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Rock Composition Differences and Diagenesis in Different Lithofacies Reservoir of Glutenite Body-An Example of Urho Formation of Mahu Depression in Junggar Basin

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Urho formation of the Mabei slope zone in Junggar basin had a stable structure and developed fan delta sedimentary system during the deposition process. Distributary channel and fan River constitute the sedimentary framework Urho formation. The research on diagenesis of Urho reservoir based on a large number of thin section and core analysis is conducted by different means of experiments such as scanning electron microscopy, X-ray diffractions and cathode luminescence, etc. The results show that the influence of diagenesis on the reservoir is duality. The effect of compaction (pressure solution) in the study layer is mainly controlled by the difference of vertical burial. The calcite cementation is mainly formed at the early stage of burial. Since the late-early diagenetic stage to the intermediate diagenetic stage, large scale of acidic dissolution and alteration occurred in Urho formation. Acid dissolution mainly exists in widely developed volcanic rocks and zeolite cements, which greatly reforms the physical properties of the reservoir. Sedimentary diagenesis plays a decisive role in the distribution of oil and gas.

1. Regional geologic generalization

The Mahu Depression is a secondary tectonic unit in the central depression of the Junggar Basin, connecting with the Krai Uxia fault zone in the west. The north slope of the north is located in the north of the Mahu depression (Davies and Walker, 1993). The tectonic pattern of Mabei and Maxi is formed in the early Cretaceous. The overall performance shows a southeast tilt of the flat monoclinic form, and partly shows low amplitude anticline and nasal structure, as show in Figure 1.

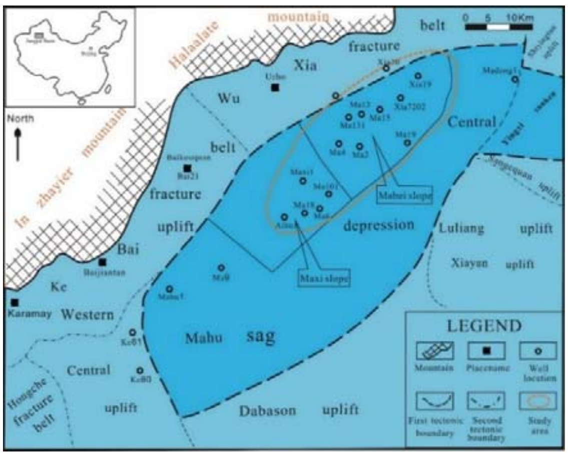

Figure 1: Geographical location and structural zoning map of the study area

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2. Difference of reservoir rock composition

Causes of the lithofacies in Urho formation in mabei slope zone can be divided into gravity-current sand bodies (glutenite facies) and tractive-current sand bodies (glutenite facies, gravelly sandstone facies and mid-coarse sandstone facies). In the glutenite facies and gravelly sandstone facies, the conglomerate is mainly composed of magmatic rocks, and is secondly composed of the sedimentary rocks and the metamorphic conglomerate, as show in Figure 2.

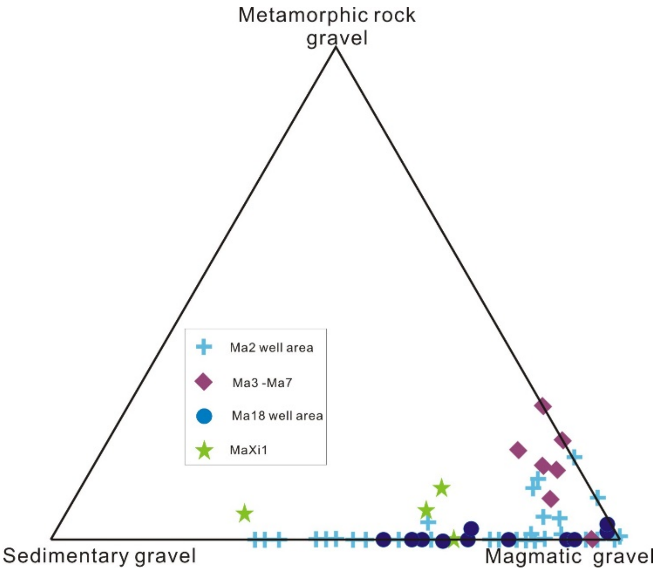

Figure 2: Lower Urho conglomerate composition triangle.

According to the plane distribution of different types of gravel composition, the difference of gravel composition on the plane is mainly reflected in the relative content between the sedimentary conglomerate and the magmatic conglomerate. Among them, magmatic conglomerate occupies an absolute majority. According to the conglomerate distribution in the main data distribution section ($P_2w_4^{1-2}$ and $P_2w_4^{2-1}$), the closer the distance to the source is, the higher content of the magmatic conglomerate is.

Sand grade particles are mainly debris particles. It is mainly composed of magmatic conglomerate, and is less composed of metamorphic debris and sedimentary debris. Taking the content of magma particles (including magmatic conglomerate and magmatic debris) as an unstable component in the overall content, it can be seen that the magmatic components are mainly tuffaceous (conglomerate and debris) with a small amount of granite, rhyolite and andesite.

3. Reservoir diagenesis

Based on the results of previous studies on the sedimentary facies, the study section is a coarse fan delta sedimentary system with a lake background. The study section is a near source transported deposition, which leads to different fluid-rock system characteristics of high unstable contents, high interstitial material contents, dry sedimentary climate and so on. The following mainly discusses the key diagenesis types that restrict reservoir physical properties.

3.1 Format

Compaction mainly refers to the process of vertical compression shear stress and lateral tectonic extrusion stress combination makes clastic particles closely packed, and plastic components squeezed into the pores, resulting in the continuous decrease of sediment volume and the discharge of pore water. According to the analysis of the preceding data, the magmatic component (conglomerate and sand debris) is the main component in the study area, but there is no obvious difference in rigidity or plasticity. Therefore, the compaction (pressure solution) of the study section is mainly controlled by vertical burial difference.

The compacting effect of the study layer is shown in the following aspects on the microscale: (1) Clear rearrangement and close accumulation of particles (mainly for non-circular particles such as long strip), as show in Figure 3a. (2) Extrusion deformation of plastic debris. The most common form is discrepant particles contact, that is, the contact between particles presents a concave and convex form, as show in Figure 3b. (3)

Many clay grade fillings are contained in some samples. These filling contents in the compaction process produced some cracks, which can be easily found in part area.
overall, the compaction effect is relatively strong in the Permian strata of the Mabei area. Most of the primary intergranular pores are destroyed by the compaction. On the one hand, the top surface of the Urho study area buried depth is greater than 3000 meters. Great buried depth makes the compaction effect stronger. On the other hand, the plastic debris (mainly part of magmatic debris and sedimentary debris) in the layer is easily deformed during the compaction process, which further strengthens the compaction effect.

3.2 Cementation

Due to the high content of argillaceous matrix in the glutenite reservoir, the development of late carbonate cementation is suppressed to some extent. The cementation effect in the study layer is relatively weak, and the content ratio of the cementation in most of the samples is between 0-2%. The type of cementation is not rich and the content is small. The common types of cementation are mainly carbonate cementation (Figure 3c, only partly rich), zeolite mineral cementation, Figure 3d, sporadic visible siliceous cements, Figure 3e, and clay mineral cements, as show in Figure 3f.

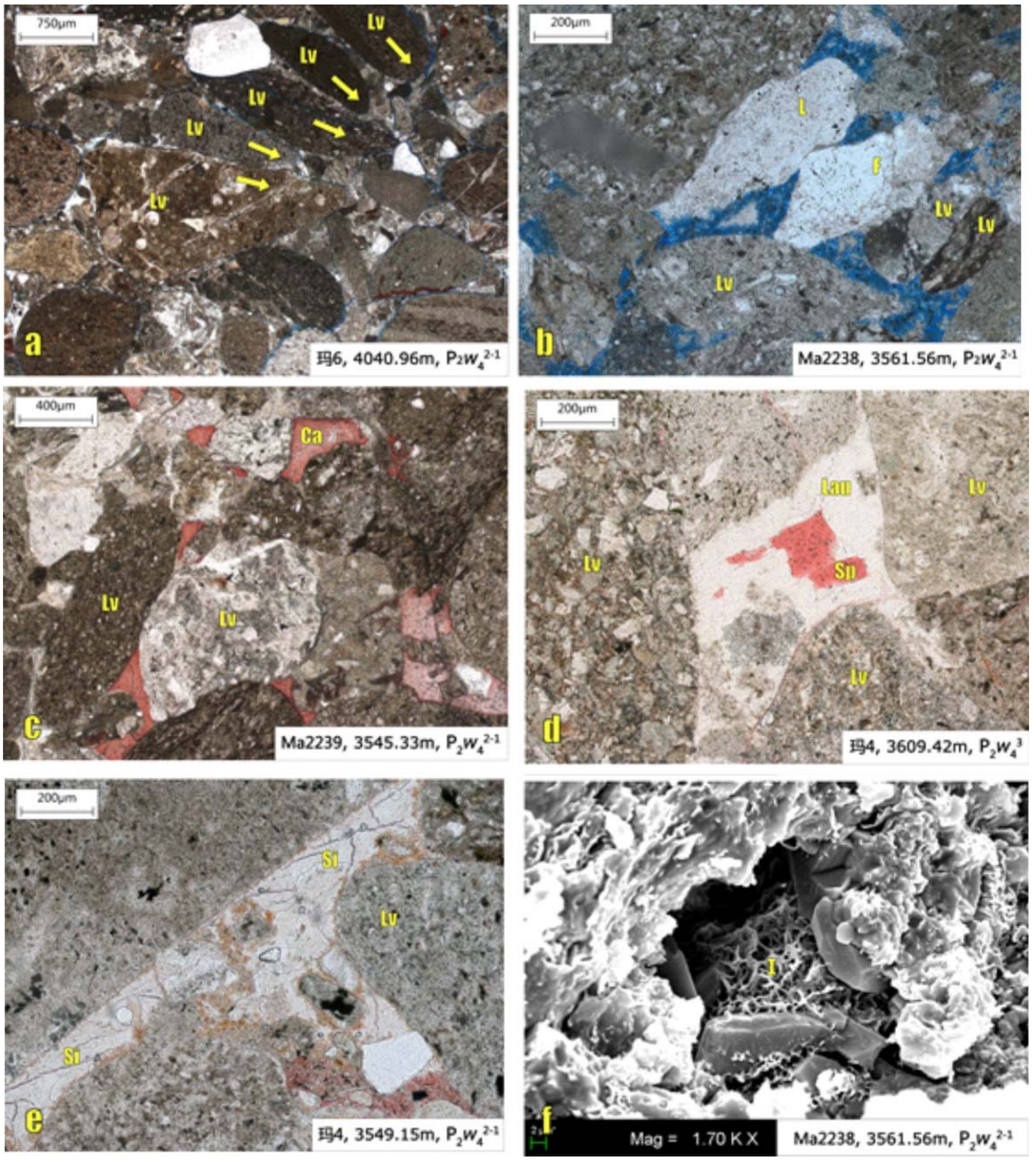

Figure 3: The microscope thin section chart of lower Urho formation.

3.2.1 Carbonate cementation

The development of carbonate cementation in the study layer is limited, only in sporadic samples, low content in overall. The common calcite cementation ($CaCO_3$) and the sporadic iron calcite cementation in the interlayer are mainly cemented in intergranular, as show in Figure 3c. The contact relationship between the product of diagenetic transformation indicates that the calcite cementation is mainly formed in the early stage of burial. In addition, the calcite cementation is mainly developed in the Gravity-Current glutenite facies, and is less developed in the other lithofacies (Leggitt, 1990).

3.2.2 Development of zeolite minerals

Zeolite minerals are formed as authigenic aluminosilicate minerals, formed in an open hydrodynamic environment. The genesis of zeolite minerals is closely related to the hydration of mass volcanic materials. The main zeolite minerals in the layer are turbid zeolites, and the chemical molecular formula is $CaAl_2Si_4O_{12}\cdot 4H_2O$. Laumonite cements of glutenite reservoir is normally within the output with pore filling, and is in form of intergrowth crystals. On the plane, the turbid zeolites cementation is only developed in some single wells.

The precipitation of the authigenic zeolite is related to the composition of the original material and is controlled by the chemical properties, composition, temperature, and pressure of the pore water in the formation. Zeolite can be formed in different environments, such as salt lake, near surface open hydrological system, soil, high heat flow and volcanic area, etc. Generally, the formation of zeolite is neutral-alkaline water, and pH is mainly 7~10. The crystalline form of the turbid zeolite is mostly intact, which is mainly formed by the alteration process of the component of the volcanic material, as show in Figure 3d. The cementing effect of the turbid zeolites is strong and almost occupying most of the visible pores in well area including well Ma 7, well Ma 009, well Ma 6 and well Ma 101. In the late stage of diagenetic transformation, turbid zeolite suffered acid corrosion and produced secondary pores in the cementation (Clarke, 1979).

3.2.3 Clay mineral cementation

The cementation of clay minerals is one of the common cementation reactions of the reservoir. There are four main types of clay minerals developed by the X-ray diffraction analysis - Illite / smectite clay minerals, kaolinite, Chlorite and illite.

(1) Illite / smectite clay minerals $\{(0.5Ca, Na)_{0.7}(Al, Mg, Fe)_4(Si, Al)_8O_{20}(OH)_4\cdot nH_2O\}$

Illite / smectite clay minerals is the most common research section, in the reservoir with irregular pieces of filamentous forms attached to the particle surface.

(2) Illite $\{KAl_2[(Al, Si)\ Si_3O_{10}]\ (OH)_2\}$

The illite is often produced with irregular small wafers, and their aggregate usually appears in the form of granular or pore lining. Illite has a lower content in the study section, mainly concentrated in well Ma 18.

(3) Chlorite $\{Mg(Fe)_2Al(SiAlO_3)\}$

Chlorite is a 2:1 type of aquilate aluminosilicate. Chlorite commonly shows a polychroism of light-green-bright-yellow under polarizing microscope, positive low protuberance, and the interference color is not higher than level one. Some varieties present abnormal interference color, such as indigo, brown rust, lilac purple, etc. Usually Chlorite is produced in the single mineral chlorite pore filling or attached to the surface of clastic particles, mainly enriched in well Ma 101 section.

(4) Kaolinite $\{Al_4[Si_4O_{10}]\ (OH)_8\}$

The content of kaolinite in the study section is low overall. It is mainly separated out from cyclic pore water rich in sufficient SiO_2 and Al^{3+}. Kaolinite is produced in the form of filling pore (mainly secondary dissolution pores) under microscope, indicating the reservoir water-rock interaction intervening by the acid fluid.

There are obvious differences in clay mineral types in the body of different sedimentary Genesis sand body. The relative content of illite / smectite mineral is relatively rich in fan delta plain sedimentary area represented by debris flow deposition (mean 73.8%), and the relative content in underwater distributary channel sand body is relatively low (mean 68.1%).

3.3 Dissolution

Clastic particles, matrix and cementation in clastic rock reservoirs can be subjected to varying degrees of dissolution and formation of dissolved pores under certain diagenetic environments and physicochemical conditions, and become important reservoir spaces for oil and gas reservoirs (Cant and Ethier, 1988).

The alteration of corrosion in the study layer is quite common, mainly aimed at the skeleton component (including the sand component and gravel component) and the alteration of the corrosion. The dissolution of skeleton components is mainly related to chemical unstable particles such as debris and gravel, and the dissolved pores from the casting solution to the mesh dissolved pores, and then to the intragranular dissolved pores and grain edge dissolved pores. The different degrees of dissolution experienced by the skeleton particles are visible. The main driving mechanism is that many organic acids produced by the pyrolysis of the underlying hydrocarbon source rocks are filled into the reservoir by the dredging system. The unstable mineral composition in the filling material is dissolved mainly because the acid fluid medium.

4. Diagenetic sequence

In the study area, the Permian lacustrine environment of the glutenite sedimentary period is brackish water, resulting in the early diagenetic stage of alkaline water medium. According to the current oil industry standard (SY/T5477-2003), the diagenetic stage of research section is in late-middle diagenetic A period. Porosity from the initial stage of deposition, through a series of diagenesis, keeps a porosity of about 7% today, as show in Figure 4.

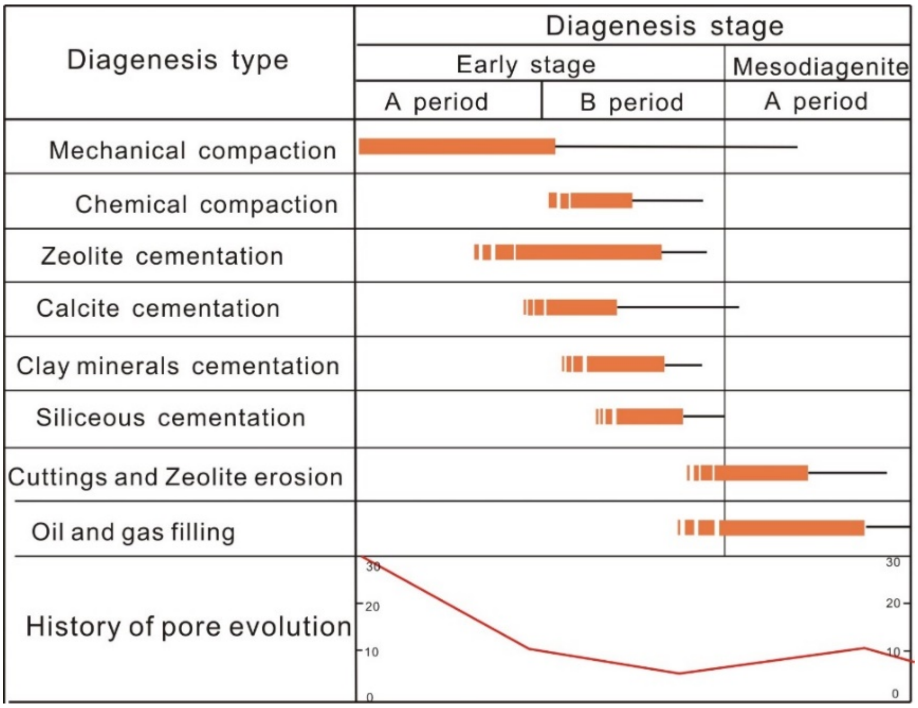

Figure 4: Key diagenesis transformation sequence of Urho formation

First stage, since the depth of initial stage to late-middle of the early diagenetic B stage, under the action of strong compaction and siliceous, zeolites and calcite cementation, the primary porosity of the study section decreased sharply, from the initial porosity of the 30% action to the porosity of 8%. Second stage, Since the late-middle of the early diagenetic B stage to middle of the middle diagenetic A stage, the dissolution and transformation after large-scale acid medium intervention took place in the study area, mainly for the widely developed volcanic rock cuttings and zeolite cements, forming acid solution pores, which widely promoted the secondary pores production in the layer. But the increase of the solid face rate caused by dissolution modification is not obvious, and the overall porosity is increased from only 8% of the first period to 12%. Third stage, since the middle diagenetic A stage to the present, due to the further increase of the buried depth, the porosity of the reservoir decreases further, and the decrease of the porosity of the reservoir obviously slows down with the charge of oil and gas, and then maintains the state of 7% porosity nowadays

5. Conclusion

1) The gravel component in Urho reservoir is mainly magmatic gravel, with farther transport distance, leading gradually less relative content.
2) Sand grade particles are mainly volcanic rocks represented by tuffaceous. High content of hetero group in the sample. On the plane, the content of the clutter in the sedimentary reservoir of the tractive-current is obviously lower than that of the sedimentary formation of the gravity-current.
3) The main types of cements are carbonate cements, zeolite cements, sporadic siliceous cements and clay mineral cements, weak cementation overall

4) The influence of diagenesis on the physical property of the reservoir is dual. The main types of destructive diagenesis are compaction and cementation. The constructive diagenesis is mainly the dissolution. Since the late-middle of the early diagenetic stage to the middle of the middle diagenetic stage. Dissolution and alteration occurred in Urho formation after the mass intervention of acidic medium, mainly for the extensive development of the volcano rock cuttings and zeolite cements, formed acid dissolution pore, and greatly transformed reservoir physical properties.

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