THE APPLICATION OF THE 't' TEST AND MARKOV CHAIN ANALYSIS IN BIOSTRATIGRAPHY OF 'X' WELL

by
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I. INTRODUCTION

There is no habit in biostratigraphers to apply the statistic methods to solve problems in their jobs, whereas in fact these methods are very useful when conventional ways failed. The use of this method has become very important in reservoir scale where microfossil content is low and indicator species is rare or absent. Applying biozonation in reservoir scale is much less reliable since reservoir layers are mostly below zonal resolution, so that the application of high resolution biostratigraphy is needed. In this case, the integration of biometric study and 't' or 'f' test can be used to define bioevent precisely.

In sequence stratigraphy, data of depositional environment in various system tracts that determined using microfossil assemblage are very important. However, for the reasons of barren or no samples, this information might not be obtained by biostratigraphy or other methods. Due to the geological cycle and repeatable nature of depositional sequence, Markov Chain analysis can be used to predict the lost information about environment of deposition.

II. CASE HISTORY MODEL

The biostratigraphic analysis based on nannofossil has been done to define Oligocene/Miocene boundary in 'X' well section. There is no zonal marker species (*Helicosphaera recta* and *Spenolithus ciperoensis*) recovered in the analysed interval due to unsupported depositional facies and lithological type. Moreover, depositional environment of the uppermost and lowermost analysed interval cannot be interpreted since they are barren of microfossil and no samples, respectively. To define Oligocene/Miocene boundary and to predict the depositional environment of uppermost and lowermost analysed interval, 't' test and Markov Chain analysis are conducted.

A. *t Test*

Biometric study and t test of *Cyclicargolithus floridanus* size are conducted since the size of this species is recognized relatively smaller in Oligocene and larger in Miocene (different). Based on vertical distribution of that species size, it is assumed that Oligocene/Miocene boundary is placed between 2130m and 2140m. The 't' test is conducted to prove that the size of *Cyclicargolithus floridanus* between two depths above is significantly different.

B. Markov Chain Analysis

Based on the composition of microfossil assemblages, interpretation of depositional environment has been defined precisely to the interval 2030m - 2420m of 'X' well section. Unfortunately, the sample 2020m is barren of microfossils, whereas the depth below 2420m is no samples, with the result that depositional environment is indeterminable. However, the depositional environmental data of those depth is required to make depositional model of the oil field. Markov Chain analysis is applied to predict depositional environment of above and below the analysed interval.

III. CONCLUSION

The development of high resolution biostratigraphy in the last decades has been giving a role to biometric study and statistic methods (especially 't' or 'f' test) to identify bioevents. It is understood that the different size in the same species can be bioevent when it has a different stratigraphic range. In Neogen nannofossils, it does not only happen in *C. floridanus,* but also *Calcidiscus* grup, *Reticulofenestra pseudoumbilica,* etc.

In biostratigraphy, Markov Chain analysis can be applied to predict indeterminate depositional environment due to cycle process and repeatable nature. The use of this method becomes more important since the frequency and relationship of paleoenvironmental type is controlled

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Size of *Cyclicargolithus floridanus* (micronmeter)

No.	Depth 2130m (X_1)	Depth 2140m (X_2)
1	6.50	4.00
2	10.00	6.00
3	7.50	3.50
4	8.50	7.50
5	4.50	3.00
6	9.00	5.00
7	6.50	4.00
8	6.00	3.50
9	9.00	3.00
10	8.00	3.50
11	5.50	4.50
12	7.50	3.00
Sum	**88.50**	**50.50**
Mean	**7.375**	**4.208**
Variance (S^2)	**2.642**	**1.885**
Standard deviation (S)	**1.625**	**1.373**

t-test

$$Sp^2 = \frac{(n_1-1)S_1^2+(n_2-1)S_2^2}{n_1+n_2-2}$$

$$= \frac{11*2.642+11*1.885}{22}$$

$$= \frac{29.062+20.735}{22}$$

$$= 2.264$$

$$Se = Sp\sqrt{\frac{1}{n_1}+\frac{1}{n_2}}$$

$$= 1.505\sqrt{0.167}$$

$$= 0.615$$

$$t = \frac{X_1-X_2}{se}$$

$$= \frac{7.375-4.208}{0.615}$$

$$= 5.15$$

$$df = 22$$

$$t(0.05,22) = 1.717144$$

t calculation > t table

Conclusion

The size of specimens at 2130m and 2140m is significantly different

2130m ⟶ Miocene
2140m ⟶ Oligocene

The Miocene/Oligocene boundary is correctly placed between 2130m and 2140m

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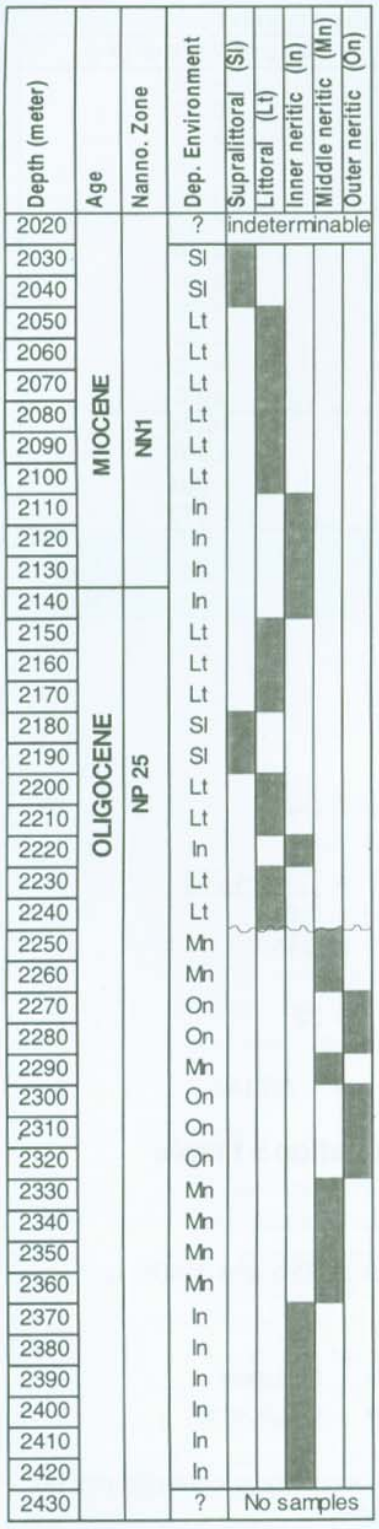

MARKOV CHAIN ANALYSIS

Downward Prediction

Basic Data

	Sl	Lt	In	Mn	On
Sl	2.00	2.00	0.00	0.00	0.00
Lt	1.00	9.00	2.00	1.00	0.00
In	0.00	2.00	8.00	0.00	0.00
Mn	0.00	0.00	1.00	4.00	2.00
On	0.00	0.00	0.00	2.00	3.00

First Order

	Sl	Lt	In	Mn	On
Sl	0.50	0.50	0.00	0.00	0.00
Lt	0.08	0.69	0.15	0.08	0.00
In	0.00	0.20	0.80	0.00	0.00
Mn	0.00	0.00	0.14	0.57	0.29
On	0.00	0.00	0.00	0.40	0.60

Second Order

	Sl	Lt	In	Mn	On
Sl	0.29	0.60	0.08	0.04	0.00
Lt	0.09	0.55	0.23	0.10	0.02
In	0.02	0.30	0.67	0.02	0.00
Mn	0.00	0.03	0.19	0.44	0.34
On	0.00	0.00	0.06	0.47	0.48

The depth 2430m

Probability for first order:
- 1st, Inner neritic (In) 80%
- 2nd, Littoral (Lt) 20%

Probability for second order:
- 1st, Inner neritic (In) 67%
- 2nd, Littoral (Lt) 30%

Upward Prediction

Basic Data

	Sl	Lt	In	Mn	On
Sl	2.00	1.00	0.00	0.00	0.00
Lt	2.00	9.00	2.00	0.00	0.00
In	0.00	2.00	8.00	1.00	2.00
Mn	0.00	1.00	0.00	4.00	2.00
On	0.00	0.00	0.00	2.00	3.00

First Order

	Sl	Lt	In	Mn	On
Sl	0.67	0.33	0.00	0.00	0.00
Lt	0.15	0.69	0.15	0.00	0.00
In	0.00	0.15	0.62	0.08	0.15
Mn	0.00	0.14	0.00	0.57	0.29
On	0.00	0.00	0.00	0.40	0.60

Second Order

	Sl	Lt	In	Mn	On
Sl	0.50	0.45	0.05	0.00	0.00
Lt	0.21	0.55	0.20	0.01	0.02
In	0.02	0.21	0.41	0.16	0.21
Mn	0.02	0.18	0.02	0.44	0.34
On	0.00	0.06	0.00	0.47	0.48

The depth 2430m

Probability for first order:
- 1st, Supralittoral (Sl) 67%
- 2nd, Littoral (Lt) 33%

Probability for second order:
- 1st, Supralittoral (Sl) 50%
- 2nd, Littoral (Lt) 45%

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by many unknown processes. On the contrary, Markov Chain can not be applied to predict biozone and bioevent because they are unindirectional processes.

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