高等学校教材

石油科技英语

江淑娟　编著

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内 容 提 要

本书选文内容包括石油工业上下游主要技术流程基本知识，所涉及专业术语均予以列出；每一章节中需重点掌握的概念知识和理解难点均有相应的思考题及阅读理解练习题；为提高读者的翻译技能，还针对英语思维典型句式选编了翻译练习题。全书语言及专业难点均通过习题方式予以解决。本书以石油高校非石油专业学生或石油专业英语基础薄弱者为对象，也可作为短期石油英语培训教材使用。

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前　言

随着石油系统对外合作项目的逐年增多，众多该领域相关人员，特别是非石油专业工作者，迫切需要掌握石油英语基础知识。即便是石油专业工作者，也需要拓展该领域内的相关知识面，及时了解国外石油工业发展动态，以便更高效地参与国际交流与合作。本书的编写正是顺应了这一需求，力图使读者短时间内系统掌握石油科学技术，同时也掌握地道、规范的石油英语表达法。

本书选材涵盖了石油上下游主要工程技术及生产流程的基本知识，包括油气藏、油气勘探、油气井工程、油田开发工程、油气集输、石油化工等内容，具有很强的系统性，语言地道、规范，内容脉络清晰、深入浅出。在编写过程中本着任务型教学理念，对语言及专业两方面的重点和难点通过科学设计练习予以解决。对需重点掌握的概念知识和理解难点配有相应的思考题及阅读理解练习题；每一章节中所涉及的专业术语均予以列出；并针对英语思维典型句式编写了翻译练习题，以示英语、汉语之间的语言差异，从而有效地提高读者的翻译技能。阅读理解题附有参考答案，思考题和翻译题答案从略，可参阅原文及译文。

作为石油科技英语基础教材，本书适合于石油高校非石油专业作为石油知识科普使用，也适合于石油专业学生提高专业英语水平、拓展相关知识面，及对油田工作人员进行专业英语短期培训使用。

在本书编写过程中，中国石油大学的孙旭东教授、戴卫平教授给予了积极的指导，吴志坚教授和朱志强博士对本书内容进行了审阅并提出了宝贵的修改意见，唐辉辉、王勃、包莎莎、黄艳丽和秦亮在资料的收集、整理等方面给予了大力协助，在此一并衷心致谢。对于书中存在的不足之处敬请广大同仁不吝指教。

编　者

2007 年 1 月

目　　录

Chapter One

Petroleum Reservoir

1.1 Generation of Oil and Gas

Petroleum is a result of the deposition of plant or animal matter in areas that are slowly subsiding. These areas are usually in the sea or along its margins in coastal lagoons or marshes, occasionally in lakes or inland swamps. Sediments are deposited along with the organic matter and the rate of deposition of the sediments must be sufficiently rapid that at least part of the organic matter is preserved by burial before being destroyed by decay. As time goes on and the area continues to sink slowly (because of the weight of sediments deposited or because of regional tectonic forces), the organic material is buried deeper and hence is exposed to higher temperatures and pressures. Eventually chemical changes result in the generation of petroleum, a complex, highly variable mixture of hydrocarbons, including both liquids and gases (part of the gas being in solution because of the high pressure). Ultimately the subsidence will stop and may even reverse.

As the great weight of the overlying rocks and sediments pushed downward, the petroleum was forced out of its birthplace. It began to migrate. Seeping through cracks and fissures, oozing through minute connections between the rock grains, petroleum began a journey upward. Indeed, some of it eventually reached the surface where it collected in large pools of tar, there to lie in wait for unsuspecting beasts to stumble into its sticky trap. However, some petroleum did not reach the surface. Instead, its upward migration was stopped by an impervious or impermeable layer of rock. It lay trapped far beneath the surface. It is this petroleum that today's oilmen seek.

Sedimentary rocks are porous, porosity being the fractional volume of the rock occupied by cavities or pores. Petroleum collects in these cavities, intermingled with the remaining water that was buried with the sediments. When a significant fraction of the pores is interconnected so that fluids can pass through the rock, the rock is permeable. Permeability permits the gas, oil and water to separate partially because of their different densities. The oil and gas tend to rise and will eventually reach the surface of the earth and be dissipated unless they encounter a barrier which stops the upward migration. Such a barrier produces a trap. Places where oil has reached the surface are called "seeps" or "shows". In Trinidad in West Indies there are a number of active seeps.

The anticline shown in vertical cross-section is a common type of trap and often the easiest to map. Cover bed is impermeable while the reservoir rock is permeable. Oil and gas can collect in the reservoir rock of the anticline until the anticline is filled to the spill point. While an ordinary diagram is two－dimensional, similar conditions must hold for the third dimension, the structure forming an inverted bowl. If spill point is the highest point at which oil or gas can escape from the anticline, the contour through spill point is the closing contour and the vertical distance between spill point and the highest point on the anticline is the amount of closure. The quantity of oil that can be trapped in the structure depends upon the amount of closure, the area within the closing contour, and the thickness and porosity of the reservoir beds.

In a fault trap a permeable bed, overlain by an impermeable bed, is faulted against impermeable beds. A trap exists if there is also closure in the direction parallel to the fault, for example because of folding. In a pinch－out reservoir bed gradually thins and eventually pinches out. A trap is formed when the upper and lower beds are impermeable and closure also exists in the direction to both sides, perhaps because of folding or faulting.

A salt dome formed when a mass of salt flows upwards under the pressure resulting from the weight of the overlying sediments. The salt dome bows up sedimentary beds and seals off disrupted beds and so provides traps over and around the sides of the dome.

A limestone reef grew upwards on a slowly subsiding platform. The reef is composed of coral or other marine animals with calcareous shells that grow prolifically under the proper conditions of water temperature and depth. As the reef subsides, sediments are deposited around it. Eventually the reef stops growing, perhaps because of a change in the water temperature or the rate of subsidence, and the reef may be buried. The reef material is usually highly porous and often is covered by impermeable sediments. Hence the reef may form a trap for petroleum generated in the reef itself or flowing into it from another bed. Some petroleum traps are shown in Fig. 1. 1.

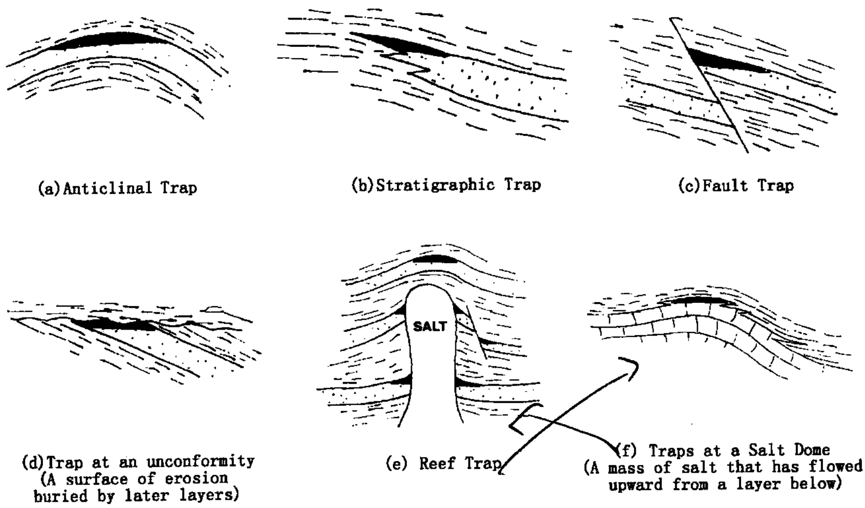


Fig. 1. 1 Some Petroleum Traps

✲ Special terms:

tectonic force 构造力
hydrocarbon 碳氢化合物，烃
overlying rock 上覆岩石
pool of tar 焦油池
sedimentary rock 沉积岩
porosity 孔隙度
permeability 渗透性，渗透率
seep 油苗
show 显示
anticline 背斜
cover bed 盖层
reservoir rock 储油岩层
spill point 溢出点
contour 等值线
closing contour 闭合等值线
amount of closure 闭合度值
fault trap 断层圈闭
closure 闭合
folding 褶皱作用
pinch out 尖灭
salt dome 盐丘
overlying sediment 上覆沉积物
seal off 封闭
limestone reef 灰岩礁
calcareous shell 钙质介壳

✲ Exercises:

Ⅰ. Answer the following questions.

1. What is petroleum?
2. How is petroleum generated?
3. How does petroleum migrate?
4. How is salt dome formed?

Ⅱ. For the passage there are some questions or unfinished statements, each of them being provided with four suggested answers marked (A), (B), (C) and (D). Decide on the best one and mark your answer.

1. According to this passage, it is less possible to find petroleum in ____________.

A. coastal lagoons
B. the margins of the sea
C. mountains
D. inland swamps

2. The rate of deposition of sediments must be rapid enough for the organic matter to ____________.

A. sink slowly
B. be preserved
C. be exposed to higher temperatures
D. be buried deeper

3. The quantity of oil trapped in a anticline depends upon all the following Except ____________.

A. the amount of closure
B. the area within the closing contour
C. the vertical distance from the bottom to the highest point of the anticline
D. the thickness and porosity of the reservoir beds.

4. A trap ____________ .

A. permits the oil and gas to be dissipated

B. stops the upward migration of oil

C. is in the anticline

D. is the closing contour

5. Which of the following does not contribute to the formation of a salt dome trap?

A. The pressure from the weight of the overlying sediments results in the upward flowing of a mass of salt.

B. A salt dome comes into being.

C. The salt dome bows up sedimentary beds and seals off disrupted beds.

D. The salt dome is usually highly porous and often covered by impermeable sediments.

Ⅲ. Translate the following sentences into Chinese.

1. The oil and gas tend to rise and will eventually reach the surface of the earth and be dissipated unless they encounter a barrier which stops the upward migration.

2. A salt dome formed when a mass of salt flows upwards under the pressure resulting from the weight of the overlying sediments.

3. The reef is composed of coral or other marine animals with calcareous shells which grow prolifically under the proper conditions of water temperature and depth.

1.2 Petroleum Traps

Traps

A trap is the place where oil and gas are barred from further movement. Notice the cap rock at the top of each trap. Cap rock is non - porous and impermeable to the fluids below. Therefore, underground pressure cannot force the reservoir fluids through the cap rock and up to the surface.

Within the trap the productive reservoir is termed the pay. The vertical distance from the top of the reservoir to the petroleum - water contact is termed gross pay. This thickness may vary from only one or two meters in Texas to several hundred meters in the North Sea and Middle East. All of the gross pay does not necessarily consist of productive reservoir, however. So gross pay is usually differentiated from net pay. The net pay is the cumulative vertical thickness of a reservoir from which petroleum may be produced. Development of a reservoir necessitates mapping the gross - net pay ratio across the field.

A trap may contain oil, gas, or both. The oil - water contact (OWC) is the deepest level of producible oil. Similarly, the gas - oil contact (GOC) or gas - water contact (GWC), as the case may be, is the lower limit of producible gas. The accurate evaluation of these surfaces is essential before the reserves of a field can be calculated, and their establishment is one of the main objectives of well logging and testing. Where oil and gas occur together in the same trap, the gas overlies the oil because the gas has a lower density. Whether a trap contains oil and/or gas depends both on the chemistry and level of maturation of the source rock, and on the pressure and temperature of the reservoir itself. Not only does a gross gravity separation of gas and oil occur within a reservoir but more subtle variation may also exist.

Types of Traps

Geologists have classified petroleum traps into two basic types: structural traps and stratigraphic traps.

Structural traps are traps that are formed because of a deformation in the rock layer that contains the hydrocarbons. Two common examples of structural traps are fault traps and anticlines.

A fault trap occurs when the formations on either side of the fault have been moved into a position that prevents further migration of petroleum. For example, an impermeable formation on one side of the fault may have moved opposite the petroleum-bearing formation on the other side of the fault. Further migration of petroleum is prevented by the impermeable layer.

An anticline is an upward fold in the layers of rock, much like an arch in a building. Petroleum migrates into the highest part of the fold, and its escape is prevented by an overlying bed of impermeable rock.

Stratigraphic traps are traps that result when the reservoir bed is sealed by other beds or by a change in porosity or permeability within the reservoir bed itself. There are many different kinds of stratigraphic traps. In one type, a tilted or inclined layer of petroleum-bearing rock is cut off or truncated by an essentially horizontal, impermeable rock layer. Or sometimes a petroleum-bearing formation pinches out; that is, the formation is gradually cut off by an overlying layer. Another stratigraphic trap occurs when a porous and permeable reservoir bed is surrounded by impermeable rock. Still another type occurs when there is a change in porosity and permeability in the reservoir itself. The upper reaches of the reservoir may be impermeable and nonporous, while the lower part is permeable and porous and contains hydrocarbons.

Petroleum Accumulation in Traps

About 80 to 90 per cent of the known petroleum reserves occur in structural traps.

The anticlinal trap is the simplest and commonest form of petroleum accumulation. A porous and permeable reservoir rock must be sealed above by a fine-grained, relatively impermeable bed such as clay, shale, marl, or salt. The structure is in the form of a dome or elliptical dome that forms a closed space in which the oil or gas, being less dense than water, accumulates. Contours drawn on the top of the reservoir form rings or ellipses (or other closed shape) because without their closure the petroleum would spill out. More technically, it is a space of minimum potential energy of the petroleum with respect to the water, and the driving force of the water is insufficient to drive the petroleum out of the anticlinal.

Within the reservoir, oil lies on water, and the interface between them is known as the "oil/water contact." This surface is horizontal or nearly horizontal. In theory, it is only horizontal if the water is at rest, but practice slopes have been found to be gentle. During production of the reservoir the oil/water contact moves upwards as the produced oil is replaced by water; but not all the oil moves, because some residual oil is left in the pores. If gas occurs associated with the oil, it forms a gas cap and the gas/oil contact initially is also a horizontal or nearly horizontal surface. Since an associated gas cap provides important reservoir energy, it is not produced until all the recoverable oil has been produced from the reservoir; so any pressure decline due to oil production results in an expansion of the gas cap, and the gas/oil contact moves downwards. This downward movement is in response to pressure changes that may not be equal over the reservoir, so the original horizontality may be lost as production begins.

Anticlinal traps may have one or several separate reservoirs (there are fields with more than fifty) and each has its own oil/water, gas/oil, or gas/water contacts. They usually behave as separate reservoirs and must be produced as separate reservoirs, but sometimes the oil/water contacts of different reservoirs are at the same level – the upper reservoir being commensurately more extensive than the lower. When this happens, it is argued that they are connected in some way and they should be regarded as a single reservoir and produced in such a manner that their equilibrium is maintained as far as possible.

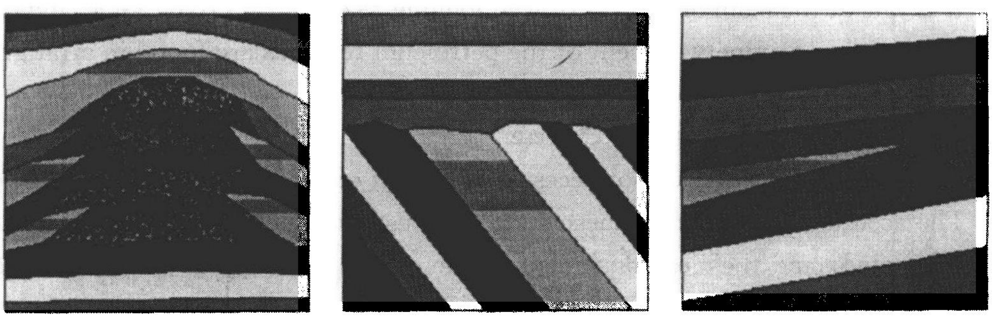
Fault traps are also common. Again, there must be a porous and permeable reservoir rock that is sealed above by a fine – grained, relatively impermeable bed. But the real trap is provided by the fault, which prevents further updip migration either by the fine – grained material in the fault itself (the so – called "fault gouge" that results from the movement on the fault plane) or by the brining of a fine – grained relatively impermeable bed on the other side of the fault to the position that truncates the reservoir.

Stratigraphic traps comprise an interesting variety of accumulations in which the trapping mechanism, as the name suggests, is from stratigraphic rather than structural causes. In these, the essential features remain a porous and permeable reservoir rock sealed by a fine – grained relatively impermeable rock, but the configuration of these to form a trap arises from the particular sedimentary process and nature of the resulting sediments. The most obvious forms of stratigraphic trap are fossil coral reefs such as those of western Canada and Libya and reef – like mounds such as those of Mexico and parts of the United States. In these, the voids in the reef or reeflike reservoir contain the petroleum that is prevented from leaking out by the clay or shale in which the reef is enveloped. These voids are not like the pore spaces in sandstone reservoirs, but more solution cavities and fractures. Production rates tend to be much higher than from sandstone reservoirs (indeed, rates over 8,000 m^3/day—50,000 bbl/day—have been obtained in Mexico and Libya). The frictional resistance to fluid movement tends to be much less, so there is better communication through the reservoir and it can be produced with fewer wells. Reefs tend to be single accumulations, some of which are very large.

Perhaps the commonest form of stratigraphic traps (but not the most important) is the wedging or pinching out of a sand. Discontinuous sands, such as those that formed part of an old river system ("shoe - string" sands) are enveloped in fine - grained sediment and may form a trap. Structural traps are shown in Fig. 1. 2. Stratigraphic traps are shown in Fig. 1. 3.

Anticline　　Salt Dome　　Fault

Fig. 1. 2 Structural Traps



Reef　　Unconformity　　Pinch-Out

Fig. 1. 3 Stratigraphic Traps

✲ Special terms:

pay 产油层
gross pay 总产油层
net pay 净产油层
petroleum - water contact /oil - water contact 油水接触面
gas - oil contact 气油接触面
gas - water contact 气水接触面
well logging 测井
well testing 试井
source rock 烃源岩
structural trap 构造圈闭
stratigraphic trap 地层圈闭
formation 地层
petroleum - bearing formation 含油层

shale 页岩
marl 泥灰岩
contour 等高线
potential energy 位能
gas cap 气顶
fault gouge 断层泥
fault plane 断层面
solution cavity 溶洞
fracture 裂缝
bbl = barrel 桶
wedge out 尖灭

✲ Exercises:

Ⅰ. Answer the following questions.

1. What is structural trap?
2. What is stratigraphic trap?
3. What are gas cap and its function?

Ⅱ. Decide whether the following statements are true or false.

1. Net pay is the vertical distance from the top of the reservoir to the petroleum - water contact.
2. Gross pay is the cumulative vertical thickness of a reservoir from which petroleum may be produced.
3. It is necessary to get the gross - net pay ratio across the field to develop a reservoir.
4. It is one of the main objectives of well logging to establish OWC, GOC and GWC.
5. Some eighty to ninety percent of the petroleum reserves are found in stratigraphic traps.

Ⅲ. Translate the following into Chinese.

1. All of the gross pay does not necessarily consist of productive reservoir, however.
2. The accurate evaluation of these surfaces is essential before the reserves of a field can be calculated, and their establishment is one of the main objectives of well logging and testing.
3. In theory, it is only horizontal if the water is at rest, but practice slopes have been found to be gentle.
4. In these, the voids in the reef or reeflike reservoir contain the petroleum which is prevented from leaking out by the clay or shale in which the reef is enveloped.
5. The frictional resistance to fluid movement tends to be much less, so there is better communication through the reservoir and it can be produced with fewer wells.

1.3 Reservoir Rock and Pod of Active Source Rock

Reservoir Rock

A petroleum reservoir consists of a suitably shaped porous stratum of rock that is capped with an impervious rock. The shape of the structure must be such that the oil (or gas) can collect in one zone to form an accumulation, and the cap rock is essential to prevent the further upward migration of the contents. The simplest type of reservoir is a dome – shaped structure or "anticline", most of the reservoirs in the Middle East are of this form. In some instances the dome may be almost hemispherical whereas in other cases it may be narrow and elongated. The size of these domes varies enormously but typical structures can be anything up to about 30 miles long and 5 miles wide.

The nature of the reservoir rock is extremely important, as the oil is stored in the small spaces or pores that separate the individual rock grains. Sandstones and limestones are generally porous, and in the main these are the most common types of reservoir rocks. Porous rocks may sometimes also contain fractures or fissures, which will add to the oil – storing capacity of the reservoir. The "porosity" of a rock is the volume of all the pores and opening expressed as a percentage of the total volume of the reservoir rock. Now if oil is to enter or to leave a porous rock, there must be free connection between one pore and the next. The ability of the rock to allow the passage of fluids through its interstices depends on the size of the connecting channels that exist between one pore space and the next and is called the "permeability" . If rocks are traversed by cracks or fissures, their permeabilities are greatly increased. The Iranian limestone reservoirs exhibit this type of permeability, and this is one of the main reasons for the tremendous productivity of the average Iranian well.

The rate at which oil can be extracted depends largely on the permeability of the rock and, if this is low, the production obtained from an individual well might be meager to offset its cost so that the development of the reservoir would be ruled out on economic grounds. Such consideration is required to be applied even more strictly in the cases of costly offshore locations such as the North Sea. In general the porosity and permeability vary from place to place within the same reservoir rock. The variations may be so marked that wells located in different parts of the reservoir may have widely differing production rates. Porosity and permeability variation is, therefore, of great importance when considering the development of the reservoir and the methods to be employed in extracting the oil from it.

Major and minor reservoir rocks are determined from the percentage of in – place petroleum that originated from a particular pod of active source rock. If the volume of in – place petroleum is unavailable, recoverable hydrocarbons are the next best volume. All the discovered oil and gas fields included in a petroleum system are listed and the original in – place (recoverable) hydrocarbons are determined by stratigraphic interval. The volumes of in – place hydrocarbons for each stratigraphic interval are added up, and the percentage for each is determined. Reservoir rocks that contain minor amounts of in – place hydrocarbons are the minor reservoir rocks. Usually one stratigraphic interval contains most of the in – place hydrocarbons, so this interval is the major reservoir rock. The major reservoir rock indicates the optimum migration path for the petroleum between the pod of active source rock and the traps that include the major reservoir rock. The minor reservoir rock indicates the least effective migration path or one that should be studied for overlooked prospects.

Pod of Active Source Rock

A pod of active source rock indicates that a contiguous volume of organic matter is creating petroleum, either through biological activity or temperature, at a specified time. The volume or pod of active source rock is determined by mapping the organic facies (quantity, quality, and thermal maturity) and considered to be the presently active, inactive, or spent source rock using organic geochemical data displayed as geochemical logs. Organic matter generates petroleum either biologically or thermally. From the time a petroleum phase is created, a petroleum system exists. A source rock is active when it is generating this petroleum, whereas an inactive or spent source rock was an active source rock at some time in the past. For example, the Deer Shale source rock was an active source rock in Late Paleozoic time, but is presently an inactive source rock. The *pod of active source rock* is that contiguous volume of source rock that is generating gas biologically or oil and gas thermally. The active time can be present day or any time in the past.

With regard to the range of ages recognized for oil source beds at the time of expulsion, the documented maximum time of expulsion after deposition of a source bed is at least 300 million years. The actual time span for the oldest effective source beds, both oil and gas, actually may be much greater. On the other end of the scale, the minimum age of a source bed at the time of oil expulsion is only a few million years and perhaps less than two million.

Exclusive of bacterial gas, the identification of very young effective gas source beds (that have released commercially significant quantities of thermally generated hydrocarbon gas) can be more difficult than for oil source beds because of the additional and very deep burial needed to attain peak gas generation in young deposits. Comparatively minor amounts of gas will precede oil from an oil source bed and gas accompanies expelling oil.

✲ Special terms:

interstice 空隙
extract 开采
fracture 裂缝
fissure 裂隙
pod of active source rock 有效烃源岩
volume of in-place petroleum 石油地质储量
volume of recoverable hydrocarbons 可采储量
rule out 取消
prospect 远景圈闭，远景构造
stratigraphic interval 地层间隔
organic facies 有机相
spent source rock 过熟烃源岩