Exploration Significance of Unconformity Structure on Subtle Pools

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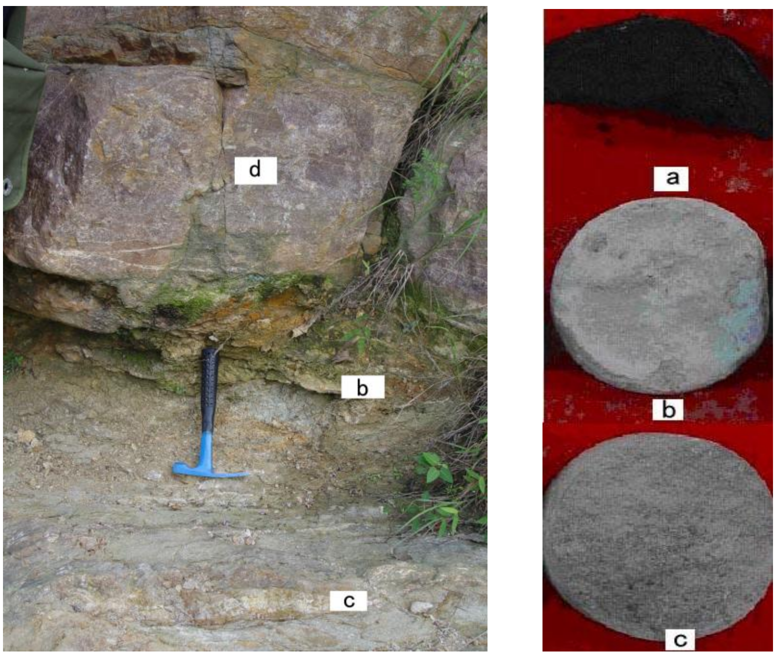
Abstract: Vertical structure of the unconformity can be divided into three layers: basal conglomerate or transgressive sand, weathered clay layer and leached rock. They not only are the pathway for oil and gas migration, but also provide accommodation for oil and gas accumulation. However, it is controlled by the lithologic configuration and the ancient landform that the unconformity surface plays the role of migration channel or trap. This lithologic difference causes different fluid transporting capacity, and it also determines whether a trap can be formed or not. If the unconformity surface was gentle, thus a migration channel had frequently been formed. If the unconformity surface was in a slope break in the early transgression, sometimes to form a stratigraphic overlap trap or a lithologic pinch trap. Simulation experiments showed that when oil and gas moved along the unconformity, the overlap traps above the unconformity surface were more favorable than the stratigraphic traps below the unconformity surface to entrap oil and gas.

Key words: Unconformity, Subtle, Migration, Simulation experiments

1 Vertical structure characteristics of unconformity

Based on previous studies, through the interpretation of seismic and logging data, as well as the core and outcrop observation, unconformity can be vertically divided into three layers: rock above the unconformity surface, weathered clay layer and leached rock (Fig.1).



Ⅰ outcrop Ⅱ rock core

Fig.1 Vertical structures of unconformity in the outcrop and rock core

a- transgressive sand; b- weathered clay layer; c- leached rock; d- basal conglomerate

Rock above the unconformity, whose rock type includes basal conglomerate and transgressive sand, is the set of rock formation that is closely above the unconformity and is located at the bottom of the overlying rock. Basal conglomerate is the product from autochthonous sedimentation of coarse residual material of weathered zone in the process of transgression; transgressive sand is the sedimentary product of sand-grade weathered detrital materials which are carried away through a certain distance or stay in the same place in the transgression. Conditions such as strong tectonic process, mainly compressive fold, great height difference of ancient landform, arid weather, moderate exposure time (less than 1Ma) are beneficial to form basal conglomerate in terrain slope (Fig.2-I); in a stable tectonic setting with humid climate and flat ancient terrain, unconformity with a short exposure time often formed transgressive sand (Fig.2-II).

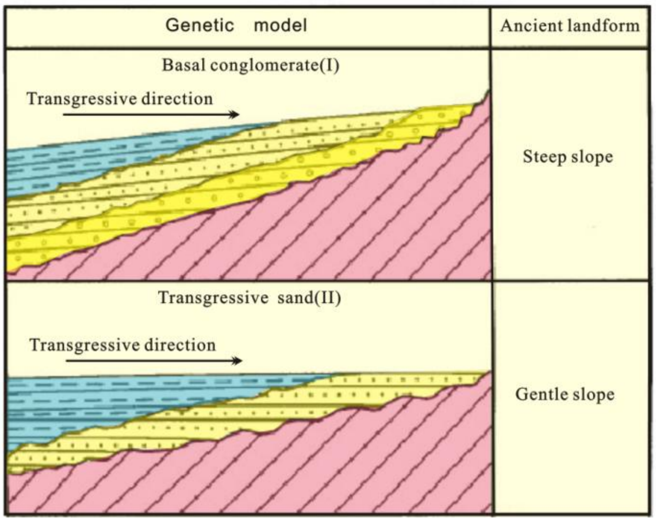


Fig.2 Genetic model of rock above the unconformity

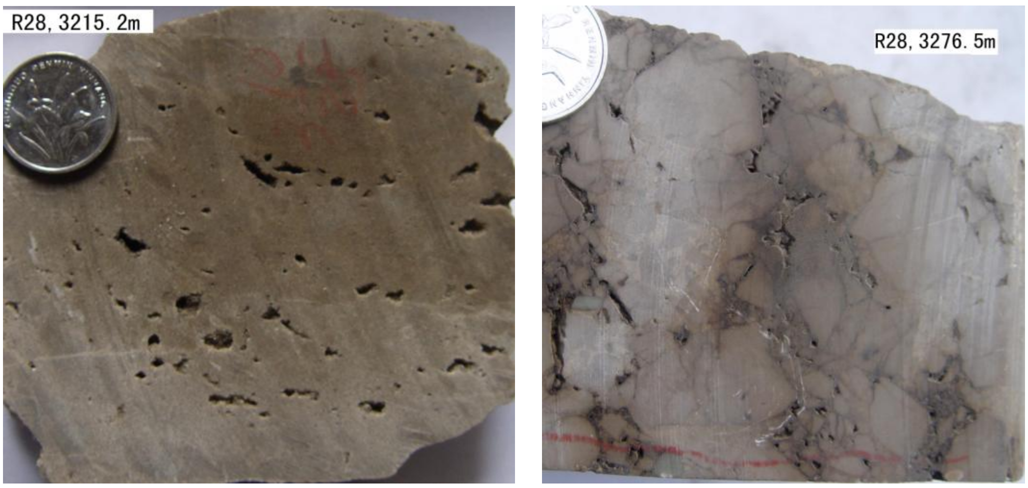


Fig.3 Secondary porosity of leached rock

Rock, exposed to earth surface in the supergene environment, is subjected to weathering and leaching from skin to depth, resulting in **secondary pores**, holes and joints. The nearer distance from the surface, the stronger the alteration is. Therefore, the leached rock contains amount of secondary porosity (Fig.3).

2 Lithologic configuration relations of unconformity

When the weathered clay has a little thickness or limited distribution, the overlying and underlying strata will contact directly, and the lithology is often different. This lithologic difference causes different fluid transporting capacity, and it also determines whether a trap can be formed or not and what kind of trap can be formed. Unconformity has three lithology configuration relations vertically: basal conglomerate - weathered clay layer – leached rock type (Ⅰ, Fig.4),transgressive sand - weathered clay layer– leached rock type (Ⅱ, Fig.5), sandy mudstone– leached rock type (Ⅲ, Fig.6).

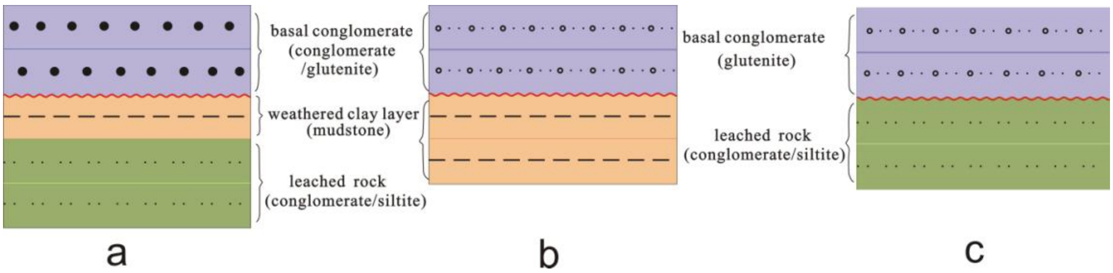
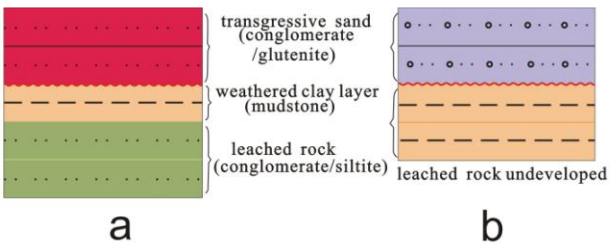


Fig.4 lithology configuration relations (Ⅰ)



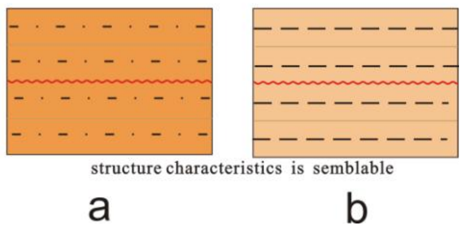


Fig.5 lithology configuration relations(Ⅱ) Fig.6 lithology configuration relations (Ⅲ)

3 Accumulation process of vertical structures of unconformity

3.1 Sealing process of vertical structures of unconformity for oil&gas

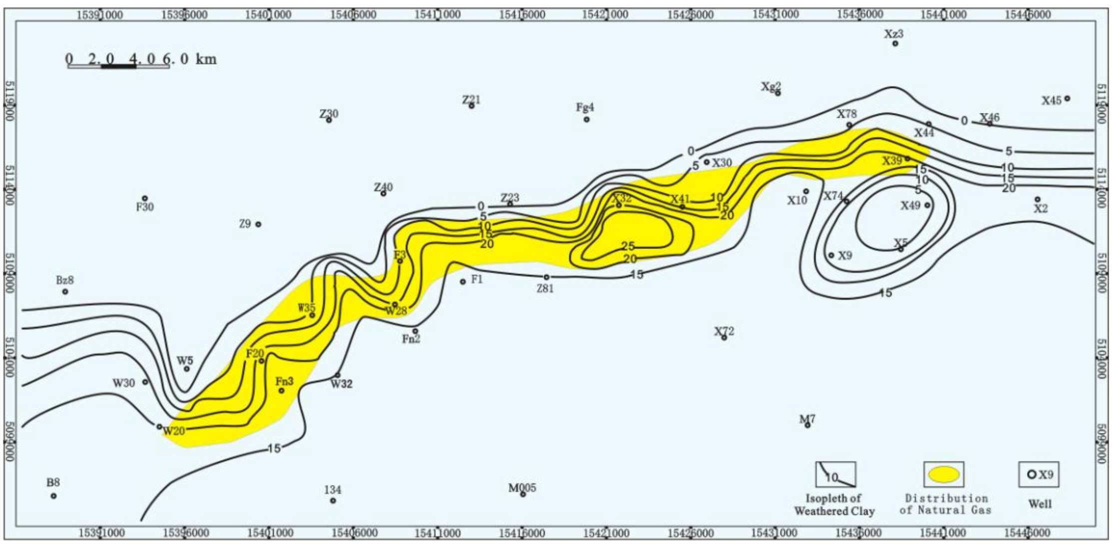


Fig.7 Relation between the thickness of weathered clay and natural gas distribution

Weathered clay layer, located in the upper part of weathering crust, which is the fine-grained of residual material formed by physical weathering, chemical weathering and biological weathering, has greater density in the compaction of sediment overlying, thus, it is a good set of sealing layer(Fig.7).

3.2 Conduction progress of vertical structure of unconformity for oil&gas

whether a stratigraphic overlap pool or a lithologic pinch pool can be formed above the unconformity surface was also controlled by the ancient landform of the unconformity surface before its deposition. If the unconformity surface was gentle, the deposited transgression sand bodies or the basal conglomerates would connect with each other, thus a migration channel had been formed（Fig.8a）.

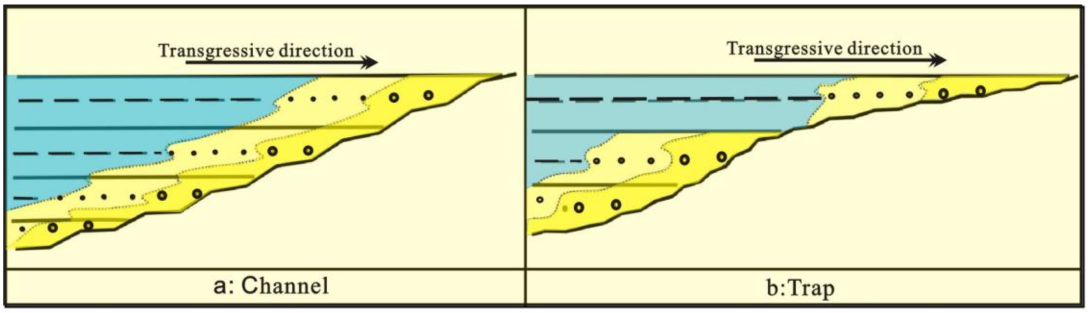


Fig.8 Migration pathway and trap forming mode above unconformity

3.3 Trap progress of vertical structure of unconformity for oil&gas

If the unconformity surface was in a slope break in the early transgression, the deposited sand bodies would be covered by the later mudstones, thus to form a stratigraphic overlap trap or a lithologic pinch trap(Fig.8b). The leached rocks developed a large number of fractures and secondary pores, and its depth can be several meters up to over hundred meters. On appropriate conditions, the sequences below the unconformity surface can form buried-hill, fractural, structural pools and reconstructed special kinds of pools.

4 Physical simulation of accumulation process of vertical structure of unconformity

4.1 Experimental model

Oil and gas migration and accumulation is simulated through rock above the unconformity (basal conglomerate or transgressive sand) and leached rock in the laboratory condition(Fig.9).

4.2 Analysis experimental process

In the early period of the experiment, oil began to fill oil-filled mouth of the sand body slowly with the migration form of wave front. Then it entered the vertical structure of the upper conducting layer, breakthrough the thin part of weathered clay layer, and migrated laterally into conducting layer. Since the permeability of the lower conducting layer is better, oil mainly migrated upward along the lower conducting layer while moving along the upper layer slowly, the main approach of which is diffusion migration, filling sand body when was encountered lateral sand.

When oil migrated to a more moderate slope of unconformity, the rate slowed down significantly, and the drainage outlet was also batch type. When it moved to the steep slope, affected by buoyancy and pressure, it migrated mainly vertically, moreover, oil was also through the lower part of the unconformity into the upper conducting layer, then entered the left side of the sandstone reservoir, the process of which is relatively rapid, formed oil and gas overlap reservoirs, at this time the amount of oil which continued to move upward was small, while the majority of oil entered the side of the trap to form a reservoir (Fig.10).

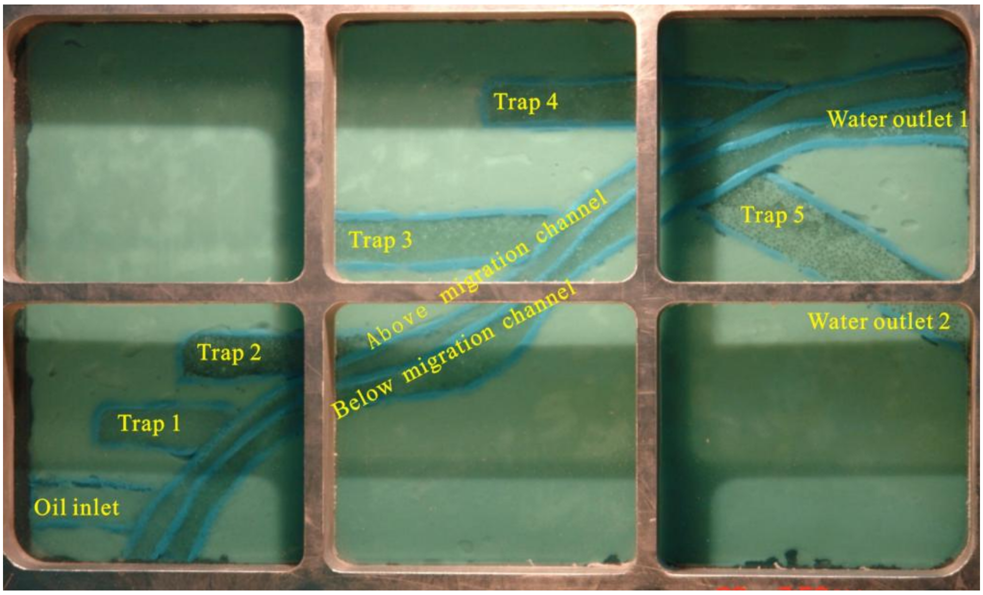


Fig.9 Experimental model

Fig.10 Modeling effect after ten hours

CONCLUSIONS

Simulation experiments showed that when oil and gas moved along the unconformity, their movements were restricted by the physical properties of the rocks and the slope. The oil and gas could easily get into other layers through the weakest part of the weathered clay layers and migrate within these layers. The overlap traps above the unconformity surface were more favorable than the stratigraphic traps (buried-hill) below the unconformity surface to entrap oil and gas.

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