Introduction

Shale gas, which is drilled from the shale stratum, is a kind of clean and efficient energy, and has been paid great attention all over the world at present. Compared with the conventional natural gas, the development of shale gas is characterized by long drilling life and production cycle. And, most of the gas shale shows wide range and great thickness, which ensures producing gas long-term and steadily. Since 2011, shale gas has become the 172th mineral in China. It always exists in the organic-rich shale or interlayer in the adsorbed and free form, whose component is dominated by methane. And, the accumulation and distribution of shale gas shows some peculiar geological characteristics, such as short migration distance, a variety of sealing mechanism, covert accumulation and water saturated. The self-generating and self-preserving, adsorption mechanism and the corresponding large-scale accumulation belong to the important geological features of shale gas.

Hunan province in China has always been out of fuel and is lack of electricity and coal. But, the gas demand is increasing every year, showing a serious shortage. According to statistics, the effective shale area in Hunan is 278,000 square kilometers, and the shale gas reserves is about 11 trillion cubic meters around 10% of the whole country. Nowadays, the proven reserves of shale gas in Hunan province is about 1.5 trillion cubic meters, among which the shale gas in northwestern Hunan has priority to develop. And, the Dongting-central Hunan area has been incorporated into the shale gas development and utilization national planning.

Regional Geology

China is located in the intersection of Pacific plate, India plate and Siberia plate with intricate basining evolution and dynamic system, whose complicated geological structure is characterized by multi-block, multi-stage and multi-cycle (Zhao et al., 2012). In China, the marine shale, marine-terrigenous facies shale and continental shale is widely distributed, showing abundant resources and good development prospect for shale gas. It is predicted that shale gas production will more than 300 trillion cubic meters by 2020. Since the 1960s, the shale gas or fractured shale reservoirs are discovered in almost all oil bearing basin of the mainland of China, such as Songliao Basin, Bohai Bay Basin, Sichuan Basin, Ordos Basin and Qaidam Basin.

From the point of regional tectonic system, Hunan across Yangtze Block and Cathaysia Massif, whose multiple stages convergence and cracking leads to the development of multiple regional fractures. The northwestern Hunan block is located at the Yangzi paraplatform, whose east side is Jiangnan geotaxis and upwelling area but depression area in the west side. From Sinian to Devonian, this area was Craton marine basin with a series of marine strata. From Triassic, because of the regional structural evolution and basin tectonic inversion, a series of thrust-nappe structure and paraforeland basin were developed. After two stage modifications of Jurassic and Himalayan, the current NNE– or NE– trending fold and fracture system was formed.

Shale Gas Development of Well Ciye 1

Well Ciye 1, which locates in Cili county of Hunan province, is the first shale gas wildcat well in northwestern Hunan.
Hunan arranged by Oil & Gas Survey, China Geological Survey. And, the drilling engineering is implemented by Oil & Gas Survey and Coal Geological Prospecting Institute of Hunan.

Since the project approval, analytical investigation on regional geology, shale gas accumulation features, generation and accumulation mechanism and enrichment regularity is to come up with favorable shale gas area and deploy 2D-seismic. And, based on 2D-seismic data processing and interpretation, the key control factor analysis of shale gas accumulation, the spatial distribution of black shale in lower Cambrian Niutitang formation was further defined, and the faults and tectonic features was also analyzed, it is to optimize favorable target area and put forward alternative well position.

Well Ciye 1 is located in northwest wing of Jinglongqiao syncline of Xuefeng thrust uplift, drilling began in On December 26, 2013. The design depth of Well Ciye 1 was 2810 meters but it was completed by 3008 m depth on June 3, 2014, spending 136 days. The whole drilling process is very smooth without well leakage, well kick, well blowing and so forth. The gradient and orientation was well-controlled which meets the design requirements. In the process of drilling, 13 layers show good gas bearing characteristic with 81 m thickness, consisting of 8 layers in Niutitang formation. The aim of Well Ciye 1 is to make sure of the gas-bearing features of lower Cambrian Niutitang formation in northwestern Hunan, acquire the key evaluation parameters for shale gas, and strive for exploration breakthrough of shale gas in northwestern Hunan. The breakthrough will facilitate shale gas development in middle and lower Yangtze region, accelerate shale gas exploration process, and contribute to the local energy supply and economic development.

4 Resource Potential Analysis

The breakthrough of Well Ciye 1 opens a window for shale gas exploration in Hunan province. The shale gas resource is the maximum amount in northwestern Hunan with 4.18 trillion cubic meters about 70% shale gas resource of Hunan province. Especially, the lower Cambrian Niutitang formation distributes and exposes widely in Hunan, which is the important shale gas reservoir in Hunan. Undoubtedly, the successful drilling of Well Ciye 1, which shows an important leading and guiding role to the adjacent Longshan, Baojing, Huayuan, Sangzhi and Yongshun, will help move forward the shale gas exploration and development to the whole middle-lower Yangtze region.

The present study suggests that the formation and enrichment of shale gas has its unique characteristics, which generally distributes in the thick and widespread shale formation. Compared with conventional natural gas, shale gas development has advantages of long mining life and long production cycle. And, most of the shale gas reservoirs are characterized by wide distribution and great thickness, which ensures the stable gas producing.

Xiao et al (2013) thought that the widespread marine mud shale of lower Cambrian Niutitang formation in northwestern Hunan shows good reservoir conditions, such as stable horizon, wide distribution, great thickness, high organic carbon content, excellent organic matter type and in stage of maturity to over-maturity, and the thickness of lower Cambrian Niutitang formation was distinctly controlled by the sedimentary facies belt. Wang et al (2013) pointed out that the micro and nanoscale pore and fracture were developed which shows good accumulation condition and a strong adsorption ability, and it is apt to develop natural fractures and induced cracks by some external force. Lin et al (2014) thought that the black shale of Niutitang formation in northwestern Hunan shows excellent shale gas accumulation conditions, such as great thickness, high organic matter content, moderate maturity, high contents of brittle minerals, low content of clay minerals, low porosity and low permeability, and middle-small hole and fracture well developed. Recently, Zhang et al (2015) found out that the organic-rich black shale is widely developed with suitable thickness and humic organic matter of lower Cambrian Niutitang formation in Baojing area, and the value of Toc ranges from 1.3% to 3.7%, but R0 is generally greater than 3%.

On this issue of shale gas exploration and development of Hunan province in the future, researchers commonly believe that in spite of abundant shale gas resources, the exploration potential area was mainly concentrated in lower Cambrian Niutitang formation and lower Silurian Longmaxi formation of northwestern Hunan, and lower Carboniferous Ceshui formation of central Hunan, all of which also shows suitable burial depth, great thickness, high organic matter content and intensive gas generation, but the maximum resource in Niutitang formation.

It is undeniable that the development of shale gas will effectively promote the rapid development of natural gas in China, which is of great significance to improve the energy structure and ensure energy security. However, some scholars point out that at present shale gas resource potential assessment in Hunan province is on the basis of the conventional oil & gas or some of America's evaluation methods. The different evaluation method considers the different key parameters, which usually leads to a large difference. So, it is extremely urgent to
establish shale gas resource evaluation method and system, adapting to the shale gas resource development of Hunan province. To this issue, Du et al (2011) explicitly point out that shale gas exploration has just started in our country, and it is necessary to reference the experience of American shale gas evaluation and combine with our country shale gas accumulation geological characteristics, taking a full consideration of reservoir distribution area, buried depth, terrain and water source and so on.

References