Porosity Evolution In Carbonate Reservoir Rock Of Sarvak Formation, Zagros Basin, Iran

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Abstract

The Sarvak Formation with middle Cretaceous age (Albian- Turonian) is the second major oil carbonate reservoir rock in Zagros area. Thickness of the Sarvak Formation is 285 meters in well No. 8 of Kuh-e Mond. For investigation of microfacies and effect of diagenetic process on the porosity evolution of this formation are studied 329 thin sections colored with red Alizarin, core data.

Based on petrographical studies, 15 microfacies were recognized. These microfacies were deposited in lagoon, back reef (leeward), reef, fore reef (seaward), shallow open marine and deep open marine settings. Six major transgressive– regressive sequences are interpreted in the Sarvak Formation. In this study, porosity types were divided into primary and secondary porosity groups that affected by sedimentary environment, diagenetic process and tectonic. In high energy microfacies, primary porosity (interparticle and intraparticle types) was formed that interparticle porosity was decreased, but moldic and vugy porosities were increased in primary diagenetic stage (eogenetic). In mezogenetic stage, cementation lead to decrease porosity, but dissolution process, dolomitization and tectonic process lead to form vugy, intercrystalin and fracture porosities. The dissolution of unstable minerals (mainly aragonite) is the major process that improves porosity and then permeability by enlarging pores and pore throats. The best reservoir quality occurs in the upper parts of the regressive systems tracts, which contain primary grainsupported intervals or dissolution porosity.

The studies show that porosity evolution controlled in sequence stratigraphy framework (A combination of depositional environment and diagenesis) in carbonate sequence of Sarvak Formation.

Keywords: *Porosity evaluation, Sarvak Formation, reservoir characterization*, *sequence stratigraphy*

1. Introduction

Generally, there are several porosity systems which let to heterogeneous Petrophysic properties in the carbonate reservoir rocks [19]. Therefore, the relative percentage and type of pores and their distributions strongly is effective in production indexes and carbonate reservoirs simulation (e.g. [15], [3], [14] [12], [27]). Pore types in the carbonate rocks can generally be classified on the basis of the timing of porosity evolution [5]: 1) primary pores (or depositional porosity), which are pores inherent in newly deposited sediments and the particles that comprise them; and 2) secondary pores, which are those that form as a result of later, generally post-depositional dissolution. Primary porosity is substantially reduced by cementation and compaction during post-depositional burial Due to the natural tendency in most carbonate sediments [10], many workers would argue that most porosity in limestone and dolomite reservoirs has secondary origin [19]. Exceptions to this statement are cases where primary porosity is preserved because of the early influx of hydrocarbons into pores [8]. Today, the subaerial meteoric diagenetic (freshwater) model is highly used to describe porosity change in carbonate, especially in sequence stratigraphic-related diagenetic studies of

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reservoirs. [9], [16]. This model presupposes that if porous carbonate rocks are present beneath unconformities, then that porosity must have been created by freshwater dissolution during subaerial exposure. But this porosity may be occluded during later burial.

2. Location Of The Study Area

The study area is located in Tangestan, south-eastern of Bushehr, southern Zagros Basin. Subsurface section (a well of Mond Oil Field) is located at 100 kilometers southeast of Bushehr city (Khormoj).

3. The Study Method

In the petrographic studies, all thin sections (329) are colored with Red-s alizarin for recognizing dolomite and calcite mineralogy. Then, thin sections are named by Dunham method [7]. After Diagenetic studies, the relationships between Diagenesis and reservoir properties were compared with Core data.

4. Porosity Evaluation In The Sarvak Carbonate Reservoir Rock

Primary Porosity:

Pelloidal microcrystalline cement is observed in the reefal setting that covered by the coarse scalenohedral crystals. Also, isopachous radial fibrous cement is distinguished in some reef pores shows undulose distinct. Primary framework growth porosity between rudist skeletal has decreased due to early isopachuos cementation and filling with internal sediments. Syntaxial cement over the crinoid’s fragments can significantly reduce the interparticle porosity [27] and occluded throat pores. Other processes that will reduce porosity in the reef cavities are internal sedimentation (regardless of its origin). Core analyses of these parts show 8.7 percent total porosity. Figure 1 shows sedimentary porosity distribution (primary porosity) through the Sarvak Formation in the study area.

Secondary Porosity Beneath Unconformities (The Subaerial Meteoric Model)

Dissolution degree of carbonates depends on the mineralogy of the sediments or rocks [17], [23]. At the beginning of this phase, dissolution of aragonite particles created moldic porosity. With increased saturated water by calcium carbonate, carbonate cement fills the porosity. Dissolutions that observed in these sections more depends on rock Fabric (moldic porosity). There are a few vuggy pores that do not depend on the Fabric. Secondary porosity in the Sarvak Formation result of dissolution after the sedimentation and including developed inter- and intraparticle porosities that all shows selective texture. For example, rudist bearing grainstones in the upper part of Sarvak Formation have been deposited in a high energy environment and have high interparticle porosity and permeability. In the facies that are formed in the Lagoon environment, only grains were dissolved, so samples have porosity and no permeability. But fractures in the reservoir rock have connected porosities and increased permeability. Average value of core porosity is 8.51% and for permeability is 3.02 md. Figure 1 shows meteoric porosity distributions. In this, meteoric porosities are limited to beneath of the sequence boundaries.

Alternative Origin Of Secondary Porosity (The Mesogenetic Model)

Since the late 1970s-early 1980s, geologists began to suspect that not all secondary dissolution porosity in carbonate rocks forms or formed solely beneath unconformities by freshwater dissolution in either the eogenetic or telogenetic environments [1], [26], [4], [23]. Choquette and Pray [4] referred this to as the mesogenetic environment. In the wackestone and packstone facies, dolomites as rhombohedral crystals with different sizes (between 10 to 220 microns) are distinguished that is floating in the Matrix. Mainly, along the pressure dissolution zone (Stylolites) have been gathering fine grain dolomites. This evidence shows that dolomites were formed in mesogenetic environment and they have increased intercrystalline porosity. The average value of porosity is 14% (totally intercrystalline, fractures and moldic porosities) and the average value of permeability is 8.44 md. Dolomite formations along the stylolites suggested that they have acted as conduits for movement of fluids in the shallow burial conditions. Petrographic studies of Sarvak carbonate Formation show that some porosity has not related to discontinuity surfaces, so their origin cannot be considered meteoric fresh water. They more were vuggy porosity that are seen in the deep marine facies and formed low percentage of porosity. A few feet below these samples were observed large vuggy porosities that were filled with coarse blocky or poikilitic cements. In addition, some cement that is probably formed in the burial diagenesis is seen in the open fractures and stylolites. Production of carbon dioxide, hydrogen sulfide and large quantities of organic acids during maturation of organic material in the buried hydrocarbon source rocks caused subsurface dissolution. As these gases and organic acids are expelled from the source rock, the evolved CO_2 combines with subsurface water to produce carbonic acid and the H_2S similarly combines with water to produce sulfuric acid. Together, these acids and associated organic acids can migrate great distances laterally as well as vertically [11]. Burial carbonate dissolution only in the upper part is done. Likewise, once the acids are spent, subsurface fluids can then precipitate carbonate cements, which is why many examples of such cements contain hydrocarbon inclusions [2]. Secondary dissolution porosity formation can alternate with cementation [24], [21], [20], [23]. The detailed petrographic Study of Sarvak Formation has shown that porosities along and associated with stylolites or which cuts across stylolites, pores that cut across cements that contain hydrocarbon inclusions and pores that cut across or which are intimately associated with pyrite must be the result of mesogenetic dissolution [24], [6], [13], [23], [21], [22]. Figure 1 shows burial porosity distribution through Sarvak Formation in this study. As can be seen this type of porosity does not depend on sequence boundaries.

Microporosity And Chalky Porosity

The term *microporosity* refers to any very small pores that can be recognized only with the aid of a high-powered binocular microscope or thin-section [5], [25] and included intraparticle pores within small particles and intercrystalline pores between dolomite crystals or between calcite cement crystals in this study. *Chalky porosity* is a term that refers to microporosity that commonly forms in highly weathered or otherwise highly diagenetically altered carbonate rocks [18]. Average value of core porosity is 3.63% and for permeability is 0.001 md in the mudstone and wackestone facies. microporosity and specifically chalky porosity were formed beneath unconformities as well as in deeply buried rocks in the Sarvak

Formation, and as such, their presence does not necessarily imply the existence of a stratigraphically-nearby unconformity.

5 - Conclusions

In this study, different porosities are divided into primary and secondary that affected by the sedimentary environment, diagenesis and tectonic processes. In the high energy microfacies (Shoal and reef microfacies), primary porosity (Inter- and intraparticles) were formed that early cementation has decreased interpartile porosity, but dissolution has increased vuggy and moldic porosities during the early diagenesis stage (Eogenese). In the Lagoon and the open marine facies that have been affected by meteoric diagenesis, aragonite grains have been resolved and have created moldic porosity. Tectonic fractures in this facies are increased permeability. In the mesogenese stage, cementation cause to decrease porosity, but dissolution, dolomitization and tectonic processes has led to form vuggy, intercrystalline and fracture porosities. Generally, important factor in to being reservoir of Sarvak Formation is porosities that was formed in the meteoric diagenesis stage and increased by tectonic fractures. As a result, porosity evaluation in the Sarvak carbonate is controlled by sequence stratigraphy. The type of Porosities that formed in mesogenese is the same in the eogenesis and telogenesis stages. So that should point to that only with determining porosity types cannot distinguish diagenetic environments.

6 - Appreciation

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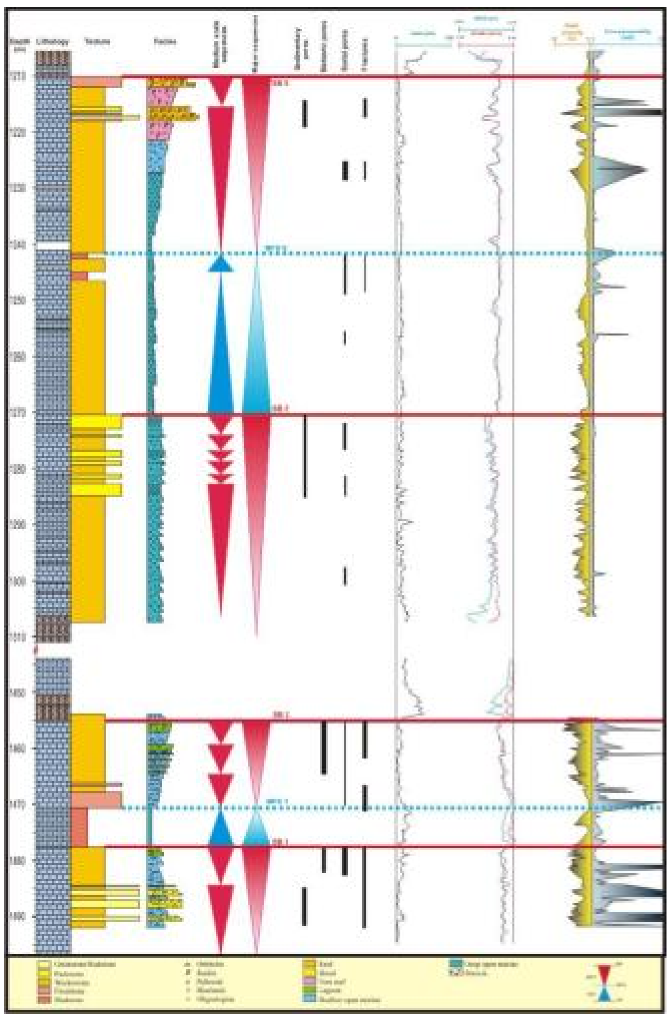

Figure 1: distribution of porosity types in 8 well of Mond Oil field