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Main Diagenesis of Middle-lower Ordovician of Yubei Area in Tarim Basin

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Abstract: The Ordovician in Yubei area is an important target and production layer of marine carbonate exploration in Tarim Basin. In order to understand the reservoir distribution and therefore to promote exploration, by means of analysis of cores, rock sections, casting sections, logging data of Ordovician carbonate reservoirs in the Yubei area, the reservoir petrology, diagenesis types and characteristics of the carbonate rocks in the study area are systematically studied, and the identification marks, development rules of various diagenesis and their influence on the formation of the reservoir are summarized. The results show that the carbonate reservoir in the study area is mainly composed of 4 types: mud micrite limestone, grain limestone, biological limestone and dolomitic limestone. In combination with core photos and imaging logging analysis，reservoir can be divided into pores and cracks, which are fracture type and fracture pore type. The diagenesis types of carbonate rocks in study area are complex and diverse, mainly including compaction, pressolution, cementation, filling, recrystallization, dolomitization, dissolution. To sum up, the main constructive diagenesis include recrystallization, dolomitization, dissolution, otherwise the main destructive diagenesis include compaction, pressolution, cementation, filling. The above research results on the diagenesis of carbonate rocks has a certain role in promoting the development of oil and gas exploration in the central Tarim Basin.

Keywords: Yubei Area, Tarim, Ordovician, Diagenesis

1. Introduction

The diagenesis of carbonate rocks refers to the various physical, chemical and biological changes that change the properties and structural characteristics of the sediments and sedimentary rocks during the long period from the end of deposition to bedore metamorphism, which has an important impact on the physical characteristics of carbonate reservoirs. The physical properties of carbonate reservoirs are mainly affected and controlled by sedimentary facies, diagenesis and tectonism, while tectonism only affects specific areas. Diagenesis and sedimentary facies are important factors affecting reservoir quality. Sedimentary facies determines the original physical properties and spatial distribution of the reservoir, and diagenesis determines the final physical properties of the reservoir [1-3]. In July 2010, yubei-1 well obtained industrial oil flow in Yingshan formation of Ordovician, and it made a breakthrough in oil and gas exploration of Ordovician carbonate reservoir in Maigaiti Slope of Tarim Basin, which confirmed that there are abundant oil and gas resources in the Ordovician of Maigaiti Slope.

Yubei area is located in the eastern maigaiti slope of tarim basin, whose northern border is bachu uplift Mazhatage fault zone, eastern border extends to Tangguzibasi sag, and southern border yecheng—hetian sag of south-western depression. The ordovician strata distribution is complex, by means of Yubei No.1 NE fault zone, it can be divided into three small unit, namely the western Yubei platform area, NE structural belt and Yudong fault depression zone (Figure 1). NE and nearly EW fracture and local structures developed very well in the area. Well Yubei 1 lies on NW fault zone, which shows "Y" shape. Multiple fault anticline traps developed in the top of the ordovician yingshan formation, which developed in middle -late caledonian and late hercynian

[4-5].

In recent years, along with the deepening of exploration, there are more researches to discuss the characteristics and genetic analysis of the ordovician reservoir in Tarim basin, putting forward a variety of the main controlling factors of diagenesis [6-8]. On the basis of a large number of core observation and thin section identification, using of the geochemical data, author probes into the ordovician diagenesis of this area, so as to provides the basis for exploration and development.

2. Main Diagenesis

There are various types of diagenesis. It includes cementation, dissolution, compaction and pressolution, dolomitization, filling and recrystallization [9-15].

2.1. Cementation

The ordovician carbonate reservoir has experienced three periods of cementation, respectively, the submarine cementation, atmospheric fresh-water cementation and burial cementation in Yubei area.

a. submarine cementation.

It occurred in the sea bottom diagenetic environment, and cement is fine columnar, fibrous, radiation fibrous, vertical grain growth (oolitic, arene) wall, isochoric thickness rim and micritic set. In yingshan calcarenite formation lots of micritic set, fiber, horse tooth shape and isochoric thickness rim cement can be microscopically observed (Figure 2); The distribution of cement was dense, and some grains were serious damage because of later dissolution, but almost have been preserved owning to the strong submarine cementation.

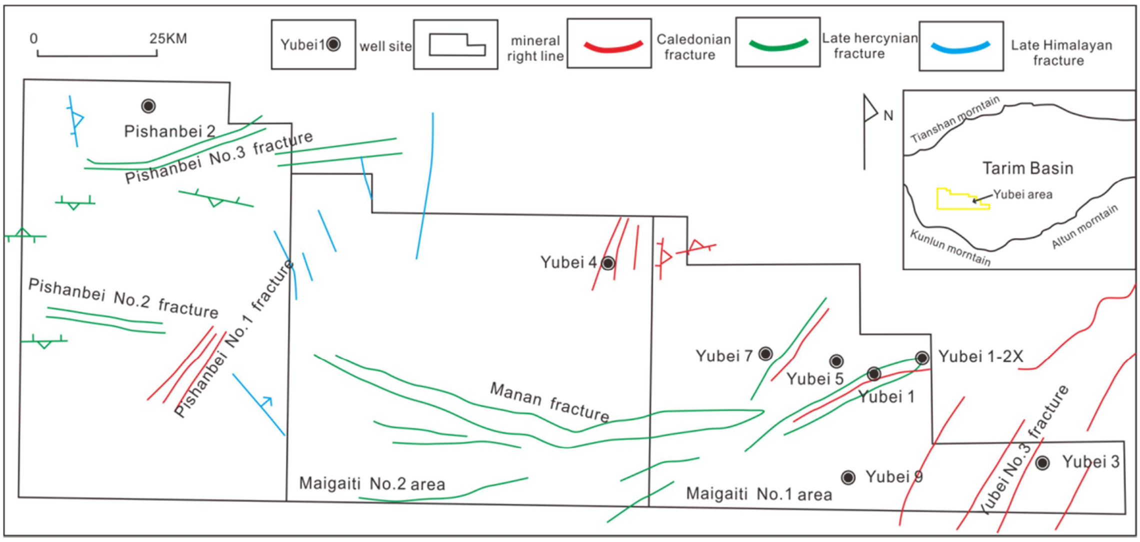
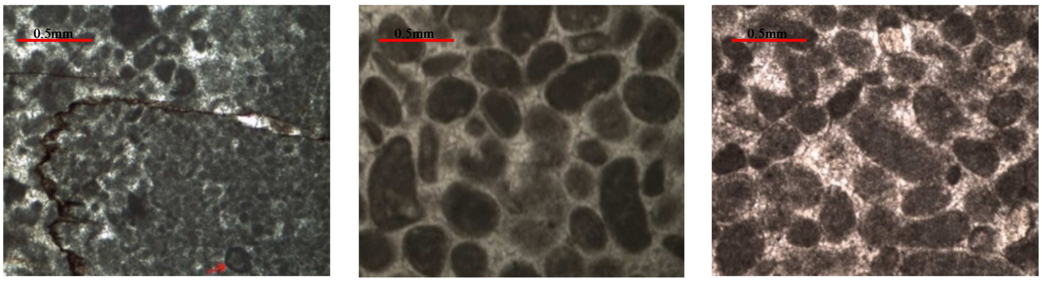


Figure 1. Tectonic location of Yubei area in Tarim Basin.



Well YD4,5403.12m,$O_{1-2}y$, sparry(algae) calcarenite Well YB8,6794.47m,O_3l, sparry(oolitic) calcarenite Well YB6A,6360.26m,O_2yj, sparry calcarenite

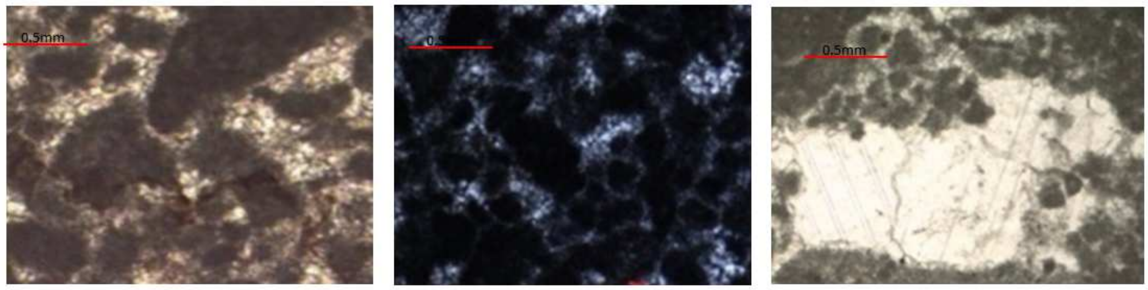
Figure 2. Submarine cementation characteristics.

b. atmospheric fresh-water cementation

It included atmospheric fresh water vadose zone and hyporheic zone two environments. In vadose zone, there are two types of cement. One is composed of fine grained calcite with crescent or pendulous shape cement, with geopetal structure or vadose silt phenomena. The diameter of vadose zone cement was general < 0.10 mm, covered on the fibre shape cement or directly covered on the grains; hyporheic zone cement were syntaxial and isometric texture and common around acanthosis clastic particles (Figure 3).

c. burial cementation

It can be seen in the remaining intergranular pore space which have been filled by the first and second phase cement, its content is less. Such as in Yubei 2 well with algal arene and maerl granular limestone, two generations of granular sparry calcite cement were visible, otherwise the third phase of cement were visible in the maerl granular limestone. In the early diagenetic period, firstly filling two phases of granular sparry calcite between maerls. In the middle diagenetic period, the second stage sparry calcite is completely dissolution; Otherwise, after the first phase sparry calcite incomplete dissolution, the third phase the single crystal calcite filled (Figure 4).

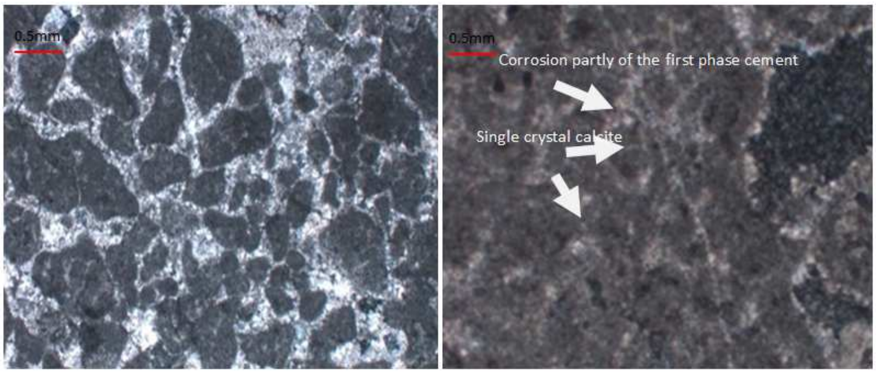


Well YB1,5615m,$O_{1-2}y$, sparry(algae) calcarenite

Well YD4,5403.88m,$O_{1-2}y$, sparry(algae) calcarenite

Well YB8,6966.15m,$O_{1-2}y$, sparry algae calcarenite

Figure 3. *Atmospheric fresh-water cementation characteristics.*



YB2 井,5929.35m,$O_{1-2}y$, sparry maerl limestone

YB2 井,5929.17m,$O_{1-2}y$, sparry calcarenite

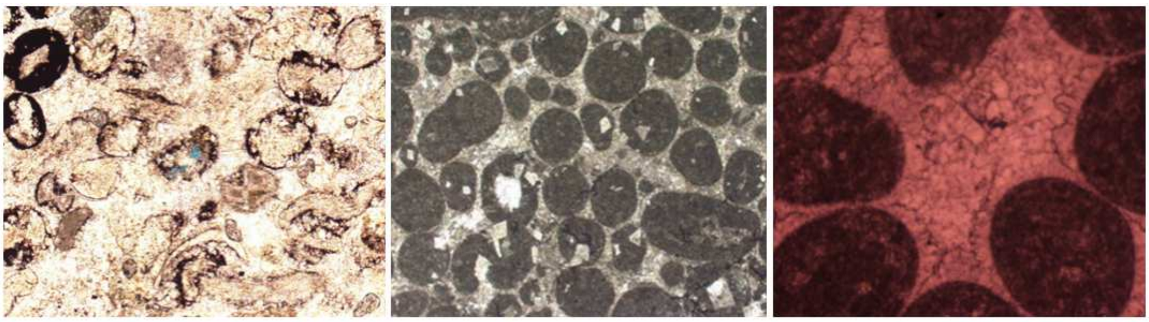
Figure 4. *Multiple cementation characteristics of well Yubei 2.*

2.2. Dissolution

The ordovician carbonate reservoir has experienced three periods of dissolution, respectively, penecontemporaneous atmospheric dissolution, burial dissolution and supergene karst dissolution, especially the supergene karst dissolution and burial dissolution was the most of importance.

a. penecontemporaneous atmospheric dissolution.

It mainly happened just from deposition to shallow burial stage, forming selective dissolution pore, such as intragranular pore, mold pore and intergranular dissolved pore. The identification marks in the study area are: in the sparry oolitic and calcarenite, fibre shape calcite cement were partly or completely dissolution, and the residual fiber calcite and the next phase granular calcite show unconformity contact. (Figure 5).



Well Pishanbei2,6898.94m,O_3l, sparry granular-clast limestone

Well YB4,5900.88m,O_3l, sparry oolitic limestone

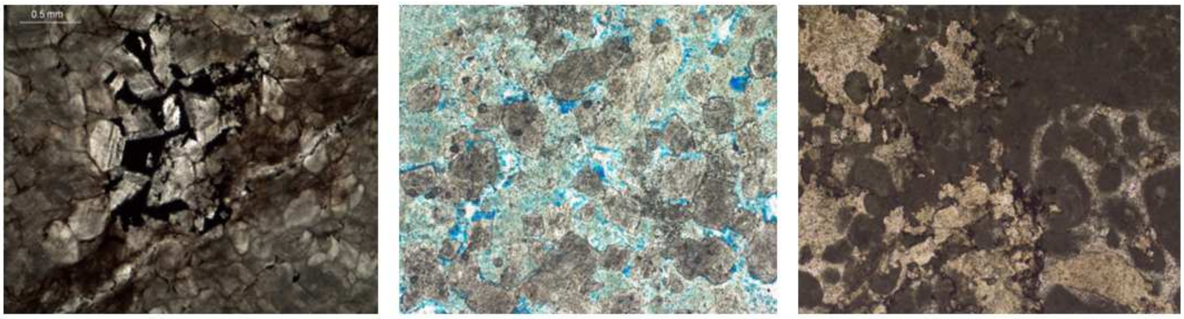
Well YB4 井,5838.6m,O_3l, sparry oolitic limestone

Figure 5. *Atmospheric dissolution characteristics.*

b. Burial dissolution

Burial dissolution is not selective which developed inter-grain pores, intergranular dissolved pore, soluble seam along suture lines, etc. its identification marks are (Figure 6):

(1) harbor shaped edge;(2) within the dolomite intracrystalline hole and siliceous dissolved pore, filling black bituminous and black carbonaceous bitumen also visible in edge;(3) bitumen also visible in solution pores around the suture line;



Well Yudong 4,5606.48m,$O_{1-2}y$, Microtek-coarse-grain dolomite

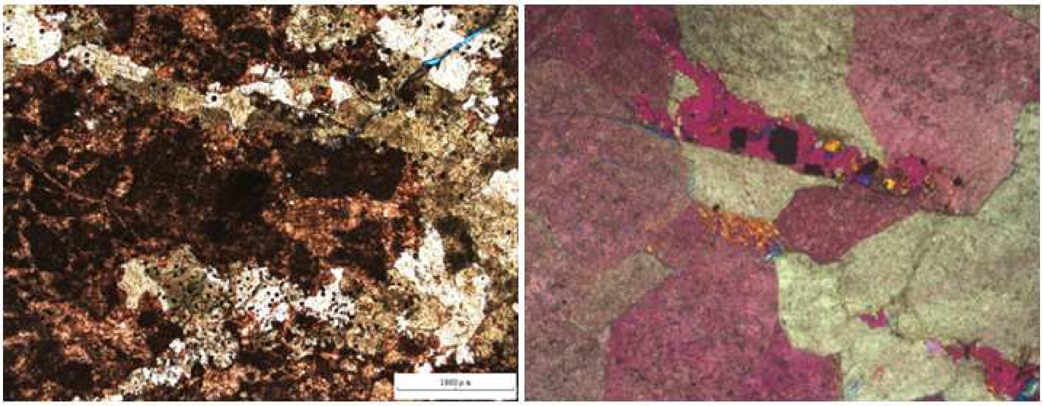
Well Yubei 5,6742.75m,$O_{1-2}y$, Microtek-coarse-grain dolomite

Well Yubei 6A,6369.45m,$O_{1-2}y$, sparry calcarenite

Figure 6. *Burial dissolution characteristics.*

c. Supergene karst dissolution

Its identification marks (Figure 7): (1) pyrites occurred ferritization;(2) iron oxide visible within the sutures and microfracture;(3) shale along the suture line corrosion.



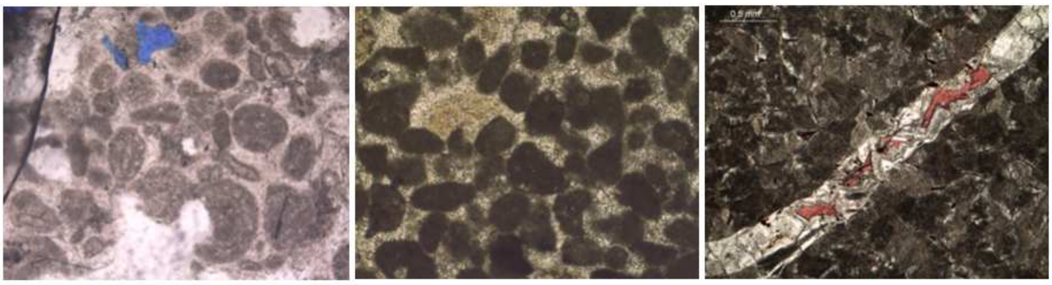
Well Yubei 3,5367.65m,$O_{1-2}y$, sparry alga-gobbet dolomitic limestone. without filling or filled by calcite, ferreous mud in structural fractures(－)×16

Well Yubei 3,5317m,O1-2y, Intergranular dissolved pore filled by silt sand, hematite, argillaceous

Figure 7. *Supergene karst dissolution characteristics.*

2.3. Compaction and Pressolution

Compaction and pressolution is the most basic diagenesis in Yubei area, one of its main performance is a particle dense filled compaction, characterized by particle flattening stretched, fragmentations. Another is chemical compaction effect existing in the form of sutures (Figure 8).



Well Yubei 8,6798.04m,O_3l, sparry intraclastic limestone

Well Yubei 6A,6371.21m,$O_{1-2}y$, sparry calcarenite limestone

Well Yudong 4,5543m,$O_{1-2}y$, microtek dolomite

Figure 8. *Compaction and pressolution characteristics.*

2.4. Dolomitization

Dolomitization occurs mainly on the top of yingshan formation in the fault zone and the bottom of yingshan formation-penglaiba formation in the whole Yubei region. It can be divided into pene-sedimentary dolomitization and burial dolomitization.

(1) penecontemporaneous dolomitization

Penecontemporaneous dolomitization mainly forms the layer micritic dolomite, arene mud-powder crystal dolomite with better crystal shape, mainly from idiomorphism, hypidiotopic crystal (Figure 9).

(2) burial dolomitization

The burial dolomitization is the most common dolomitization in Yubei region. The grain is relatively bulky, microtek - coarse grain; Crystal shape is mainly idiomorphism, hypidiotopic, with a inlay contact between grains, apparent wavy extinction, fog heart and bright edges, metasomatism and burial, recrystallization characteristics. The burial dolomitization is common on the top of yingshan formation, the bottom of yingshan formation-penglaiba formation in fault zone; very rare on Lianglitage formation-Yijianfang formation (Figure 10).

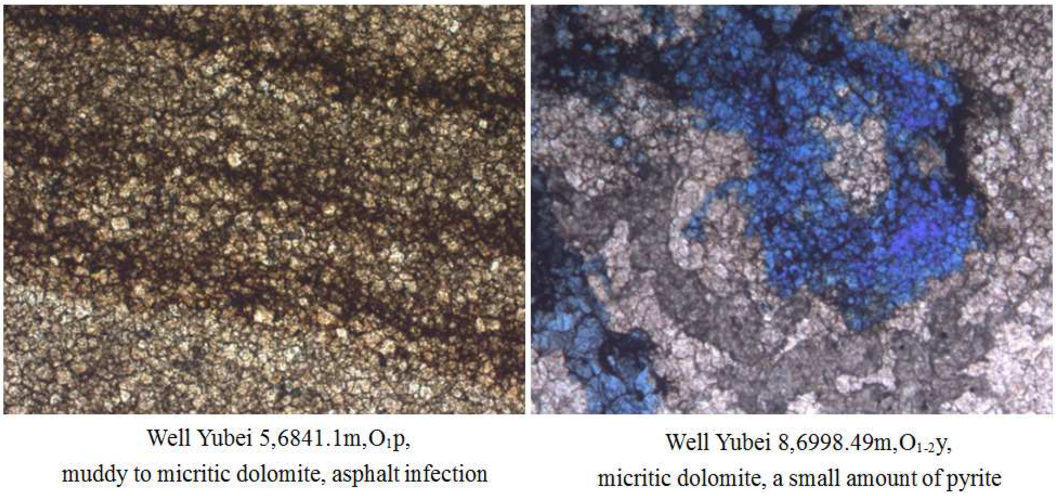


Figure 9. *Penecontemporaneous dolomitization characteristics in Yubei area.*

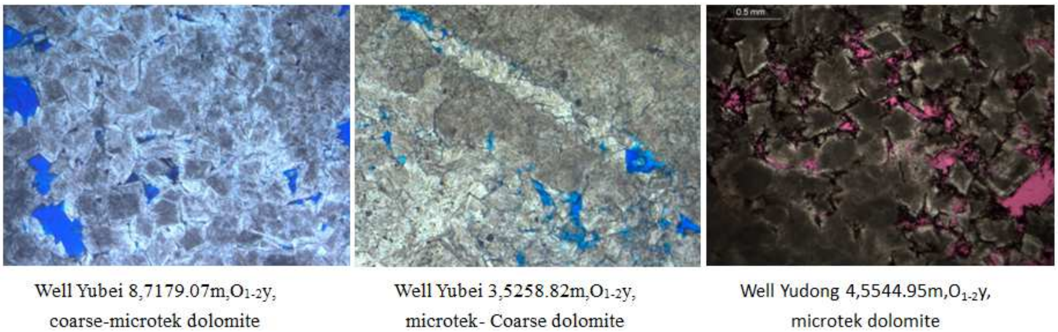


Figure 10. *Burial dolomitization characteristics in Yubei area.*

2.5. Filling

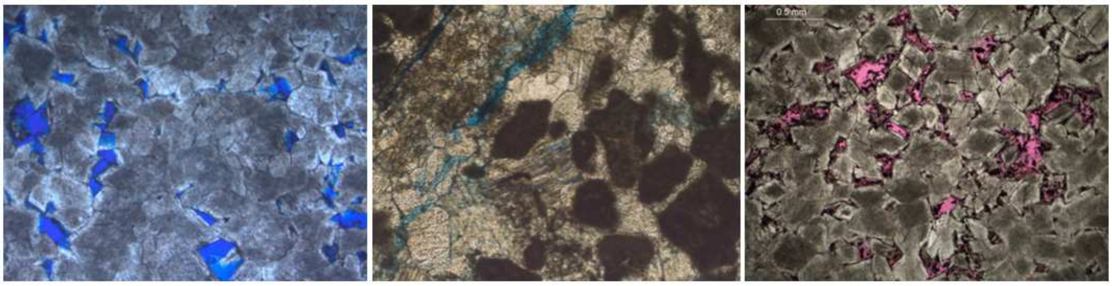
Filling is also a kind of very common destructive diagenesis in YuBei region. Cave and cleft are filled by calcite, shale, dolomite, siliceous, asphaltenes, organic matter and so on, and the most common filling is dolomite. Overall, Cave and cleft filling in YuBei region showed the following characteristics: Calcite and a little of shale is mainly holes fillings in Lianglitage formation and upper Yingshan formation at the platform area; the upper Yingshan formation in the fault belt is filled by calcite, shale mainly, and filled by organic matter (oil), asphaltenes, siliceous and dolomite partly; semi-calcite filling, asphaltene and siliceous are mainly holes fillings in the bottom member of Yingshan formation- Penglaiba formation. Thus, the caves in Lianglitake formation, Yijianfang formation, and the upper Yingshan formation which is not in the fault belt are basically full-filled, and a little of holes are half-filled, In upper Yinshan formation in the fault belt and the bottom member of Yingshan formation- Penglaiba formation, there are many caves and cleft was not filled, both of them are isolated with poor connectivity (Figure 11).

2.6. Recrystallization

Recrystallization in Yubei areas are also more common constructive diagenesis. In the bottom of yingshan formation-penglaiba formation, it is common, showing the mud - powder crystal recrystallization formed fine microtek dolomite, partially recrystallization into coarse grain dolomite, and mineral structure be thicker, throat also be more smooth and flat and intercrystalline pore increasing, providing more conducive to later dissolution channels, forming more intergranular pore and intergranular dissolved pore. Recrystallization cannot form a large storage space, but it can improve the original microscopic pore structure of rock. According to 47 casting microvoid structure in Yubei area, dolomite intercrystal pore, intergranular dissolved pore rate was 4% (Figure 12).

Well Yubei 8,6920m,$O_{1-2}y$,micrite,the holes filled by calcareous; Well Yubei 6A,6920m, micritic calcarenite, sutures filled by asphalt; Well Yudong 4,5543m, microtek dolomite, the second phase crack filled by calcareous

Figure 11. *Filling characteristics in Yubei area.*



Well Yubei 8,7176.34m，O1-2y，Coarse-microtek dolomite,×14; Well Yubei 6A, 6375.63m, sparry calcarenite limestone, local micritic recrystallization,×30; Well Yudong 4,5545.16m, microtek dolomite, the intergranular hole, intergranular dissolved pore

Figure 12. *Recrystallization characteristics in Yubei area.*

3. Conclusion

According to the study above, main diagenesis of Yubei area in Tarim basin is divided into cementation, dissolution, compaction and pressolution, dolomitization, filling and recrystallization. The constructive diagenesis includes dissolution, dolomitization and recrystallization; while the destructive diagenesis includes cemetation, compaction and pressolution and filling.

The author believes that the key to the systematic study of Paleozoic carbonate karst in the superimposed basin lies in the study of karst dynamic system, including the analysis of paleohydrodynamic, paleoclimate, paleogeomorphology and other factors. However, it may be more important to study the uplift denudation, fold fracture related to multi-stage faults and paleophreatic surface fluid properties and water rock reaction related to structural unconformity. Furthermore, the complex diagenetic system can be better interpreted, and the mechanism and temporal and spatial distribution of reservoir development can be revealed.

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