
Analysis of cause characteristics of Pisha-sandstone in Mu US Desert — Based on Sedimentary Environment Perspective

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Abstract

The Pisha-sandstone, located in the southeastern margin of the Ordos Basin, which is the thick sandstone, sand shale and argillaceous sandstone interbedded rocks of Paleozoic Permian Triassic and Jurassic Cretaceous Mesozoic, mainly composed of continental clastic rock. The study found that when the hard Pisha-sandstone are anhydrous water, such as sludge, vulnerable to erosion characteristics which due to its good permeability, high plasticity index, good hydrophilicity. From the micro perspective, the rock composition has mainly the quartz that due to its simple structure, low degree of cementation, poor construction strength. In addition, through the analysis of Pisha-sandstone lithic-facies characteristics, composition, characteristics of sedimentary evolution in the various strata of Paleozoic and Mesozoic, to restore Pisha-sandstone formed in different sedimentary environment during the period, in order to explain the causes of the different thick layer of Pisha-sandstone.

Keywords

Pisha-sands; Mu US Desert; sedimentary environment; petrological characteristics; cause; Ordos Basin.

1. Introduction

Since the end of the 50s of the last century, there are so many former researches on Pisha-sandstone in Ordos basin, different scholars from different angles, in order to solve the problem of soil erosion and desertification in Mu US Desert produced by the different aspects, including the formation and development of deserts, the movement rule and rate of dunes, the change of desertification in human history, and the global climate change and the climate response to desertification, and so on, which have made significant progress[1-6]. It is found that Mu US Desert has its own sedimentary sequence of ancient lakes, wind sand, loess and paleosol. It records one hundred thousand years of climate change and major climate events[7-9]. Wang Yuanchang[10] have used computer aided manual interpreter, under the support of geographic information system, made a comprehensive definition of the Pisha-sandstone distribution range in the contiguous area as the center, and the Pisha-sandstone is divided into 3 types: bare sandstone areas, cover soil in soft sandstone area and cover sand in soft sandstone area, for the future of sandstone range are determined.

The causes for sandstone, there has been a different understanding, Long Hao[11] made northern Mu US Desert section grain size characteristics and environment analysis, the region mainly in the sediment of lake sediments and aeolian deposition, deposition after weathering is very few, and these wind sand mingled with three lacustrine deposits. In the previous experiments, Shi Yingchun[12] combined with lithology, vertical sequence, sedimentary structure, palaeo-flow characteristics and spatial distribution of sand bodies of information, have researched the sedimentary characteristics of the sandstone of Taiyuan formation in the south of Inner Mongolia. It is considered that the formation of sandstone in this area is obviously controlled by the factors of paleotectonic background, differential settlement, sediment supply and sea level rise and fall. In the context of the same or similar sedimentary environment, the size composition and distribution of the sediment should be comparable [13]. Therefore, after the analysis of lithofacies characteristic and composition analysis in Mu US Desert sandstone, prediction of sedimentary environment in different periods of the formation of sandstone, then further study of sandstone rock causes on formation characteristics.

2. Geographical Location of the Research Area

Mu US Desert is also known as Ordos sandy land, whose name comes from Maowusu village in Jingbian County, Shaanxi county. Mu US Desert is located 107°20' to 111°30' E, 37°30' to 39°20' N, a total area of about 4×10⁴ km², landform is bounded by the Great Wall, the north region are wind sand area, southern region are hilly and gully region, northwest high and southeast low in terrain, as Ordos plateau to the transition zone between the South East of the Northern Shaanxi Plateau.

3. Evolution of Sedimentary Environment in the Historical Period of Mu US Desert

3.1 Geological Background

The Pisha-sandstone, located in the southeastern margin of the Ordos Basin, which is the thick sandstone, sand shale and argillaceous sandstone interbedded rocks of Paleozoic Permian (about 250 million years ago) Triassic and Jurassic Cretaceous Mesozoic. At the end of the early Paleozoic Ordovician Caledonian orogeny, caused Ordos basin comprehensive uplift, leading to lack of sandstone deposition of the upper Silurian, Devonian and lower Carboniferous, sedimentary interruption reached more than 100 million years. In the late Paleozoic, Ordos basin has entered the ongoing comprehensive settlement period, from the bottom up continuously in Benxi group to Liujiagou group deposited in each period of formation of the mineral composition (Table 1), chemical composition, lithology combination, particle density of different sandstone.

Table 1 The division of Upper Paleozoic in the Ordos Basin

erathem	system	series	formation
Mesozoic	Triassic	Lower	Liu Jiagou
Upper Paleozoic	Permian	Upper	Shi Qianfeng
		Middle	Upper Shihezi
			Lower Shihezi
	Lower	Shanxi	
	Carboniferous	Upper	Taiyuan
Lower Paleozoic	Ordovician	Lower	Ben xi
			Ma jiagou

3.2 Petrological Characteristics of Pisha-sandstone in Mu US Desert

As a kind of soft sandstone sedimentary rock, the physicochemical properties and their special strata in Mu US Desert natural and humanistic environment, so that the rock is so vulnerable to weathering. Yu Jiwei[14] made a physical characteristics of sandstone from the Inner Mongolia study area, have found that the measured sandstone density is 1.85-1.96 g/cm³ and the permeability coefficient is

5.2×10⁻³mm/s. After Checking the rock permeability coefficient (K) classification, also found that Pisha-sandstone belong to medium grade (K=10⁻⁵ -10⁻³mm/s), have a greater permeability; in the natural state as hard as stone, natural moisture content is only 7.7-8.83%, the saturated moisture content of 18.6-19.5%. The liquid limit WL is 29.30%, the plastic limit W_p is 19.60%, the plastic index I_p is 9.40. The bigger plastic index shows the larger the finer particles, the content of soil clay or hydrophilic minerals (such as Montmorillonite) the higher sandstone plastic index smaller, good hydrophilicity, it shows that characteristics of Pisha-sandstone water like mud in engineering application.

Li Changming[15] selected Pisha-sandstone in the study area and did the water resistance test, have found in hydrostatic conditions, soft rock broken the fastest time for 5 minutes, the precipitation and water erosion, broken the process will be shorter, it is obvious that Pisha-sandstone have a poor corrosion, easily disintegration in water, and further explain why Pisha-sandstone area the characteristics of soil erosion.

From the microscopic point of view, Song Tushun [16] using optical microscopy, have observed meso structure, material morphology, pore structure and all kinds of material between the combination in Pisha-sandstone. The microstructure of Pisha-sandstone is mainly like block links or flocculent links, which have particle surface roughness, loose structure, single particle size, low content fine particle, and unable to make up the gap between particles. So the particles will appear crack easily along these fissure water infiltration, major content in Pisha-sandstone, especially under the action of gravity, easily to cause the collapse, which is vulnerable to the causes of invasion of Pisha-sandstone.

Pisha-sandstone belongs to continental clastic rock series, including clastic and interstitial material in the matrix and the cement composition of the material, which formed in sedimentary, and precipitation occurs in the stage of rock solution. The total trend of the change of cementation content in the study area have three points: the lowest in the upper Palaeozoic era is 6.97%, the 9.99% in the Jurassic, and the highest in the Triassic(13.36%)[17]. In general, the content of the cementation is low, which indicate that the porosity and permeability of the sediments are better. The change of content indicates that the transport medium in the study area during the Triassic period was a continuous and steady flow. Sediments were deposited after long distance transportation. During the late Paleozoic and early Middle Jurassic, the transport medium in the study area was intermittent, poorly stable flow. The transport distance of sediments was relatively short, and the characteristics of near source accumulation were obvious.

Used by optical microscope, Leng Yuanbao[18] have taken a small watershed of Huangfuchuan Watershed typical sandstone samples, found that the main mineral compositions in sandstone are quartz, calcium montmorillonite, potassium feldspar and calcite. The results of chemical analysis of different color sandstone showed that the content of SiO₂ in each color sandstone were the highest, range in 54.11% to 65.42%, the maximum can reach 77.75%. The main component of quartz is SiO₂, which is the most stable rock forming mineral. It is not only resistant to weathering, but also not easy to wear.

3.3 Evolution History of Sedimentary Environment

The formation of terrigenous clastic rocks is restricted by sedimentary environment, and the deposition is characterized by multi source, multi system, polycyclic, multi-layer and heterogeneity[19]. The debris in the sedimentary basin mainly comes from the mechanical weathering of the parent rock. Therefore, the characteristics and structure of the sandstone components are closely related to the source area, and can directly reflect the tectonic environment of the source and sedimentary basins [20-21]. The mainly source from the north Ordos basin of Yinshan, Mount Daqing area in Upper Proterozoic and Archean metamorphic rocks (Guo Yinghai, 1998; Yan Weihong, 2001); Yang Yihua thought that the main reason for the concentrated deposition of coarse sand deposits in the Shanxi Shihezi period and the formation of thick sandstone deposits were the concentrated and exhumation of the thick and rich coarse quartz grains in the northern provenance

area of the basin[22]. Ma Gang [23] pointed out that the geological structure of Mu Us desert belongs to the Ordos platform, also known as the Northern Shaanxi structural basin. The basement of the platform is pre Sinian. It began to receive sedimentary formation continuously from the Sinian period, and the basement overburden is mainly Paleozoic and Cenozoic sedimentary rocks.

In summary, sedimentary facies and sedimentary characteristics are different in different developmental stages of continental clastic sedimentary basins, and the depositional systems are also different. The basic geological models of reservoirs represent the concept of meso and micro.

Figure 1 is the basic geological model of the sedimentary formation of continental clastic rocks. The Ordos Pisha-sandstone Basin Southeast Margin of deposition in different times, all have distinct characteristics, also formed its unique sandstone sandwich, following through a detailed analysis of the characteristics of different ages of sandstone to restore the sedimentary environment.

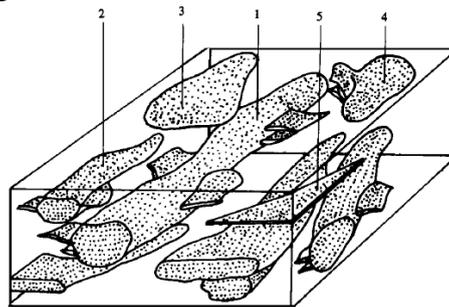


Figure 1 Basic geological model of continental clastic rock reservoir

(1. main channel sand body; 2. channel sand body; 3. overbank sand body; 4. channel sand body; 5. flood plain thin layer sand)

In the Ordovician Majiagou formation, the L - shaped uplift zone is formed in the western and southern margins of the Ordos Basin, due to the expansion and splitting of the rise of rift valley. In the south of the L - shaped uplift zone, that is, the Weibei uplift area, the whole Majiagou period developed into a sedimentary environment with steep slope. [24]

In the upper Paleozoic of the Taiyuan formation, change of sandstone thickness in the area is large, the first section is Ordos before basin deposition of a Western sea connected on the formation, the whole basin is still a matter of filling a gap. Two kinds of sedimentary types are mainly distributed in the southeastern edge of Ordos which are the coastal lake type of North China and the offshore type of Qilian.

The Lower Shihezi formation in the Late Permian has a set of river - lacustrine deposits near the sea. The upper Shihezi formation as a whole set of continental lacustrine sedimentary lithology, with yellow green and mottled purple mudstone, sandy mudstone, and in the Late Permian Shiqianfeng formation is a lacustrine sedimentary sandstone and mudstone.

4. Conclusion

1)The Pisha-sandstone in Mu US Desert have large density, good permeability, high plasticity index, good hydrophilicity. When the moisture content is close to the saturated water, sandstone cohesion is close to zero, so that the sandstone in water like mud, serious soil and water loss of soft sandstone area characteristics.

2)The main cause of sedimentary rocks in Pisha-sandstone area of sand shale interbed is Ordos basin movement uplift in early Paleozoic Ordovician late Garito, which resulted in loss of the Silurian, Devonian and lower Carboniferous. From late Paleozoic to Mesozoic era, the Ordos Basin successively entered the Indosinian movement period and the Yanshan movement period. Although the total settlement continue to receive sediments from different provenances, it is also accompanied by intermittent uplift, which lead to the change of sedimentary thickness, loose cementation and low diagenetic strength.

3)After the analysis of petrology, sandstone vertical sequence, sedimentary structure, palaeo- flow characteristics and spatial distribution of Pisha-sandstone, in the early Carboniferous and early Permian, the sedimentary environment was mainly composed of sea and land, and the sandstone reservoir was widely distributed in the basin. During the Late Permian to Mesozoic Triassic, it became continental facies and developed multi-stage superimposed, massive distributional river delta facies sand bodies and lacustrine mudstone cap rock.

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