Subsurface Geology Structure

At each stage of a field life cycle raw data has to be converted into information, but for the information to have value it must be influence decision making and profitability.

Methods：

Well-to-Well correlation -- Sequence

Geological Mapping -- Subsurface Geology Research

Contents:

- **Well Correlation**
- **Subsurface Structure of Oil and Gas Fields**

Practices:

- **Well to Well Correlation**
- **Geological Cross Section**

Chapter 3 Well Correlation

Well correlation is used to establish the lateral extent and the variation of the formation and reservoir parameters.

In carrying out a correlation we subdivide the objective sequence into lithologic units and follow those units well to well correlation laterally through the study area.

By correlation we can establish lateral and vertical trends of those parameters throughout the structure.

Chapter 3 Well Correlation

Section 1 Stratigraphic Division Unit

Section 2 Stratigraphic Correlation

Section 3 Lithofacies Correlation

Section 4 Oil Bed Correlation

Section 2 Stratigraphic Correlation

Foundation

Based on Rock Record

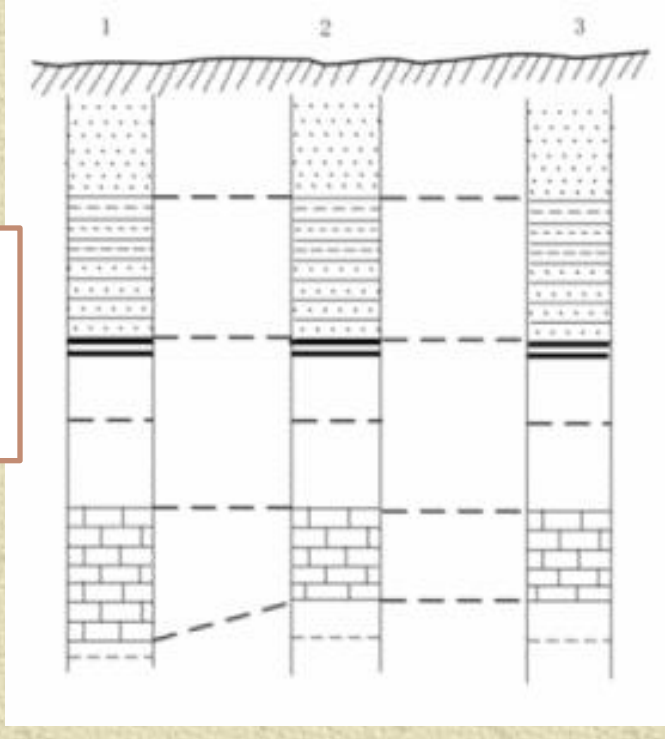
Basis?

▲ **sedimentary sequence**

sedimentary environment and provenance difference in different periods

vertical difference of rock record

（vertical division）



▲**same sedimentary environment and period**

lateral similarity of rock record

（lateral correlation）

I.Scope and Range
II.Method
III. Procedures

I. Scope of Stratigraphic Correlation

1. Global Correlation — Palaeontological and absolute age

2. Regional Correlation — Palaeontological population features

3. Field Correlation — Palaeontological population and combination features, Lithology and sedimentary features

4. Oil Beds Correlation （Chronostratigraphic unit correlation） — lateral similarity

Field wide

II. Correlation Methods

1. Lithological correlation
2. Lithofacies correlation
3. Well logging curve correction
4. Paleontological correction
5. Geochemistry correlation
6. Structure correlation
7. Clay mineral correlation

1. Lithological Correlation

Use lithology and lithological association, sedimentary cycle to conduct stratigraphic correlation, tracing lateral lithological distribution pattern.

- **marker bed correction**
- **cyclic correlation**

1.Llithological correlation

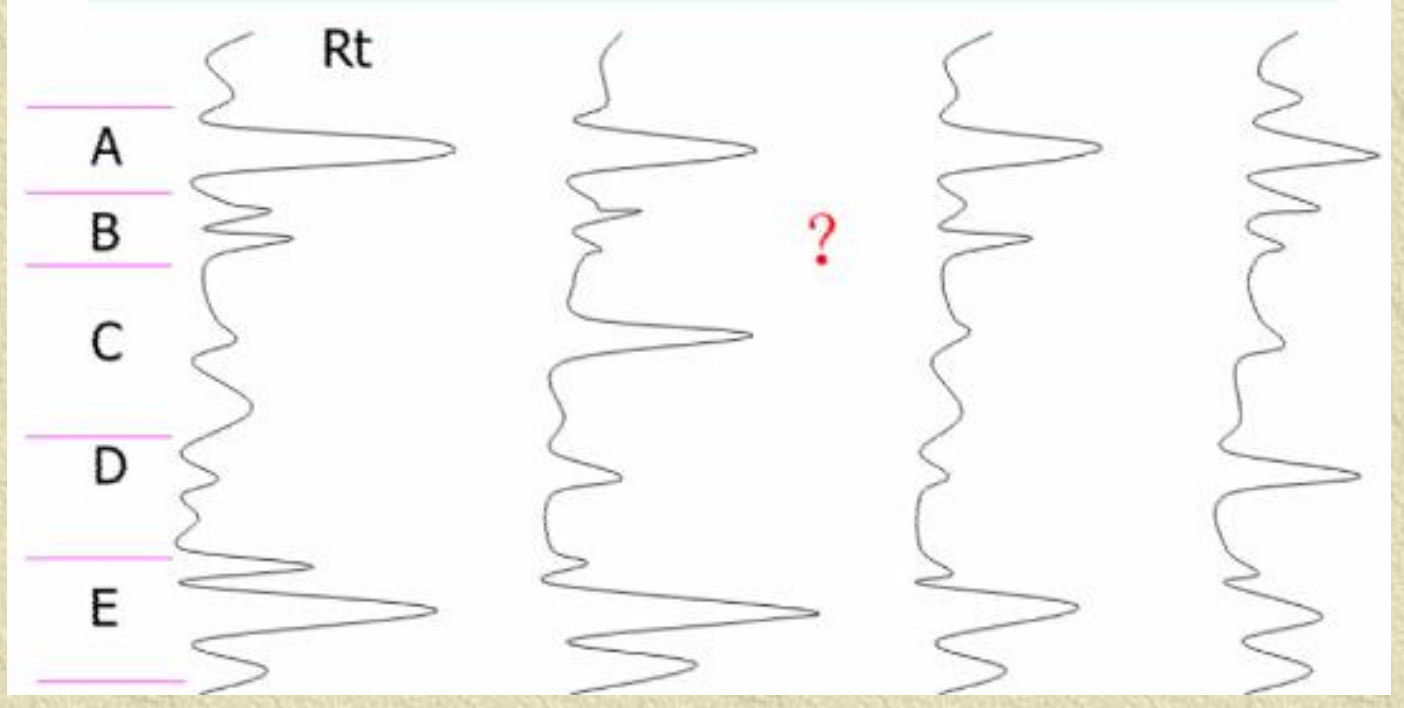
(1) Marker bed correlation

Use regional stable, easily recognized and wide distributed formation as marker bed.

- **Marker bed or standard mark is important indicator because it is special lithology which is easy to identify on the profile and logging curve. In most situation, it is isochronous mark such as steady mudstone, thin carbonate rock (limestone and dolomite), oil shale and thin coal bed and so on.**

Marker bed

Concept： obvious characteristic, wide distribution, isochronic formation or lithologic interface.



Example

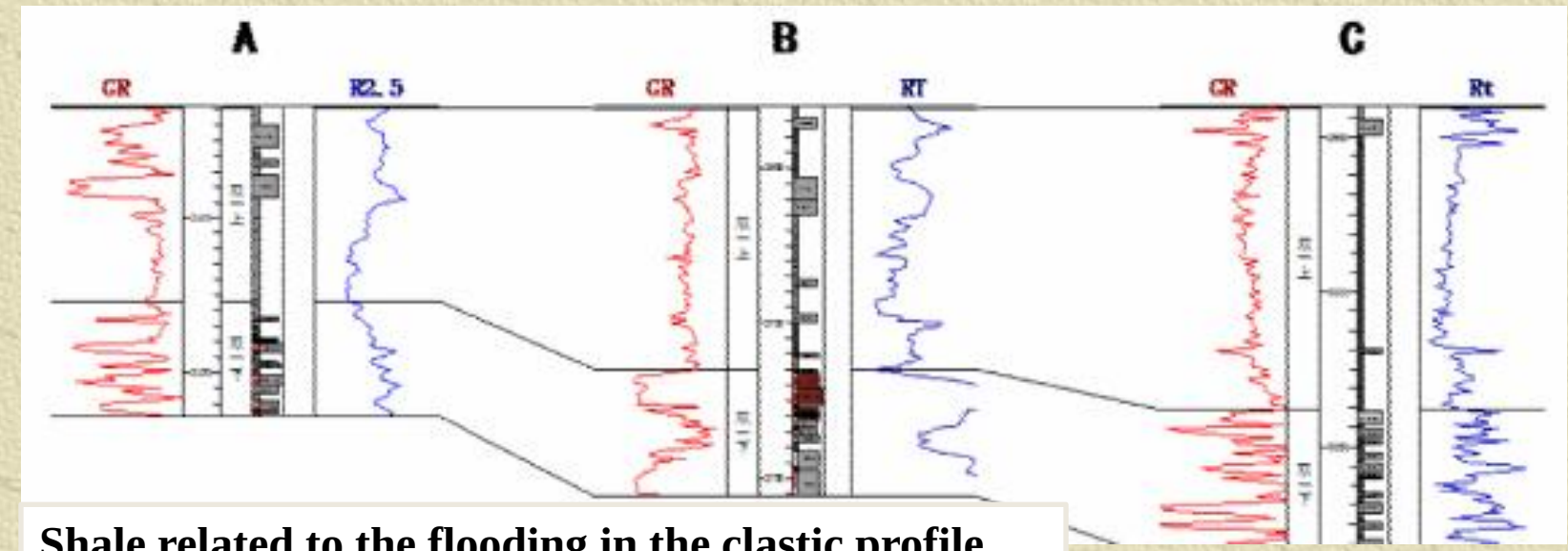
A good datum plane would be a continuous shale because we can assume that it represents a “flooding surface” present over a wide area. Since shales are low energy deposits we may also assume that they have been deposited mostly horizontally, blanketing the underlying sediments thus “creating” a true datum plane.

Isochonism?

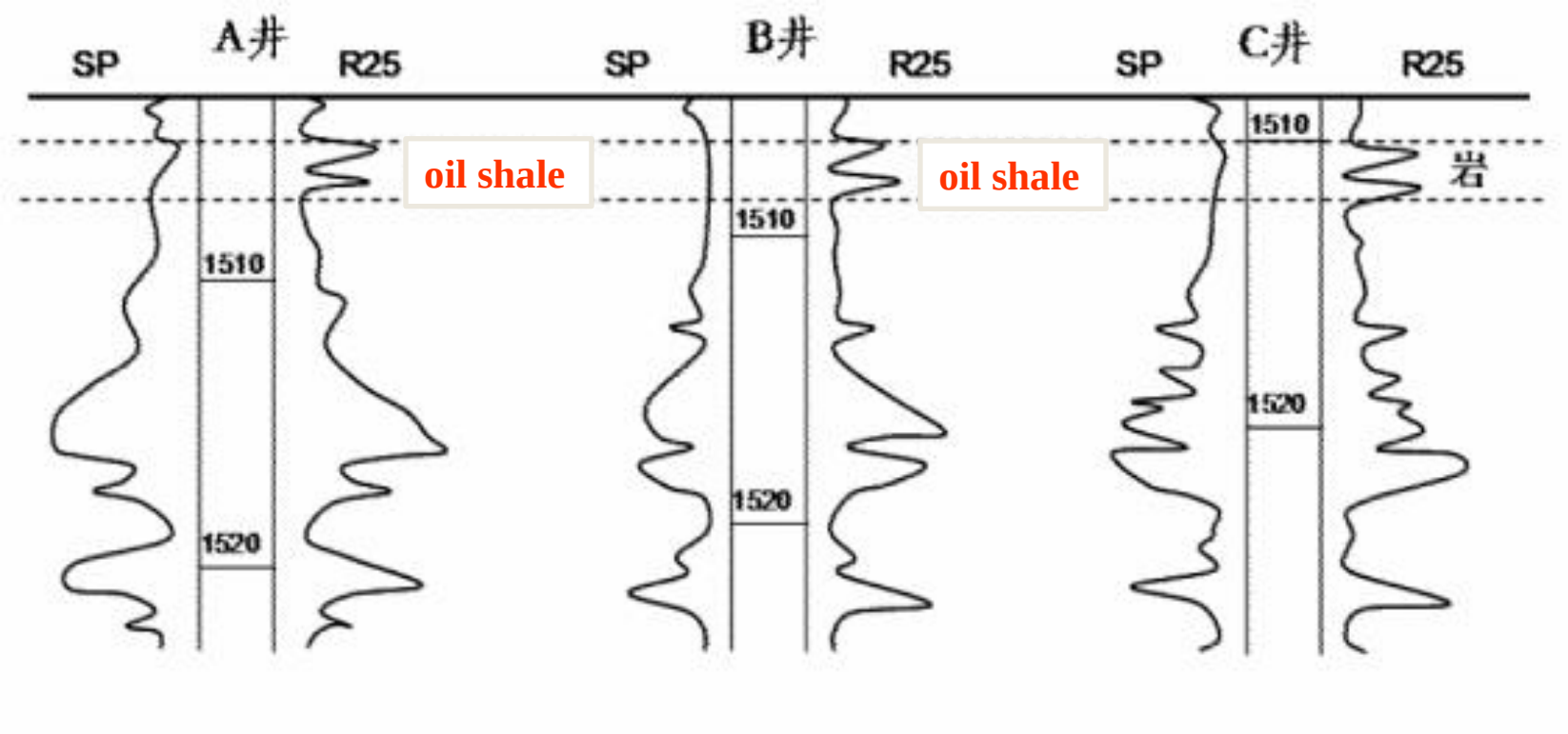
wide sedimentation in the same period

Marker bed associated with flooding

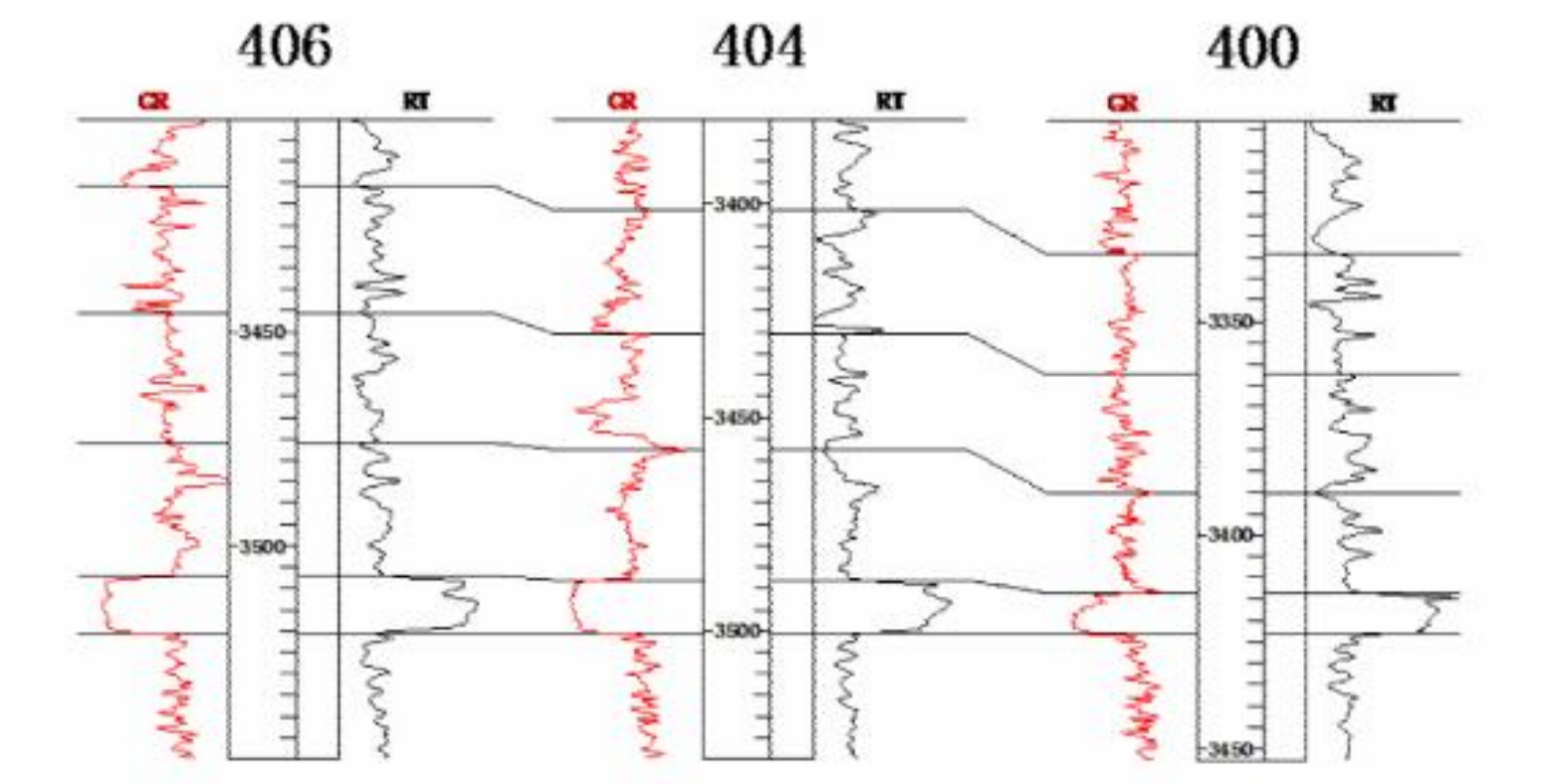
flooding: large-scale rapid transgression of flooding.



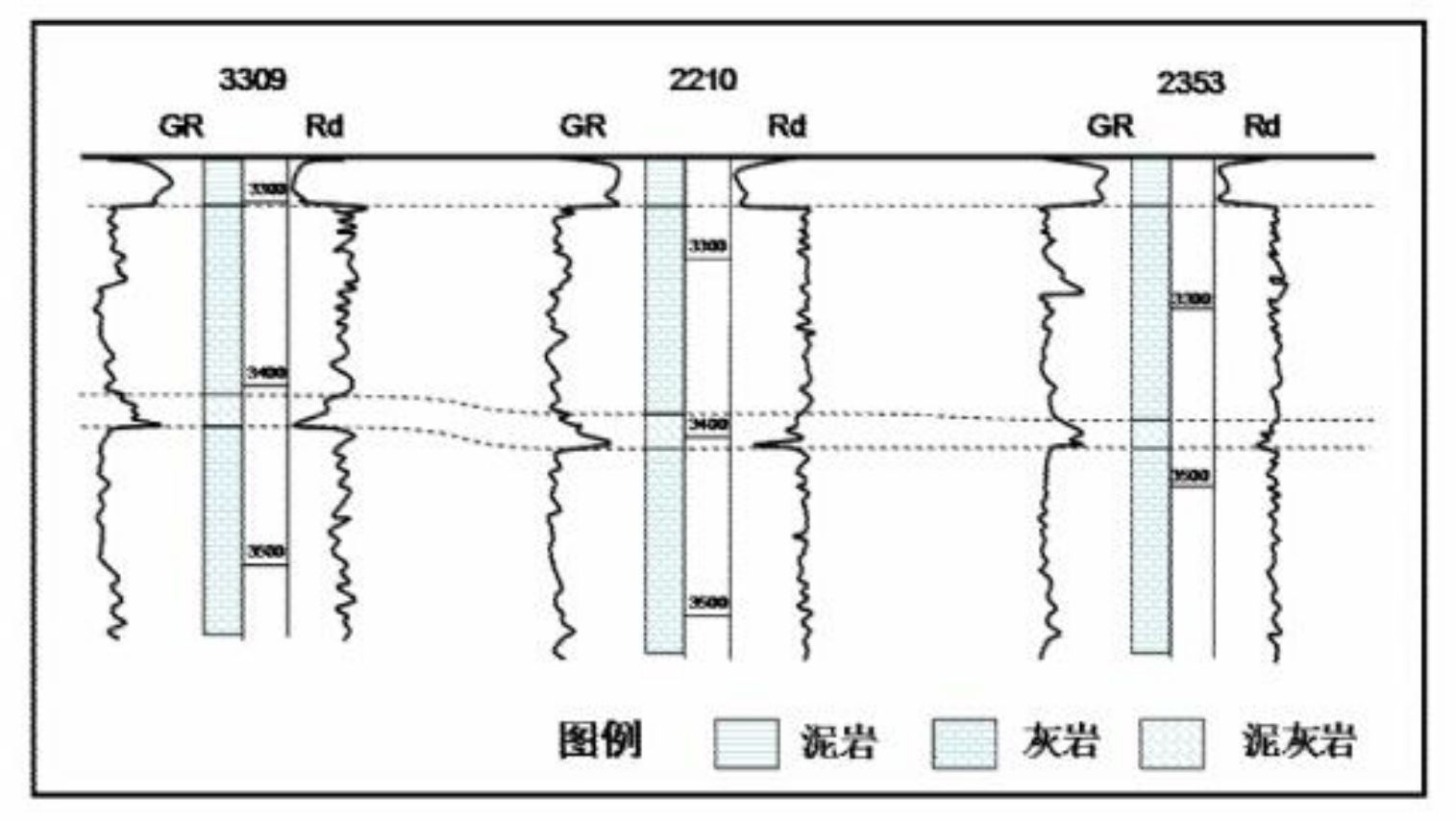
Shale related to the flooding in the clastic profile



lagoonal facies, lacustrine facies oil shale ?



Thin limestone in clastic rock?



Thin bed mud in carbonate rock

1. lithological correlation

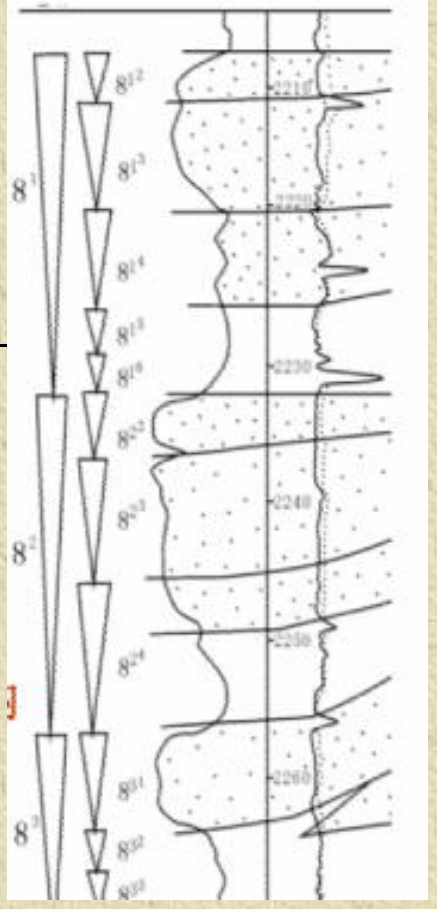
(2)cyclic correlation

- macro cycle
- mesocycle

} allocycle

- epicycle
- microcycle

} autocycle



Cycle is another important indicator. Cycle has different scale. High scale cycle can be used in large scope, and lower scale cycle in small scope.

We can identify many standard mark and different cycle on the profile by using logging curve.

2.Lithofacies Correlation

Lithofacies：the sum of connate deposit in a geomorphic unit

Facies sequence----facies analysis and correlation

Applied range:

(1) Lithology and thickness variation;

(2) Unconformity and tectonic movement;

(3) Area with few drilling data

3. Well logging curve correlation

Well logging data including a great amount of geological information are the main sources applied to study formation correlation.

Condition: **area with little lithologic variation**

Principle: **similarity of well logging curve,**

or based on stable electrical logo layer.

Method: **controlling correlation by long interval curves,**

then correction layer by layer.

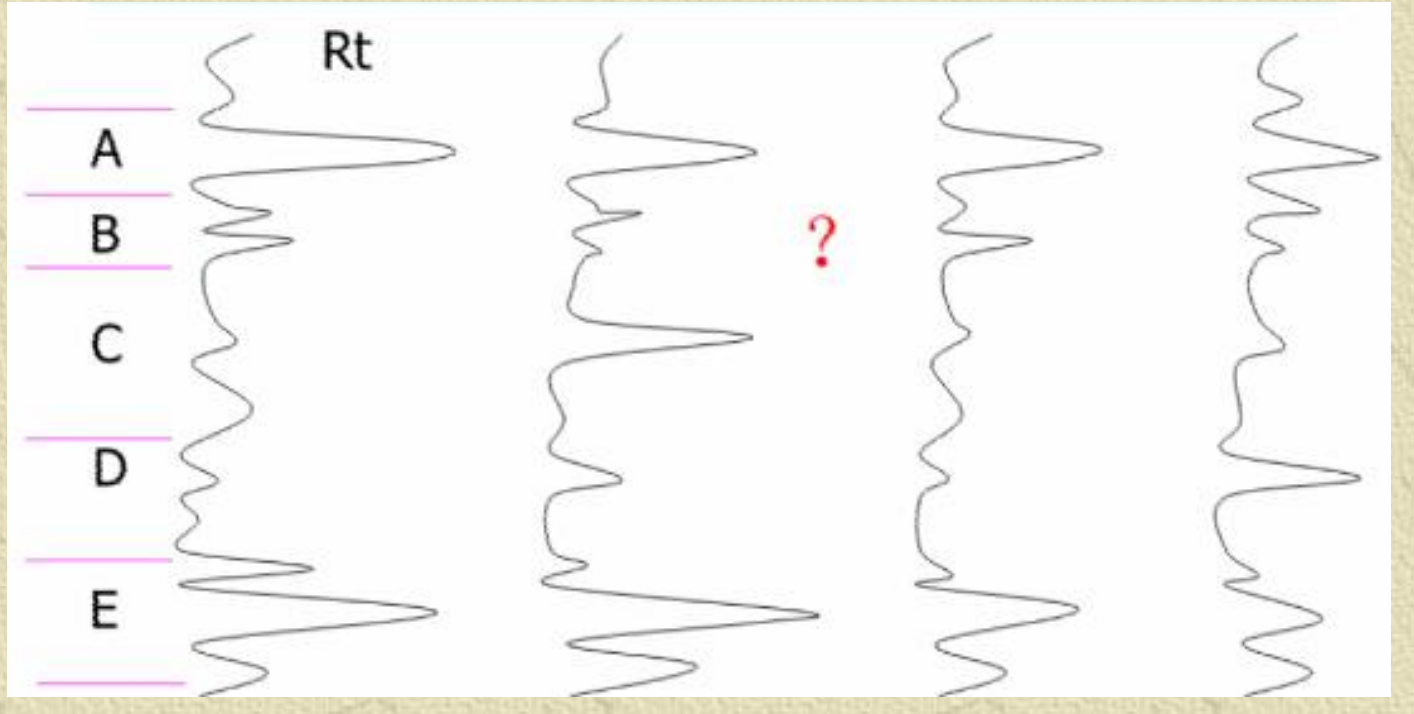
Advantages **(1) accurate depth;**

(2) continuous well logging of full well section

Common curves: **R, SP, GR, Cal**

Usually well logs are important type of data used to establish a correlation. Any meaningful interpretation will need to be supported by palaeontological data (micro fossils) and palynological data (pollen of plants). The logs most frequently for correlation are: SP, R,GR and so on.

On a detailed scale, these curves should always be calibrated with core data.



4. Palaeontological correction

identification → statistics → biozone → correlation

5. Geochemistry correlation

Based on microelement content in rock and other kinds of element contents.

V/Ni>1 marine
V/Ni<1 terrestrial

6.Structure Correlation

According to unconformity and parallel unconformity to divide formations and conduct stratigraphic correlation.

7. Clay mineral correlation

II. Correlation methods

1. Lithological correlation
2. Lithofacies correlation
3. Well logging curve correction
4. Palaeontological correction
5. Geochemistry correlation
6. Structure correlation
7. Clay mineral correlation

III. Correlation procedure

1. Correction Principle

A. Data collection and compilation

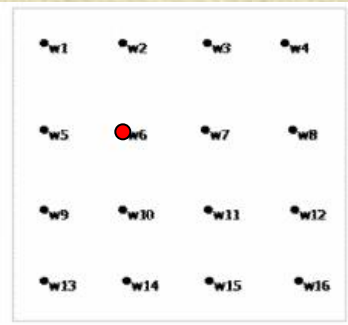
B. in complex study area, establish type well and establish marker bed.

type well:

continuous coring,

interval integrity,

No stratigraphic break or degradation



marker

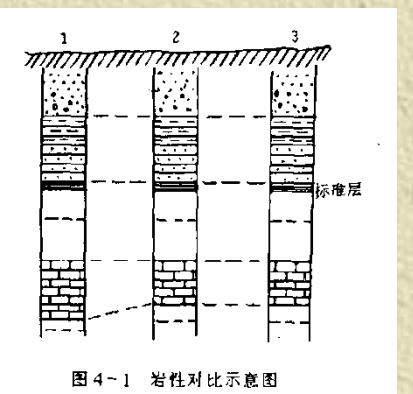


图 4-1 岩性对比示意图

C. notice large-scale facies change

2.Correlation procedures

A. Select type well

B. Define markers

C.Select key section

D.Well correlation

E.Correlation mapping

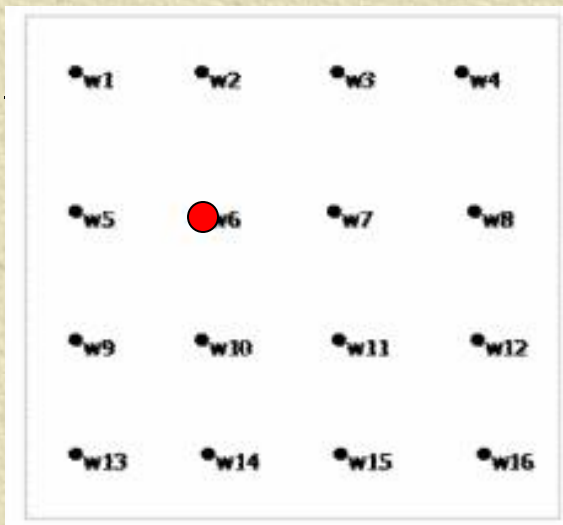
F. Enclose all profiles

G. Fill uniform Hierarchical data table

Regional Hierarchical data table

	w1	w2	w3	w4
A	1612		1615	
B	1650	1640	1655	1660
C	1693	1672	1710	1723
D	1712 1742	1722	1766	1770

2.Correlation procedures



A. Select type well

B. Define markers

Select type well or standard well which has high quality data (including wellsite geologic data, well logging data and lab analysis data).

Standard mark and cycle must be analyzed on the standard well profile.

2.Correlation procedures

A. Select type well

B. Define markers

C.Select key sections

Select correlation sections

In most case, we will select several the sections which are parallel to depositional direction because of the little change of lithology along the direction.

Meanwhile, we should select several assistant sections which are vertical to depositional direction. It makes network correlation sections for master and assistant sections.

2.Correlation procedures

A. Select type well

B. Define markers

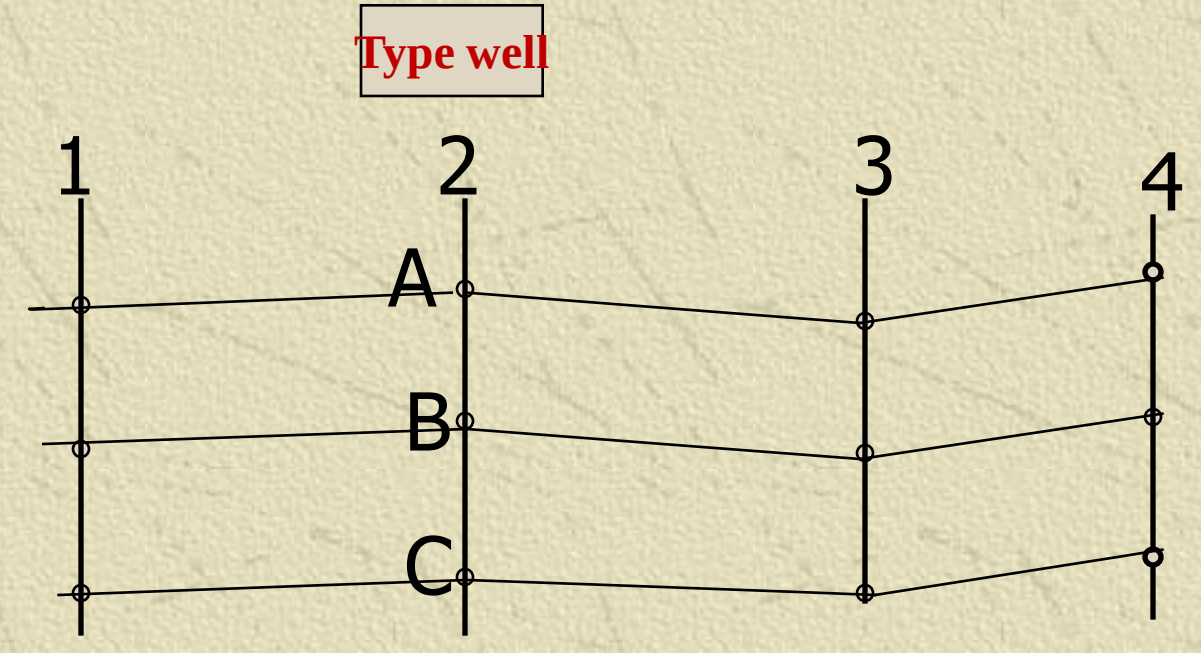
C.Select key section

D.Well correlation

correlation will be begun to do starting from standard well from near to far across the master and assistant section.

E.Correlation mapping

correlation will be begun to do starting from standard well(type well) from near to far across the master and assistant section.



2.Correlation procedures

A. Select type well

B. Define markers

C.Select key section

D.Well correlation

E.Correlation mapping

We connect correlation line between wells. If we find the change of formation thickness unreasonable, we should inspect correlation from two ways, the first is unreasonable for formation dividing, and the second is we may meet some geologic matter such as fault or unconformity.

If it is the first case, we must be careful to inspect formation dividing.

If it is the second case, we will do analysis of geologic matter other wells. If there is local change, such as formation thickness between two or three wells, we can infer that fault may be. Thus fault point should be determined on the well profile. Meanwhile, different fault point on the different wells will be assembled on the cross section.

We correlate all “events” by comparing the markers and log response. In many instance correlations are ambiguous. Where two or more correlation options seem possible the problem may be resolved by checking whether an interpretation is consistent with the geological Model and by further validating it with other data.

For instance, pressure data that will indicate whether or not sands in different wells communicate.

2.Correlation procedures

A. Select type well

B. Define markers

C.Select key section

D.Well correlation

E.Correlation mapping

F. Enclose all profiles

G. Fill uniform Hierarchical data table

Regional Hierarchical data table

	w1	w2	w3	w4
A	1612		1615	
B	1650	1640	1655	1660
C	1693	1672	1710	1723
D	1712 1742	1722	1766	1770

If all the geologic interpretation is reasonable on the correlation section, All divided data will be recorded in the form. This is a correlation results which will be used to do subsurface geology works.

3. Correlation Results

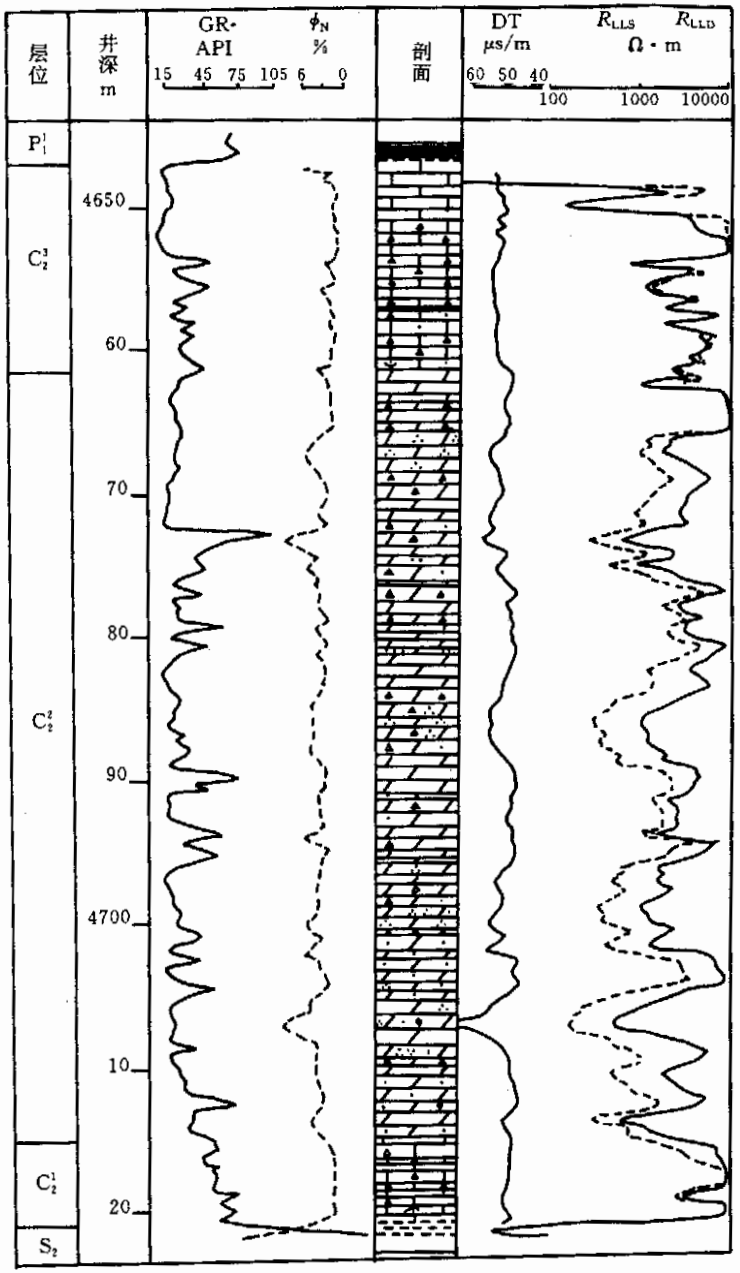
Correlation is a process of geologic study again and again. We can know features of formation distribution, fault, unconformity and facies distribution from correlation.

Master profile:

Using the average thickness of the formation to draw histogram, reflex the abstract lithologic characteristic.

Generalized columnar section:

Profile consisting of sections with the most complete and most obvious curve markers in each formation.



Generalized columnar section

Chapter 3 Well Correlation

Section 1 Stratigraphic Division

Section 2 Stratigraphic Correlation

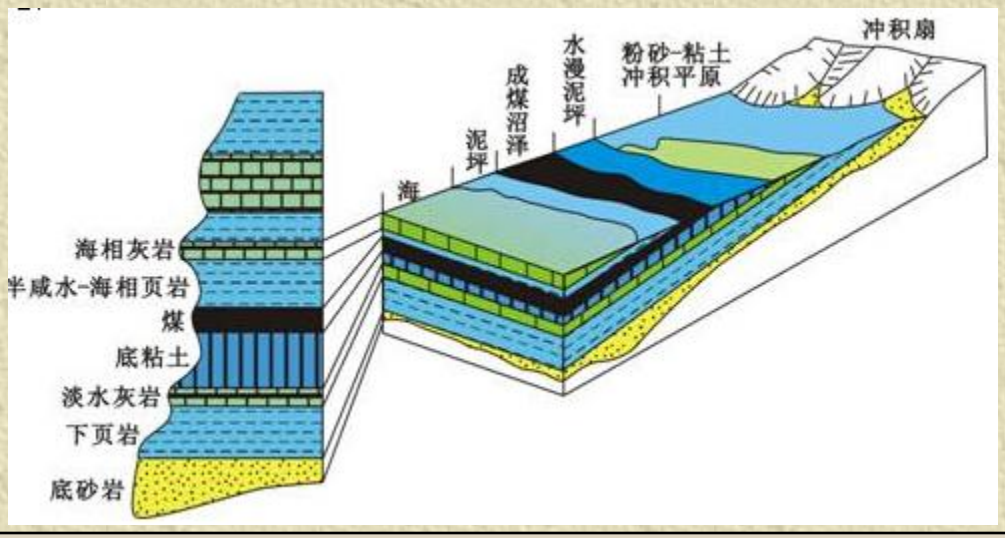
Section 3 Lithofacies Correlation

Section 4 Correlation of Oil Beds

Section 3 Lithofacial Correlation

On the lateral causes similar closely adjacent to phase in a vertical appeared in turn without interval

The vertical progression of facies should be the same as corresponding lateral facies changes



I. Well loggings of Interpretation Sedimentary Environment

II. SP Geological Significance

I.Well loggings of Interpretation Sedimentary Environment

1. Spontaneous Potential
2. Natural GR---- clay content
3. Interval transit time--- rock structure
4. Micro electric log-- micronormal， microinverse
5. Risitivity---Pore structure, fluid property, mineralization, lithology
6. Dipmeter log
7. NGS---natural gamma-ray spectrometry
8. FMS----formation microscanner

I. Well loggings of Interpretation Sedimentary Environment

1. SP(Spontaneous Potential)

$$Eda = - k \lg Rmf / Rw$$

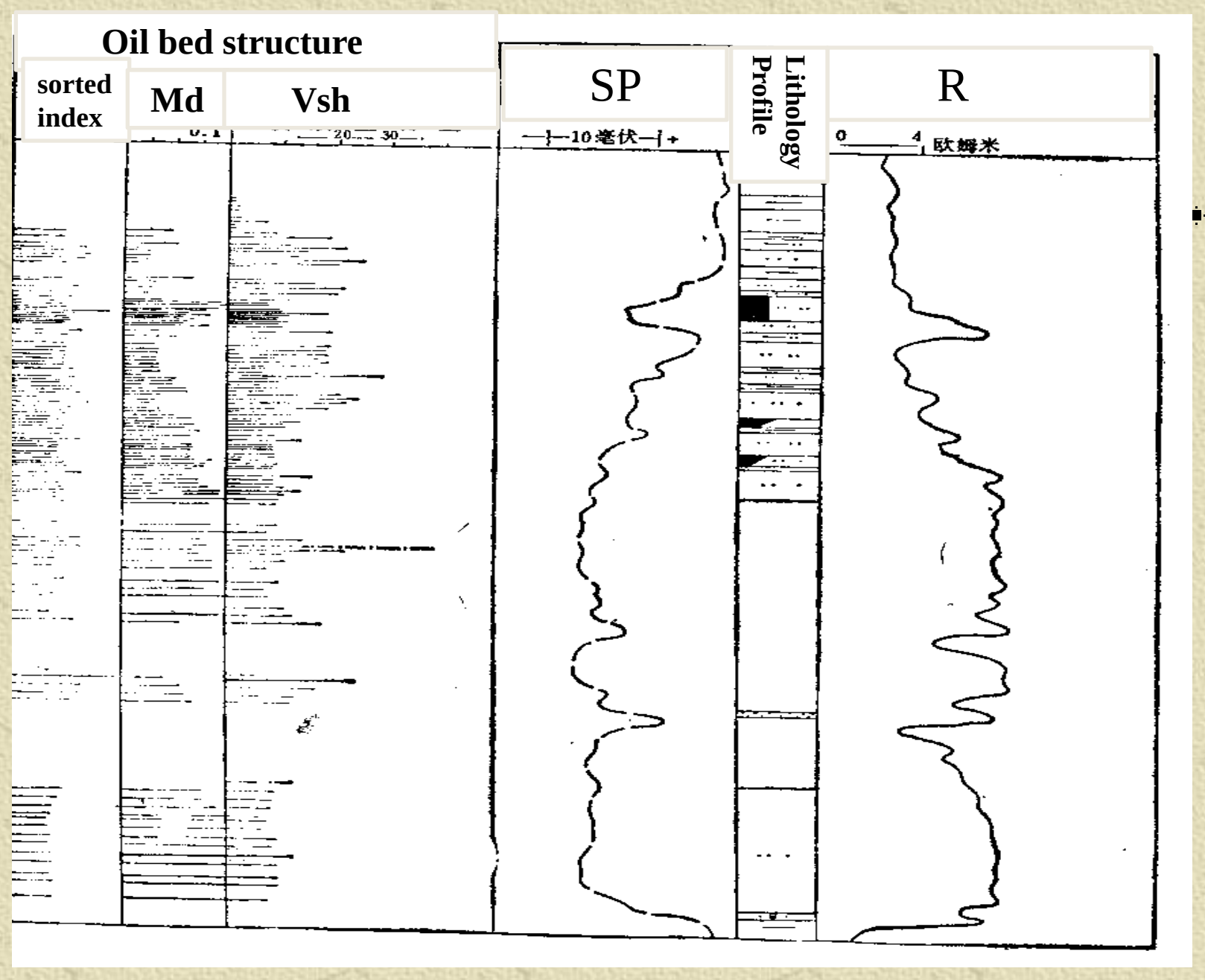
Eda: Electrodynamic potential

Eda depends on:

(1) The difference between the formation water salinity and drilling fluid salinity;

(2) Pore structure

(3) Hydrodynamic force


Oil bed structure
sorted index
Md
Vsh
SP
Lithology Profile
R
10 毫伏
0
4
欧姆米

I. Well loggings

of Interpretation Sedimentary Environment

2. Natural GR---- clay content

3. Interval transit time--- rock structure Δt-----Φ

4. Micro electric log-- micronormal，microinverse

5. R---pore structure, fluid property, mineralization, lithology

6. dipmeter log ----direction of dip, dip

7. NGS---natural gamma-ray spectrometry

---U(uranium), Th(thorite), K(potassium) → Vsh

→Sedimentary Environment

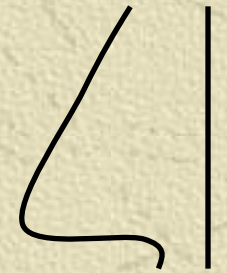
8. FMS---formation microscanner

II. SP Geological Significance

The SP curve is important in geological correlation because the shapes of these curves in different wells for certain geologic horizons will be comparable.

1.Curve morphological feature

A.bell



Positive cycle

- Typical environment:
- Point bar

B. Funnel

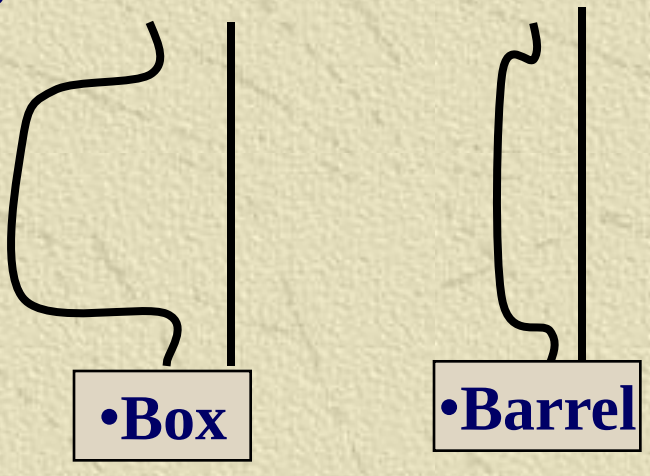
inverse cycle

- Typical environment：
- debouch bar

II. SP Geological significance

1. Curve Morphological Feature

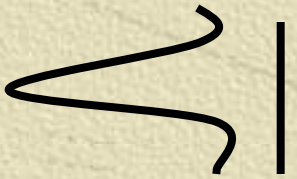
C. Cylindrical



•Box

•Barrel

D. Finger



•Typical environment：

•Sand beach

II. SP Geological significance

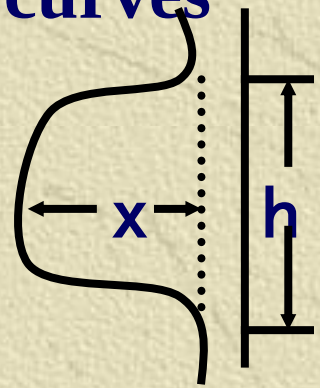
1.curve morphological feature

E.Funnel-Box

F.Box-Bell

II. SP Geological significance

2. Amplitude of curves



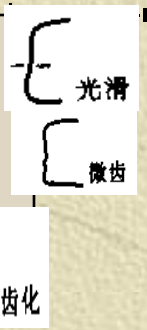
x/h
- <1 low
- 1-2 moderate
- >2 high

$$\Delta SP = \frac{SP - SP\min}{SP\max - SP\min}$$

II. SP Geological significance

3. Smooth degree

- smooth curve
- micro tooth
- tooth



1. Hydrodynamic energy and provenance supply;

2. Reflect one phase sedimentation or multi-phase sedimentation

Section 3 Lithofacial Correlation

Sedimentary facies: is a distinctive rock unit that forms under certain conditions of sedimentation, reflecting a particular process or environment.

Lithofacies: The rock record of any particular sedimentary environment, including rock color, lithological association sedimentary structure and so on.

⇨ **Interpret sedimentary process, infer sedimentary environment**

- **individual well facies analysis**
- **Lithofacial correlation**

Chapter 3 Well Correlation

Section 1 Stratigraphic Division

Section 2 Stratigraphic Correlation

Section 3 Lithofacies Correlation

Section 4 Correlation of Oil Beds

Section 4 Correlation of Oil layers

Oil bed correlation is done on the base of formation correlation. When we are doing oilfield development geologic works, in order to determine development interval and study oil bed heterogeneity, we should do oil bed correlation.

- Oil layers correlation is the foundation for subsurface geological research in oilfield
- Understand the spatial distribution pattern by dividing oil layers in each well, and divide oil layers of the same geological time.

Correlation of Oil layers: the correlation of oil bearing sequence which have been identified in regional stratigraphic correlation in an oil field.

Section 4 Correlation of Oil layers

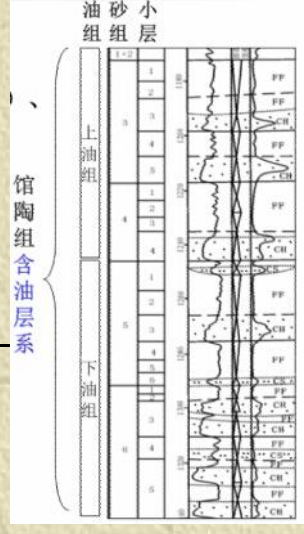
Correlation of Oil Layers: the correlation of oil bearing sequence which have been identified in regional stratigraphic correlation in an oil field.

I. Correlation Unit of Oil Layers

II. Sedimentary Cycle Graduation

III . Oil Correlation Method

Section 4 Correlation of Oil Beds



I. Correlation Unit of Oil Layers

Objective: research the layer series of development, provide geologic basis for arranging well pattern

- **reservoir characteristic**: uniformity of lithology and oil storage property
- **interlayer**: the thickness and distribution range

- single sand layer(substratum, individual layer, single layer)
- sand group
- reservoir group
- oil bearing sequence

•The smaller the correlation unit of oil layers, the better uniformity of reservoir property, and better lateral connectivity.

Correlation of Oil Layers

I. Correlation Unit of Oil Layers

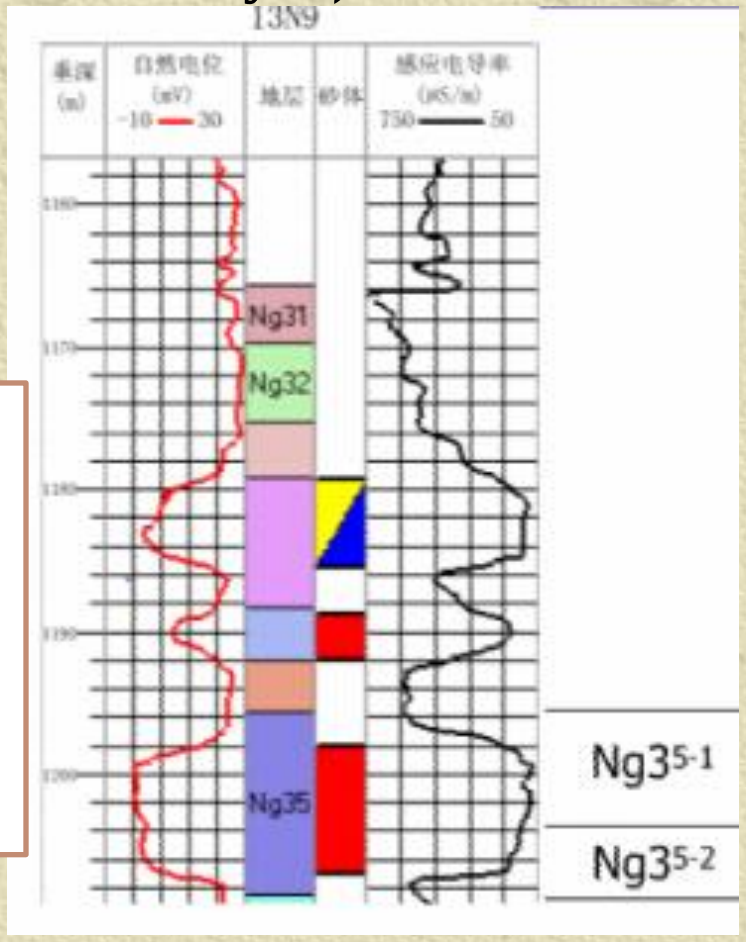
1. Single sand layer (substratum, individual layer): the smallest unit consists the reservoir system. Equal to the Coarse part of sedimentary rhythm. It has certain thickness and distribution range in the same oil field , and the lithology and oil storage property is uniform within the sand layer. It is divided by interbeds, and area of divided single sand layer is bigger than the connected area between sand layers, Single sand layer do not have independent hydrodynamic system, that is, it can not be independent development unit.

Correlation of Oil Layers

1. Single sand layer(substratum, individual layer)

- certain thickness and distribution range
- divided by interbed,

divided area bigger than connected area



Single sand layer is one single bed which may be one microfacies, for example: channel sand, point bar, mouth bar, beech sand, dalta front sheet sand, it make small cycle which contain one microfacies.

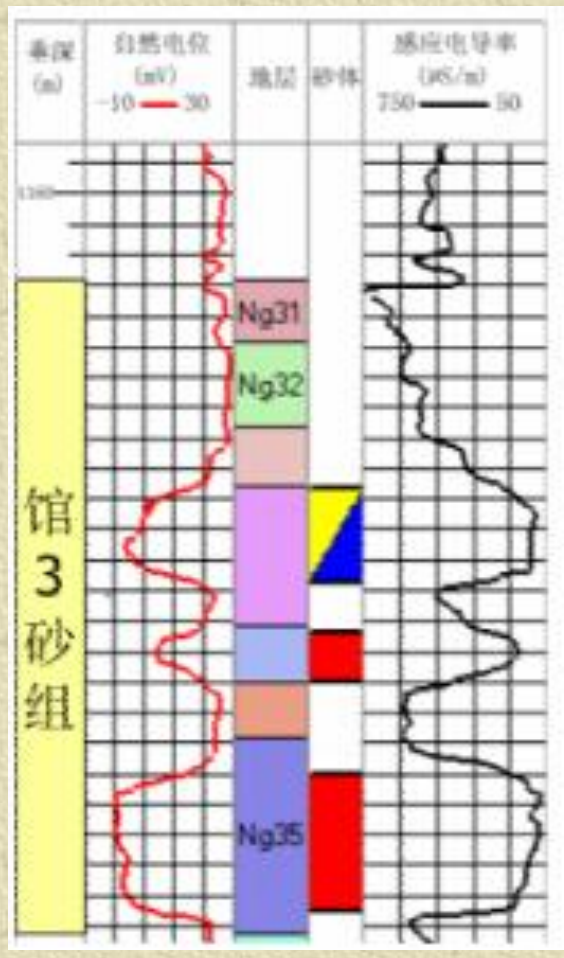
Single SP curve shape will be used to determine this small cycle.

Correlation of Oil layers

——— Stratigraphic unit classification

2. Sand group

- **Composed by adjacent single sand layers.**
- **Uniform lithology**
- **Sand groups are divided by stead interbeds**



Section 4 Correlation of Oil Beds

I. Correlation Unit of Oil Beds

3. Reservoir group: composed of several sand groups with similar reservoir property, the cap and bottom bed is thick impermeable mudstones. Distributed in the same facies, and belongs to the same sedimentary system.

The reservoir group is divided in to several independent development systems based on heterogeneity and pressure characteristics.

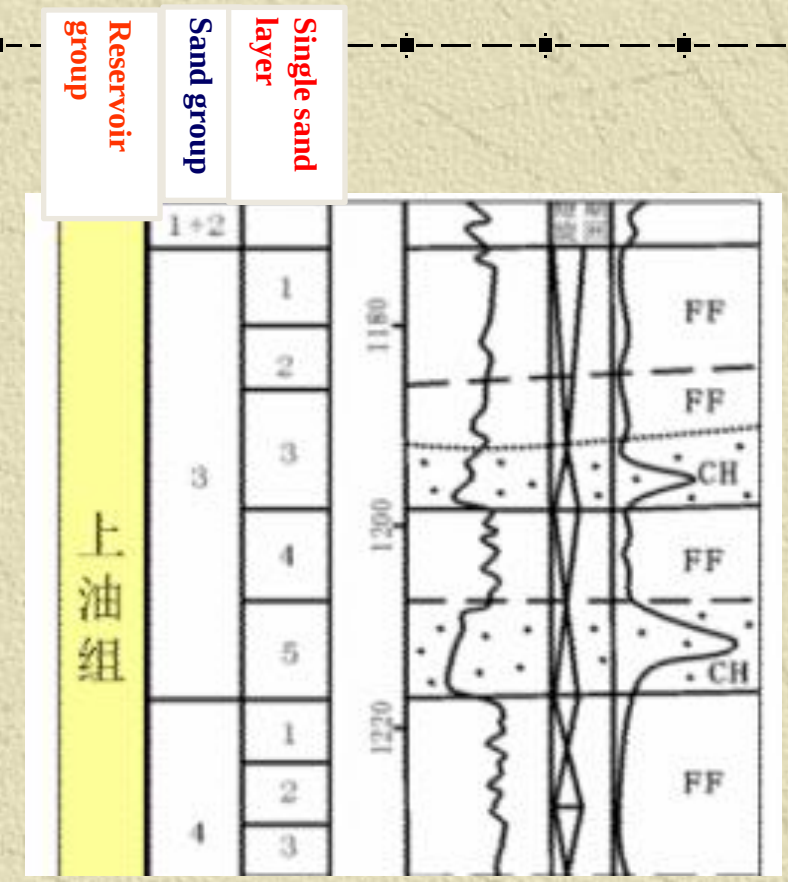
Correlation of Oil Beds----

classification of stratigraphic units

3. Reservoir group

▲Composed of several sand groups with similar oil layer property.

▲The top and bottom is thick impermeable mudstone.



Sand package is assembly of beds which has the same genesis, such as river bed, delta bed and beech or bar bed etc. it make a middle cycle which contain a depositional sequence, such as one delta sequence. We can use SP curve association shape to divide it into progressive, regressive and stacking cycle.

Section 4 Correlation of Oil Layers

I. Correlation unit of oil layers

4. Oil bearing sequence, oil-bearing series: combination of several reservoir groups, a set of source-reservoir-cap rock association with same sedimentary origin. Within an Oil bearing sequence, the sedimentary origin, rock types and oil and water features are relatively the same.

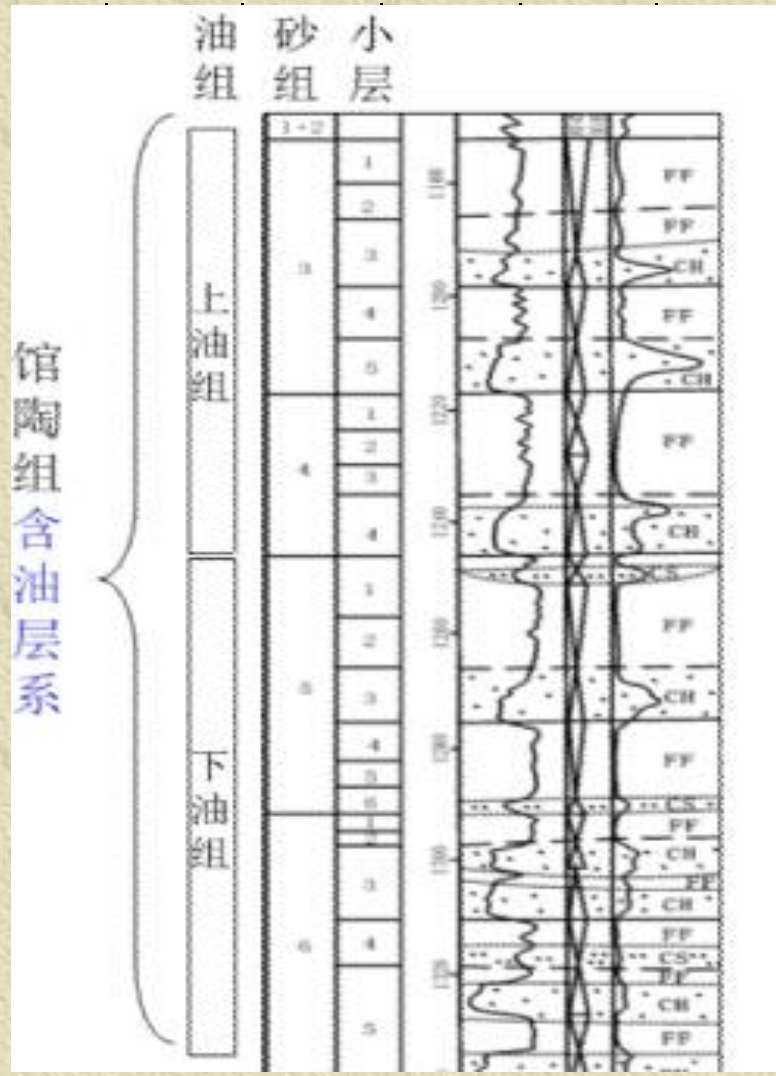
Correlation of Oil Beds----
classification of stratigraphic units

4. Oil bearing sequence

- combination of reservoir groups.
- Similar sedimentary origin, rock types and oil-water characteristic in the same oil bearing sequence.

Top and bottom surface of reservoir unit is uniform with the stratigraphic-age boundary.

（isochronous）



Section 4 Correlation of Oil Beds

I. Correlation Unit of Oil Beds

single sand layer

sand group

reservoir group

oil bearing sequence

•The smaller the correlation unit of oil layers, the better uniformity of reservoir property, and better lateral connectivity.

Yanqi basin Baolang oilfield

oil bearing sequence

oil group

substratum

- **I oilgroup：**
- **Baozhong block——I1,I2,I3**
- **Baobei block——I1,I2**

Section 4 Correlation of Oil Layers

II. Classification of Sedimentary Cycle

- By Individual Reservoir Lithologic features and evolution
- By Individual reservoir at all levels of depositional cycle in combination

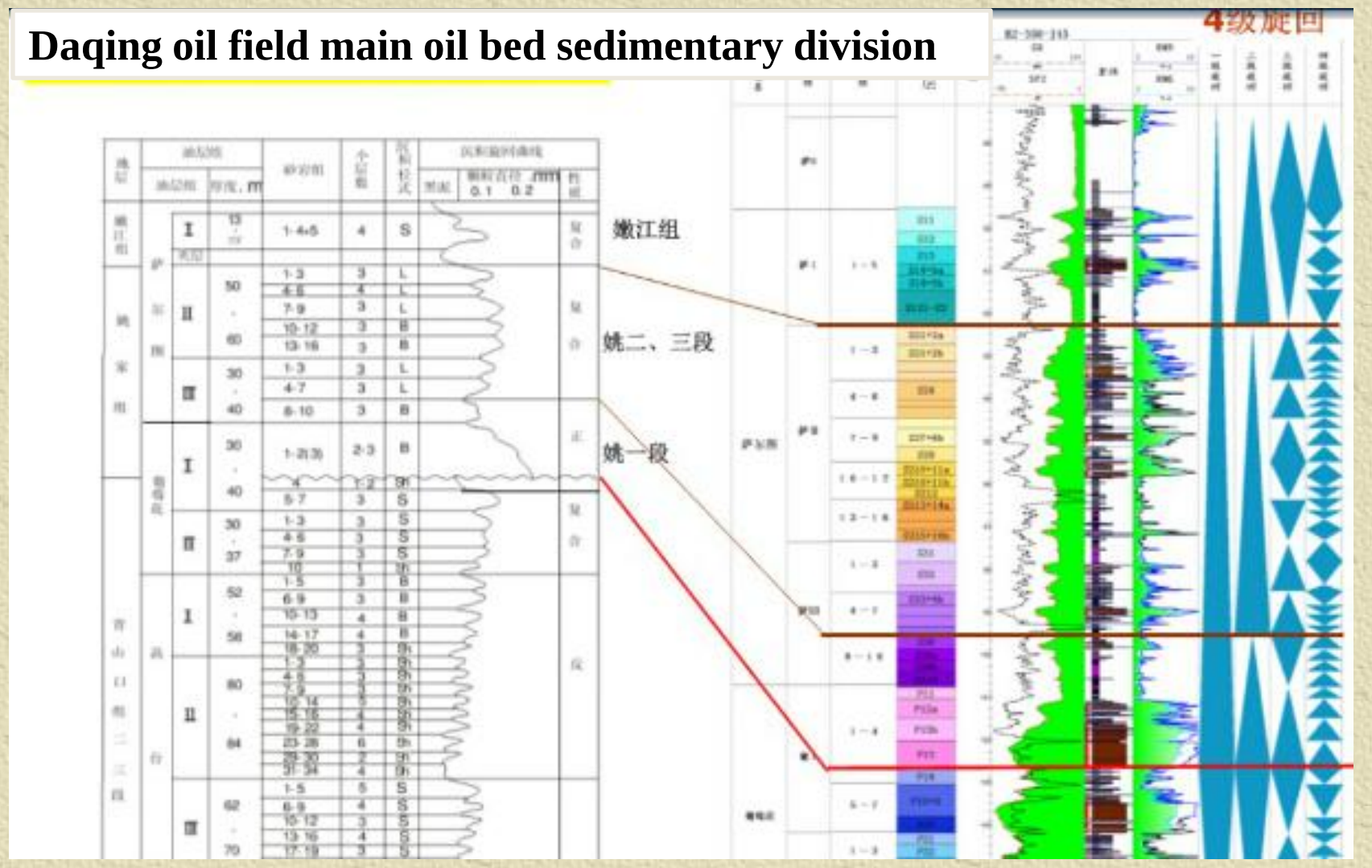
Section 4 Correlation of Oil Layers

II. Classification of Sedimentary Cycle

- **4^{th} level sedimentary cycle(**rhythm **)**
- **3^{rd} level sedimentary cycle**
- **2^{nd} level sedimentary cycle**
- **1^{st} level sedimentary cycle**

Positive Rhythm,
Inverted Rhythm

Daqing oil field main oil bed sedimentary division



Section 4
Correlation of Oil layers

II. Classificaiton of Sedimentary cycle

4th level sedimentary cycle(rhythm): within a sedimentary event, in a sedimentary mode, due to the current energy periodical change of water, the combined rhythm formed.

Single sand layer

- **where delta sandstone most developed,**

single sand layer has thickness of 20-30m,

Medium-fine sand, Cross-bedding ,Positive rhythm ,

Half deep lacustrine facies ,Deep lake facies,

outer margin single sand layer thickness less than 3m,

Siltstone, Horizontal bedding , rhythm not obvious.

Section 4 Correlation of Oil Beds

II.Cassification of Sedimentary Cycle

3rd level sedimentary cycle: within a sedimentary event, continuous deposition by different depositional mode, equal to sand group. Concentrational develped oil bearing sand stone has certain connectivity, with stable mudstone interlayer, can be the basis for identifying cyclic boundary.

- Like sand group, oil bearing sand stone has certain connectivity
- With stable mudstone interlayer

Section 4 Correlation of Oil Beds

II.Classification of Sedimentary Cycle

2^{nd} level sedimentary cycle : in a uniform sedimentary setting, the continuous deposition composed of multi sedimentary events. Resemble depositional system or reservoir group.

Section 4 Correlation of Oil Beds

II. Classification of Sedimentary Cycle

1st level sedimentary cycle: within the same petroliferous basins, in a certain period, in different sedimentary backgrounds, the continuous deposition composed of multi sedimentary events and different depositional mode, that is, 1st level sedimentary cycle is formed in a certain period of basin evolution.

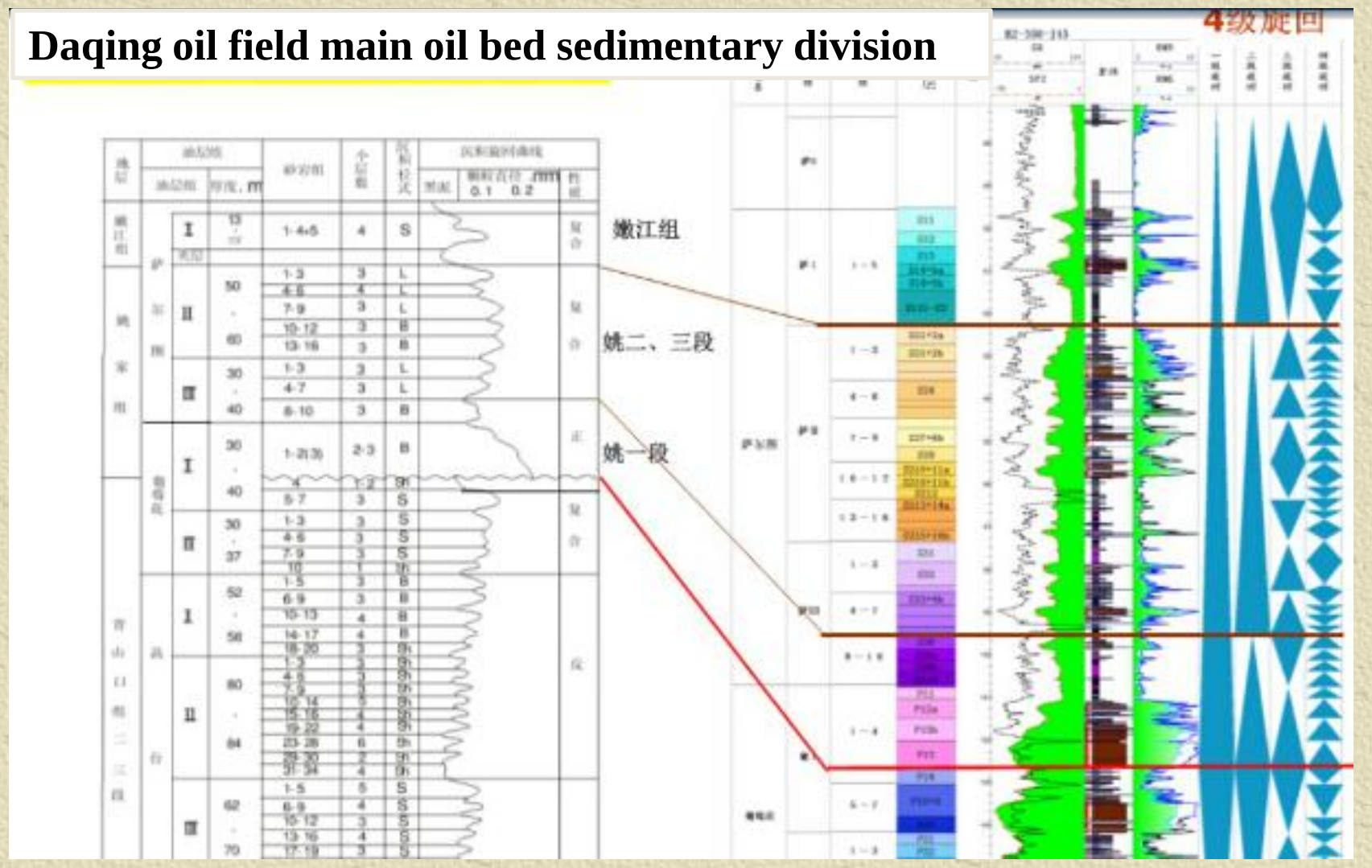
Section 4 Correlation of Oil Beds

II. Classification of Sedimentary Cycle

- By Individual reservoir Lithologic features and evolution
- By Individual reservoir at all levels of depositional cycle in combination

4^{th} level sedimentary cycle(rhythm)
3^{rd} level sedimentary cycle
2^{nd} level sedimentary cycle
1^{st} level sedimentary cycle

Daqing oil field main oil bed sedimentary division



Section 4 Correlation of Oil Bed

III. Correction Methods of Oil Bed

Correlation process is the same not only to formation correlation but also to oil bed correlation.

cycle-thickness correlation

“cycle comparison and hierarchical controlling”

Correlation of Oil Layrers

III. Oil bed correction

cycle-thickness correlation

(1)Condition: stable depositional environment

such as lacustrine facies and delta-front facies

(2)Definition: controlled by standard layer or marker, according to the relation between the order of sedimentary cycle and thickness ratio, conduct correlation step-by-step from large to small till to the single layer.

Correlation of Oil Beds

III. Oil bed correction

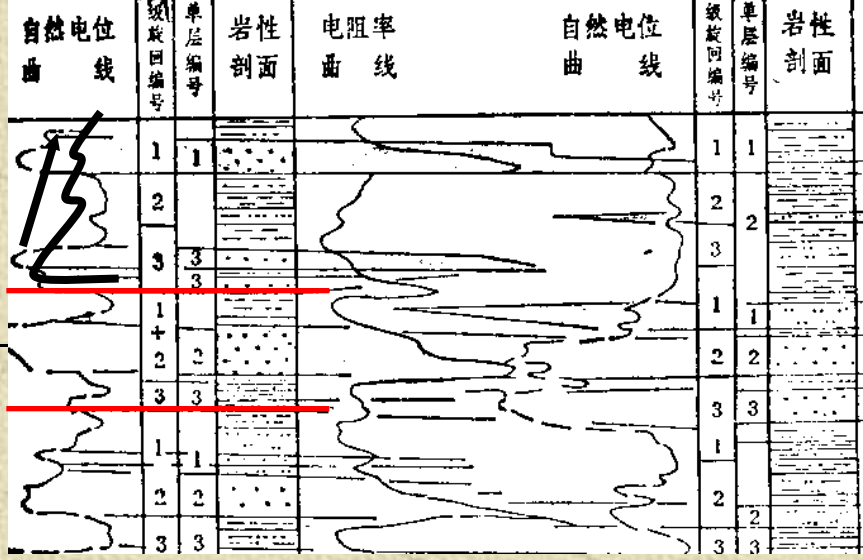
cycle-thickness correlation

(3)procedure：

A. use marker and 2nd level sedimentary cycle to correlate reservoir group；

- **the distribution of markers**
- **2nd sedimentary cycle feature**

Correlation of Oil Beds



III. Oil bed correction

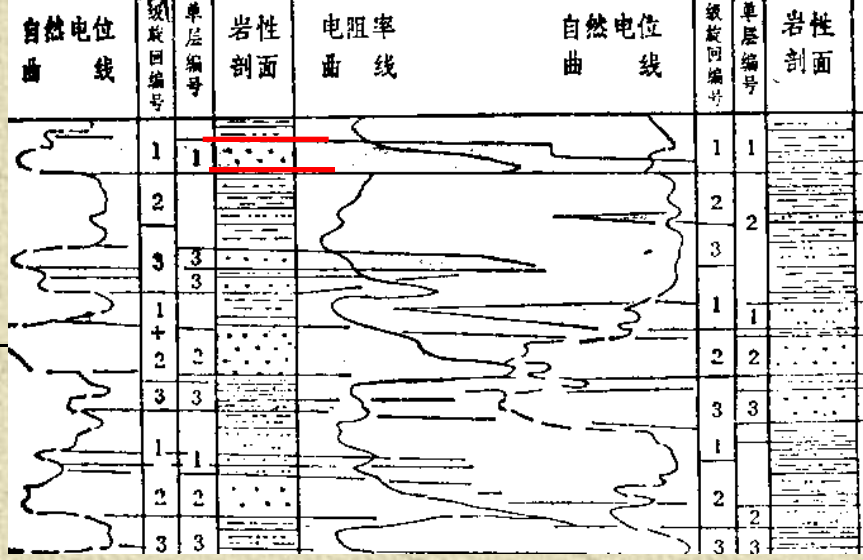
cycle-thickness correlation

(3)procedure：

B.use 3rd level sedimentary cycle sand group；

- lithological association
- evolution
- cycle
- well log curves combination characteristic

Section 4
Correlation of Oil Beds



III. Oil bed correction

cycle-thickness correlation

(3)procedure：

C.use 4th level sedimentary cycle, lithology and thickness to conduct time-stratigraphic unit correlation of single sand layer.

- **relative development degree of single sand layer**
- **stability of mudstone layer**

Section 4 Correlation of Oil Beds

3rd level sedimentary cycle	4th level sedimentary cycle	Single layer	lithology
	1	1	
	2		
	3		

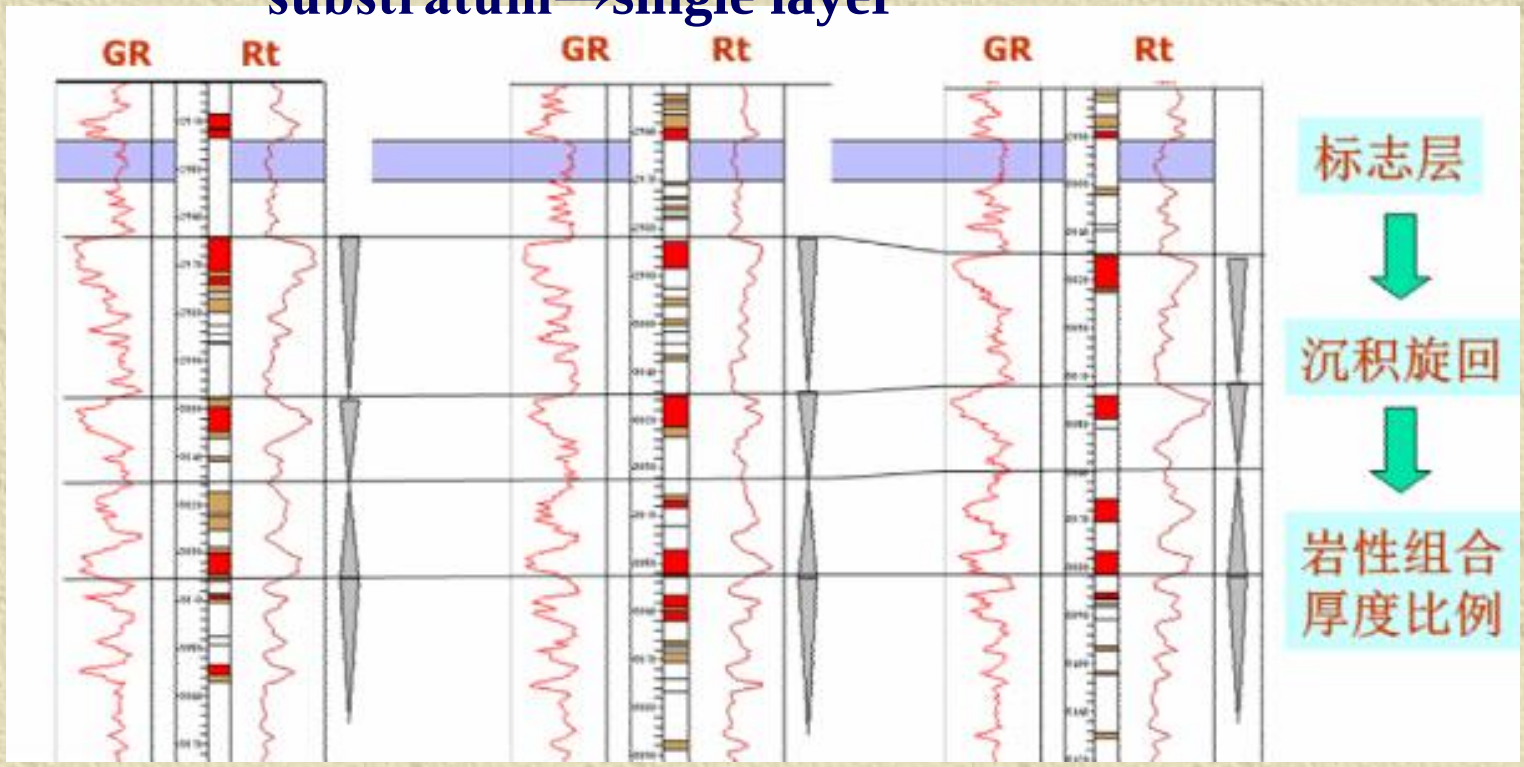
	rhythm	Single layer	lithology
	1	1	
	2		
	3		

Correlation of oil layers----methods

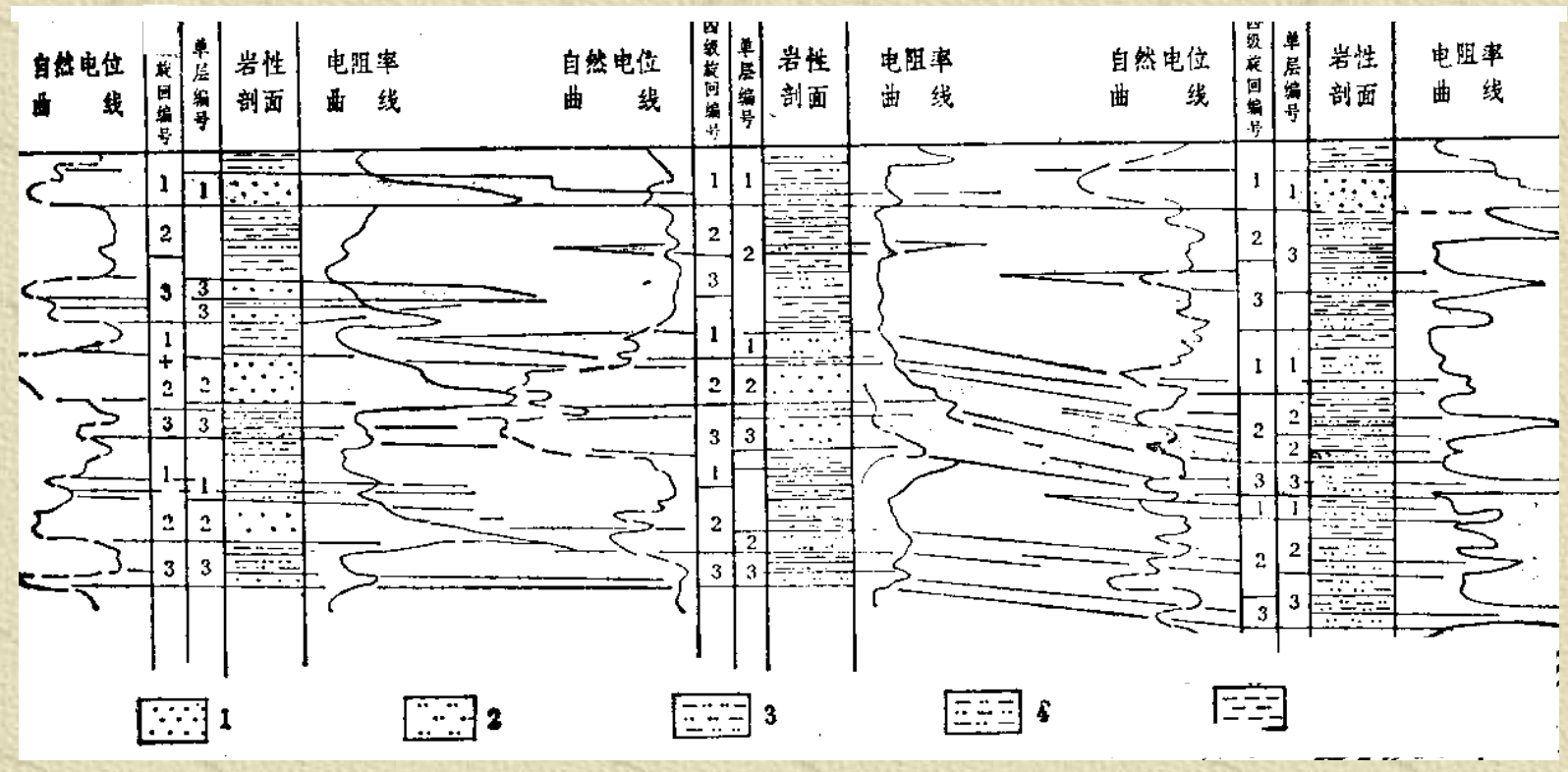
hierarchical control

Reservoir group→sand group→ substratum→single layer

step by step comparison



Correlation of Oil Beds



oil beds correlation map

Section 4 Correlation of Oil Beds

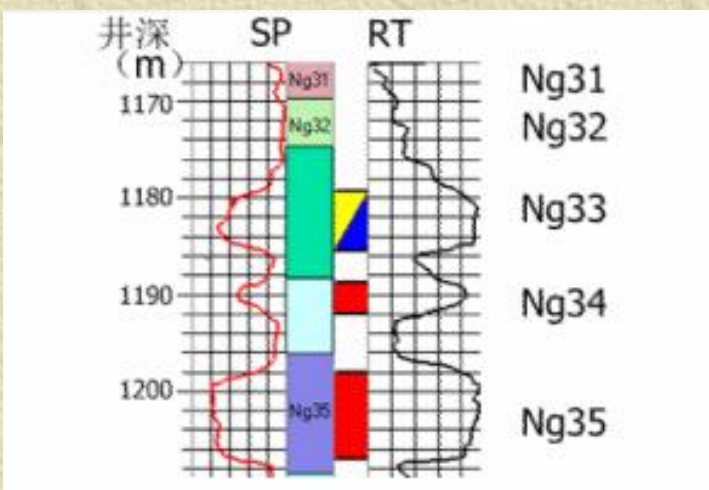
Cycle-thickness correlation：

controlled by standard layer, according to the relation between the order of sedimentary cycle and thickness ratio, conduct correlation step-by-step from large to small till to the single layer.

Correlation of oil layers-methods

Result list

substratum data table



油层组	砂层组	小层	小层井段 m	砂岩井段 m	有效厚度，m		有效孔隙度 %	渗透率 $10^{-3}\ \mu m^2$
					一类	二类		
上油组	Ng3	Ng35	1196.0-1208.2	1198.0-1207.0	10		20	125

Section 4 Correlation of Oil Beds

IV. Reservoir Characteristic Research

1. Plane graph
2. Profile chart
3. Block diagram, fence diagram
4. Reservoir physical property map

Comprehensive Questions:

1. What's the main stratigraphic division units for a field wide?
2. Explain the definition of rock stratigraphic unit?
3. What's the characteristics of rock stratigraphic unit?
4. What features of index fossil have?
5. Explain the sequence stratigraphy unit?
6. What is the basis of formation correction?
7. Explain the scope of stratigraphic correlation.
8. Sum the main formation method in an oil field.
9. Analysis the features of marker bed.
10. What are common logging curves to be used correction?
11. Explain the type well or standard well.
12. Describe the correlation procedures
13. How to select correlation sections?
14. What are factors to influence the SP curve?
15. Draw the SP curve morphology of point bar and debouch bar, and explain their sedimentary features.
16. Oil bed correction
17. How to define oil bed correction unit?
18. Analysis the features of single oil method
19. Explain the cycle-thickness correlation method

Maps and Sections

Having gathered and evaluated relevant reservoir data it is desirable to present this data in a waythat allows easy visualisation of the subsurface situation. With a workstation it is easy to create a three-dimensional picture of the reservoir, displaying the distribution of a variety of parameters, e.g. reservoir thickness or saturations. All realisations need to be in line with the geological model.

- **The maps most frequently consulted in field development are structural maps and reservoir quality maps. Commonly a set of maps will be constructed for each drainage unit.**

Section 4 Correlation of Oil Beds

IV. reservoir characteristic resea

1.Plane graph

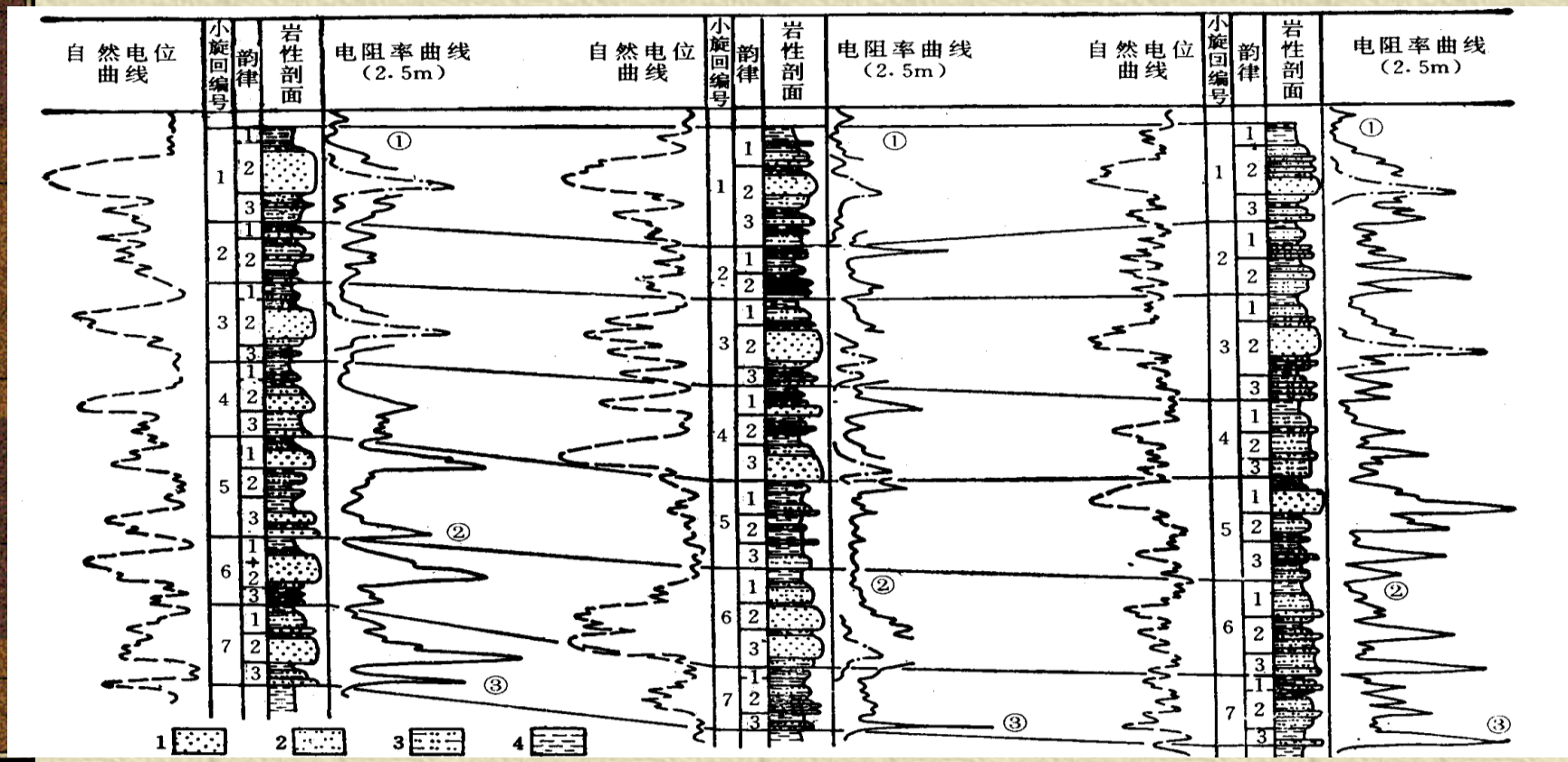
Yao Er in the north of Daqing Oilfield

Facies distribtion in the top of third member

Section 4 Correlation of Oil Beds

IV. reservoir characteristic research

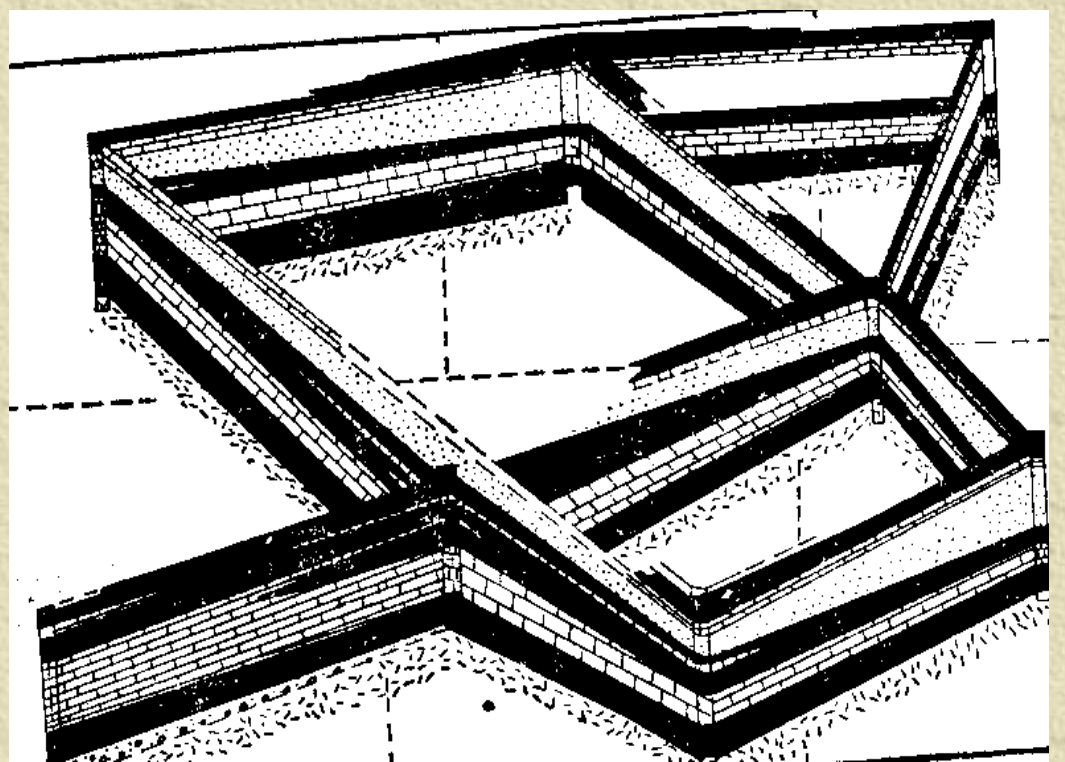
2. profile, section



Correlation of Oil Beds

IV. reservoir characteristic research

3. block diagram, fence diagram

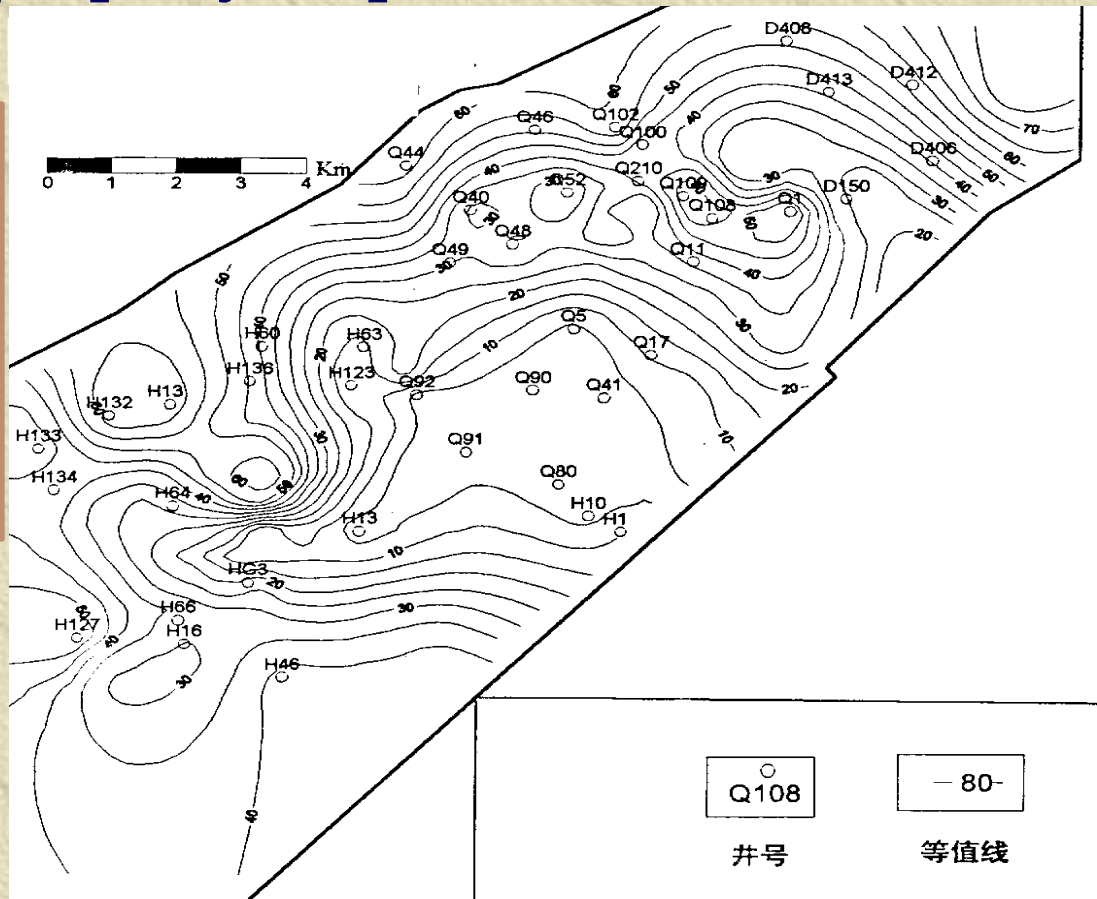


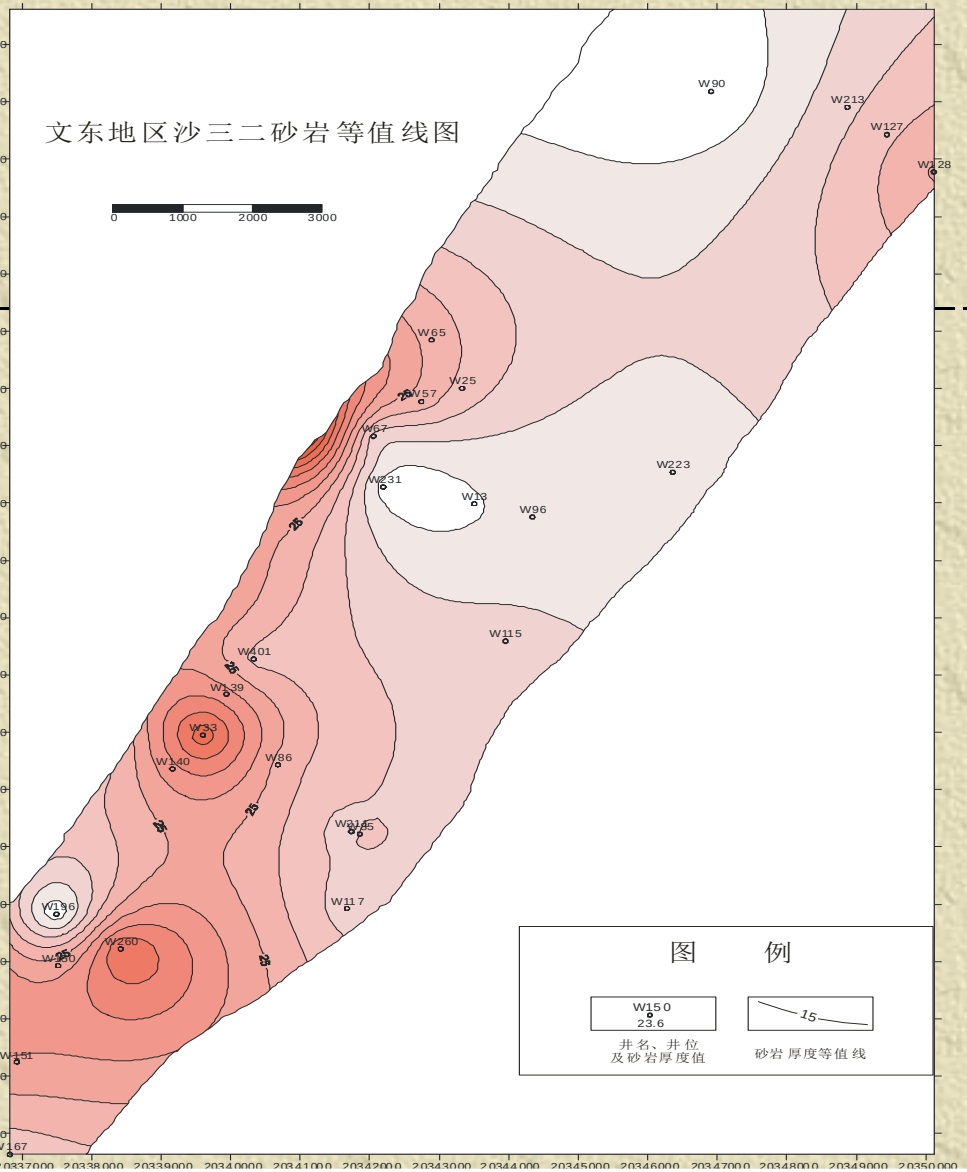
Section 4 Correlation of Oil Beds

IV. reservoir characteristic research

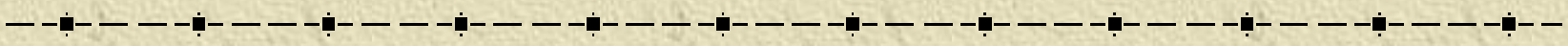
4.Reservoir physical property map

Reservoir quality maps are used to illustrate the distribution of reservoir parameters such as net sand, porosity or reservoir thickness.





•Sandstone isopach map



Exercise 3 Well Correlation

Well correlation is used to establish the lateral extent and the variation of the formation and reservoir parameters.

In carrying out a correlation we subdivide the objective sequence into lithologic units first and then correlate the sequence well to well laterally through the study area.

By correlation we can establish lateral and vertical trends of those parameters throughout the structure.

Scope of Stratigraphic Correlation

1. Global Correlation

2. Regional Correlation

3. Field Correlation

4. Oil Beds Correlation（Chronostratigraphic unit correlation）

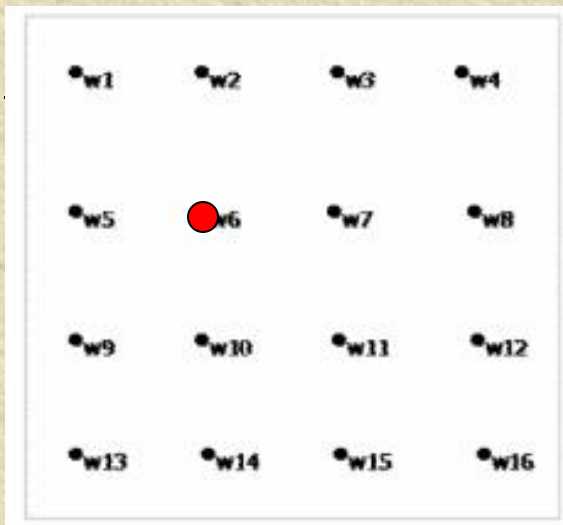
Field wide

Correlation Methods

1. Lithological correlation
2. Lithofacies correlation
3. Well logging curve correction

Establish the sequence of the basin

Correlation procedures



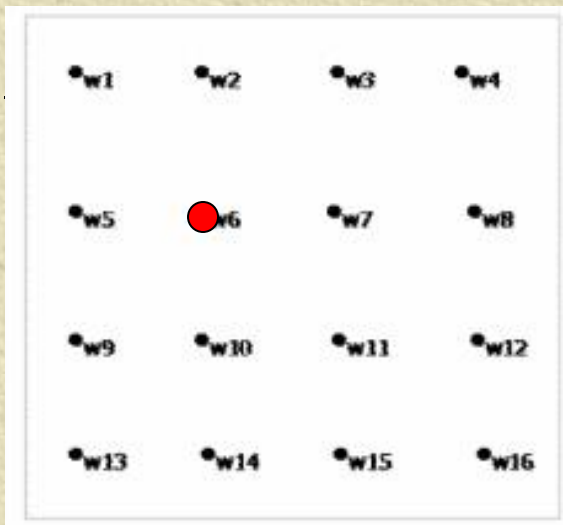
A. Select type well

B. Define markers

Select type well or standard well which has interval integrity(no stratigraphic break or degradation) and high quality data (including wellsite geologic data, well logging data and lab analysis data).

Standard mark and cycle must be analyzed on the type well profile.

2.Correlation procedures



A. Select type well

B. Define markers

C.Select key section

D.Well correlation

correlation will be begun with standard well from near to far across the selected section.

E.Correlation mapping

2.Correlation procedures

A. Select type well

B. Define markers

C.Select key section

D.Well correlation

E.Correlation mapping

We connect correlation line between wells.

Figure 3-1 is a well log section of 5 wells in a clastic oil field. The left curve is natural gamma(GR), the right is resistivity log(R). Conduct stratigraphy and well correlation based on the single layer division in well 12(Well 12 is the type well and the dotted line is boundary of single layers)

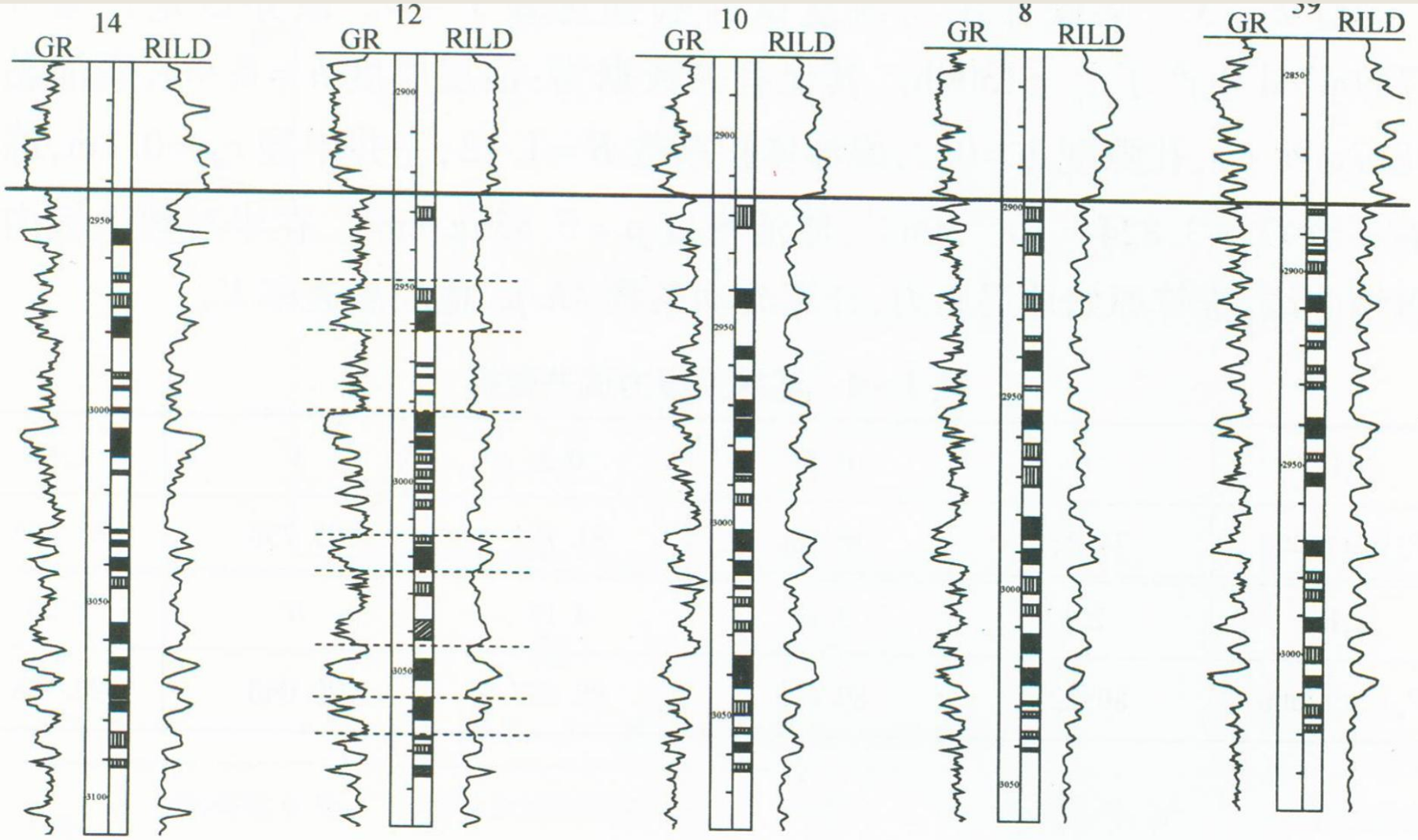


Fig 3-1 5 Well log tie section in a clastic oil field

Type well

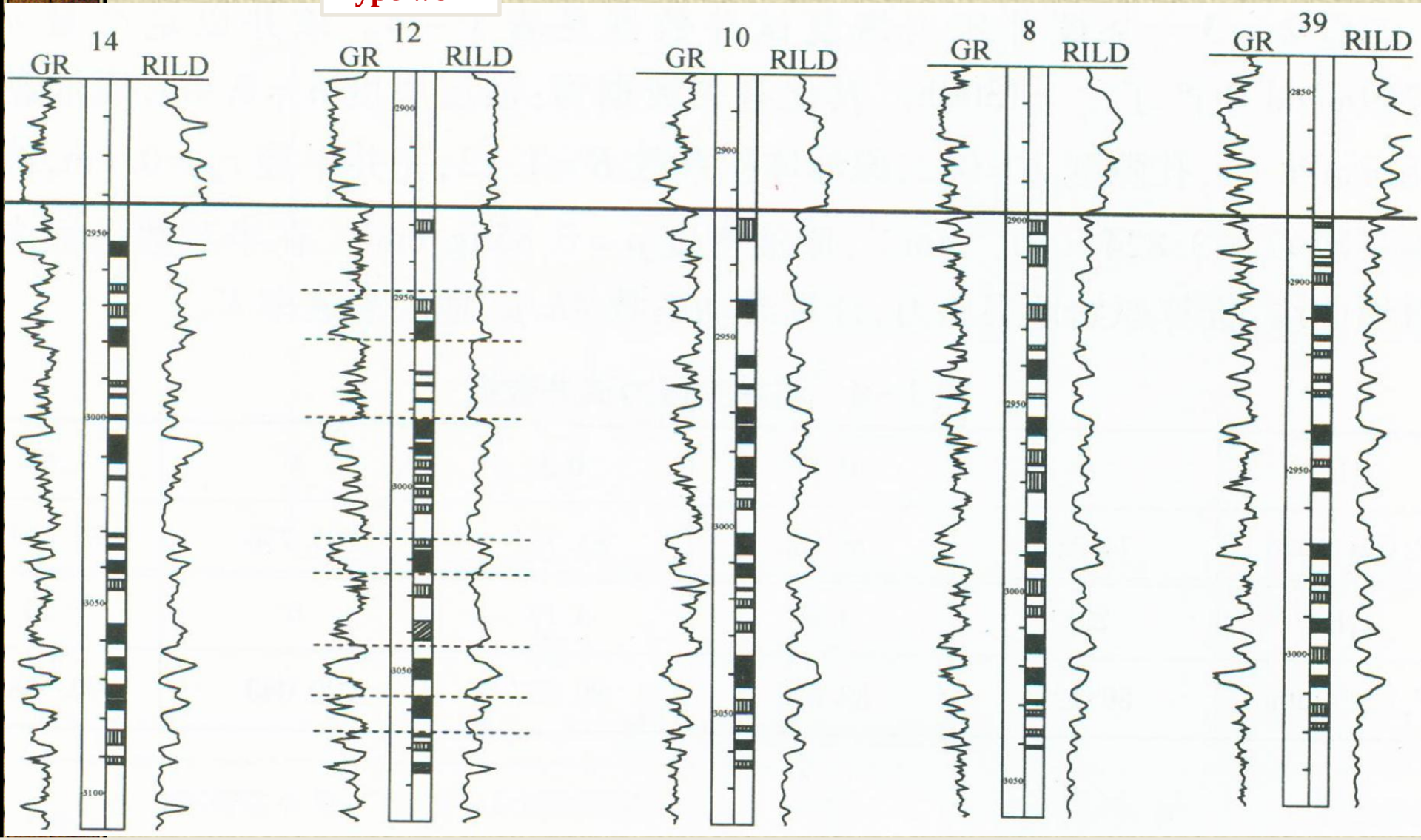


Fig 3-1 5 Well logs tie section in a clastic oil field

Exercise 3-2 **Conduct stratigraphy and well correction (well log is natural gamma) based on the data of 4 wells in a certain area**

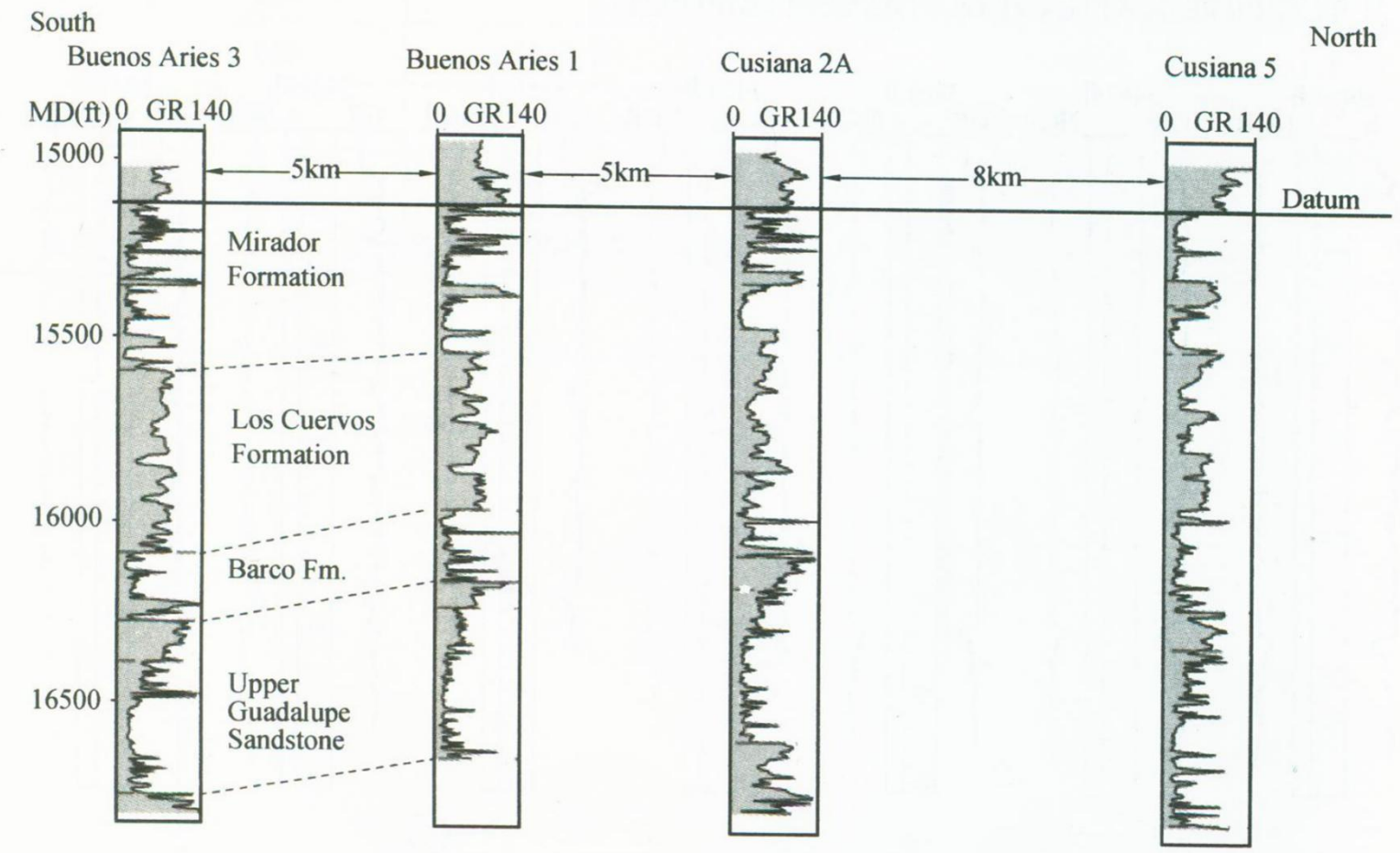


Fig 3-2 **Well logs tie section of 4 wells in a certain area**

Oil Bed Correlation

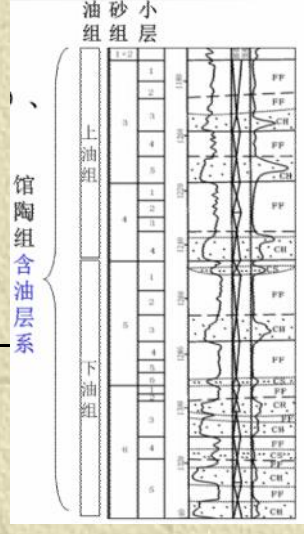
Oil bed correlation is done on the base of regional formation correlation.

In order to determine development interval and research oil bed heterogeneity, oil bed should be correlated.

- **Oil bed correlation is the foundation for subsurface geological research in an oilfield**
- **Understand the spatial distribution pattern by dividing oil layers in each well, and divide oil beds of the same geological time.**

Correlation of Oil layers: the correlation of oil bearing sequence which have been identified in regional stratigraphic correlation in an oil field.

Correlation of Oil Beds



I. Correlation Unit of Oil Layers

Objective: research the layer series of development, provide geologic basis for arranging well pattern

- **reservoir characteristic**: uniformity of lithology and oil storage property
- **interlayer**: the thickness and distribution range

- single sand layer(substratum, individual layer, single layer)
- sand group
- reservoir group
- oil bearing sequence

•The smaller the correlation unit of oil layers, the better uniformity of reservoir property, and better lateral connectivity.

Correlation of Oil Beds

II. Classification of Sedimentary Cycle

- By Individual oil bed Lithologic features and evolution
- By Individual oil bed at all levels of depositional cycle in combination

4th level sedimentary cycle(rhythm)	single sand layer(individual layer)
3rd level sedimentary cycle	sand group
2nd level sedimentary cycle	reservoir group
1st level sedimentary cycle	oil bearing sequence

Correlation of Oil Beds

1.Cycle-thickness correlation：

controlled by standard layer, according to the relationship between the order of sedimentary cycle and depth ratio, conduct correlation step-by-step from large to small till to the single layer.

Correlation of oil layers----methods

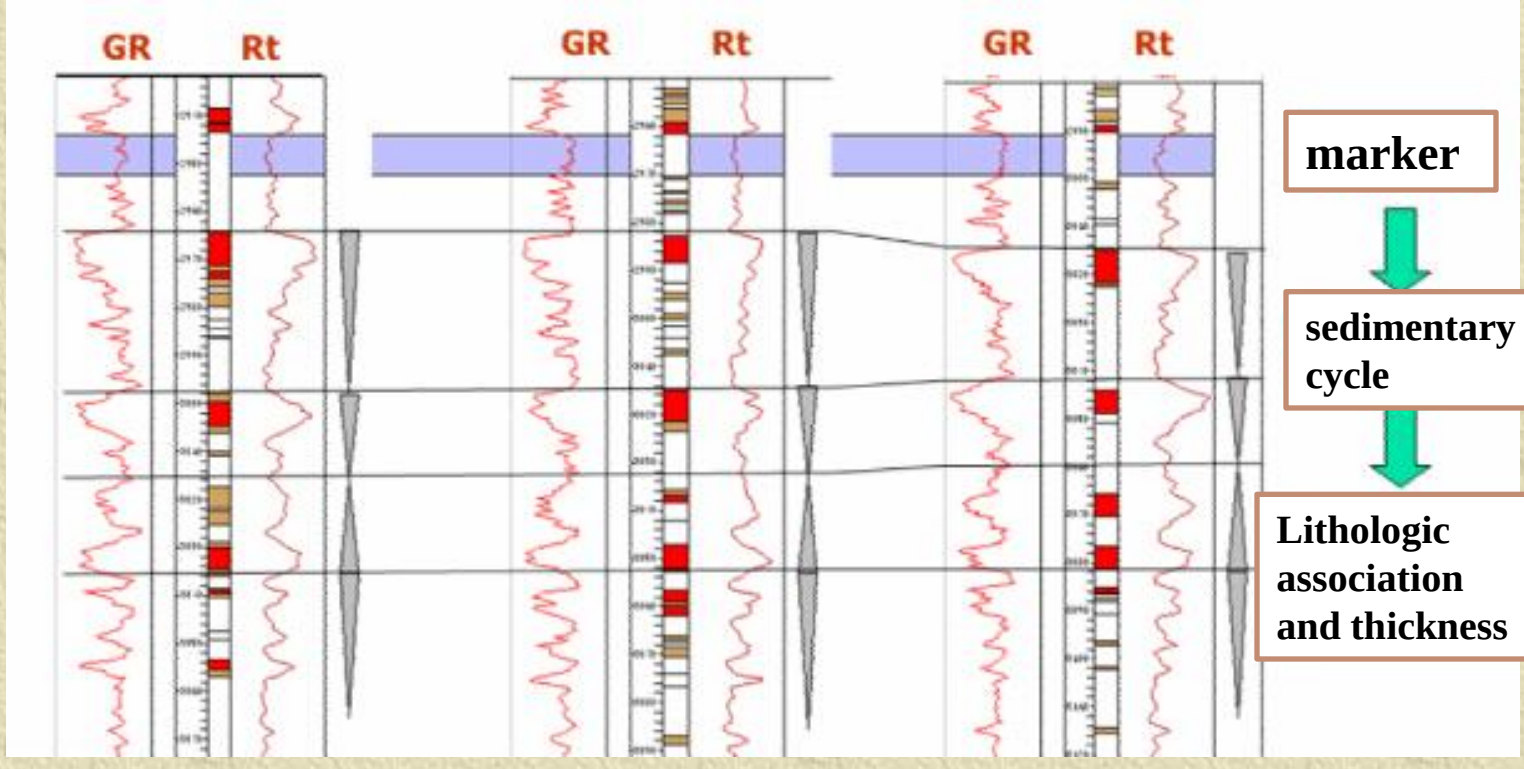
1.Cycle-thickness correlation：

controlled by standard layer, according to the relationship between the order of sedimentary cycle and depth ratio, conduct correlation step-by-step from large to small till to the single layer.

Stable depositional environment (lacustrine facies and delta-front facies)

Reservoir group→sand group→ substratum→single layer

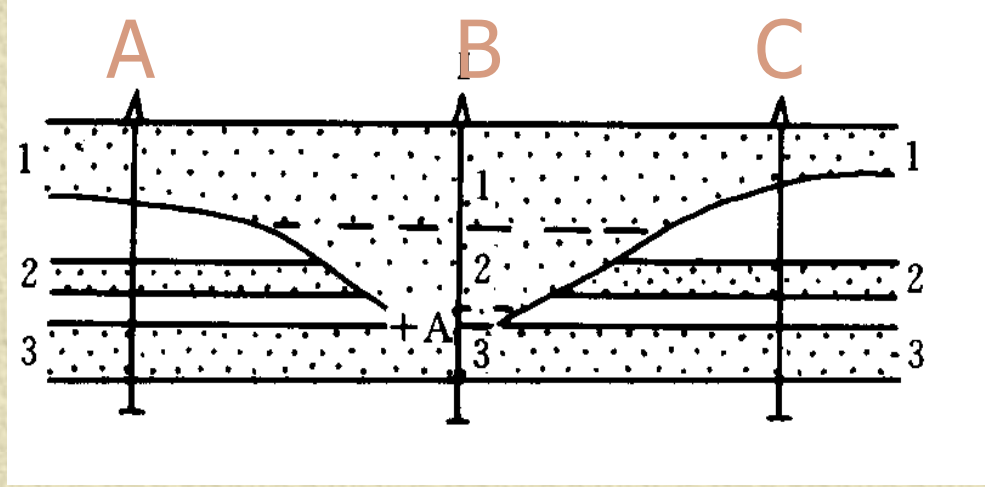
step by step comparison



Oil bed Correlation

Methods

2. Equielevation correlation：



A good datum plane would be a continuous shale because we can assume that it represents a “flooding surface” present over a wide area. Since shales are low energy deposits we may also assume that they have been deposited mostly horizontally, blanketing the underlying sediments thus “creating” a true datum plane.

Isochonism----

wide sedimentation in the same period

Marker bed associated with flooding

flooding: large-scale rapid transgression of flooding.

Shale related to the flooding in the clastic profile

Oil bed Correlation

Methods

2.Equielevation correlation：

condition:

for fluvial facies and other facies with strong heterogeneity.

The sand top in a same channal is isochronous. The isochronous surface is parallel to marker.

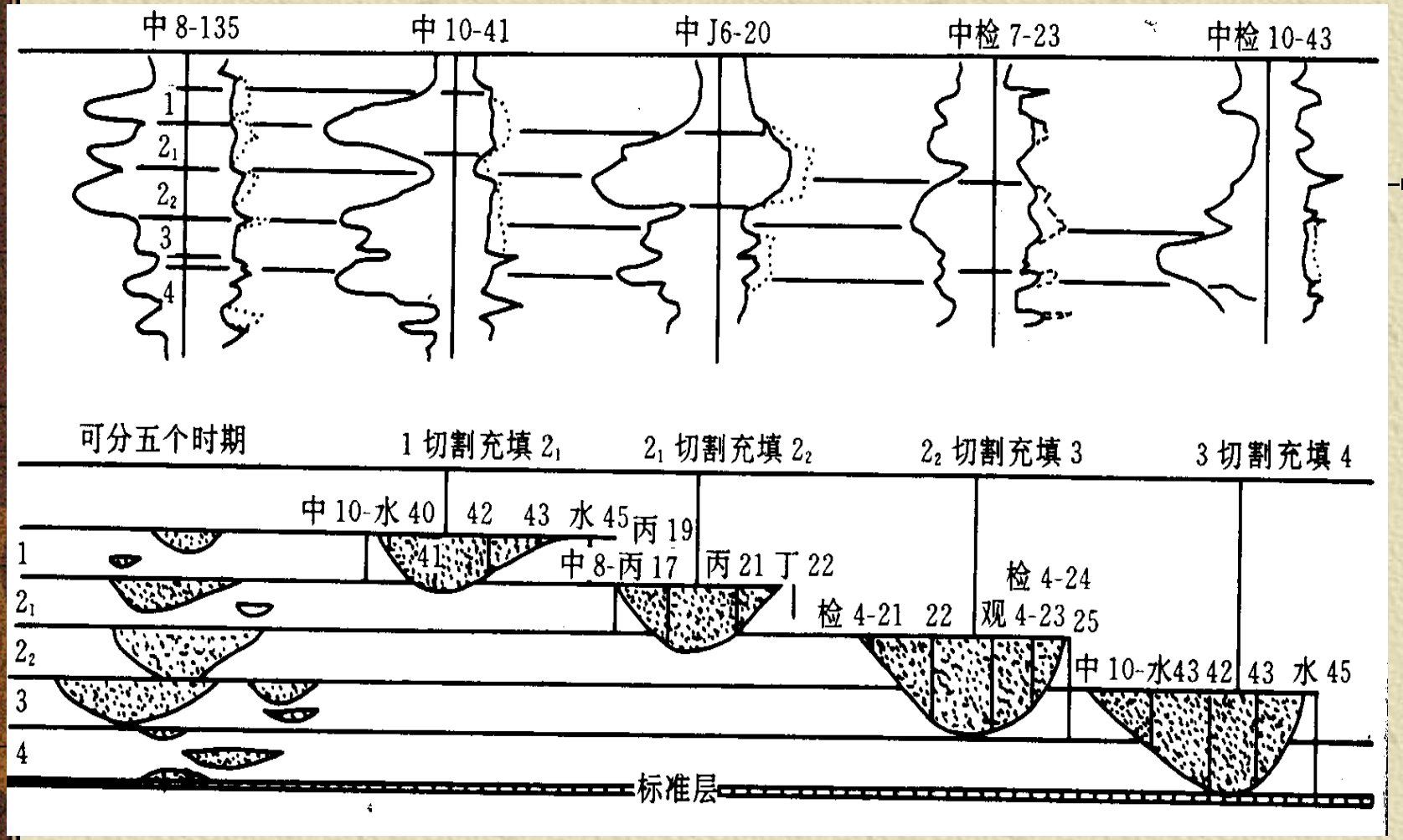
For the same channel deposit, the distance between sand top and marker is same height, otherwise different period sand channel will have different heights

Oil Bed Correlation

Methods

2. Equielevation Correlation：

- Define type well and select marker layer；
- Count the distance between main sand bodies top and marker layer;
- Make the top of sand bodies which has same distance to marker layer as isochronous surface, meanwhile divide the sand stone has different distance to marker layer into several time units.



time unit division

Make the top of sand bodies which has same distance to marker layer as isochronous surface, meanwhile divide the sand stone has different distance to marker layer into several time units.

Oil bed Correlation

2. Equielevation correlation：

method：

- Define type well and select marker layer；
- Count the distance between main sand bodies top and marker layer;
- Make the top of sand bodies which has same distance to marker layer as isochronous surface, meanwhile divide the sand stone has different distance to marker layer into several time units.

Exercise 3-3 Sand Group Correction

I. Data

II. Correlation of facies profile

1. Analyze sand body;

2. Equielevation correlation, divide time-stratigraphic units

3. According to facies migration characteristics in profile, draw sand body of different origin.

III. Comprehensive Question:

From point bar migration path, infer current direction.

Ming 2nd Member Sand Group

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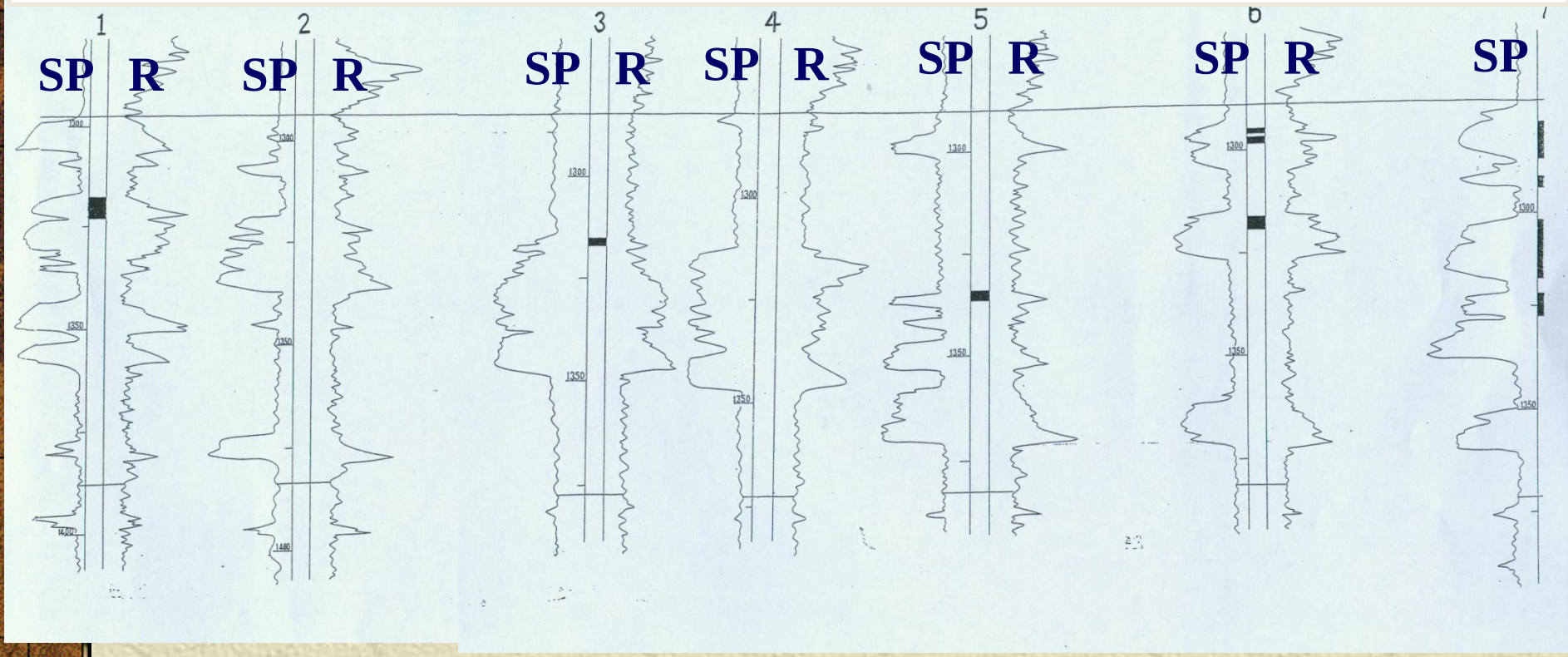


Well 3 ---- cored hole

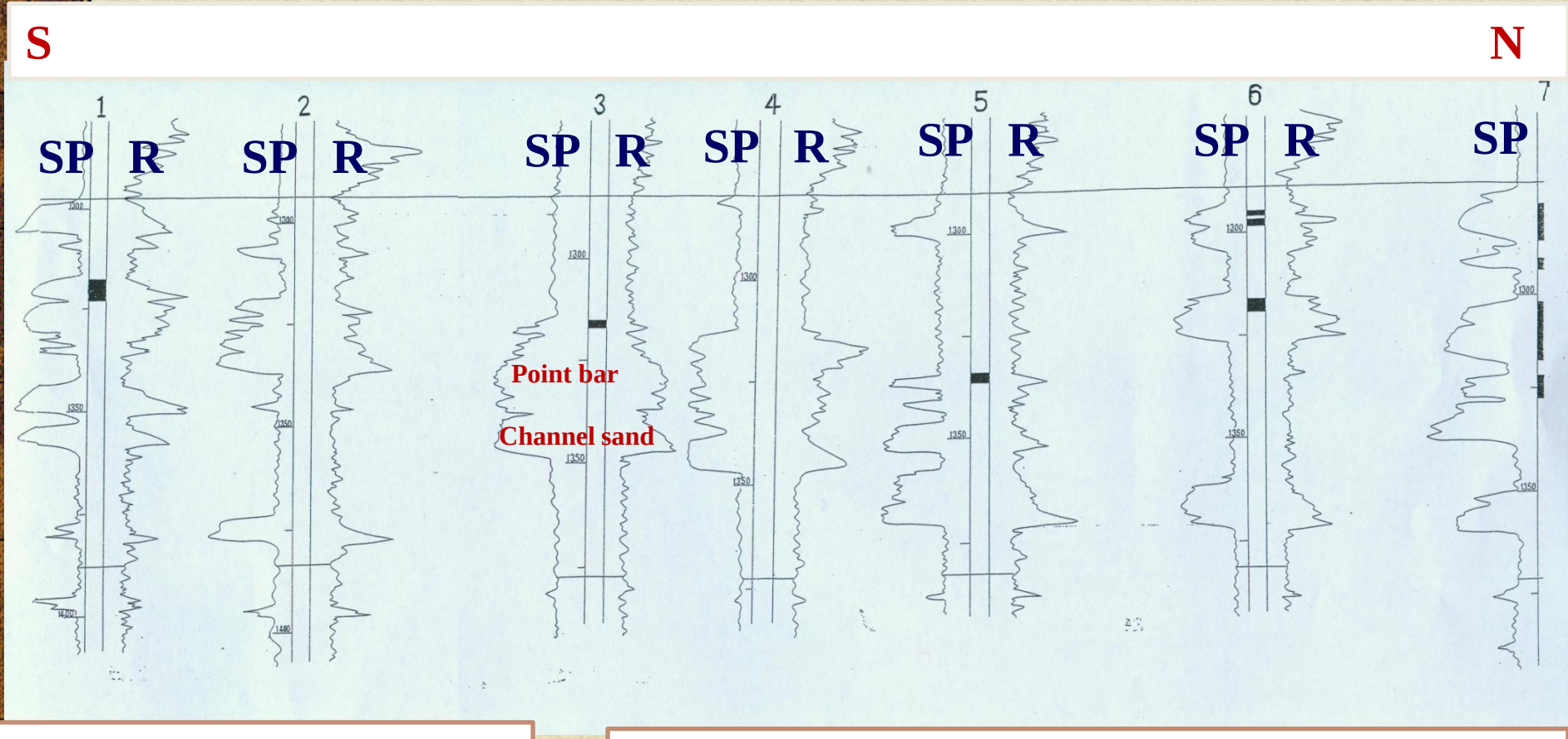
1337-1347m, channel sand

1318-1336m, point bar

1314-1317m, raised bank

1314m, flood plain

Ming 2nd Member Sand Group



Well 3 ---- cored hole
1337-1347m, channel sand
1318-1336m, point bar
1314-1317m, raised bank
1314m, flood plain

II. Correlation method

1. Analyze sand body;
2. Equielevation correlation, divide time-stratigraphic units
3. According to facies migration characteristics in profile, draw sand body of different origin.

Exercise 3-3 Sand Group Correction

I. Data

II. Correlation of facies profile

1. Analyze sand body;

2. Equielevation correlation, divide time-stratigraphic units

3. According to facies migration characteristics in profile, draw sand body of different origin.

III. Comprehensive Question:

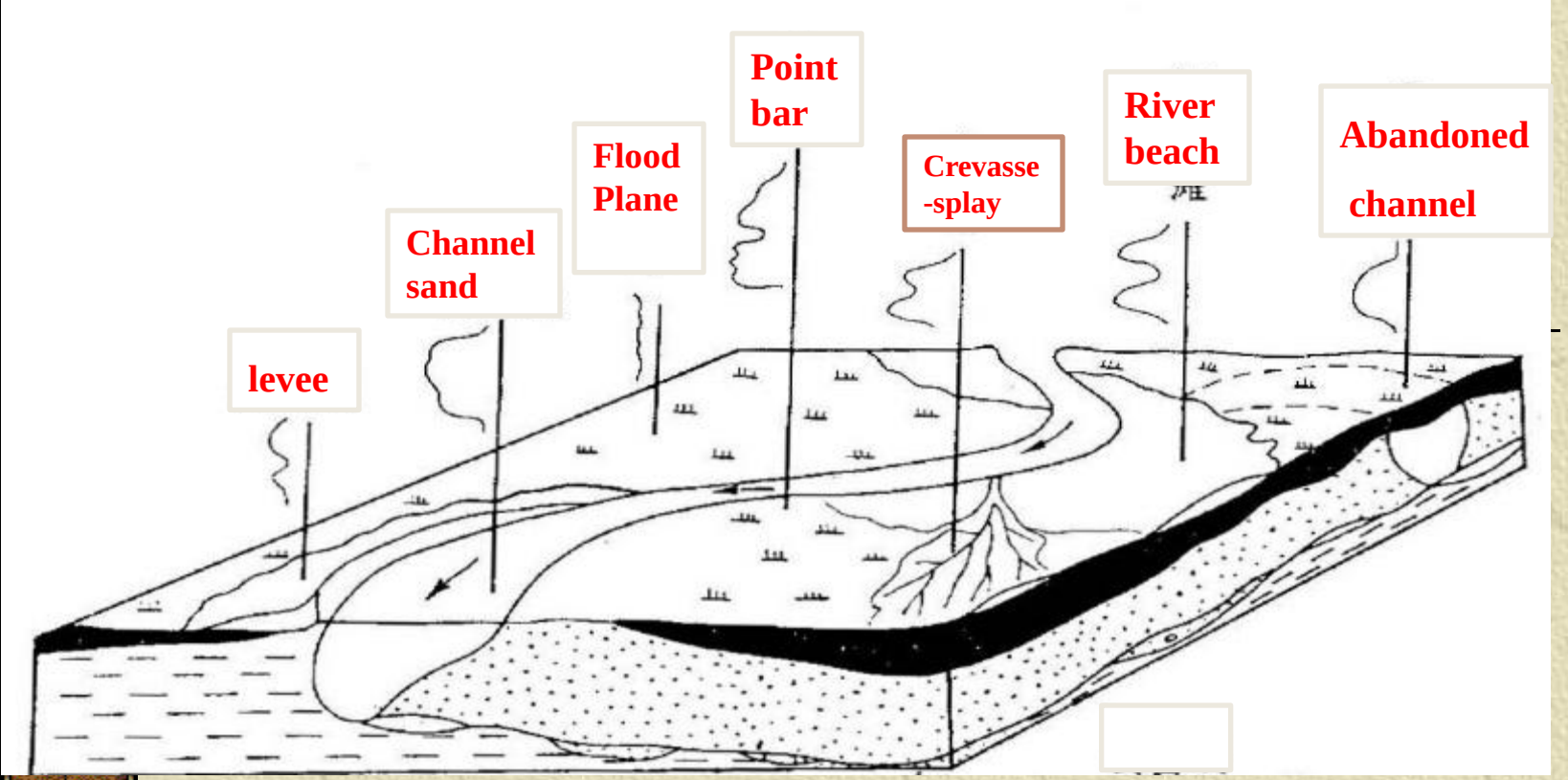
From point bar migration path, infer current direction.

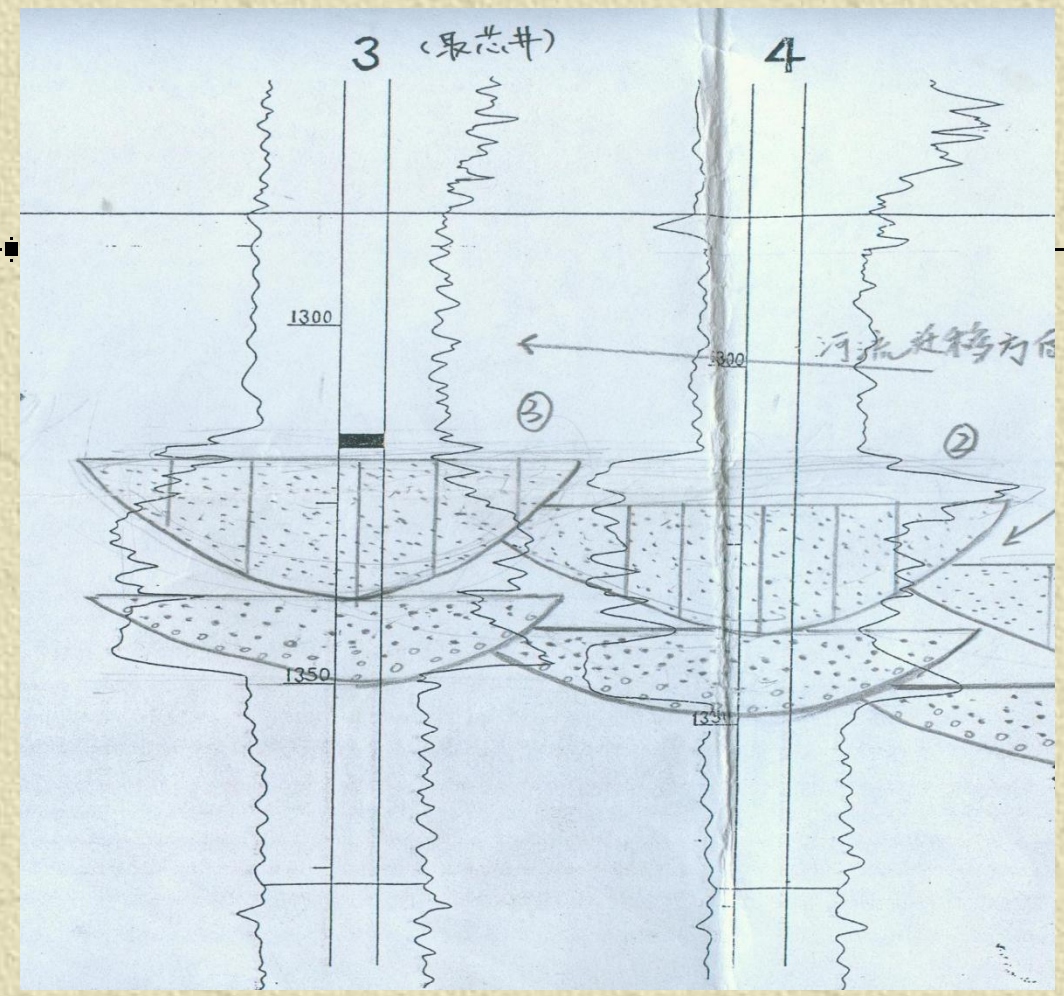
Meandering river----where is the sand?

rivers concave bank erosion,
rivers in the convex bank pushed up

Meandering river----where is the sand?

Meandering river----sand


Point bar
Flood Plane
Crevasse -splay
River beach
Abandoned channel
Channel sand
levee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