Survey of the diagenesis process and effect these process on reservoir quality of the Kangan formation in South Pars Field

Gh. Hosseinyar[1]; H. Rahimpour-Bonab[2]; A. Asadi Esksndar[3] ,M. Asgharian Rostami[4]

1, 2,4: School of Geology- University College of Science, University of Tehran-Iran

3: Expert in geology- Pars oil and gas co.-tehran-Iran

Abstract

Kangan and Upper Dalan formations are forming reservoir sequence of the South Pars field. Litology of the kangan formation is carbonate and (limestone and dolomite with anhydrite intervals), so digenetic processes were very active in this formation and these processes have changeed the reservoir quality. Importances of the digenetic process are including dissolution, calcite cements, dolomitization, anhydritization, physical and chemical compaction and fracturing.

Keywords: Diagenesis, Reservoir quality, Kangan, Triassic.

Introduction

Diversity of reservoir quality in shallow carbonate is usual (Lucia, 2007; Moore, 2001). Diversity reflects the effect of sedimentary environment process and diagenetical process. This paper focuses on the Kangan formation in the Persian gulf in Iran (figure 1). Upper Dalan (upper Permian) and Kangan (lower Triassic) formations (equivalent to the upper khuff) are main gas reservoir section in Middle East region that include about 18% of world gas reserve. These formations are usually subdivid into the 4reservoires zone; the Upper Dalan subdivide into the K4, K3reservoirs and Kangan subdivide into the K2 and K1reservoirs (Insalaco et al., 2006).

Methodology

For identify facies and sedimentary environment, in this project, we use 2050 thin section for petrographic studies that have supplied from 3 wells of South pars field in Persian Gulf (fig 1). Thin sections cut from horizontal plug samples (with 35^{cm} from each other) and all of them stained by Alizarin Red-S (relevant Dickson, 1965) to identify calcite from dolomite mineralogy. We survey the diagenetical processes completely and 15 samples from Kangan formation had selected for scanning electron microscopy (SEM) observation.

Figure 1: Location map of study area

The microfacies of Kangan formation are including: Bioclast grainstone – packstone microfacies, Coarse to medium Oncoid-intraclast-bioclast grainstone(dolograinstone) microfacies, medium to coarse ooid-bioclast grainstone to packstone (and dolostone) microfacies, Ooid grainstone to packstone microfacies(and dolostone), peloid-ooid-bioclast packstone to grainstone microfacies, peloid-bioclast packstone to wackstone microfacies, Mudstone to wackstone (and dolostone) microfacies, Thrombolite microfacies, Dolomudstone with anhydrite microfacies and layered to massive anhydrite microfacies.

Discussion

Diagenetical processes that acted in this section have been formed in all of diagenetic environments such as marine, meteoric and burial environments (Scholle and Scholle, 2003; Flügel, 2004). Some of these processes interpret below:

1- Micritization: in the Kangan, micritization is common process and has formed in more of the facies. This process has affected ooids, peloids and some of sceltal fragments and envelope rim of the grains (whole of the grain in several samples). Micrite envelope has replaced by dolomite on the part of section (Figure 2- A).

2- Calcite cementation: calcite cements are very important and also more effective diagenetic processes in the Kangan formation and have different kinds that summarized below: Isopachous Cement, Circumgranular Bladed Cement, Equant Calcite Cement, Drusy Calcite Cement and Coarse Crystalline Calcite Cement. Equant calcite cement is frequent than the others, that is interpreting here.

- **Equant Calcite Cement:** this cement type form on meteoric and burial diagenetic environments and filled the void spaces in grain-dominated facies (Scholle and Scholle, 2003). Association of this cement with creation of moldic porosity indicates that provide from solution flour of grains on meteoric environment. Equant calcite cement, in Kangan formation, is observe in coarse to medium Oncoid-intraclast-bioclast grainstone(dolograinstone) microfacies, medium to coarse ooid-bioclast grainstone to packstone(and dolostone) microfacies, Peloid-ooid-bioclast packstone to grainstone microfacies and ooid grainstone to packstone microfacies. Filling the interparticle porosity by this cement type and creation mold voids associate it lead to very decreasing on permeability values (Figure 2- B).

3- Mechanical-chemical compaction: same process usually in the muddominated facies (or dolo) is more effective than graindominated ones and decreases porosity and permeability. In the Kangan formation, this process lead to creation presser-solution situation in facies. Form of the stylolites through the section (commonly in facies boundary), presser-solution on dolomite crystals and grain contacts with each other are instances for this topic (Figure 2- C).

4- Dolomitization: Jones and Xiao, 2005 Lucia, 2007 hypothesized that the porosity in dolostones is a function of a) the porosity of the precursor limestone, b) source of the co_3^{--} , c) compaction, d) cementation by later dolomite flour and e) the amount of overdolomitization. Dolomitization connect the voids with each other and increase the permeability.

From the models that have suggested for dolomitization of strata, dolomitization based the evaporative model, the seepage-reflux model, the Dorag model and subsurface burial dolomitization and dolomite cementation have acted in this section. The replacement of dolomite in facies is possible retain the original fabric (fabric retentive dolomite) or destruct it (fabric destructive dolomite) and/or select the fabric of rocks (fabric selective dolomite (Figure 2- D and E)), (Machel, 2004). In dolomitized facies in Kangan formation, we observe all of dolomite fabrics and also observe planner (e and s) and non-planner dolomite crystals (Sibly and Gregg, 1987). Planner dolomite crystals (e and s) have formed in fabric destructive dolomite on sand shoals facies and non-planner dolomite crystals present in facies have dolomitized by replacement on primary diagenesis time in most of the facies (mostly in dolomudestones(figure 3)).

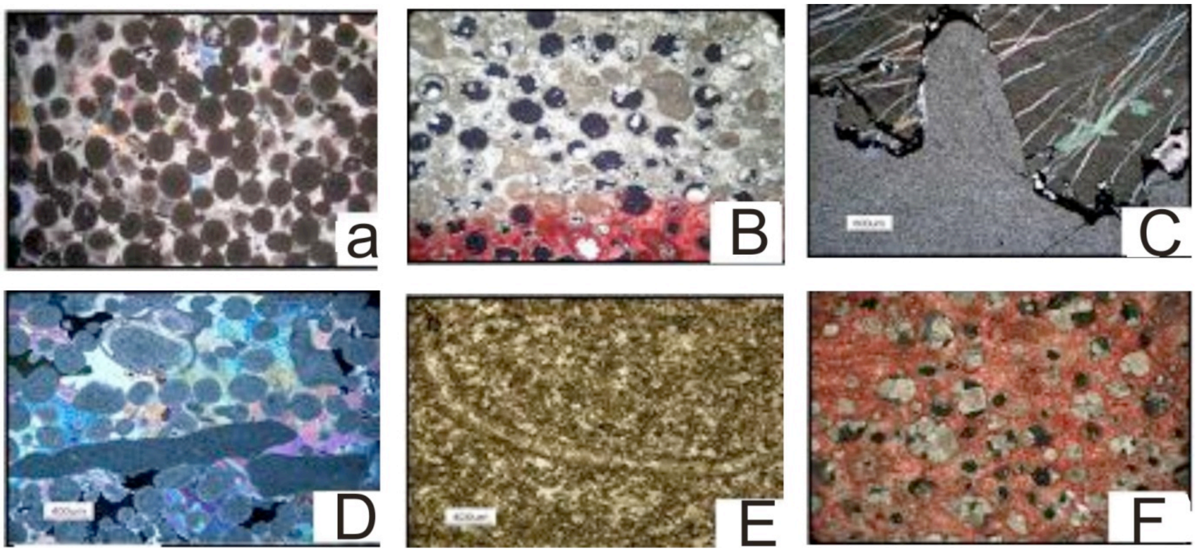

Figure 2: a) Micritization on ooids in ooid grainstone with pore filling anhydrite cements; B) ooid grainstone microfacies with equant calcite cement and moldic porosity assocate it; C) physical-chemical compaction (evaporate veins staple on stylolite ’ s strike; D) fabric selective dolomite that create by replacement; E) overdolomitization and fabric destructive dolomite type; F) oomolde filling dolomite cement (burial)

Figure 3: Scanning electron microscopy image: a) Planner-s dolomite crystal (scale 20 µ); b) Planner-e dolomite crystal (scale 10 µ)

Most of the dolomitic cements have formed on somedeal depth to depth stage and indicate oil window in reservoirs. Dolomitic cements are including:

- Filling cements: these type cements are idiomorphic and coarse crystal that have filled molds and some of interparticle pores in grain-dominated facies (Figure 2- F).

- Rim dolomite cements: this cement have formed on side of some ooids and peloids and some of the bioclasts. The frequent of the rim cement is very low in Kangan formation.
- Fin crystal dolomite cement: these cements have formed on strike of the stylolites and indicate burial origin for them. Some of these cements have filled pores partly and our surveys show that permeability decrease in same facies.

5- Anhydritization: anhydrite (CaSO4) and gypsum ($CaSo_4.2H_2O$) are common minerals in dolostones reservoirs. Most of the gypsum changed to anhydrite; so we interpret the anhydrite cements in here. Distribution of anhydritic cements in Kangan formation is very much and have destructed the quality of reservoir on parts of the section. Anhydrite present in most of the facies and has filed pores such as interparticle, intercristalin, moldic and fenestral pores. The time of form of the anhydrite had widespread and we can observe primary to burial original anhydrite through the section. Anhydrite fabrics have identified(based lucia, 2007), that have summarized below:

Poikilotopic Anhydrite, Pore-Filling Anhydrite or Pervasive Anhydrite, Bedded or Layered Anhydrite, Nodular Anhydrite, Single and sporadic crystals anhydrite, evaporate veins(Figure 2- A, C and D). From these fabrics, poikilotopic and pore-filling anhydrite are the most common form of anhydrite in the par of dolostone in our studding reservoir.

6- Dissolution: The observations suggest that solution process in carbonate facies lead to creation mold and vuggy pore space (Saller and Henderson, 1998; lucia, 2007). In effect of this process on meteoric phase in the Kangan formation facies, ooid grains and some skeletal fragments (such as gastropods, foraminifer and some bivalves) have solved in grain-dominated facies and so, the moldic porosity is very distributed. Although creation of new pore spaces through this process has increased the porosity, but cementation by the calcite associate it has occluded interparticle pores and permeability of the facies decline.

7- Fracturing: fractures are phenomena that increase reservoir quality (especially permeability). This phenomenon has created through diagenes in the Kangan formation but most of them have occluded by anhydrite and calcite cements. So are vacant of fractures.

Conclusion:

From the present diagenetic processes in Kangan formation, calcite cementation (especially equant and drusy calcite cements) and anhydritization and compaction had most effect on decline the porosity and permeability in reservoir. Whereas dissolution and fracturing have caused that reservoir quality improve. Dolomitization has bilateral effect; in some cases dolomitization has connected pore space with each other and has increased relevance them (increasing reservoir quality), but in some of facies amount of dolomitization had more and growth of the crystals lead to occluding the pores (decreasing reservoir quality). Dolomite cementation cased reservoir quality decline, too.

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