[PS]Key Factors for Oil Accumulation of Mesozoic Granite Buried Hill in Penglai 9-1 Oil Field, Bohai Bay Basin*

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Abstract

The Penglai 9-1 buried-hill oil field is located on the Miao Xi Uplift, and has proven reserves of more than 2×10^8 m^3 with a large oil-bearing area (more than 80 km^2) and a high oil column height (maximum height over 230 m). It is so far the single largest and the only Mesozoic granite oil field in Bohai Bay Basin. Restricted by the degree of reservoir development, the oil-water interface along the buried hill was dome-shaped. The oil accumulation region is mainly in the saddle of the hill where the granite exists, with local hydrocarbon shows on both sides of the higher quartz schist hills. Oil and source correlation shows that the lacustrine source rocks of the first and the third member of the Shahejie Formation in Bozhong and Miaoxi Sag provide hydrocarbons for the large reservoir. A thick layer of weathered crust leached by atmospheric water is the main reservoir space and conducting layer. The shallow buried depth is a key factor for the weathered crust to maintain good physical properties. Faults connect oil sources and the lateral interconnection in the weathered crust provide good hydrocarbon migration and accumulation systems. Overlying shallow lake mudstones of the Guantao Formation form a regional cap rock. The reason that thin shallow lake mudstones in an early diagenesis phase can seal the oil column over 200 meters high is the density difference between the oil in the Penglai 9-1 oil field (0.987g/cm^3) and water is small. The bigger fault throw of boundary faults separated the granite and the quartz schist on both sides of the hills, and avoided the docking of weathered crust between granite rocks and quartz schist, then prevented the migration of oil to both sides of the quartz schist hills. In addition, the weathered crust of the buried hills was thin with a limited distribution as quartz schist has strong resistance to weathering. All of the above may be the main reasons for oil accumulation on the saddle of granite hill, but not on either of the higher quartz schist hills.

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Abstract

Penglai9-1 buried-hill oil field locates at Miaoxi Uplift, and has proved reserves of more than 2×10^8 m^3 with a large oil-bearing area(more than 80 km^2) and a high oil column height(maximum height over 230 m). It is so far the single largest and the only Mesozoic granite oil field in Bohai Bay Basin.

Restricting by the degree of reservoir development, the Oil-water interface along the buried hill was dome-shaped. Oil accumulation region is mainly in the saddle of hill where the granite is distributed, while only local hydrocarbon are shown on both sides of the higher quartz schist hills. Oil and source correlation shows that the lacustrine source rocks in the first and the third member of Shahejie formation in Bozhong and Miaoxi sag around the hill provide hydrocarbon for the large reservoir. A thick layer of weathering crust leaching by atmospheric water is the major reservoir space and carrier layer. Shallow buried depth of is a key factor for weathering crust to maintain good physical properties. Efficient faults, weathering body connecting oil source and the good lateral interconnectivity in thick weathering crust make up the good hydrocarbon migration and accumulation system.

Overlying shallow lake mudstones of Guantao Formation form regional cap rocks, the reason that thin shallow lake mudstones in early diagenetic phase can seal the oil column height over 200 meters is that the density difference between the water and the oil in Penglai 9-1 oil field (0.987g/cm^3) is small.

The bigger fault throw of boundary faults separated the granite and the quartz schist on both sides of the hills, and avoided the docking of weathering crust between granite rocks and quartz schist, then prevented the migration of oil to both sides of the quartz schist hills. In addition, the weathering crust of the metamorphic buried hills was thin with a limited distribution for mainly quartz schist constitution and has strong resistance to weathering, which is difficult to reserve for steep landform, restricting the formation of the horizontal channel layer for oil migration on both sides of Metamorphic hills. All of the above may be the main reasons for oil accumulation on the saddle of granite hill, but not on the two higher quartz schist hills.

1. Geological settings

Penglai9-1 buried-hill oil field locates at Miaoxi Uplift, Bozhong depression, Bohai Bay Basin, which is the single largest and the only Mesozoic granite oil field with a large oil-bearing area over 80 km^2 and a big oil column height(maximum height over 230 m)

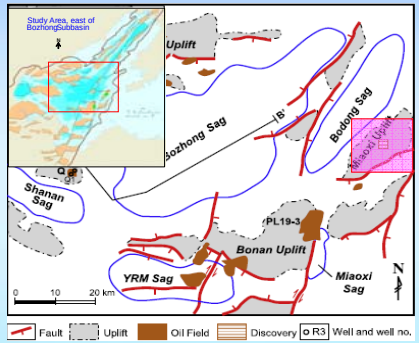

Fig.1.1 Geological location of the study area

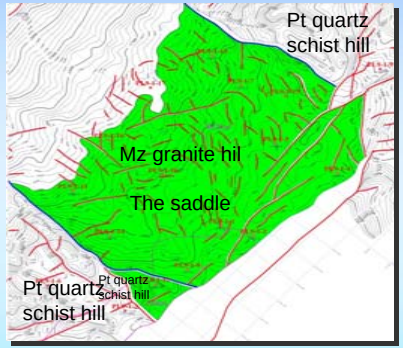

Fig.1.2 Oil-bearing area distribution map of Penglai9-1 oil field

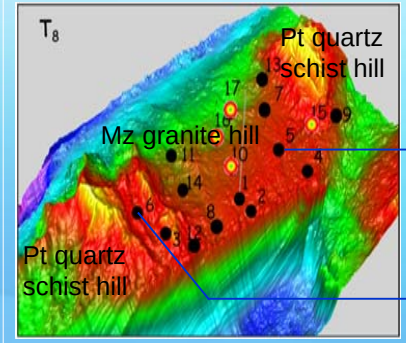

Fig.1.3 3D visible palaeogeomorphology and lithology distribution of the Penglai9-1

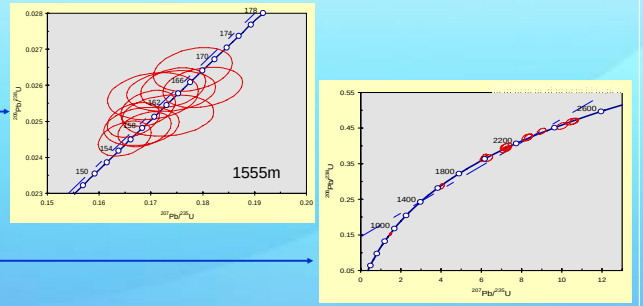

Fig.1.4 Age of different part of PL9-1 buried hill (single grain zircon U-Pb dating by LA-ICP-MS)

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2. Reservoir distribution model and migration pathway

A thick layer of weathering crust leaching by atmospheric water is the main reservoir space and carrier layer. Shallow burial depth of weathering body is a key factor for weathering crust maintaining good physical properties. The strongly weathered layer mainly keeps granite shape, which is easy to break, while the others are sand-shaped. The thickness of the sand-like granite is horizontal stable which is necessary to the forming of a carrier layer. The reservoir development degree will lead to the forming of dome-shaped oil-water interface along the buried hill.

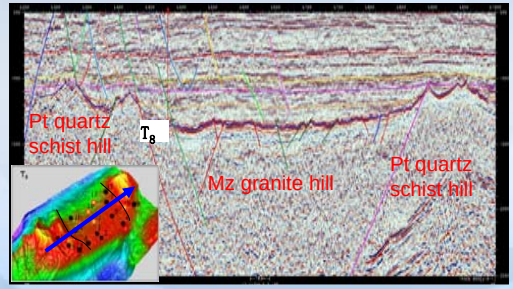

Fig.2.1 Lithology distribution map of the profile

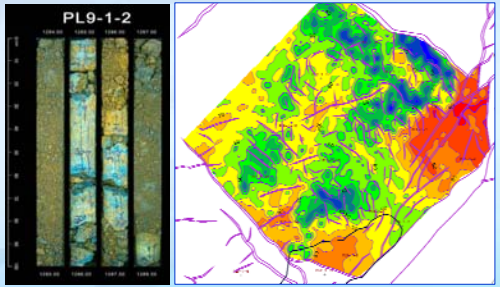

Fig.2.2 Core photograph of strong weathered layer & Diagram of reservoir thickness of 100m below the top of the granite

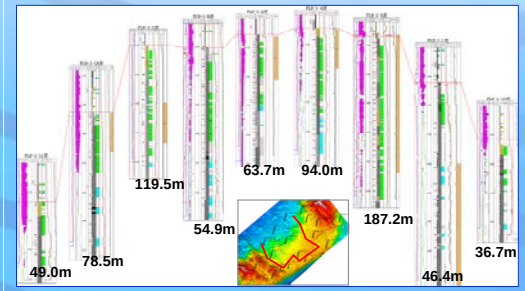

Fig.2.3 Diagram of well correlation depicting oil distribution

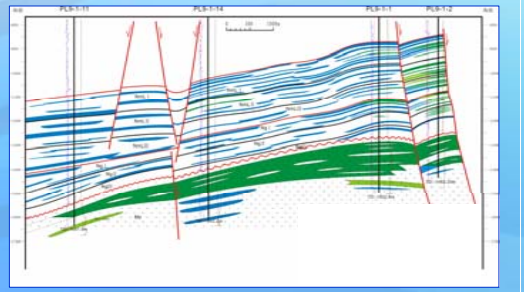

Fig.2.4 Reservoir model shows lateral distribution of the bend oil-water interface

3.Oil and source rock correlation and accumulation system

Oil-source correlation is done for sags on both sides. C_{27}-C_{29} 4-methyl Triaromatic Sterane Homologues (M/Z=245) can distinguish oil from the three source rocks.
Buried hill oil: mainly from E_2S_3 and E_3S_1 SR, some are from E_3d SR
Direction: mainly Bodong depression

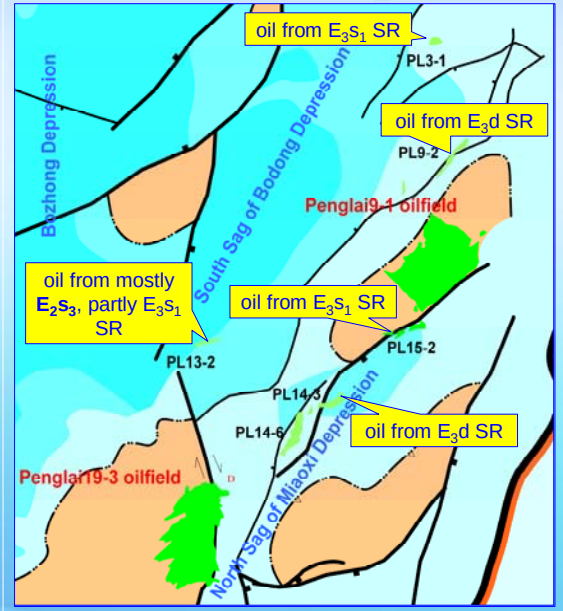

Fig.3.1 Oil source of the adjacent oilfields around Penglai9-1

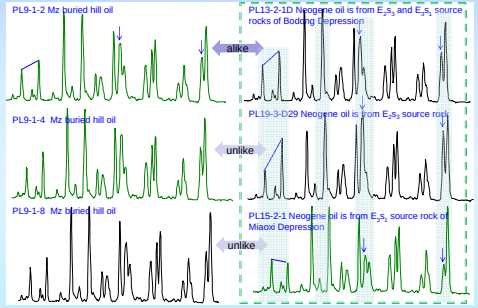

Fig.3.2 Oils of Penglai9-1 Buried Hill are from E_2S_3 and E_3S_1 Source Rocks

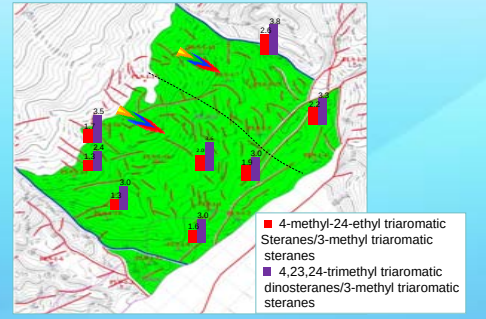

Fig.3.3 Buried hill oils: mainly from E_2S_3 and E_3S_1 SR, some are from E_3d SR

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4. Accumulation model and accumulation system

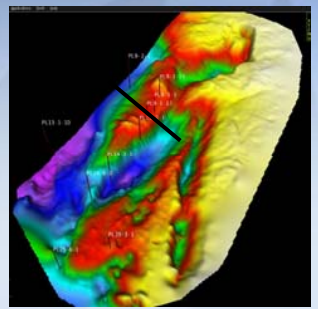

Fig.4.1 3D visible palaeogeomorphology of the interest region

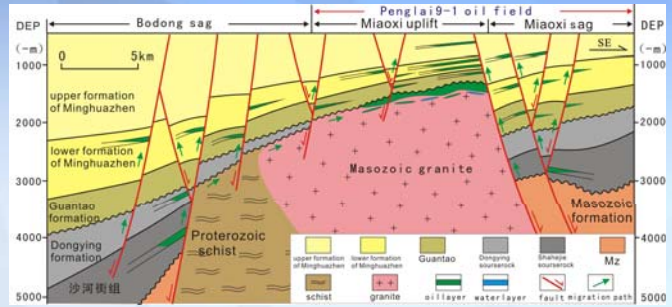

Fig.4.2 Hydrocarbon accumulation model

5. Regional cap rock condition

Neogene Guantao Formation develops shallow water delta facies. Thick mudstone forms a regional cap. The density difference between water and the oil in Penglai 9-1 oil field is small.

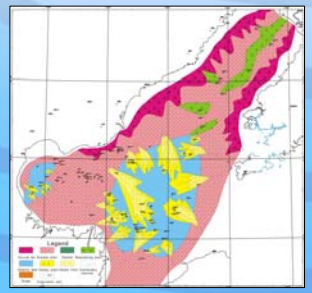

Fig.5.1 Sedimentary Facies (shallow water lake) of Neogene Guantao Formation

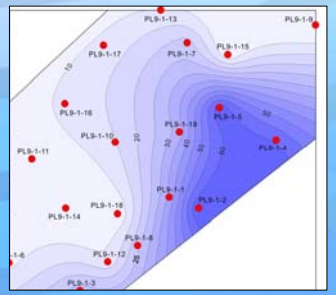

Fig.5.2 Mudstone thickness Contours of Guantao Formation

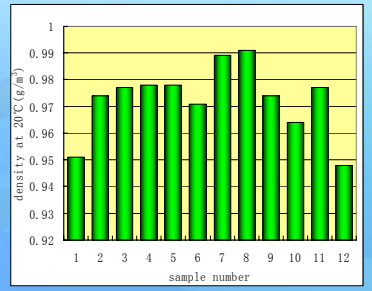

Fig.5.3 Oil density of Penglai9-1

6. Key factors for oil accumulation on the saddle but not on the both higher schist buried hills

Big boundary fault divided the weathering crust of granite and that of schist.
Quartz schist is hard for weathering, thus the weathering crust is undeveloped.
The thickness of weathering layer on the two high schist hills is unstable and with a limited distribution for steep landform.
Factors above are unfavorable for the oil accumulation on the high schist hill.

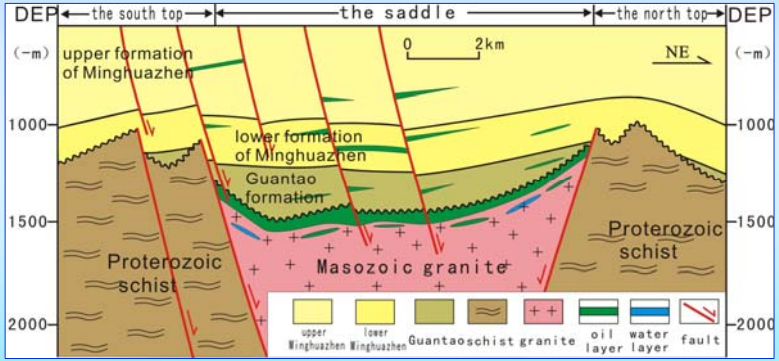

Fig.6.1 Reservoir model and fault distribution of the buried hill

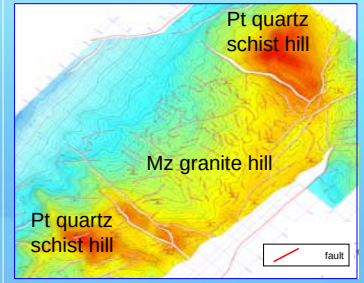

Fig.6.2 Fault distribution map

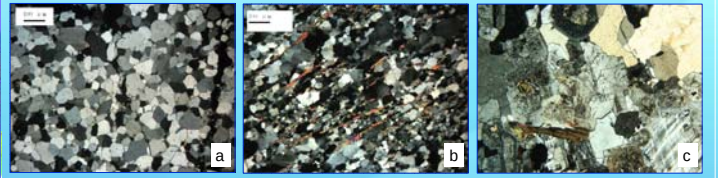

Fig.6.3 The lithology of different part of the buried hill
a. well 3, 1250-1255m, quartzite , +25x b. well 6, 1385-1387m, muscovite quartz schist, +25x c. well 13, 1493m, granite is rich in feldspar