Available online at www.sciencedirect.com

ScienceDirect

Journal of Natural Gas Geoscience 1 (2016) 277−286

http://www.keaipublishing.com/jnggs

Original research paper

Geochemical characteristics of natural gas in the hydrocarbon accumulation history, and its difference among gas reservoirs in the Upper Triassic formation of Sichuan Basin, China☆

Peng Wang [a,*], Sibing Liu [b], Zhongmin Shen [b], Fei Huang [a], Zili Luo [a], Fei Chen [c]

[a] College of Resources and Environmental Engineering, Yibin University, Yibin 644000, China
[b] State Key Laboratory of Oil and Gas Reservoir Geology and Exploration, Chengdu University of Technology, Chengdu 610059, China
[c] PetroChina Southwest Oil and Gas Field in Sichuan Gas Mine Company, Nanchong 637000, China

Received 23 July 2016; revised 19 August 2016
Available online 19 October 2016

Abstract

The analysis of hydrocarbon generation, trap formation, inclusion homogenization temperature, authigenic illite dating, and ESR dating were used to understand the history of hydrocarbon accumulation and its difference among gas reservoirs in the Upper Triassic formation of Sichuan Basin. The results show the hydrocarbon accumulation mainly occurred during the Jurassic and Cretaceous periods; they could also be classified into three stages: (1) early hydrocarbon generation accumulation stage, (2) mass hydrocarbon generation accumulation stage before the Himalayan Epoch, (3) and parts of hydrocarbon adjustment and re-accumulation during Himalayan Epoch. The second stage is more important than the other two. The Hydrocarbon accumulation histories are obviously dissimilar in different regions. In western Sichuan Basin, the gas accumulation began at the deposition period of member 5 of Xujiahe Formation, and mass accumulation occurred during the early Middle Jurassic up to the end of the Late Cretaceous. In central Sichuan Basin, the accumulation began at the early Late Jurassic, and the mass accumulation occurred from the middle Early Cretaceous till the end of the Late Cretaceous. In southern Sichuan Basin, the accumulation began at the middle Late Jurassic, and the mass accumulation occurred from the middle of the Late Cretaceous to the end of the Later Cretaceous. The accumulation history of the western Sichuan Basin is the earliest, and the southern Sichuan Basin is the latest. This paper will help to understand the accumulation process, accumulation mechanism, and gas reservoir distribution of the Triassic gas reservoirs in the Sichuan Basin better. Meanwhile, it is found that the authigenic illite in the Upper Triassic formation of Sichuan Basin origin of deep-burial and its dating is a record of the later accumulation. This suggests that the illite dating needs to fully consider illite origin; otherwise the dating results may not accurately reflect the hydrocarbon accumulation history.

Keywords: Sichuan Basin; Upper Triassic; Hydrocarbon accumulation history; Hydrocarbon generation history; Inclusion homogenization temperature; Authigenic illite dating; ESR dating

1. Introduction

The geochronology of hydrocarbon accumulation is one of the cores in hydrocarbon accumulation process analysis and hydrocarbon accumulation mechanism research, especially for superimposed basins which have experienced multi-stage tectonic movements and multi-stage destruction, with the features of multiple source rocks, multiple hydrocarbon source

☆ This is English translational work of an article originally published in *Natural Gas Geoscience* (in Chinese).The original article can be found at:10.11764/j.issn.1672-1926.2016.01.0050.

* Corresponding author.
E-mail address: wp2009@126.com (P. Wang).

Peer review under responsibility of Editorial Office of *Journal of Natural Gas Geoscience*.

http://dx.doi.org/10.1016/j.jnggs.2016.10.002

regions, multi-stage hydrocarbon generation, multi-period charging, and multiple petroleum systems, hydrocarbon accumulation might occur at any tectonic stage [1–3]. The geochronology of hydrocarbon accumulation can help to determine the time when the hydrocarbon charging started and ended in the present oil and gas reservoirs, the number of hydrocarbon charging periods and the period of charging giving the most contribution to oil and gas reservoirs. Furthermore, the accurate understanding of the geochronology of hydrocarbon accumulation of superimposed basins is quite significant for analyzing hydrocarbon accumulation mechanism, ascertaining hydrocarbon distribution regularities, and improving oil and gas exploration efficiency. There are many methods and techniques to define the geochronology of hydrocarbon accumulation, such as hydrocarbon generation history method, trap formation period method, reservoir saturation pressure method, fluid inclusion method, reservoir geochemistry method, isotopic dating method, reservoir bitumen dating method and hydrocarbon-water contact retrospection method, etc. [2–5]. These methods include direct or indirect, microscopic or macroscopic, qualitative or quantitative, and forward or inversion. They provide the basis for the accurate dating of hydrocarbon accumulation.

The Sichuan Basin is a typical multi-stage superimposed basin with abundant oil and gas resources, and its hydrocarbon accumulation mechanisms and hydrocarbon distribution are very complicated [6–8]. The Upper Triassic, a critical gas pay zone in the Sichuan Basin, provides the gas reserves that was discovered only second to the Lower Triassic Feixianguan Formation. Moreover, the Upper Triassic contributes the second largest gas field (i.e., Guang'an) in the Sichuan Basin [6]. Therefore, it is quite significant to study the geochronology of hydrocarbon accumulation of the Upper Triassic reservoirs in the Sichuan Basin. Studies in such aspect were conducted to a certain extent previously, and mainly focused on the western and central Sichuan Basin, but less focused on the southern Sichuan Basin [5]. Analysis on the differences of geochronology of hydrocarbon accumulation in different areas of the Sichuan Basin has rarely been reported. In order to comprehensively figure out hydrocarbon accumulation mechanisms and hydrocarbon reservoir distribution in the Sichuan Basin, it is necessary to analyze and compare the geochronology of hydrocarbon accumulation of the Upper Triassic reservoirs in different areas of the Sichuan Basin. In this paper, such geochronology was analyzed and determined comprehensively by means of hydrocarbon generation history method, trap formation period method, inclusion homogenization temperature method, authigenic illite dating method, and ESR dating method. Then, the differences of such geochronology in different areas of the Sichuan Basin were analyzed and compared.

2. Geologic setting

The Sichuan Basin is the largest gas-bearing basin in China; it also contributes the highest proven gas reserves, cumulative gas production, and yearly gas production, as well as the most discovered gas fields and gas-producing intervals in China (Fig. 1) [6,7]. The Upper Triassic, one of the major pay zones in the Sichuan Basin, presents bright prospects of exploration with its estimated gas resources reaching as much as 3250×10^8 m^3 [9]. The Upper Triassic experienced sedimentation from marine facies to continental facies, from bottom to top, this includes the first member of the Xujiahe Formation (Xu 1 Member) marine sediments, the Xu 2 Member transitional sediments, and the Xu 3-Xu 6 Members continental coal measure sediments.

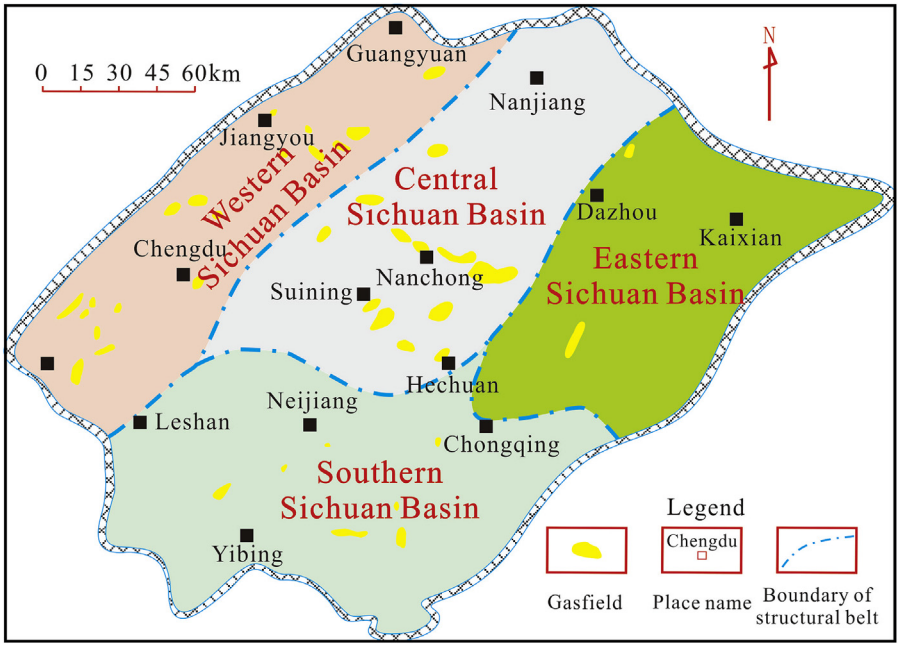

Fig. 1. The distribution of hydrocarbon accumulation zone and gas fields of the Upper Triassic in the Sichuan Basin (modified from Ref. [7]).