

# Detailed assessment of a single-combination oil-gas accumulation zone in a mature exploration basin, China

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**Abstract:** As some basins or blocks in China, especially matured and gas fields, have already entered the mature or highly mature stage in exploration, the old traditional assessment method that treats “complex horizons” as a whole part can not meet the high resolution and precision requirements for detailed exploration in these areas. By comparing oil-gas evaluation systems at home and abroad and considering the evaluation method for “play” abroad, a single-combination assessment method for oil and gas accumulations in high matured exploration basins were put forward. The new method, composed of geological evaluation, resources estimation and target selection, focuses on conducting a division of the assessment horizon based on a combination of a regional/sub-regional seal and its corresponding reservoirs and hydrocarbon-supplying area, confirms the test results of drilled wells and the distribution of known reservoirs, and depicts boundaries of every key geological element. Finally, these preliminary maps of key elements are overlapped to figure out the scope and type of favorable exploration targets, hydrocarbon-supplying system, channel types, charge capacities, and the most favorable prospective traps. Detailed exploration practices in Qikou depression, Bohai Bay Basin, show this evaluation method works well.

**Key words:** fine exploration; exploration assessment system; play; single-combination assessment

## Introduction

A mature exploration basin/depression is generally defined as an area where the exploration level is relatively high after a long history of exploration and production, the proven rate of petroleum resources is more than 50%, new discovered oil-gas fields are mainly small and medium in size, and non-structural oil-gas reservoirs are major prospects in recent years of exploration. Now mature exploration areas in China include Songliao Basin, Bohai Bay Basin, northwestern margin of Jungar Basin, Jiuxi Area of Qiuquan Basin, and Chuanzhong Area of Sichuan Basin. Exploration of recent years in China show that the mature exploration areas are still the major contributor to reserves and production increase, from which more than 50% increment in reserve comes. Meanwhile, a lot of effective and applicable assessment methods and corresponding ideas have taken shape during the fine exploration in these areas, one of which is the assessment of oil-gas accumulation zone in a single-combination, not in “complex” horizons or combinations as a whole held by the old traditional method.

## 1 Comparison of oil-gas exploration evaluation systems from different countries/organizations

Since the first exploration well in the world was drilled in

1859, more than 100 years have passed in petroleum exploration and research. China and other countries/organizations have established different exploration assessment systems of their own, targeting each geological unit at different level/category ranking from petroliferous provinces, basins, sub-units in a basin, finally to traps (Fig. 1). The exploration assessment systems of China and America are different in definition and assessment method of sub-units of a basin [1–5]. Petroleum geologists in China successively proposed terms like “source control” in a hydrocarbon-generating sag and “complex oil-gas accumulation zone”, and their corresponding evaluating processes, guiding the discovery of many large-size oil-gas fields in China during continuous exploration activities in Chinese terrestrial basins since the 1960s; while researchers from America proposed the assessment method of “petroleum system” and “play”. Figure 1 shows that there is a big difference at the third and fourth levels between China and American systems. At the third level, study on petroleum systems focusing around “four figures and one table” was proposed by foreign researchers [6]. Meanwhile, Chinese researchers realized that distribution of oil and gas is controlled by hydrocarbon-generating centers in terrestrial basins in China [7], and then established an oil and gas distribution model according to so called “source control” concept

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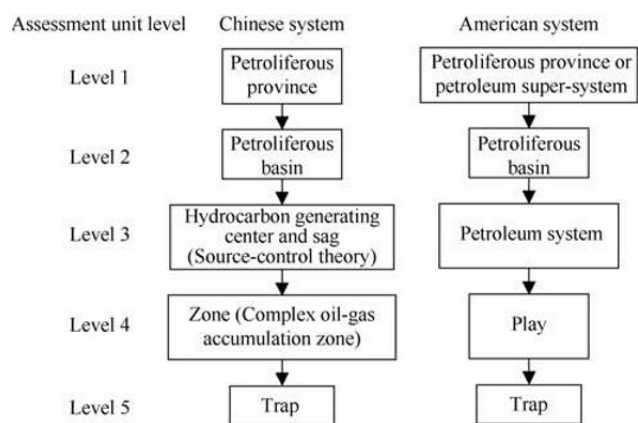


Fig. 1 Comparison of exploration assessment systems between China and America

in a sedimentary sag/fault depression. Therefore, every aspect of comprehensive assessment in petroleum geology is conducted around a sag or fault depression at the third level in China. But no corresponding standards have been set up, and there is great flexibility during assessment.

As for the fourth level, “play” was proposed by overseas researchers, Chinese researchers have different expressions for “play” due to understanding and translation from English into Chinese. If “play” is translated into the Chinese term “accumulation-forming combination”, more components of geological features on profile are literally added to the term “play” in meaning. If “play” is translated into the Chinese term “complex oil-gas accumulation zone”, the fourth assessment unit in China system, more components of areal multi-horizon overlapping on plain are literally added to the term “play” in meaning. So there is an obvious difference between “complex oil-gas accumulation zone” in the China System and “play” in the American system (Table 1). We think that there is no need to dispute how to translate and express “play” in Chinese. The key question that requires us to answer is how to absorb, digest and use the idea and key elements from “play” into our assessment system.

## 2 Connotation comparison of “play” and the Chinese “complex oil-gas accumulation zone”

During exploration, the most attention is often paid to the fourth and fifth units, the major targets in commercial exploration stage [1]. As traps are the most direct drilling targets, trap assessment is the most mature and complete section in the Chinese oil-gas assessment flowchart. On the contrary, “accumulation zone” assessment is basically a relatively weak link in exploration practices in China. However, the “accumulation zone” assessment has a direct effect on strategic planning of exploration, investment decision and exploration prospect selection.

As to “play”, researchers have different understandings on its meaning [8–11]. But its core content is unified. The most popular definition of a play proposed by P.A. Allen in 1990 is a family of undrilled prospects and discovered pools of petroleum that are believed to share a common gross reservoir, regional seal, and petroleum charge system. The key factors/elements of the petroleum play include a reservoir unit, a regional/sub-regional seal, an oil-gas charge system, a petroleum trap, and the proper configuration of the above four elements. If there is some doubt as to whether the geological factors actually do combine to produce a petroleum accumulation, the play is considered “unproven”. In addition, D.A. White (1988) listed all key items of geological information that is involved in mapping an oil-gas play for exploration and assessment [10], such as the areas where source rocks are present and mature, migration zones around the kitchen, the depositional or erosional limits of the reservoir unit, the areas where there is an effective regional seal, the areas where traps are present, and so on, and stressed all the above items should be present to define the favorable areas for oil-gas prospects. This kind of mapping is very similar to the comprehensive assessment map of complex oil-gas accumulation zone in China’s exploration evaluation system.

P.A. Allen (1990) proposed “play fairway” be used to

Table 1 Comparison of “play” abroad and the Chinese “complex oil-gas accumulation zone”

Unit	Naming principle	Assessment extent	Horizon	Seal	Reservoir	Oil-gas charging system	Trap type	Expl. ideas	Availability
Play	Mainly by reservoir name	From source area, via conduit area, to the known oil-gas reservoirs and prospective traps	One single combination consisting largely of reservoir rock and seal	A set of sub-regional seal (covering the extent from hydrocarbon source area to oil-gas reservoirs and prospective traps)	One set of reservoir rock	From the same charging system. Emphasizing on the whole extent of hydrocarbon source and conduit areas, easy to calculate oil-gas accumulation volume	One type or multiple types	Aiming at one set of combination to conduct assessment and exploration	Quickly commercial assessment
Zone	Chiefly by names of place, structural or sedimentary units	A structural belt or stratigraphic belt with multiple sets of combinations	Multiple sets of combinations	More than two sets of regional or sub-regional seals	Multiple horizons of reservoir rock	Possibly from more than one charging system. Often dividing the lower part of a slope or the deep hydrocarbon source area of a sag into a single zone	Multiple types	Emphasizing the integrated assessment and exploration of multiple combinations	Early and middle stages of exploration assessment

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