries.

Gmg facies: this facies composed of matrix supported conglomerate with normal grading. Mial (2006) believed that this facies was produced by psedoplastic debris flow.

Gci facies: this facies includes of claste-supported conglomerates with reverse grading . Clast-rich or psedoplastic debris flow was the response of this facies (Mial 2006).

Gcm facies: clast supported conglomerates without any indicative structures . formed this facies. Pesudoplastic debris flow can make the facies (Mial 2006).

Gh facies: this facies consist of well bedded, clast-supported conglomerates, that have weakly grading and also imberication

. Longitudinal bar and sieve deposits can produce such conglomerates (Mial 2006). Althouth, thickness of each layer in the facies is up to several decimeters only but reapitation and moultistori caused the facies became thick.

Gt facies: trough cross-bedded clast-supported conglomerates, which occurred in some minor channels (Mial 2006), form this facies . Eroding of their bases, presenting of more coarse grains in the trough basements, 2 to 12 m wide and 2 to 3 m thicknesses are the characteristics of the conglomerates that exactly coincide with Mial's (2006) definition .

All of these facies were reported from Miocene of the northern Vietnam (Wysoka & Świerczewska 2010) and Tertiary of SE Brazil (Neves et.al 2005)

5-2- Sandstone lithofacies:

Ss facies: very fine to coarse sandstones or gravely sandstones make this facies. This sediment filled the scores. Weakly planar cross-bedding structures can be seen in them occasionally.

6- Sequence stratigraphy of the successions:

According to the changes of the lithofacies and to the trend of the changes of the longer gravels through the successions, and by means of the Fisher's (1964) method sequence stratigraphy of these sections are analyzed . Subsequently, two depositional 3rd order sequences (Sq1 & Sq2) are recognized. In the west succession, the Sq1, which started with first-type sequence boundary ($SB_{I)}$, is located on the volcanic rocks and is covered by the Sq2. A two-type sequence boundary (SB_{II}) separets these two from each other. The latest sequence is partial and is covered by recent alluvial sediments. The Sq1 composes of HST and FSST, while the Sq2 consists of LST only and the other system tract (or tracts) is (or are) not exposed. Here depositional sequences and their system tracts completely coincide with lithostratigraphic units. Consequently, unit 1, unit 2, and unit 3 are equivalent of HST, FSST of Sq1 and LST of Sq2 respectively. In the east succession, the Sq1 is located between tow SB_I. This sequence, here, composed of a carbonate HST and FSST cannot be seen. In the Sq2, like the west section, LST can be followed, only. Also here we can correlate the lithostratigraphic units with the obtained sequence stratigraphy data so that unit 1, unit2 and unit 3 are correspondingly coincided with HST of Sq1, second SB_I, and LST of Sq2.

7- Discussion:

Statistical analyses shows that the Gcm facies is the most frequent conglomerate lithofacies in the west section. After that the Gmg facies is the most. Furthermore, the Gh and Gmm facies are on third and fourth frequency ranking, respectively . the other conglomerate and also sandstone lithofacies are very infrequent. Consequently the Gcm, Cmg, Gh, and Gmm are the main lithofacies group and the Gci, Gt, and Ss are the minor one. According to Mial (1985, 2006), this main and this minor lithofacies can be referred to the SG and GB elementary structures, correspondingly. The field data, such as convex upward lens shape of these elementary, confirm those . Like the west section, Gcm facies is aboundant in the east section. The Gci, Gmg, Gh, Gmm,and Ss are less frequent respectively. The Gt facies doesn’t find here. Elementary structures in this succession exactly are equal the west section .

The Gcm, Gmm, and Gcm are the most frequent facies in the HST of the west section. The important elementary structure of this system tract is SG. Althouth the Gmm facies cannot be seen in the FSST, the SG elementary structure is predominant, yet. Main facies of the LST, here, which show the SG and probably HO elementary structurs, are Gmm, Gmg, Gcm, and Gh facies .

8- Concolusion:

According to Mial (2006) all the previous mentioned lithofacies and the main elementary structure were produced by the debris flows. Consequently, they occurred in an arid alluvial fan. Infrequency of the sandstone facies confirms this idea and also shows that these sediments were deposited in the proximal portion of the proposed alluvial fan. This lithofacies association approximately is the same as the polygenic Conglomerate (pC) of Luzón (2005) that was referred to the flash flood and sheet flood of a proximal sector of large alluvial fans. Based on Sthnistreet and McCarthy (1993) this fan was a debris flow dominated kind that occurred in the barren and very steep landscapes in front of the mountains. Mial (2006) believed that such alluvial fans are small (less than 10 km long) and produced in the arid climate. Decreasing of the gravel diameters toward the east section, relative increasing in repetition and thicknes of the sandstone lithofasies toward the same direction, abruptly decreasing of the siliciclastic sediments and appearance of carbonet rocks (unit1) and also absent of a siliciclastic unit 2 in this sections (figure 11) show that the apex of this fan and the paleorelief were near the west section in that time. A weakly paleodirecton structure (imbrications of the Gh facies; show a flow that had moved toward the northeast of this area. However, this alluvial fan was no large and for this reason there aren't many outcroup of it in the district. The occurence of such alluvial was referred to the falt events by Mial (1986). Safaea et.al (2008) and Safaea (2004) recorded such falts that were produced by Qom falt movment and have activated and affected the topography of the quarter since lower cretaceous. According to deposition of both successions on the Eocene volcanic and Volcaniclastic rocks (Radfar 2001) probably this alluvial fan was active in Oligocene/Miocene time and its sediments are the equivalent of the Qom Formation.

The trend of the change in the variety of the gravels in this area (chart 1) points not only to the variety of their source petrotrology but also to very strange tectonic activity in this district. So that in course of time, the amount of Volcaniclastic gravels (that were destroyed from the Eocene rocks) suddenly decreased and instead the proportion of older carbonate gravels (which destroyed from cretaceous dolostone and limestones) increased. Sandstone gravels probably are broken from the oldest rocks in the source area and are abundant in the top of the sections (unit 3). So it can point to the tectonic activity of the region based on Dickinson (1985). Relatively lacks of changing and even a virtual increasing in the size of the gravels upwardly in the succession confirm this clime.

Sequence stratigraphy data also show that after a maximum flooding, the east area submerged and carbonate sediments were being deposited . While in this time (HST stage) the west region was out of the water and conglomerate and agglomerate sediments were deposited there in an alluvial fan environment. With gradually decreasing of the accommodation space and regression of the relative sea level, the east area came out of the water again. Instead, in this time (FSST stage), the accommodation space and rate of sedimentation increased in the alluvial fan on the west area by the marine regression whereas lack of sedimentation and to be a long time sub meteoric conditions produced a paleosoile layers (unit 3) in the east region. Although these two regions were not submerged after the re rising (LST stage) in Neotethys and the accommodation spaces decreased a little but the alluvial fan activations in the west extended to the east area. Consequently alluvial sediment covered the paleosoile there (12 d). The mentioned depositional 3rd order sequences are acceptable if their correct interval age can be obtain in the future study. The authors believed that it's better to call them, tectonic sequences instead of depositional sequences because sedimentation in an alluvial fan is not depend to sea level change directly but tectonic and weather conditions influence it powerfully, and in the other hand tectonic activation of these areas was very intense because they were located near a convergent plate boundary (Safaea and et.al 2008, Arfaneia and Shahreiari 2009).

10- Acknowledge:

This work is the result of a project supported by Islamic Azad university-Khorasgan branch. We are indebted to chancellor of this university and his colleagues for their logistics and financial support of this project.

Reference:

Arfania, R., Shahriari, S., 2009. Role of southeastern Sanandaj-Sirjan Zone in the tectonic evolution of Zagros Orogenic Belt, Iran. Island Arc doi:10.1111/j: 1440-1738.

Catuneanu, O., 2006, Principles of Sequence Stratigraphy, Deparìment of Earth and Atmospheric Sciences, University of Alberta Edmonion, Alberia, Canada, 375pp.

Cheel, R.J., 2005, Introduction to Clastic Sedimentology, Prentice Hall Inc.,130p.p

Coe, A, Bosence, D., Pam, WJ. Church, Revin, D., Flint, Stephen, Howell, J.A., Wilson, R., Chris,L., 2005, The Sedimentary records of Sea-Level changes, Cambridge university press & the open university, Cambridge, UK. 427pp.

Dickinson,W.R., 1985. Interprating provenance relations from detrital modes of sandstones. In: Provenance of arenites (Ed. By G.G. Zuffa), pp. 333-361. Reidel, Dordrecht

Fisher, AG., 1964, The loafer Cyclothems in the Alpine Triassic Kansas. Journal of Geology Survy. Vol. 169: 107-146.

Grabau, AW., 1904, on the classification of sedimentary rocks, American geologists, 33:228-243.

Gholamalian, h. 2007. Conodont biostratigraphy of the Frasnian–Famennian boundary in the Esfahan and tabas areas, Central Iran. Geological Quarterly, 51, 453–476.

Hairapetian, V., Ginter, M., 2009. Famennian chondrichthyan remains from the

Chahriseh section, central Iran. Acta Palaeontologica Polonica, 59(2), 173–200.

Jafarian, M.A., et Brice, D., 1973, Biostratigraphy des Brachioopds dans le Famennien superieur de la region d'Isfahan (Iran central), Misen evidence de la Zone dEtreungt. CR4c.Sc., t.276, S.D. Paris.

Luzón, A. 2005. Oligocene-Miocene alluvial sedimentation in the northern Ebro Basin, NESpain: Tectonic control and paleogeographical evolution. Sedimentary Geology, 177: 19-39.

Miall, A. D., 1985, Architectural-element analysts: a new method of factes analysts applied to fluvial deposits, Erth Sci. Rev. 22: 261-308

Miall, A. D., 2006, The Geology of Fluvial Deposits, Springer, 582pp.

Neves M.A., Morales N., Saad A.R. 2005, Facies analysis of tertiary alluvial fan deposits inthe Jundiaí region, São Paulo, southeastern Brazil. Journal of South American Earth Science, 19: 513-524.

Pettijohn, F.J., 1975, Sedimentary Rocks, Harper & Row,New York, 628 pp.

Radfar, J., 2002. A quadrangle Kuhpaieh geology map. Geological survive of iran.

Reuter, M., Piller,W. E., Harzhauser, M., Mandic, O., Berning, B., Rogl, F., Kroh, A., Aubry M.P., Wielandt-Schuster, U., Hamedani, A., 2007, The Oligo-/Miocene QomFormation (Iran): evidence for an early Burdigalian restriction of the TethyanSeaway and closure of Iranian gateways, Int J Earth Sci (Geol Rundsch), original paper.

Safaea, H., Taheri, A., Vaziri moghadam, H., 2008, Structural Analysts and Evolution of the Kashan (Qom – Zefreh) Fault, Central Iran. Journal of Applied Sciences 8 (8): 1426-1434.

Sthnistreet, IG., McCarthy, TS., 1993, The Okavango fan and the classification of subaerial fan systems., Sediment Geol.,85: 115-133.

Tucker, ME., 2003, The field description of Sedimentary rocks, Geological Society of London, 112pp.

Wysoka A. & Świerczewska A. 2010, Lithofacies and depositional environments of Miocenedeposits from tectonically-controlled basins (Red River Fau
Zone, northern Vietnam). Journal of Asian Earth Sciences, 39(3): 109-124.