"十三五"高等院校石油天然气类规划教材

应用地球物理专业英语

地球物理测井分册

宋延杰 ◎ 主编

石油工业出版社
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内 容 提 要

本书根据编者多年从事地球物理测井专业英语教学工作的经验编写而成。全书按地球物理测井内容进行编排,共8章,每章由课文、词汇及难句翻译三部分组成。本书包括电法测井、核测井、声波测井、电声成像测井以及泥质地层解释等内容,全面介绍了地球物理测井的各种方法和综合解释方法。

本书可作为石油高等院校勘查技术与工程及地球物理学本科专业英语教材,也可作为这些专业及其他有关专业的科技人员的在职培训或进修用书。

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前　言

随着我国经济的快速发展，对能源尤其是石油的需求越来越大，我国国内能源的生产和消费结构逐渐成为钳制我国经济发展的瓶颈，这就迫切需要中国的能源企业走出国门，积极参与国际能源市场，为确保我国的能源稳定供给奠定良好的基础。同时，作为企业，在全球化越来越深入的背景下，更加需要我国石油企业实施"走出去"战略，从而提高自身的管理能力、技术水平、盈利能力，实现我国石油企业的可持续发展，提升其在国际市场上的竞争力。为了适应我国石油企业的国际化，培养专业知识扎实、英语交际流畅的人才，让学生具备较强的专业英语的听、说、读、写、译能力已成为我国石油企业对石油专业毕业生的基本要求。

本教材是为石油高等院校中勘查技术与工程、地球物理学等专业的全日制本科设置的应用地球物理专业英语课所编写的，包括地球物理测井和地震勘探两个分册。作为本科生教材，本书力求全面地覆盖勘查技术与工程专业地球物理测井的各种方法和综合解释方法的英语词汇及专业术语，专业内容涉及面广而新。全书按勘查技术与工程专业地球物理测井方向内容进行编排，做到图文并茂，原理与应用并重，同时在每章课文后附有专业词汇及难句翻译。本书题材广泛、内容丰富、重点突出、难度适中，具有系统性和可读性。

本书由东北石油大学宋延杰担任主编。第一章、第五章、第六章、第七章、第八章由宋延杰编写，第二章、第三章、第四章由唐晓敏编写。全书由宋延杰统稿。在本书编写过程中，参考了多部国内外相关教材和专著，在此向其作者表示衷心的感谢。

由于编者水平有限，书中一定还有许多不当之处，在此恳请广大读者批评指正。

编　者

2016 年 5 月

Contents

1 Fundamentals of Reservoir Evaluation

□ Text

1.1 Definitions of Geological Terms

As we will try to demonstrate, in any **reservoir** evaluation, the **log analyst** or, the **geologist** must respond to several questions by asking why, how, when, where, and who. [1]

In order to better respond to these questions it is probably important to review some fundamental notions, starting by the definitions of the terms used in **formation** evaluation.

1.1.1 Formation

A formation "is a **genetic** unit, or a product of uniform or uniformly alternating conditions, and may contain rock of one **lithologic** type, repetitions of two or more types, or extreme **heterogeneity** that in itself may constitute a form of unity compared to the adjacent **strata**". [2]

A formation may be composed of reservoir rocks and/or impervious rocks and/or source rocks. Its "thickness may range from less than a meter to several thousand meters depending on the size of units locally required to best express the lithologic development of a region".

1.1.2 Formation evaluation

Formation evaluation is "the process of evaluating gas-bearing or oil-bearing formations penetrated by a well or wells, and of appraising their commercial significance".

It corresponds to the following steps: (1) determine the **petrophysical** properties of reservoir rocks; (2) evaluate their volume and the nature of their content in gas or oil; (3) estimate their economical potential.

This evaluation implies the study of all the available data that are of: (1) different origins and natures (qualitative, and quantitative); (2) obtained at different scales (kilometric to micrometric), linking constantly the observations made at one scale to those made at another scale.

A typical formation may contain intervals which exhibit the properties of a reservoir.

1.1.3 Reservoir

A reservoir may be defined as a "subsurface volume of rock that has sufficient **porosity** and **permeability** to permit the accumulation of crude oil or natural gas under adequate trap condition". It is generally composed of several **beds** with a typical rock composition.

1.1.4 Bed

A bed is "the smallest formal unit in the **hierarchy** of **lithostratigraphic** units". Its thickness varies between 1cm and several meters. It is generally composed of several depositional or **sedimentation units**.

1.1.5 Sedimentation Unit

A sedimentation unit is "a layer or **deposit** resulting from one distinct act of sedimentation, defined by Otto (1938) as "that thickness of sediment which was deposited under essentially constant physical conditions"; the deposit made during a time period when the **prevailing current** has a mean velocity and deposits some mean size, such as a cross-bedded layer of sand formed under conditions of essentially constant flow and sediment discharge. It is distinguished from like units by changes in particle size and/or fabric indicating changes in velocity and/or direction of flow".

A sedimentation unit has various thickness and extent, in other terms is defined by a succession of two types of geological objects: volumes (**laminae**, strata) determined by the extent of their delimiting surfaces.

1.1.6 Facies

Each sedimentation unit is characterized by its **facies** of which the definition is: "the aspect, appearance, and characteristics of a rock unit, usually reflecting the conditions of its origin; esp. as differentiating the unit from adjacent or associated units".

The attributes describing a facies are: Composition—mineralogic, chemical or elemental; **Texture**; Color; **Structure** (internal)—sedimentary features, direction of transport **paleocurrents**, organic activity; **Fossils** (if any); Geometry—length, width, thickness.

1.1.6.1 Mineralogic Composition

The mineralogic composition is "the make-up of a rock in terms of the species and number of minerals present". A mineral is "a naturally occurring inorganic element or compound having an orderly internal structure and characteristic chemical composition, crystal form, and physical properties (hardness, density, resistivity, magnetism, …)". More than 3,500 minerals have been identified, but most of them are rare species essentially found in **igneous** or **metamorphic** rocks.

Although over 160 different minerals have so far been identified in sediments, less than twenty mineral species form well over 99% of the bulk of sedimentary rocks. 95% of the whole sedimentary rocks can be formed from 10 fundamental mineral species. The most abundant minerals are listed in Tab. 1.1.

Tab. 1.1 The Most Abundant Minerals

Mineral		Percentage, %
Quartz		31.5
Carbonates	**Calcite**	20
	Dolomite	

continued

Mineral		Percentage, %
Micas and **chlorite**		19
Chalcedony (**Chert**)		9
Feldspars	**Potassic feldspars**	7.5
	Plagioclases	
Clay minerals		7.5
Iron oxides		3
All others		3

The mineral identification is traditionally based on certain attributes: color, hardness, specific mass (density), crystal system, optical properties in polarized light, chemical composition, etc. One must add their well logging characteristic. It is the reason why a complete set of logging data will allow the determination of the main minerals composing a rock.

1.1.6.2 Chemical Composition

The chemical composition is "the weight percent of the elements (generally expressed as certain oxide molecules) composing a rock". More than 102 elements have so far been recognized.

But, one must remember that only 8 elements are abundant as constituents of the Earth's crust (Tab. 1.2). They represent more than 99% of the total mass of the Earth's crust. Also, as it can be observed, oxygen is the most abundant component both in weight percentage, atom percentage and volume percentage. Oxygen is associated to a lot of other elements to compose molecules and minerals. Tab. 1.3 lists the oxygen content of the most abundant minerals. In average the weight percentage is close to 50%.

Tab. 1.2 Relative Abundance of Elements in the Earth's Crust

Element	Weight Percentage, %	Element	Weight Percentage, %
Oxygen	46	Calcium	2.4
Silicon	28	Potassium	2.3
Aluminum	8	Sodium	2.1
Iron	6	Other	<1
Magnesium	4		

Tab. 1.3 Oxygen Percentage of the Most Abundant Minerals

Mineral	Oxygen (weight percentage), %	Mineral	Oxygen (weight percentage), %
Quartz	53	Muscovite	48
Calcite	48	Biotite	40
Dolomite	52	Glauconite	49
Anhydrite	47	Illite	50
Orthose	46	Kaolinite	55.7
Albite	48	Chlorite	52
Anorthite	46	Montmorillonite	53

Most of these fundamental elements can be detected and their percentage measured by well logging techniques involving interactions of neutrons with nuclei and spectrometry of the induced and natural gamma rays.

So, any formation is composed of several sedimentation units themselves composed of a collection of rock fragments and/or minerals—themselves composed of elements—presenting a typical internal organization (texture and structure) giving to the sedimentation units some well defined initial petrophysical properties: (1) porosity, **pore** size and distribution; (2) permeability value and **anisotropy**. High vertical resolution measurements will be necessary to precisely recognize each sedimentation unit.

1.1.6.3 Texture

Texture is "the general physical appearance or character of a rock, including the geometric aspects of, and the mutual relations among, its component particles or crystals; e.g. the size, the shape, and arrangement of the constituent elements of a sedimentary rock, or the **crystallinity**, **granularity** and fabric of the constituent elements of an igneous rock. The term is applied to the smaller (**megascopic** or **microscopic**) features as seen on a smooth surface of a **homogeneous** rock or mineral aggregate".

1.1.6.4 Structure

Structure is "a megascopic feature of a rock mass or rock unit generally seen best in the **outcrop** rather than in hand specimen or **thin section**, such as **columnar structure**, **blocky fracture**, **platy parting**, or **foliation**".

1.2 Definitions of Petrophysical Terms

The petrophysical properties of a rock are essentially linked to its porosity, its **water saturation** and its permeability. These **parameters** control the economic potential of a reservoir. Consequently, it is fundamental to determine them.

1.2.1 Porosity

Porosity is the fraction of the total volume of a rock that is not occupied by the solid constituents.[3]

There are several kinds of porosity:

(1) Total porosity, symbol ϕ_t, consists of all the **void** spaces (pores, **channels**, **fissures**, **molds**, **vugs**) between the solid components.

$$\phi_t = \frac{V_t - V_s}{V_t} = \frac{V_p}{V_t} \tag{1.1}$$

where V_p—volume of all the empty spaces (generally occupied by oil, gas or water);

V_s—volume of the solid materials;

V_t—total volume of the rock.

Two components may compose the total porosity:

$$\phi_t = \phi_1 + \phi_2 \qquad (1.2)$$

ϕ_1 is the **primary porosity**. It corresponds to the porosity which existed at the time of the sediment deposition. Generally, it is **intergranular** or **intercrystalline**. It depends on the shape, size and arrangement of the solid particles, and is the type of porosity encountered in **clastic rocks**. It has generally evolved since the sediment deposition due to **compaction** and **diagenetic** effects.

ϕ_2 is the **secondary porosity**, made up either of molds or vugs caused by dissolution or transformation (**dolomitization**) of certain minerals by water circulation, or of cracks, fissures, or fractures generated by mechanical forces (**stresses**). The latters do not increase the porosity of the rocks significantly, although they may considerably increase their permeabilities.

Secondary porosity is a common feature of formations of chemical or organic (**biochemical**) origin. It is generated after the **lithification**.

(2) Interconnected porosity, ϕ_{conn}, is made up only of those spaces which are in communication. This may be considerably less than the total porosity. Consider **pumice stone** for instance, where ϕ_t is of the order of 50%, but ϕ_{conn} is zero because each pore-space is isolated from the others: there are no interconnecting channels.

(3) **Potential porosity**, ϕ_{pot}, is that part of the interconnected porosity which the diameter of the connecting channels is large enough to permit fluid to flow (greater than 20 mm for oil, 5mm for gas). ϕ_{pot} may in some cases be considerably smaller than ϕ_{conn}. Clays or **shales**, for instance, have a very high connected porosity (40%-50% when compacted, and as much as 90% for newly deposited **muds**). However, owing to their very small pores and channels, molecular attraction prevents fluid circulation.

(4) **Effective porosity**, ϕ_e, is a term used specifically in log analysis. It is the porosity that is accessible to free fluids, and excludes, therefore, non-connected porosity and the volume occupied by the **clay-bound** water or **clay-hydration water** (adsorbed water, hydration water of the **exchange cations**) surrounding the clay particles.

N. B. Porosity is a dimensionless quantity, being by definition a fraction or ratio. It is expressed either as a percentage (e. g. 30%), as a decimal (e. g. 0.30) or in porosity units (e. g. 30 p. u.).

The porosity types depend on the rock type.

In reservoirs of detrital or clastic origin, the porosity is essentially intergranular or interparticle. It is controlled by textural parameters such as **sorting**, **packing** and **cement** percentage.

In carbonate reservoirs, Choquette & Pray (1970) have identified several types of pores. They linked them with phenomena (original fabric or other factors) and with time of pore formation. To classify the pore types, they have proposed to take into account some modifying terms such as process, time of formation, size.

Porosities of rocks can vary widely. For example, **salt**, anhydrite, **gypsum**, **sylvite**, very compact **limestones** or **dolostones**, **quartzites** show practically zero porosity. At the opposite, unconsolidated sands may have more than 30% porosity. **Chalk** may have up to 36% porosity.

Shales or claystones may contain over 40% water-filled porosity.

The porosity of a reservoir can be measured with the help of numerous logging tools as it will be indicated through this handbook. But, one of the first physical measurements linked to porosity is the resistivity or its inverse the conductivity.

Indeed, practically all the minerals composing the rocks have a quasi infinite resistivity. However, most of the reservoir rocks show a much lower resistivity. This is due to the water filling the pore space, and the connectivity between pores.

1.2.2 Permeability

The permeability of a rock is a measure of the ease with which fluid of a certain viscosity can flow through it, under a pressure gradient.[4] A permeable rock must have connected porosity.

The **absolute permeability**, symbol K, describes the flow of a homogeneous fluid, having no chemical interaction with the rock through which it is flowing. Darcy's law describes this flow as:

$$Q = K\frac{S(p_1 - p_2)}{\mu h} \tag{1.3}$$

where Q—flow rate, cm^3/s;

μ—fluid viscosity, cP;

S—surface area across which flow occurs, cm^2;

h—thickness of material through which flow occurs, in the direction of flow, cm;

p_1, p_2—pressures, in atmospheres, at the upflow and downflow faces of the material, respectively, Pa;

K—absolute permeability, D.

N. B. The milliDarcy (mD) is the commonly used unit of permeability. 1D (Darcy) = 1000mD (milliDarcies).

In the majority of sediments, initially impregnated with water, oil can only penetrate the water-filled pore-space under a driving force superior to the capillary pressure at the oil-water interface. In other words, in formations possessing very fine channels, where capillary forces are high, a very high driving pressure would be required to cause the oil to displace the water. Under ordinary conditions, such formations would be impermeable to oil. Thus the concept of permeability is a relative one; the same rock being permeable to water, impermeable to oil, at a certain pressure, but permeable to both fluids if one of them is submitted to a force greater than the capillary forces acting.

Darcy's law (Eq. 1.3) in fact assumes a single fluid. Now, a reservoir can quite well contain two or even three fluids (water, oil and gas). In such cases, we must consider **diphasic flow** and **relative permeability**; the flows of the individual fluids interfere and their effective permeabilities are less than absolute permeability, K, defined in Darcy's equation.

The **effective permeability** describes the passage of a fluid through a rock, in the presence of other pore fluids. It depends not only on the rock itself, but also on the percentages of fluids present in the pores, that is, their saturations.

The relative permeabilities (K_{rw}, K_{ro}) are simply the ratios of the effective permeabilities (K_w, K_o) to the absolute (singe-fluid) permeability, K. They vary between 0 and 1, and can also be expressed as percentages: $K_{ro} = K_o/K$ for oil, $K_{rw} = K_w/K$ for water.

Fig. 1. 1 shows a typical variation of relative permeability with saturation for an oil-water system, in a water-wet rock. As the water saturation increases, the relative permeability to oil, K_{ro}, decreases, while for the water, K_{rw}, it increases. Water, therefore, flows with greater ease through the rock and would be produced in increasing quantities at surface. When the oil saturation has decreases to **residual**, S_{hr}, its permeability is zero, and only water will flow.

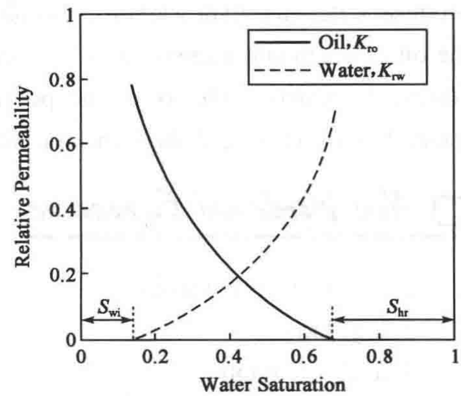

Fig. 1.1 Relative Permeability as a Function of Saturation

The water saturation above which a commercially unacceptable quantity of water (or water-cut) is produced, is called the limiting saturation, $(S_w)_{lim}$.

The converse applies in an oil **imbibition** situation. As the oil saturation increases, so does its relative permeability, K_{ro}. K_{rw} decreases, and it reaches zero at the **irreducible water saturation** S_{wi}; No further displacement of water is now possible.

1.2.3 Saturation

The saturation of a formation is the fraction of its pore volume occupied by the fluid considered.[5] Water saturation, then, is the fraction (or percentage) of the pore volume that contains formation water. If nothing but water exists in the pores, a formation has a water saturation of 100%. The symbol for saturation is S; various subscripts are used to denote saturation of a particular fluid (S_w for water saturation, S_o for oil saturation, S_h for hydrocarbon saturation, etc.).

Oil, or gas, saturation is the fraction of the pore volume that contains oil, or gas. The pores must be saturated with some fluid. Thus, the summation of all saturations in a given formation rock must total to 100%. Although there are some rare instances of saturating fluids other than water, oil, and gas (such as carbon dioxide or simply air), the existence of a water saturation less than 100% generally implies a hydrocarbon saturation equal to 100% less the water saturation (or $1 - S_w$).

The water saturation of a formation can vary from 100% to a quite small value, but it is seldom, if ever, zero.[6] No matter how "rich" the oil or gas reservoir rock may be, there is always a small amount of capillary water that cannot be displaced by the oil; this saturation is generally referred to as irreducible or **connate** water saturation.[7]

Similarly, for an oil-bearing or gas-bearing reservoir rock, it is impossible to remove all the hydrocarbons by ordinary fluid drives or recovery techniques. Some hydrocarbons remain trapped in parts of the pore volume; this hydrocarbon saturation is called the **residual oil saturation**.

In a reservoir that contains water in the bottom and oil in the top the demarcation between the two is not always sharp; there is a more or less gradual **transition** from 100% water to mostly oil.

If the oil-bearing interval is thick enough, water saturation at the top approaches a minimum value, the irreducible water saturation, S_{wi}. Because of capillary forces, some water clings to the grains of the rock and cannot be displaced. A formation at irreducible water saturation will produce water-free hydrocarbons. Within the transition interval some water will be produced with the oil, the amount increasing as S_w increases. Below the transition interval, water saturation is 100%. In general, the lower the permeability of the reservoir rock, the longer the transition interval. Conversely, if the transition interval is short, permeability will be high.

□ New Words and Expressions

1. reservoir[ˈrezəvwɑː] *n.* 储层,油藏
2. log[lɔg] *n.* 测井,测井曲线
3. analyst[ˈænəlɪst] *n.* 分析家
4. geologist[dʒɪˈɔlədʒɪst] *n.* 地质学家
5. formation[fɔːˈmeɪʃən] *n.* 组,地层
6. genetic[dʒɪˈnetɪk] *a.* 成因的
7. lithologic[ˌlɪθəuˈlɔdʒɪk] *a.* 岩性的
8. heterogeneity[ˌhetərədʒəˈnɪətɪ] *n.* 非均质性
9. strata[ˈstrɑːtə] *n.* 地层
10. petrophysical[petrəuˈfɪzɪkəl] *a.* 岩石物理的;岩石物性的
11. porosity[pɔːˈrɔsɪtɪ] *n.* 孔隙度
12. permeability[ˌpəːmɪəˈbɪlɪtɪ] *n.* 渗透率
13. bed[bed] *n.* 层
14. hierarchy[ˈhaɪərɑːkɪ] *n.* 层次,等级
15. lithostratigraphic[ˌlɪθəstrətəˈgræfɪk] *a.* 岩性地层的
16. sedimentation unit 沉积单元
17. deposit[dɪˈpɔzɪt] *n.* 沉积,沉积物
18. prevailing current 主流
19. lamina[ˈlæmɪnə] *n.* 薄层,纹层
20. facies[ˈfeɪʃɪˌiːz] *n.* 相
21. texture[ˈtekstʃə] *n.* 结构
22. structure[ˈstrʌktʃə] *n.* 构造
23. paleocurrent[ˌpælɪəuˈkʌrənt] *n.* 古水流
24. fossil[ˈfɔsl] *n.* 化石
25. igneous[ˈɪgnɪəs] *a.* 火成的
26. metamorphic[ˌmetəˈmɔːfɪk] *a.* 变质的
27. quartz[kwɔːts] *n.* 石英
28. carbonate[ˈkɑːbəneɪt] *n.* 碳酸盐岩
29. calcite[ˈkælsaɪt] *n.* 方解石
30. dolomite[ˈdɔləmaɪt] *n.* 白云石,白云岩

31. mica[ˈmaɪkə]　*n.* 云母
32. chlorite[ˈklɔːraɪt]　*n.* 绿泥石
33. chalcedony(=chalcedonite)
[kælˈsedənɪ]　*n.* 玉髓
34. chert[tʃəːt]　*n.* 燧石
35. feldspar[ˈfeldspɑː]　*n.* 长石
36. potassic[pəˈtæsɪk]　*a.* 含钾的
potassic feldspar　钾长石
37. plagioclase[ˈpleɪdʒɪəukleɪz]　*n.* 斜长石
38. clay[kleɪ]　*n.* 黏土
39. iron oxide　氧化铁
40. anhydrite[ænˈhaɪdraɪt]　*n.* 硬石膏
41. pore[pɔː]　*n.* 孔隙
42. anisotropy[ˌænaɪˈsɔtrəpɪ]　*n.* 各向异性
43. crystallinity[ˌkrɪstəˈlɪnətɪ]　*n.* 结晶度,结晶性
44. granularity[grænjuˈlærɪtɪ]　*n.* 粒度
45. megascopic[ˌmegəˈskɔpɪk]　*a.* 放大的,肉眼可见的
46. microscopic[ˌmaɪkrəˈskɔpɪk]　*a.* 显微的,微观的
47. homogeneous[ˌhɔməˈdʒiːnɪəs]　*a.* 均匀的,均质的
48. outcrop[ˈautkrɔp]　*n.* 露头
49. thin section　薄片
50. columnar structure　柱状构造
51. blocky fracture　块状裂缝
52. platy parting　片状裂开
53. foliation[ˌfəulɪˈeɪʃɪən]　*n.* 叶理
54. saturation[sætʃəˈreɪʃən]　*n.* 饱和度
water saturation　含水饱和度
55. parameter[pəˈræmɪtə]　*n.* 参数
56. void[vɔɪd]　*n.* 空隙,孔隙
57. channel[ˈtʃænl]　*n.* 通道,孔道
58. fissure[ˈfɪʃə]　*n.* 裂缝,裂隙
59. mold[məuld]　*n.* 铸模(孔)
60. vug[vʌg]　*n.* 孔洞
61. primary porosity　原生孔隙度
62. intergranular[ˌɪntəˈgrænjələ]　*a.* 颗粒间的
63. intercrystalline[ˌɪntəˈkrɪstəlaɪn]　*a.* 晶间的
64. clastic rock　碎屑岩
65. compaction[kəmˈpækʃən]　*n.* 压实
66. diagenetic[ˌdaɪədʒəˈnetɪk]　*a.* 成岩作用的
67. secondary porosity　次生孔隙度

68. dolomitization[ˌdɔləmɪtɪ ˈzeɪʃən]	*n.*	白云石化
69. stress[stres]	*n.*	应力
70. biochemical[ˌbaɪəu ˈkemɪkl]	*a.*	生物化学的
71. lithification(= lithifaction) [ˌlɪθɪfɪ ˈkeɪʃɪ]	*n.*	岩化作用,石化作用
72. pumice stone		浮石
73. potential porosity		流通孔隙度
74. shale[ʃeɪl]	*n.*	泥岩,页岩
75. mud[mʌd]	*n.*	泥,泥浆
76. effective porosity		有效孔隙度
77. clay-bound water		黏土束缚水
78. clay-hydration water		黏土水合水
79. exchange cation		可交换阳离子
80. sorting[ˈsɔːtɪŋ]	*n.*	分选
81. packing[ˈpækɪŋ]	*n.*	充填
82. cement[sɪ ˈment]	*n.*	胶结物,水泥
83. salt[sɔːlt]	*n.*	盐岩
84. gypsum ˈdʒɪpsəm]	*n.*	石膏
85. sylvite(= sylvine) [ˈsɪlvaɪt]	*n.*	钾盐
86. limestone[ˈlaɪmstəun]	*n.*	石灰岩
87. dolostone[dəulə ˈstəun]	*n.*	白云岩
88. quartzite[ˈkwɔːtsaɪt]	*n.*	石英岩
89. chalk[tʃɔːk]	*n.*	白垩
90. absolute permeability		绝对渗透率
91. diphasic flow		两相流动
92. relative permeability		相对渗透率
93. effective permeability		有效渗透率
94. residual[rɪ ˈzɪdjuəl]	*a.*	残余的
residual oil saturation		残余油饱和度
95. imbibition[ˌɪmbɪ ˈbɪʃən]	*n.*	吸入,吸渗
96. irreducible[ˌɪrɪ ˈdjuːsəbl]	*a.*	束缚的
irreducible water saturation		束缚水饱和度
97. connate[ˈkɔneɪt]	*a.*	共生的
98. transition[træn ˈzɪʃən]	*n.*	过渡

☐ Notes

1. 正如下文所述,在储层评价中,测井分析家或地质学家必须回答如下几个问题:为什么进行储层评价,怎样进行储层评价,在什么时间和地点进行储层评价,由谁进行储层评价。

2. 地层(组)定义为相同条件下或相同变化条件下的成因单元或产物,它可能包含一种岩性的岩石,或者两种或两种以上岩性重复叠置的岩石,或者非均质性很强的岩石,与相邻岩层