Factors influencing the reservoir characteristics of the Ooid facies (Dalan formation in the Persian Gulf)

Abdolhosein.Amini and Masoomeh. Haghdoost

Corresponding author: [a]School of Earth Sciences Tarbiat Moalem University,Tehran,Iran
E-mail address : m.haghdoost20@gmail.com

Abstract

The Dalan Formation is among the most important reservior rocks in Zagros 3 zone .The major reservior facies of this formation are ooid grainstone facies . The aim of the study of the facies in order to discover factors affecting their reservior quality . The1500 thin section from 290 meters of well cores were studied . According to the sedimentological studies ,the reservoir facies were composed including three microfacies of fine grained ooid / peloid dolograinstone ,medium grained ooid dolograinstone and coarse grained ooid/ bioclast/intraclast dolograinstone . the sedimentary environment of this facies varies from tidal flat to oolitic/bioclastic shoal.In order to study factors which influenced reserviore quality,the textural and diagenetic factors were analyzed separately and the effect of each of these factors was demonstrated by drawing related charts. Size , shape of grains, and sorting are among the facors affecting the reservoir quality of the facies under study. Campaction , cementation , dissolution , dolomitization , anhydratization and fracture are the most important diagenetic phenomena which have influenced the reservior characteristics of grainstone facies.

Key words : *oolitic facies , reservoir charactericitic, diagenesis , Persian Gulf*

Introduction

The Dalan Formation is one of the most important gas reservoirs in the Middle East.This formation, located in South of Iran and in the Persian Gulf, has encorporated 18%of the worlds gas reservoirs (kashfi, 2000).The sedimentological and statigraphical analysis of this formation were first studied Szabo & Kheradpir (1987).from a litological perspective, this formation can be divided to three parts: namely, dolomitic lower part ,limestone middle part, and dolomitic upper part. According to this study, this formation has sedimented in fine belts of supratidal, intertidal, restrict logoon, shoal and open marin which all are part of carbonate ramp. In this article the factors influencing the resevior characteristics of the formation are investigated and the effect of each of these factores is cleared.

Methology

In order to study the ooid grainstone facies, 1500 thin sections of three wells were analyzed. The thin sections have been stained using Alizarin-Red S for detailed petrographical studies and some of the porous samples have been injected by blue dyed epoxy resin. In this study the texture (according to Dunham (1962) classification), litology, types of porosity, sediment structure, diagentic processes (like cementation, dolomitization, dissolution, campaction and replacement) were determined for better understanding the reservoir characteristics of different core facies in this interval.

Ultimately , the effect of different factors on the resrvior characteristics of the studied facies , by drawing related charts and interpreting the results , was determined .

Microfacies and depositional environment of the ooid grainstone facies of Dalan

According to the microscopic studies, ooid grainstone facies can be divided into the following three microfacies**:**

1)fine grained pelloid ooid grainstone

This microfacies is composed of ooid and pelloid and in some cases have gastropod and green algae . The size of the ooids is smaller than 0.25 mm. Its sedimentary structure are cross bedding and key stone vugs. Dolomitization, anhydritization and micritization processes are abundant in this facies. The pore filling cements are mostly composed of mosaic and equant type. The minimum and maximum porosity and permeability were 0.13 ,21% and 0.03 ,47 md respectively. According to the mentioned evidences, it seems that the depositional environment of this microfacies are leeward shoal and lower intertidal .

2)Medium grained ooid grainstone

The facies is a dolomitic grainstones whose ooids vary between 0.1 to 0.6 mm in size. This facies is the most important reservoir facies in the Dalan unit .Other Allochems like bioclast, intraclast and mirror pelloid are less than which usully often found.The cement found in this facies includes isopachus, blocky,equant,drusy and even anhydrate cements .The most common types of porosity in the microfacies are moldic and interparticle porosities . The fracturing led to the linkage of the unrelated moldic prosity and the increase in permeability . The minimum and maximum of porosity and permeability were o.1,31% and 0.03,107 md respectively .The existance of sedimentary structures such as cross bedding all show that sedimentation of this facies was occured in a high energy environment that is influenced by tide and wave (Tucker &Wright,1990) .

3)Coarse grained interclast /bioclast ooid grainstone

This facies is composed of ooid ,interclast and bioclasts (bivalve,echinoderm,brachiopod ,gastropod and bryozoa).The size of ooids of the is smaller than 0.5 mm.The cements observed in this facies are bloky ,equant ,isopachous and anhydratic types.The most common types of porosity were moldic and interparticle .The minimum and maximum of porosity and permeability in this microfacies are 0.13 , 26% and 0.4 , 103 md respectively. this facies is formed in a high energy see ward shoal environment (Tucker &Wright ,1990) .

Factors influencing the reservoir characteristics

In order to study the factores influencing the reservoir characteristics of the facies under study , These two major factors should be taken into account (Lucia ,1999): 1) The textural factors which are usually affected by sedimentary processes and determine the sedimentary facies. 2) Diagenetic factors which are studied as a part of stone fabric due to their importance.The results of study show that the dispersion of data in each microfacies is due to the change in the size of the grains ,sorting and the distribution of cement and the percentage of its frequency.

Textural factors

The size, sorting and the amount of micrite reflect the energy of the environment (tucker,1991). The ooid facies,due to their grainstone texture ,are classified in to Lucia (1999) first petrophisical group . In the studied facies the primary porosities including intraparticle and interparticle types . Interparticle porosity, which is observed in the stone is mainly influenced by the texture. These textural characteristics are the shape of the grain ,roundness ,sorting and fabric .When the paking of the grains was more compact,the porosity and permeability were lower . In the sand-size facies,a direct relationship between porosity & permeabilitt was observed . There was no relation between the amount of porosity and the size of the grains and the percentage of the porosity will remain constant despite the change in size if the grains .However the permeability is controlled by the size of the grains.The grain size is proportional to the permeability. Size and the sorting of the grains were the most important factors in interparticle porosity . In the studied facies ,the decrease in the size of the grains to the contraction of porosity throat and this the grains can hardly pass through the stone.Effective the permeability and porosity.According to the aforementioned explanations,interparticle porosity can be observed incoarser and wele sorted sediments. In the studied samples related to the first microfacies ,the rock component are fine-grained and well sorted .In the secend microfacies , the grains are medium sized and well sorted. In the 3rd microfacies, size of the grains was medium to coarse with poor sorting.It seems that the best reservoir potential is for the seemed microfacies. According to the result mentioned above,it can be implied that the percentage of allochems influenced the reservoir characteristic so that with increase in the percentage of the medium grained ooid , reservoir characteristics. As discussed, the second microfacies has higher permeability and porosity . The fabric of the sediment includes their packing and orientation . The packing of the grains depends on factors like compaction and cementation(Tucker,1991). The orientation of the grains will influence the permeability of the stons.Allochem due to the oscillation of wave and the tide,stand perpendicular to sand mass axis.Thus the orientation of the primary permeability will be perpendicular to sand masses.Access to such information will be of high importance in designing reservoir models .

Diagenetic Events

Diagenetic processes are responsible for modification of original porosity and thus reservoir quality in the Dalan Formation.

Compaction

Mechanical compaction, mainly induced by lithostatic pressure, causes bulk volume reduction in sediments. EvidenceS of mechanical compaction in the samples, include broken and deformed grains and grain slippage and rearrangement . Chemical compaction defined as bulk volume reduction caused by the dissolution of carbonate grains at the contact points due to overburden pressure.In these two formations,chemical compaction can be distinguished by the presence of stylolites, sutured grain contacts and pressure dissolution seams.

Cementation

Various types of cements formed at different times can be distinguished in the Formation. These cements include calcite, anhydrite and dolomite cements that partially or completely filled pore porosities.

Dolomitization

Dolomitization is the most important factor that has enhanced the reservoir quality in the Dalan Formation. Dolomitization also increases the pore throat size and reduces pore roughness and lead to an increase in permeability (sun,1999).Meanwhile, dolomites are less sensitive to compaction.The recognition of the hydrologic process is very important for dolomite reservoir characterization. Hydrologic process controls the geometry of the dolomitization.

Dissolution

Evidence of rock components and cement dissolution is common in the studied samples.Dissolution of skeletal debris and ooids is pervasive in limestone intervals and increases reservoir quality. This process has led to generation of abundant skeletal moldic, oomoldic and vuggy porosity in some samples.

Result

The result of the study indicated that the ooid grainstone facies of this unit can be devided in to tree microfacies,these microfacies were deposited in tidal flat to shoal setting .this study also shows that both textural and diagenetic factors are immensely influential on the reservoir characteristics .Size, shape, sorting and fabric are among the textural factors which impact the reservoir characteristics and are controlled by sedimentation.By considering the two factors of sorting and the size of the grains,we found the best reservoir characteristics in the second microfacies .The important diagenetic phenomena observed in the studied samples and influencing the reservoir charastistics include compaction, cementation, dissolution, dolomitization, anhydratization and fractureing. Campaction and cementation decrease the reservoir qualities . Dissulotion, however,increase theextent of porosity while it doesn't have a nonceable effect on the extent of permeability. These dolomites are campared to large dolomite grains, but dolomitization did not influence the distribution of the pores. Its should not be expected of the porosity and permeability to increase more than what is observed .Hetrogeneous distribution of anhydrate led to porosity while it doesn't influenced the permeability.The percentage of anhydrate in dolomitic samples is larger than that in lime stons and its increase led to decreasing reservoir effeciency. Fractures in the Dalan are not so extended and most of the fractures were filled by anhydrited and calcite cements .

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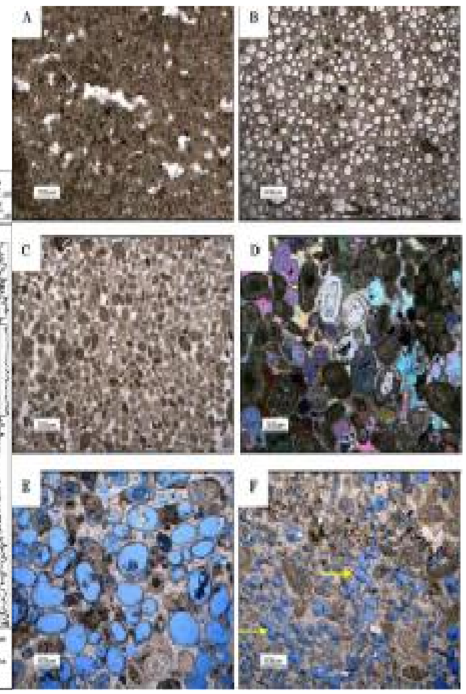
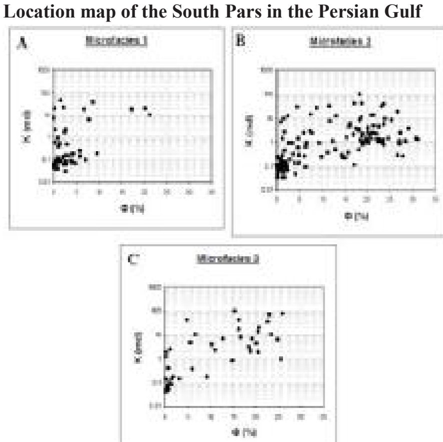
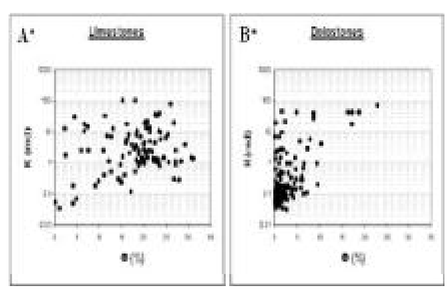


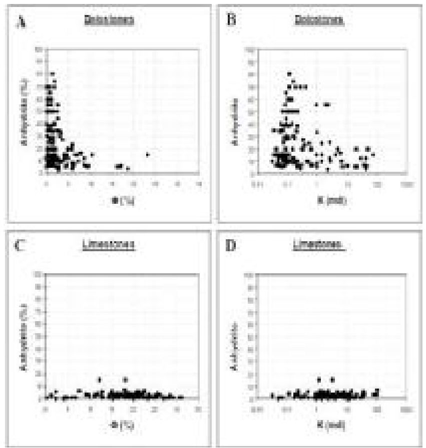
Location map of the South Pars in the Persian Gulf





Porosity&permeability diagram for microfacies 1,2,3

Porosity&permeability diagram in dolomitic&lime sample



Porosity/permeability &anhydrite diagram in dolomitic&lime sample