[PS]Structure of Weathered Clastic Crust and Its Significance in Deep, Ultra-Deep Petroleum Exploration*

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Abstract

Weathered clastic crust can be subdivided into weathered clay and leached zone in terms of variable weathering of different minerals and mobility of weathering products. The Junggar Basin, situated in Western China, has experienced extrusion and collision by the Siberian, Kazakhstan, and Tarim plates during the Hercynian, Indosinian, Yanshanian and Himalayan movements. It exhibits 13 regional unconformities and several sub-unconformities, which is perfect for researching clastic unconformities. Based on clastic outcrops and well cores in the Junggar Basin, the dark red Fe-rich weathered clay is formed in an arid environment, while the light blue Al-rich weathered clay under humid conditions. According to the geochemical analysis, a new weathering index for weathered clastic crust is built mainly on Fe and Al contents, accurately indicating the weathered clay, sandy leached zone, and muddy leached zone in the Junggar Basin. The breaking pressure of weathered clay is rather large, the same as that of normal muddy cap, effectively to seal oil or gas. The porosity of underlying leached zone is greatly enhanced by due to weathering and leaching, but its permeability is a function of clay mineral content, i.e., the higher the clay content and the worse the permeability. Weathered crust provides effective sealing conditions for both top and bottom layers of a petroleum reservoir, and deepens the clastic hydrocarbon exploration. The structure of weathered clastic crust has an important theoretical value and scientific significance to clastic stratigraphic reservoirs and deep petroleum exploration.

Structure of Weathered Clastic Crust and Its Significance in Deep, Ultra-deep Petroleum Exploration

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Abstract

Deep, ultra-deep are one of the most important hydrocarbon exploration areas in the future. Most of the ultra-deep reservoirs relate to unconformity, such as Junggar Basin. Good reservoirs whose porosity above 15% are developed at the burial depth of about 6500m because of the influence of K-J unconformity. Based on clastic outcrops and well cores in Junggar Basin, considering the lithology of weathered layers, the weathered clastic crust was divided into 2-layer structure model, which are weathered clay, eluvial zone (sandy or muddy). Weathered clay mainly distributed at the slopes and low places, and had an inverse proportional development relationship with the eluvial zone. Analyzing reservoir properties of rock samples from the outcrop and well cores, detailed describing reservoirs beneath the J-K unconformity in western Junggar Basin, the results suggest that the porosity of eluvial zone is greatly improved due to weathering and leaching, but the permeability depends on the clay mineral contents. The higher the clay content, the worse the permeability is. The weathered clay has a high breaking pressure and could be treated as a good cap rock. The lower limits of hydrocarbon exploration depth are greatly downward because of weathering effect.

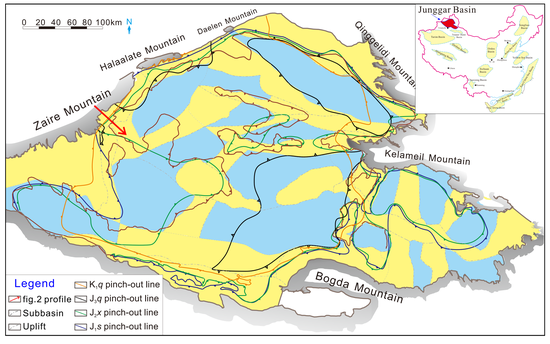


Fig.1 Location map of the outcrop

Junggar basin situates in the northwest of China. The red arow shows the seismic profile and outcrops in the figure 2.

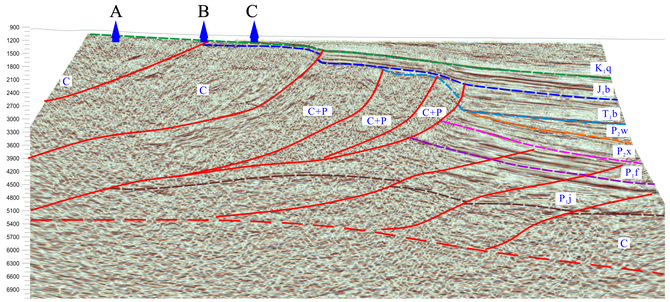
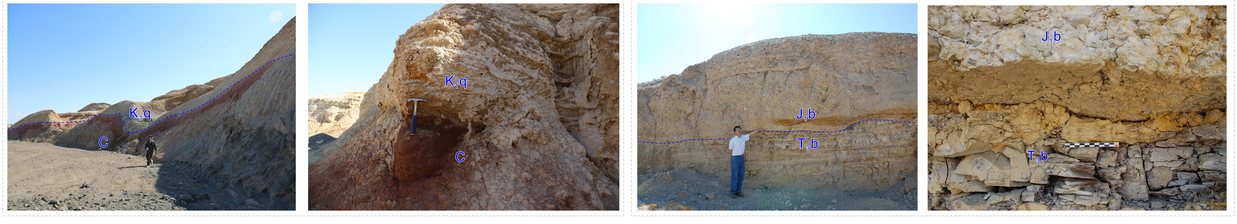


Fig.2 Seismic profile of northwest Junggar basin

Figure 2 shows a thrusting nappe structrue of northwest Junggar basin. 3 outcrops located in the edge of west Junggar basin.

Outcrop A: an unconformity between C-K1q. Lower Cretaceous delta covered directly on Carboniferous volcanic rocks. 1~1.5m thick wide distributed maroon weathered clay was developed.

Outcrop B: an unconformity between J1b-T3b. T3b is mainly composed of shallow lacustrine mudstone, while J1b is composed of delta glutenite. 10~20 cm yellow weathered clay was developed.



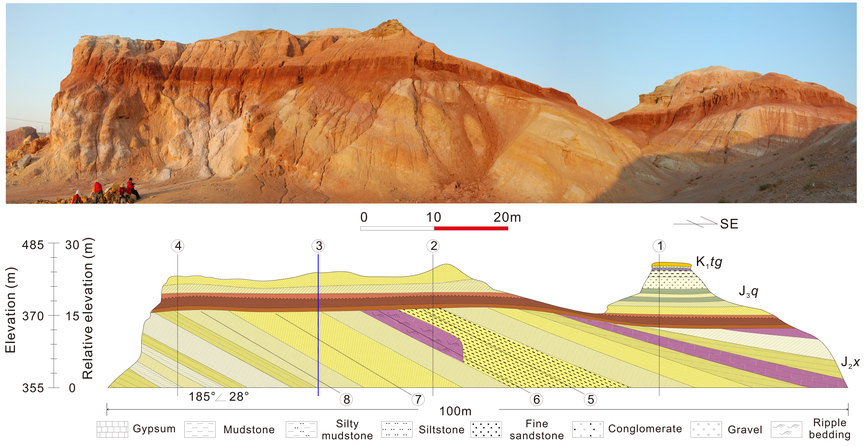


Fig.3 Outcrop C profile of Unconformity in the figure 2

A 100 m clastic angular unconformity outcrop c shows in the figure 3.

J_3q-J_2x has an angular unconformity. It consists of a 1~2 m thick weathered maroon clay and underneath eluvial zone. The underlying strata is about 25m thick, and consists of inter-bedded by grayish kaolinite, yellow mudstone, purple-red sandstone, off-white sandstone and conglomerate.

K_1tg-J_3q is a parallel unconformity. It was formed by incised channel. The thickness of weathered clay is very thin.

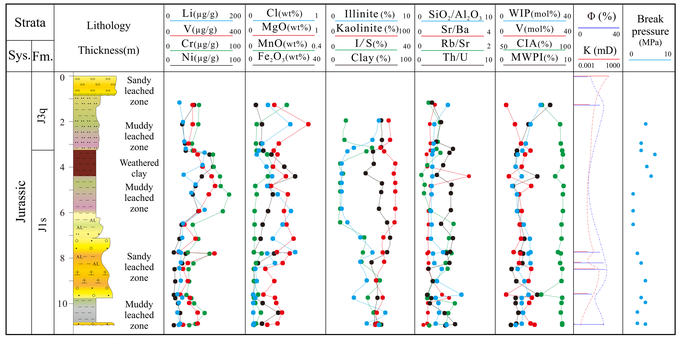


Fig.4 Mineral constituents of outcrop c profile #3

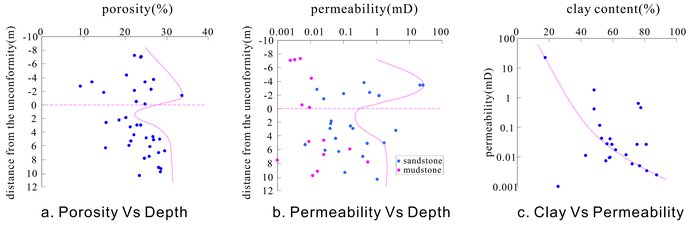


Fig.6 Physical properties of weathered clastic crust

a. Porosity decreases on weathered clay, increases with distances between unconformity.
b. Permeability decreases just below the unconformity and bear some relation to lithology.
c. Below the unconformity, permeability decreases as clay content increases.

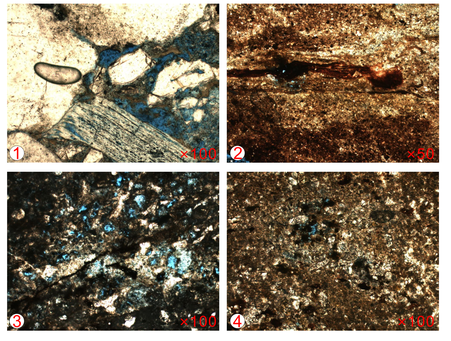


Fig.5 Weathered clastic crust under microscope

1. Microscope photo (×100) of basal glutenite above the J_3q-J_2x unconformity. Dissolved pores are developed.

2. Microscope photo (×50) of weathered clay of the J_3q-J_2x unconformity. The photo shows rare porosity.

3. Microscope photo (×100) of purple silty mudstone below the J_3q-J_2x unconformity. Note dissolved pores developed in grains.

4. Microscope photo (×100) of gray mudstone below the J_3q-J_2x unconformity. Note that little intergranular pores were developed.