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Pollen Analysis of the Cretaceous Sediments in Taiwan[1]

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ABSTRACT: Fifty eight form genera, one hundred and thirty four form species of fossil palynomorphs were reported from the early Cretaceous strata based on materials from seventeen exploration wells in Taiwan. Among these , there are fourty-five form genera and ninety eight form species of pteridophytic spores, eleven form genera and twenty six form species of gymnospermous grains, and two form genera and ten form species of angiospermous grains and one form genus and one form species of algal spores. These early Cretaceous palynomorphic assemblages are predominated by gymnosperms in species quantity but by pteridophytes in species diversity. Angiospermous species are only represented by primitive monocolpate and tricolpate pollen grains. The flora assemblages of the early Cretaceous of Taiwan might suggest a tropical to subtropical climate at that time and the plant community was dominated by coastal scrub plants such as *Classopollis*. More landwards, the flora was replaced by pteridophytic Cyatheaceae and gymnospermous *Classopollis* savanna plants in which local pteridophytic grassland was also common.

KEY WORDS: Cretaceous, Pollen analysis, Taiwan.

INTRODUCTION

The first part of this work on fossil palynomorphs was published in 1994 (Shaw,1994; Shaw & Huang, 1994). This is the second part and is concentrated on the pollen analysis. The work is still continuing. We plan to report the evolution of the early angiospermous pollen, and the palynological biostratigraphy in subsequent issues of the series .

MATERIALS AND METHODS

Since this is part of a series of our papers, the materials and methods refer the reader to our previous publication in *Taiwania* (Shaw & Huang, 1994) except for the preparation of pollen diagrams. The pollen diagrams (Figs. 1-6) are constructed by using a sum of total

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palynomorphs. The percentage of each taxon is also based on the total palynomorphs. The numbers of palynomorphs in differrent strata of the different wells are showin in Tables 1-10. However, the percentage tables of palynomorphs are intentionally omitted to save space.

RESULTS

Samples used in this study include conventional cores, side-wall-cores and cuttings. Among these samples, the results obtained from the analysis of conventional cores are the most reliable, and the weights of the samples are all over 20 g. The reliability of the results from the side-wall-cores are less than that from the conventional cores, as mud cake from the wall of the well may mix with the samples and therefore the mud on the side-wall-cores should be removed. Further, side-wall-cores are limited in quantity; sometimes only a few grams to less than one gram are available for analysis. Cuttings are the less reliable samples because the exact depth of each sample cannot be precisely identified. It is due to the fact that the circulation of the cuttings to the surface takes a long time. In addition, cavings, additives to mud, and the materials used to block the leaking of mud would cause serious contamination to the samples.

This study is based primarily on conventional and side-wall-core samples and when cuttings are used, they are thoroughly cleaned before being used.

I. The kind of palynomorphs

Two hundred specimens of spores and pollen from each sample, either derived from conventional cores, side-wall-cores, or slightly contaminated cuttings, were analyzed, and basically five slides of specimen were used for species identification. The stratigraphic sequences from the oldest to the youngest age of each well were delineated.

The pollen and spores were counted. The number of pteridophytic spores is 4635; gymnospermous grains is 4259; angiospermous grains is 110, and non-identified palynomorphs is 672. These grains were identified and classified into the following taxa. One hundred and thirty four species of fossil palynomorphs belonging to fourty-five genera and ninety eight species of pteridophytic spores, eleven genera and twenty six species of gymnospermous grains, and two genera and ten species of angiospermous grains have been recorded in those samples as below:

A. GYMNOSPERMAE

1. ARAUCARIACITES Cookson *ex* Cpuper 1953
   (1) *Araucariacites australis* Cookson *ex* Cpuper
   (2) *Araucariacites taiwanensis* Shaw & Huang
2. CALLIALASPORITES Sukh Dev 1961
   (1) *Callialasporites taiwanensis* Shaw & Huang0
   (2) *Callialasporites striatus* Shaw & Huang
3. CAMEROSPORITES Leschik 1956
   (1) *Camerosporites taiwanensis* Shaw & Huang

(2) *Camerosporites tuberosus* Shaw & Huang
(3) *Camerosporites formosus* Shaw & Huang
4. CLASSOPOLLIS (Pflug) Pocock & Jansonius 1961
(1) *Classopollis annulatus* (Verb.) Li
(2) *Classopollis parvus* (Brenner) Xu & Zhang
(3) *Classopollis classoides* (Pflug) Pocock & Jansonius
5. CYCADOPITES Wodehouse 1933
(1) *Cycadopites lanceolatus* Shaw & Huang
(2) *Cycadopites lanceolatus var. scabratus* Shaw & Huang
(3) *Cycadopites ovalis* Shaw & Huang
(4) *Cycadopites yunlinensis* Shaw & Huang
6. EPHEDRACEAE Bolkhoviyina 1953 *ex* Potonie 1958
(1) *Ephedripites formosensis* Shaw & Huang
(2) *Ephedripites speciosus* Shaw & Huang
(3) *Ephedripites mundulus* Shaw & Huang
(4) *Ephedripites chinensis* Shaw & Huang
(5) *Ephedripites yunlinensis* Shaw & Huang
7. EUCOMMIDITES Erdtman 1948 ex Potonie 1958
(1) *Eucommidites formosus* Shaw & Huang
8. PITYOSPORITES Seward 1914
(1) *Pityosporites longicorpus* Shaw & Huang
(2) *Pityosporites vulgaris* Shaw & Huang
9. TAXODIACEAEPOLLENITES Kremp 1949 *ex* Potonie 1958
(1) *Taxodiaceaepollenites taiwanensis* Huang
10. VITREISPORITES Leschik 1956
(1) *Vitreisporites mediocris* Shaw & Huang
(2) *Vitreisporites pallidas* (Reissienger) Nilsson
11. ZONALAPOLLENITES Pflug in Thomoson & Pflug 1953
(1) *Zonalapollenites peikangensis* Shaw & Huang

B .ANGIOSPERMAE

1. CONFERTISULCITES Anderson 1960
(1) *Confertisulcites formosus* Shaw & Huang
(2) *Confertisulcites cretaceous* Shaw & Huang
2. TRICOLPOPOLLENITES Pflug & Thomson in Thomson & Pflug 1953
(1) *Tricolpopollenites lepidus* Shaw & Huang
(2) *Tricolpopollenites medieus* Shaw & Huang
(3) *Tricolpopollenites oblongs* Shaw & Huang
(4) *Tricolpopollenites mundulus* Shaw & Huang
(5) *Tricolpopollenites perprolatus* Shaw & Huang
(6) *Tricolpopollenites orientalis* Shaw & Huang
(7) *Tricolpopollenites peikangensis* Shaw & Huang
(8) *Tricolpopollenites houpiensis* Shaw & Huang

C .PTERIDOPHYTA

CLASS 1. ALETE

1. BACUIAPERTURITES Pierce 1961

(1) *Bacuinaperturites taiwanensis* Shaw & Huang

2. ECHINATIAPERTURITES Shaw & Huang 1994

Note: After International Code of Botanical Nomenclature (1988), Article 73.1, the correction of typographic error is here proposed, the original spelling for this genus is ECHINATINAPERTURITES.

(1) *Echinatiaperturites taiwanensis* Shaw & Huang

(2) *Echinatiaperturites spinulosus* Shaw & Huang

Note: After Article 23.4 of the same code mentioned above, the epithet is proposed to be *spinulosus*, the original spelling for this species epithet is *echinatus*.

3. HUANGASPORITES Shaw 1994

(1) *Huangasporites taiwanensis* Shaw

(2) *Huangasporites parvus* Shaw

4. LAEVIGATASPORITES Potonie & Gekketich 1933

(1) *Laevigatasporites irregularis* Shaw & Huang

5. MEMBRANOSPHAERA Samoilovich 1961 in Samoilovich & Mchedlishvili 1961

(1) *Membranosphaera taiwaniana* Shaw & Huang

(2) *Membranosphaera rugosa* Shaw & Huang

6. RUBINELLA Maljavkina 1949 *ex* Trudy Vnigri1953

(1) *Rubinella taiwanensis* Shaw & Huang

CLASS 2. MONOLETE

1. CICATRICOSOSPORITES Pflug & Thomsson in Thomson & Pflug 1953

(1) *Cicatricososporites taiwanensis* Shaw & Huang

2. LAEVIGATOSPORITES Ibrahim 1933

(1) *Laevigatosporites nudum* Shaw & Huang

(2) *Laevigatosporites sinensis* Shaw & Huang

(3) *Laevigatosporites gracilis* Wilson & Webster

(4) *Laevigatosporites minor* Shaw & Huang

CLASS 3. TRILETES

1. AEQUITRIRADITES Delicourt & Sprumont 1955

(1) *Aequitriradites spinulosus* var. *taiwanensis* Shaw & Huang

(2) *Aequitriradites speciosus* Shaw & Huang

2. BIRETISPORITES Delcourt & Sprumont 1955

(1) *Biretisporites cretaceous* Shaw & Huang

(2) *Biretisporites crassimagosus* Shaw & Huang

(3) *Biretisporites vulgaris* Shaw & Huang

(4) *Biretisporites taiwanensis* Shaw & Huang

(5) *Biretisporites magnus* Shaw & Huang

3. CANALICULATISPORITES Dybova & Jachowicz 1957

(1) *Canaliculatisporites taiwanensis* Shaw & Huang

4. CIBOTIUMSPORA Chang 1965

(1) *Cibotiumspora taiwaniana* Shaw & Huang

5. CICATRICOSISPORITES Potonie & Gelletich 1933

(1) *Cicatricosisporites tersus* (Kara-Mursa) Pocock

(2) *Cicatricosisporites nankingensis* (Zhang) Zhang

(3) *Cicatricosisporites minor* (Bolch.) Pocock

(4) *Cicatricosisporites rarustriatus* Shaw & Huang
(5) *Cicatricosisporites communis* Shaw & Huang
(6) *Cicatricosisporites vulgaris* Shaw & Huang
(7) *Cicatricosisporites mundulus* Shaw & Huang

6. CONCAVISSIMISPORITES Delcourt & Sprumont 1955
(1) *Concavissimisporites taiwanensis* Shaw & Huang
(2) *Concavissimisporites speciosus* Shaw & Huang
(3) *Concavissimisporites lepidus* Shaw & Huang

7. CONVOLUTISPORA Hoffmeister, Staplin & Malloy 1955
(1) *Convolutispora formosana* Shaw & Huang

8. CORRUGATISPORITES Thomson & Pflug 1953
(1) *Corrugatisporites formatus* Shaw & Huang
(2) *Corrugatisporites taiwanensis* Shaw & Huang

9. COSTATISPORITES Shaw & Huang 1994
(1) *Costatisporites taiwanensis* Shaw & Huang

10. CRYBELOSPORITES Dettmann 1963
(1) *Crybelosporites taiwanensis* Shaw & Huang

11. CYATHEIDITES Maljavkina 1958
(1) *Cyatheidites formosus* Shaw & Huang
(2) *Cyatheidites taiwanensis* Shaw & Huang
(3) *Cyatheidites orientalis* Shaw & Huang

12. CYATHIDITES Couper 1953
(1) *Cyathidites crassimarginatus* Shaw & Huang
(2) *Cyathidites formosus* Shaw & Huang
(3) *Cyathidites mundulus* Shaw & Huang
(4) *Cyathidites parvus* Shaw & Huang
(5) *Cyathidites minus* Shaw & Huang

13. DELTOIDOSPORA Miner 1935
(1) *Deltoidospora communis* Shaw & Huang
(2) *Deltoidospora parvus* Shaw & Huang

14. ECHINATISPORIS Krutzsch 1959
(1) *Echinatisporis taiwanensis* Shaw & Huang

15. GEMMATRILETES Pierce 1961
(1) *Gemmatriletes specious* Shaw & Huang
(2) *Gemmatriletes crassimaginatus* Shaw & Huang

16. GLEICHENIIDITES Ross 1949, Krutzsch 1959
(1) *Gleicheniidites orientalis* Shaw & Huang
(2) *Gleicheniidites peikangensis* Shaw & Huang

17. GRANULATISPORITES Ibrahim 1933
(1) *Granulatisporites taiwanensis* Shaw & Huang
(2) *Granulatisporites parvus* Shaw & Huang
(3) *Granulatisporites peikangensis* Shaw & Huang

18. HYMENORETICULISPORITES Doring 1964
(1) *Hymenoreticulisporites taiwanensis* Shaw & Huang

19. IMPARDECISPORA Venkatachala et. al. 1969

(1) *Impardecispora apiverrucata* var. *taiwaniana* Shaw & Huang
(2) *Impardecispora determinatus* Shaw & Huang

20. KEWANEESPORITES Peppers 1970
(1) *Kewaneesporites rotundus* Shaw & Huang
(2) *Kewaneesporites taiwanensis* Shaw & Huang
(3) *Kewaneesporites rarigranulatus* Shaw & Huang
(4) *Kewaneesporites formosus* Shaw & Huang

21. KLUKISPORITES Couper 1958
(1) *Klukisporites taiwanensis* Shaw & Huang
(2) *Klukisporites subrotundus* Shaw & Huang
(3) *Klukisporites specious* Shaw & Huang

22. LEIOTRILETES Naumova 1939 *ex* Ishchenko 1952
(1) *Leiotriletes roundus* Shaw & Huang
(2) *Leiotriletes menbranus* Shaw & Huang
(3) *Leiotriletes communis* Shaw & Huang
(4) *Leiotriletes taiwanensis* Huang
(5) *Leiotriletes obovatus* Huang
(6) *Leiotriletes wolffi* subsp. *brevis* Kr.
(7) *Leiotriletes sphaerotriangulus* Huang

23. LEPTOLEPIDITES Couper 1953
(1) *Leptolepidites taiwanensis* Shaw & Huang

24. OSMUNDACIDITES Couper 1953
(1) *Osmundacidites orientalis* Shaw & Huang

25. PILOSISPORITES Delcourt & Sprumont 1955
(1) *Pilosisporites verus* var. *formosensis* Shaw & Huang
(2) *Pilosisporites taiwanensis* Shaw & Huang
(3) *Pilosisporites parvus* Shaw & Huang
(4) *Pilosisporites paucipilosus* Shaw & Huang
(5) *Pilosisporites triplanatus* Shaw & Huang

26. PRAEMEROSISPORITES Shaw & Huang 1994
(1) *Praemerosisporites taiwanensis* Shaw & Huang

27. RARITUBERISPORITES Shaw & Huang
(1) *Rarituberisporites taiwanensis* Shaw & Huang

28. RETITRILETES Pierce 1961
(1) *Retitriletes aerolatus* Shaw & Huang
(2) *Retitriletes cretaceous* Shaw & Huang

29. SCABRATISPORITES Visscher 1966
(1) *Scabratisporites taiwanensis* Shaw & Huang

30. STAPLINISPORITES Pocock 1962
(1) *Staplinisporites taiwanensis* Shaw & Huang

31. TRIANGULATISPORITES Potonie & Kremp 1954
(1) *Triangulatisporites taiwanensis* Shaw & Huang

32. TRIASSISPORIS Schulz 1965
(1) *Triassisporis taiwaniana* Shaw & Huang

33. TRILOBOSPORITES Pant 1954 *ex* Potonie 1956

(1) *Trilobosporites formosensis* Shaw & Huang
(2) *Trilobosporites deltoidus* Shaw & Huang
(3) *Trilobosporites rotundus* Shaw & Huang

34. TRIPLANOSPORITES Pflug (in Thomson & Pflug1952) *ex* Thomson
(1) *Triplanosporites tuberosus* Shaw & Huang
(2) *Triplanosporites minor* Shaw & Huang
(3) *Triplanosporites cretaceous* Shaw & Huang
(4) *Triplanosporites formosus* Shaw & Huang
(5)*Triplanosporites figuratus* Shaw & Huang

35. TUBEROSITRILETES Doring 1964
(1) *Tuberositriletes formosensis* Shaw & Huang

36. VERRUCOSISPORITES Ibrahim 1933
(1) *Verrucosisporites cretaceous* Shaw & Huang

37. UNDULATISPORITES Pflug in Thomson & Pflug 1953
(1) *Undulatisporites parvirotundus* Shaw & Huang

II. Pollen Analysis of Wells

A. The Peikang PK-2 Well

Twenty-three samples below 1614m from the Peikang PK-2 Well were collected. Results show that spores and pollen are present from the samples between 1614m and 1787.3m;but between 1840m and 2171.81m, no spores and pollen are recovered (Table 1).

The eleven samples between 1614m and 1787.3m are comprised of over 50% of *Classopollis,* belonging to conifers and are associated with *Cicatricosisporites* (3-15%), *Klukisporites* (0-5%) and *Leiotrietes* (0-7%). Angiosperm is only represented by two primitive genera: *Confertisulcites* and *Tricolpopollenites* (Fig. 1). *Classopollis* is considered by paleobotanists (Alvin, 1982) and palynologists (Pocock & Jansonius, 1961) as belonging to Cheirolepidiaceae, which occurs mainly in the form of shrubs rather than trees, and the leaves are in the form of scales so that water contents are not easily transpirated. This phenomenon explains why this plant can survive in arid climate. On the other hand, abundant *Classopollis* was recovered from neritic and coastal sediments and it was concluded that it is a near-shore plant dominating the tropical region (Alvin, 1982; Sung et al., 1986; Traverse, 1988).

Venkatachala *et al.* (1980) used the relative abundance of *Classopollis* to classify the climate zones and advocated that a tropical-subtropical arid climate is characteristic to the assemblages of pollen dominated by 50% or more of *Classopollis.* (Jian-Xi Geological Survey, 1985).

The comparative study of *Cicatricosisporites* and the extant pteridophytic spores proves that the former is very similar to the spore of *Anemia,* both belonging to Schizaeaceae (Kremp & Kawasaki, 1972). The distribution of *Anemia* ranges from Florida to the north and Africa and Madagascar to the south (Copeland, 1947). Furthermore, *Klukisporites* also belongs to Schizaeaceous ferns, both genera are representatives of tropical-subtropical vegetations.

The pollen assemblages from this interval reveal that the climate was tropical-subtropical and the vegetation was dominated by shrub-type gymnospermous *Classopollis* community

with locally distributed herb-type community of pteridophytes (Fig. 1).

Table 1. Vertical stratigraphic distribution of palynomorphs in PK-2 Well.

		WELL:PK-2	SAMPLE DEPTH (m)										
		TAXA	*1614 1615	*1620	*1689	*1691	*1695	*1697.9	*1700	*1723.4 1725.2	*1750.3 1752.7	*1754	*1785.4 1787.3
Gymnosperm	1	*Araucariacites australis*							2				
	2	*Araucariacites taiwanensis*							1	1			
	3	*Camerosporites formosus*					1						
	4	*Camerosporites taiwanensis*								2	1		
	5	*Camerosporites tuberosus*							4		1		
	6	*Classopollis annulatus*	6	30	14	2	4	5	18	6	4	21	2
	7	*Classopollis classoides*	2	20	2		5	1	9	2	1	2	1
	8	*Classopollis parvus*	16	148	26	7	13	8	49	12	12	26	4
	9	*Ephedripites spp.*			1							1	
		SUBTOTAL	24	198	43	9	23	14	83	23	19	50	7
Angiosperm	1	*Confertisulcites formosus*										1	
	2	*Tricolpopollenites medieus*			2								
	3	*Tricolpopollenites mundulus*		1									
	4	*Tricolpopollenites oblongus*		1	1					2			
	5	*Tricolpopollenites peikangensis*		1									
		SUBTOTAL	0	3	3	0	0	0	0	2	0	1	0
Pteridophyte	1	*Laevigatosporites gracilis*		2									
	2	*Laevigatosporites minor*		1									
	3	*Laevigatosporites sinensis*		1									
	4	*Biretisporites crassimagosus*		4								1	
	5	*Biretisporites cretaceous*		1						1			
	6	*Biretisporites vulgaris*		2						1			
	7	*Cicatricosisporites communis*		1									
	8	*Cicatricosisporites minor*	1	3						1			
	9	*Cicatricosisporites rarustriatus*		1					1				
	10	*Cicatricosisporites taiwanensis*							1	1			
	11	*Cicatricosisporites tersus*	1	5	1	1	1	1	2	3	1	2	1
	12	*Cicatricosisporites vulgaris*	1	2			1	1	2	1	1	1	
	13	*Cyathidites minus*	2	13							1	1	1
	14	*Cyathidites mundulus*									1		
	15	*Cyathidites parvus*	2	7				1				1	1
	16	*Gleicheniidites peikangensis*		1	1		1	1			1		1
	17	*Leiotriletes communis*		1					1		1		1
	18	*Klukisporites specious*	1	1				1		1		1	
	19	*Triplanosporites cretaceous*	1	3									
	20	*Triplanosporites minor*	1	2									
	21	*Triplanosporites taiwanensis*		1			1						
	22	*Undulatisporites parvirotundus*		2									1
	23	*Verrucosisporites cretaceous*											
		SUBTOTAL	10	54	2	1	4	5	7	9	6	7	6
		Unidentified	5	36	14	4	5	5	6	4	4	11	2
		TOTAL	**39**	**291**	**62**	**14**	**32**	**24**	**96**	**38**	**29**	**69**	**15**

* CONVENTIONAL CORE, · SIDE-WELL CORE, OTHERS ARE CUTTING.

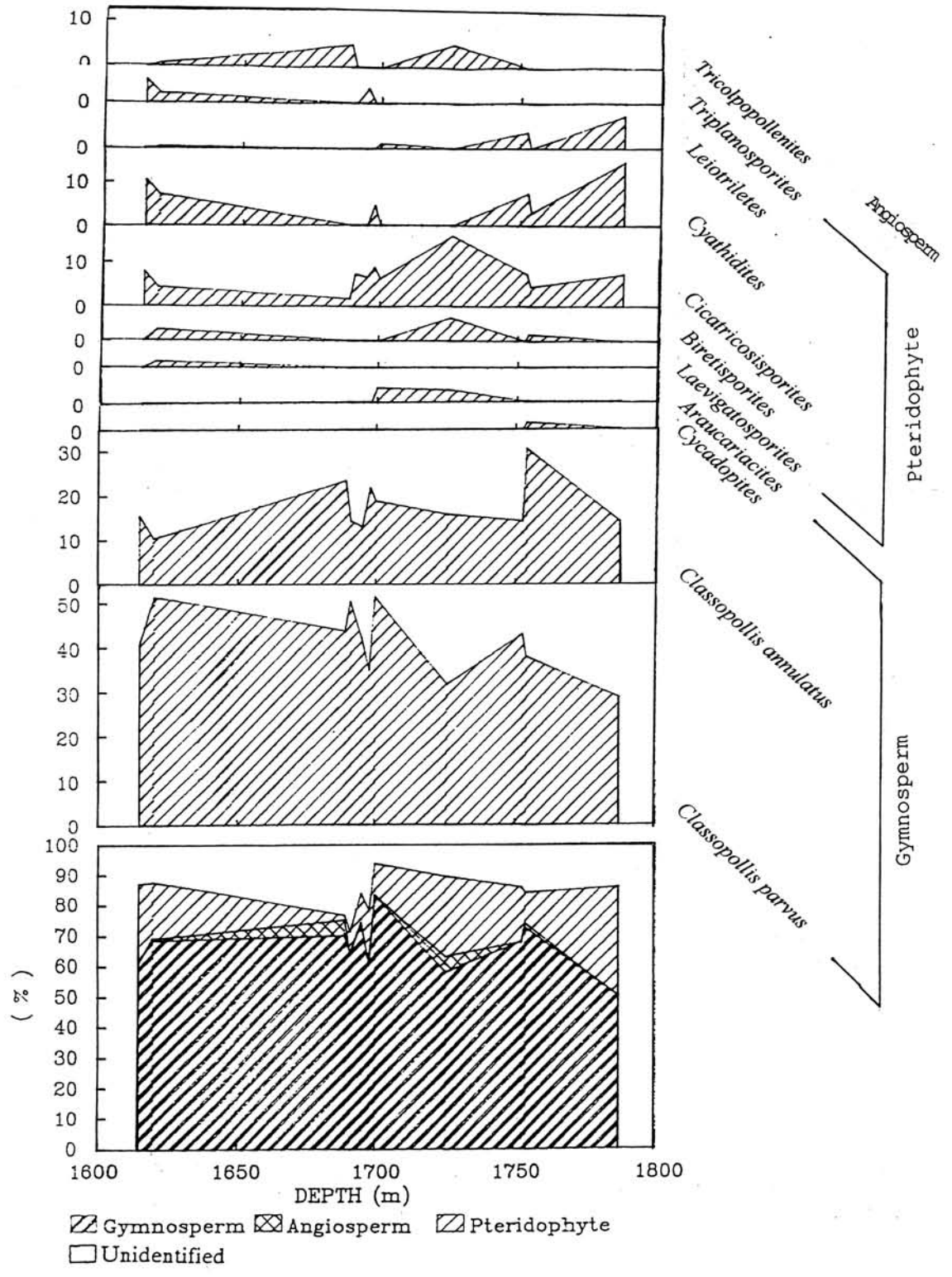

Fig. 1. Early Cretaceous Pollen diagram of PK-2 Well in Yunlin, Certral Taiwan.

B. The Peikang PK-3 Well

Eleven samples below 1965m from the Peikang PK-3 Well were collected. Results show that spores and pollen are present from the samples between 1965m and 2074.74m (Table 2).

The eleven samples between 1965m and 2074.74m are comprised of 37-77% of *Classopollis*, belonging to conifers and are associated with *Cicatricosisporites* (2.6-16.6%), *Triplanosporites* (4.5-12.5%) and *Biretisporites* (2.2-7.1%). Angiosperm is only represented by two primitive genera: *Confertisulcites* and *Tricolpopollenites* (Fig. 2).

The pollen assemblages from this interval reveal that the climate was tropical-subtropical and the vegetation was dominated by shrub-type of gymnospermous *Classopollis* community with locally distributed herb-type community of pteridophytes (Fig. 2).

C. The HM-3 Well

One conventional core (4397-4398m), six cuttings samples were collected from the HM-3 Well. As the lower end of the well caving was only set at the middle of the Peiling Shale, therefore the abundant Miocene fossils recovered from the cuttings are probably derived from cavings. No pollen is recovered from the section at 3940-3950m. For the interval 4250-4260m, no angiosperm was recovered from the cuttings samples and the pollen assemblages are very similar to those below 1750m in the PK-2 Well. The pollen assemblages are not complicated, and are dominated by *Classopollis parvus* (more than 30%) (Table 3) with some pteridophytic spores such as *Cicatricosisoprites* spp., *Klukisporites* spp., and *Triplanosporites* spp. As the assemblages are devoid of angiosperm pollen, the interval is interpreted to represent the Early Aptian.

The pollen assemblages of HM-3 Well indicate that the climate then was tropical-subtropical. The vegetation was dominated by shrub-type of gymnospermous *Classopollis* community with occassional occurrence of herb-type community of pteridophytes.

Below 3642-3645m the cuttings samples from the well are dominated by *Classopollis minor* and *Cicatricosisporites*. The occurrence of angiosperm is attributed to the contamination caused by caving from the upper part of the well. As interpreted by the appearance of *Classopollis* and *Cicatricosisporites*, the interval 3642-4160m of the HM-3 Well is in Cretaceous age.

D. The GH-1 Well

A conventional core sample at 1602m from the GH-1 Well was collected and the pollen is fair in abundance. The assemblages are extremely similar to those in the six core samples at the interval 1614-1754m of the PK-2 Well. They are predominated by *Classopollis parvus*, *C. annulatus* and *C. classoides* which constitute over 70% of the pollen assemblages (Table 4). The pteridophytes include *Cicatricosisporites* and *Triplanosporites* come to the next, and the angiosperm is only consisted of primitive *Tricolpopollenites*. Thus, the age of the sample is Albian-Aptian.

The pollen assemblages of GH-1 Well suggest that the climate was tropical-subtropical and the vegetation was dominated by shrub-type of gymnospermous *Classopollis* community with local occurrence of herb-type community of pteridophytes.

Table 2. Vertical stratigraphic distribution of palynomorphs in PK-3 Well

		WELL:PK-3	SAMPLE DEPTH (m)								
		TAXA	*2008.5 2009.8	*2029.4 2031.2	*2032.9 2034.4	*2036.1 2037.8	*2047 2050	*2057 2058.1	*2062 2064	*2065.7 2067.3	*2073 2074.7
Gymnosperm	1	*Araucariacites australis*	16	22	2		3		1		3
	2	*Camerosporites taiwanensis*		1							
	3	*Camerosporites tuberosus*	1	1	1		7		2		2
	4	*Classopollis annulatus*	30	16	14	44	22	18	22	21	26
	5	*Classopollis classoides*	1				1	3	2	2	1
	6	*Classopollis parvus*	82	70	60	80	65	120	111	97	89
	7	*Cycadopites attenuatus*						1			
	8	*Cycadopites yunlinensis*	3		1		1				2
	9	*Ephedripites spp.*		1	1	1	2	1	1		1
	10	*Eucommidites formosus*					1				
	11	*Pityosporites longicorpus*			1						
	12	*Pityosporites spp.*				3	1	1			1
	13	*Taxodiaceaepollenites taiwanensis*			3		6		3		1
	14	*Vitreisporites pallidus*		1							
		SUBTOTAL	133	112	83	128	109	144	142	120	126
Angiosperm	1	*Confertisulcites cretaceous*			1						
	2	*Tricolpopollenites medieus*				1					
	3	*Tricolpopollenites oblongus*	3	2			1		3	2	
	4	*Tricolpopollenites peikangensis*		4	1						
		SUBTOTAL	3	6	2	1	1	0	3	2	0
Pteridophyte	1	*Bacuinaperturites taiwanensis*								1	
	2	*Laevigatasporites irregularis*	1	3	1		1		1		
	3	*Membranosphaera taiwaniana*			4		21		3	6	2
	4	*Rubinella taiwaniana*	3							2	1
	5	*Laevigatosporites gracilis*		2	3	1	1		2		
	6	*Laevigatosporites minor*		1							
	7	*Laevigatosporites sinensis*				1					
	8	*Biretisporites crassimagosus*		1	4	1	7	1	3		4
	9	*Biretisporites cretaceous*		3	2	2	1	1	2	1	1
	10	*Biretisporites magnus*	2	2		2		1	1		1
	11	*Biretisporites parvus*	1		3	2		2		3	1
	12	*Biretisporites taiwanensis*		1							
	13	*Biretisporites vulgaris*	2	2	5	4	2	3	1	1	1
	14	*Cibotumspora taiwaniana*	1								
	15	*Cicatricosisporites communis*			1			1			
	16	*Cicatricosisporites minor Pocock*	2		5	1	6	2		2	2
	17	*Cicatricosisporites mundulus*			1						
	18	*Cicatricosisporites rarustriatus*	1		1	2	1		1		1
	19	*Cicatricosisporites taiwanensis*								1	
	20	*Cicatricosisporites tersus*		5	16	2	2	5	3	5	1
	21	*Cicatricosisporites vulgaris*	3	5	12	3	7	5	6	5	2
	22	*Concavissimisporites lepidus*			1						
	23	*Concavissimisporites speciosus*				2					
	24	*Concavissimisporites taiwanensis*				2	1	1			
	25	*Corrugatisporites formatus*						1			

Table 2. continued.

		WELL:PK-3	SAMPLE DEPTH (m)								
		TAXA	*2008.5 2009.8	*2029.4 2031.2	*2032.9 2034.4	*2036.1 2037.8	*2047 2050	*2057 2058.1	*2062 2064	*2065.7 2067.3	*2073 2074.7
Pteridophyte	26	*Corrugatisporites taiwanensis*			1	3	1		2		
	27	*Costatisporites taiwanensis*				1				3	
	28	*Cyatheidites formosus*								2	
	29	*Cyatheidites orientalis*			1	1				1	
	30	*Cyatheidites taiwanensis*	5		2						
	31	*Cyathidites formosus*		1	2	2	1		3	3	1
	32	*Cyathidites minus*	3	2	4	5	2	3	3	4	1
	33	*Cyathidites mundulus*		3	2	4	2			1	3
	34	*Cyathidites parvus*	5	2	1		1		1		1
	35	*Deltoidospora communis*		4		2		1			
	36	*Deltoidospora parvus*		3	2	2	3	2	1	4	
	37	*Gleicheniidites orientalies*				2	5	1	1	1	
	38	*Gleicheniidites peikangensis*					1				
	39	*Granulatisporites parvus*			1						
	40	*Granulatisporites peikangensis*	4		3			1	2		2
	41	*Granulatisporites taiwanensis*			3						
	42	*Kewanaesporites formosus*	1		1	1			1		
	43	*Kewanaesporites taiwanensis*			1				1		
	44	*Leiotriletes communis*	3	10	3	3	2	3	1	2	3
	45	*Leiotriletes menbranus*			1						
	46	*Leiotriletes obovatus*	1	2		6			2	2	1
	47	*Leiotriletes rotundus*	2	2	1		1				1
	48	*Leiotriletes sphaerotriangulus*	2		1	1	1				
	49	*Leiotriletes taiwanensis*	5	3		1			2		
	50	*Klukisporites specious*	1		2		1				2
	51	*Klukisporites subrotundus*		1							
	52	*Klukisporites taiwanensis*	1		9	5	1		1		
	53	*Osmundacidites orientalis*						1			
	54	*Retitriletes cretaceous*			1						
	55	*Staplinisporites taiwanensis*		1							
	56	*Trilobosporites rotundus*									
	57	*Triplanosporites cretaceous*	4	3	9	14	4	3	4	7	4
	58	*Triplanosporites figuratus*	2	4	1	5	1	4			
	59	*Triplanosporites minor*	1	2	7	3	3	3	4	7	1
	60	*Triplanosporites taiwanensis*	3	4	3	4		9		2	2
		SUBTOTAL	59	72	121	90	80	54	52	66	39
		Unidentified	23						17		
		Dinoflagellate						6	6	2	
		TOTAL	**218**	**190**	**206**	**219**	**190**	**204**	**220**	**190**	**165**

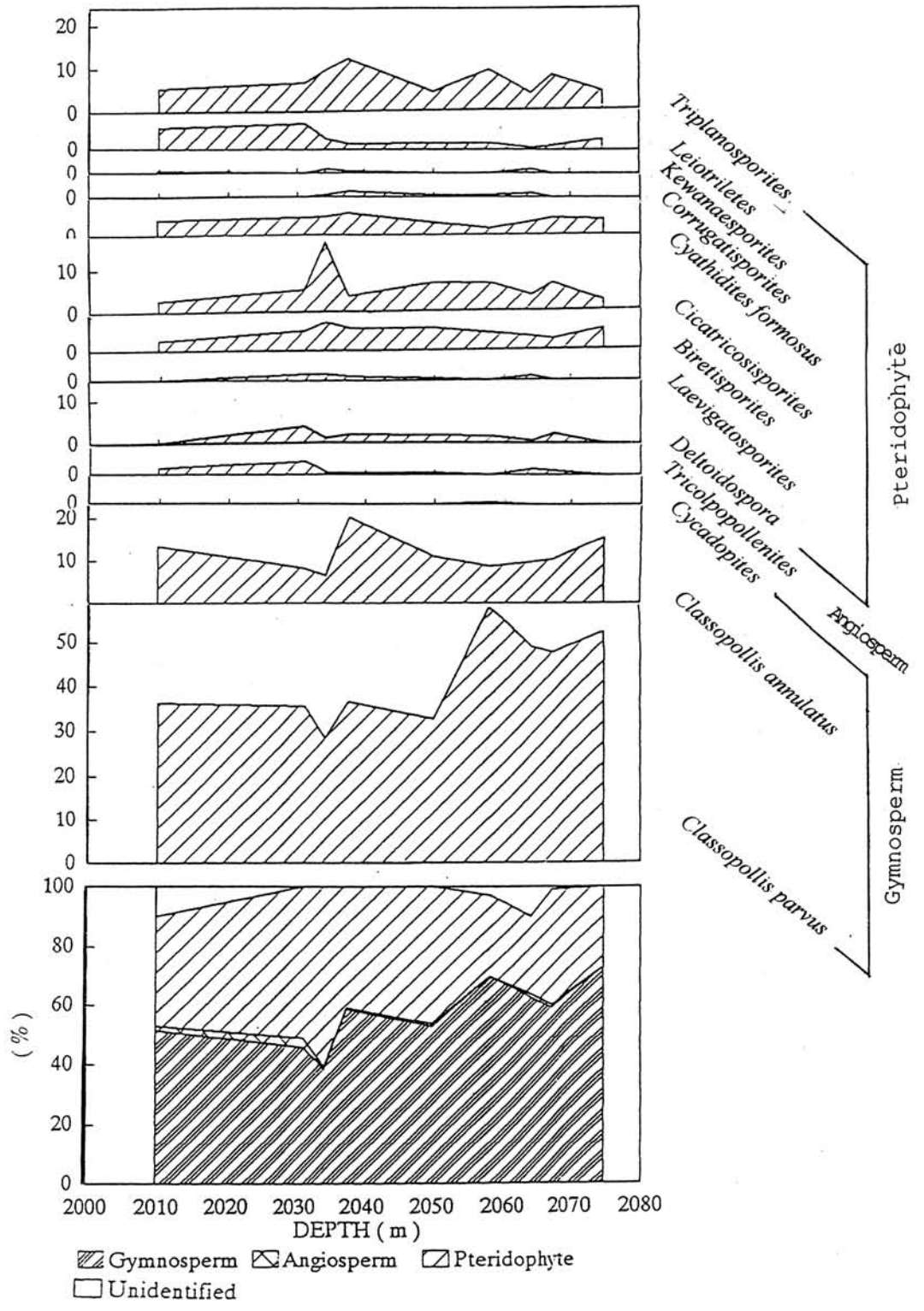

Fig. 2. Early Cretaceous Pollen diagram of PK-3 Well in Yunlin, Certral Taiwan.

Table 3. Vertical stratigraphic distribution and percentage of palynomorphs in HM-3 Well.

		WELL: HM-3	SAMPLE DEPTH (m)		
		TAXA	*4397 4398		*4397 4398
	1	*Araucariacites australis*	2		4.00
	2	*Classopollis annulatus*	3		6.00
	3	*Classopollis parvus*	16		32.00
		SUBTOTAL	21		42.00
Pteridophyte	1	*Biretisporites crassimagosus*	2		4.00
	2	*Biretisporites magnus*	1		2.00
	3	*Biretisporites vulgaris*	2		4.00
	4	*Cicatricosisporites minor Pocock*	2		4.00
	5	*Cicatricosisporites taiwanensis*	1		2.00
	6	*Cicatricosisporites tersus*	3		6.00
	7	*Cicatricosisporites vulgaris*	2		4.00
	8	*Corrugatisporites taiwanensis*	1		2.00
	9	*Cyathidites formosus*	1		2.00
	10	*Leiotriletes sphaerotriangulus*	1		2.00
	11	*Klukisporites specious*	1		2.00
	12	*Klukisporites taiwanensis*	2		4.00
	13	*Triplanosporites cretaceous*	1		2.00
	14	*Triplanosporites taiwanensis*	1		2.00
		SUBTOTAL	21		42.00
		Unidentified	8		16.00
		TOTAL	**50**		**100.00**

* CONVENTIONAL CORE, · SIDE-WELL CORE, OTHERS ARE CUTTING.

Table 4. Vertical stratigraphic distribution and percentage of palynomorphs in GH-1 Well.

		WELL: GH-1	SAMPLE DEPTH (m)		
		TAXA	*1602		*1602
Gymnosperm	1	*Araucariacites australis*	4		2.34
	2	*Classopollis annulatus*	12		7.02
	3	*Classopollis classoides*	2		1.17
	4	*Classopollis parvus*	113		66.08
	5	*Ephedripites spp.*	1		0.58
	6	*Taxodiaceaepollenites taiwanensis*	3		1.75
		SUBTOTAL	135		78.95
Angiosperm	1	*Tricolpopollenites medieus*	1		0.58
	2	*Tricolpopollenites oblongus*	1		0.58
		SUBTOTAL	2		1.17
Pteridophyte	1	*Laevigatasporites irregularis*	2		1.17
	2	*Biretisporites crassimagosus*	3		1.75
	3	*Biretisporites parvus*	1		0.58
	4	*Biretisporites vulgaris*	3		1.75
	5	*Cicatricosisporites minor Pocock*	1		0.58
	6	*Cicatricosisporites rarustriatus*	1		0.58
	7	*Cicatricosisporites tersus*	2		1.17
	8	*Cicatricosisporites vulgaris*	3		1.75
	9	*Cyathidites mundulus*	1		0.58
	10	*Deltoidospora parvus*	1		0.58
	11	*Leiotriletes obovatus*	2		1.17
	12	*Klukisporites specious*	1		0.58
	13	*Triplanosporites minor*	2		1.17
	14	*Triplanosporites taiwanensis*	1		0.58
		SUBTOTAL	24		14.04
		Unidentified	10		5.85
		TOTAL	**171**		**100.00**

* CONVENTIONAL CORE, · SIDE-WELL CORE, OTHERS ARE CUTTING.

E. The MLN-1 Well

Two cores from 3980.8-3988.5m and 4264-4272m were studied. No pollen was recovered from the kerogen in the sample, but nannofossils indicate an Early Cretaceous age for these samples (Huang, 1978).

F. The HP-1 Well

Three conventional core (4077.3-4111 m) and three cuttings samples were collected from the HP-1 Well. The pollen assemblages are fair in abundance, and are dominated by *Classopollis* spp. (more than 50%), with some pteridophytic spores such as *Cicatricosisoprites* spp., *Biretisporites* spp., and *Triplanosporites* spp. The conventional core (4077.3-4077.9m) is also consisted of primitive *Tricolpopollenites* (Table 5). Thus, the age of the sample is Albian-Aptian.

The pollen assemblages of HP-1 Well indicate that the climate then was tropical-subtropical. The vegetation was dominated by shrub-type of gymnospermous *Classopollis* community with occassional occurrence of herb-type community of pteridophytes.

G. The YTN-1 Well

Twenty-three samples, including nine conventional cores and fourteen cuttings samples were collected from the YTN-1 Well. Quantitative analysis indicates that pollen is generally present (Table 6). It is obvious from the pollen assemblages that the following taxa vary in abundance: *Cicatricosisporites* (7-69%), *Triplanosporites* (4-46.7%), and *Cyathiclites* (2.3-25.6%) of pteridophytes, and the *Classopollis* (1-16.3%) of gymnosperms. Angiosperm was only represented by two genera which are *Conferticulcites* and *Tricolpopollenites* (Fig. 3). These assemblages strongly suggest that the climate then was tropical-subtropical and the vegetation was dominated by pteridophytic community of Cyatheaceae and the shrub-type gymnospermous *Classopollis* community was only rare in abundance. Locally there was some herb-type community of pteriophytes (Fig. 3).

H. The YPT-1 Well

Twelve samples of four conventional cores, five side-wall-cores, and three cuttings samples were collected from the well. Quantitative analysis of the core and side-wall-core samples indicates that pollen is generally present (Table 7). The Table 8 also shows that the pollen assemblages are dominated by *Cicatricosisporites* (4.5-61%), *Cyathidites* (1.5-15%), *Triplanosporites* (5.7-31.6%) and *Classopollis* (2-57.4%). Angiosperm is only represented by two genera and they are *Confertisulcites* and *Tricolpopollenites* (Fig. 4).

As mentioned in the PK-2 Well, *Classopollis* and *Cicatricosisporites* belong to tropical-subtropical plants. *Troplanosporites* is probably the pollen of Cyatheaceae (Huang, 1978). Also, *Cyathidites* is probably the pollen of Cyatheaceae (Traverse, 1988). As Cyatheaceae is a typical composition of tropical-subtropical forests, its pollen assemblages naturally are indicative of a similar tropical-subtropical climate. The vegetation is dominated by shrub-type of gymnospermous *Classopollis* community, with occassional herb-type community of pteridophytic Cyatheaceae (Fig. 4).

The pollen assemblages of YPT-1 Well suggest a tropical-subtropical climate at that time and the vegetation was dominated by coastal shrub-type community of *Classopollis*.

More inland, the flora was replaced by pteridophytic Cyatheaceae and gymnospermous *Classopollis* shrub-type communities in which pteridophyte herb-type community was also common.

Table 5. Vertical stratigraphic distribution and percentage of palynomorphs in HP-1 Well.

		WELL:HP-1	SAMPLE DEPTH (m)						
		TAXA	*4077.3 4077.9	*4107 4107	*4109 4111		*4077.3 4077.9	*4107 4107	*4109 4111
Gymnosperm	1	*Araucariacites taiwanensis*	1				2.70	0.00	0.00
	2	*Classopollis annulatus*	5	1	1		13.51	10.00	9.09
	3	*Classopollis parvus*	14	5	6		37.84	50.00	54.55
		SUBTOTAL	20	6	7		54.05	60.00	63.64
Angiosperm	1	*Tricolpopollenites houpiensis*	1				2.70	0.00	0.00
	2	*Tricolpopollenites oblongus*	1				2.70	0.00	0.00
		SUBTOTAL	2	0	0		5.41	0.00	0.00
Pteridophyte	1	*Biretisporites crassimagosus*	1				2.70	0.00	0.00
	2	*Biretisporites cretaceous*	1				2.70	0.00	0.00
	3	*Biretisporites parvus*		1	1		0.00	10.00	9.09
	4	*Cicatricosisporites minor Pocock*	1				2.70	0.00	0.00
	5	*Cicatricosisporites tersus*	1				2.70	0.00	0.00
	6	*Cyathidites mundulus*	1				2.70	0.00	0.00
	7	*Leiotriletes communis*	1				2.70	0.00	0.00
	8	*Leiotriletes sphaerotriangulus*	1				2.70	0.00	0.00
	9	*Triplanosporites cretaceous*		1			0.00	10.00	0.00
	10	*Triplanosporites minor*		1	1		0.00	10.00	9.09
	11	*Triplanosporites taiwanensis*	1				2.70	0.00	0.00
		SUBTOTAL	8	3	2		21.62	30.00	18.18
		Unidentified	7	1	2		18.92	10.00	18.18
		TOTAL	**37**	**10**	**11**		**100.00**	**100.00**	**100.00**

* CONVENTIONAL CORE, · SIDE-WELL CORE, OTHERS ARE CUTTING.

Table. 6 Vertical stratigraphic distribution of palynomorphs in YTN-1 Well.

		WELL:YTN-1	SAMPLE DEPTH (m)							
		TAXA	*3700.7	*3702.54	*3703.5 3703.6	*3708.93 3709.0	*3711	*3712.2 3712.3	*3718.03 3718.08	*3722.1 3722.3
Gymnosperm	1	*Araucariacites australis*					1		2	3
	2	*Araucariacites taiwanensis*					1	1		3
	3	*Callialasporites taiwanensis*								3
	4	*Camerosporites tuberosus*								2
	5	*Classopollis annulatus*		5	3	1	6	1	4	1
	6	*Classopollis classoides*	2	1	2	1	1		1	
	7	*Classopollis parvus*	6	25	6	14	27	6	32	1
	8	*Cycadopites lanceolatus*					1		1	
	9	*Pityosporites longicorpus*								1
	10	*Pityosporites vulgaris*					2			
	11	*Taxodiaceaepollenites taiwanensis*					2	1		
		SUBTOTAL	8	31	11	16	41	9	40	14
Angiosperm	1	*Confertisulcites cretaceous*							1	1
	2	*Confertisulcites formosus*			1				1	
	3	*Tricolpopollenites medieus*			1		1		1	
	4	*Tricolpopollenites mundulus*					1	1		
	5	*Tricolpopollenites oblongus*					1			
		SUBTOTAL	0	0	2	0	3	1	3	1
Pteridophyte	1	*Echinatinaperturites taiwanensis*								1
	2	*Huangasporites parvus*						1		3
	3	*Huangasporites taiwanensis*						1		5
	4	*Laevigatasporites irregularis*		2						
	5	*Membranosphaera taiwaniana*					1	1		1
	6	*Rubinella taiwaniana*					2		1	
	7	*Cicatricososporites taiwanensis*							1	
	8	*Laevigatosporites gracilis*				1			3	
	9	*Laevigatosporites minor*						1	4	
	10	*Aequitriradites specious*				1	1			
	11	*Aequitriradites spinulosus taiwanensis*				1	1	1	1	1
	12	*Biretisporites crassimagosus*		2	1	2	1		3	1
	13	*Biretisporites cretaceous*		1		1	1			
	14	*Biretisporites magnus*			3		2			1
	15	*Biretisporites parvus*	1		1	1	4	1	4	1
	16	*Biretisporites vulgaris*	3	5	7	2	3	2	2	5
	17	*Canaliculatisporites taiwanensis*							1	1
	18	*Cibotumspora taiwaniana*								1

Table. 6. continued

		WELL:YTN-1	SAMPLE DEPTH (m)							
		TAXA	*3700.7	*3702.54	*3703.5 3703.6	*3708.93 3709.0	*3711	*3712.2 3712.3	*3718.03 3718.08	*3722.1 3722.3
Pteridophyte	19	*Cicatricosisporites communis*			1					
	20	*Cicatricosisporites minor Pocock*	3	30	4	1	7	6	19	6
	21	*Cicatricosisporites mundulus*								1
	22	*Cicatricosisporites rarustriatus*		16	1	1	2	1	21	3
	23	*Cicatricosisporites taiwanensis*		1			1		5	1
	24	*Cicatricosisporites tersus*	2	32	4	4	36	81	3	15
	25	*Cicatricosisporites vulgaris*	11	46	2	9	50	66	13	28
	26	*Concavissimisporites lepidus*				2	1			1
	27	*Concavissimisporites speciosus*				2	3	2		
	28	*Concavissimisporites taiwanensis*		2	1	1	2	1	1	2
	29	*Corrugatisporites taiwanensis*			1		1	2		
	30	*Costatisporites taiwanensis*	1							
	31	*Crybelosporites taiwanensis*								2
	32	*Cyatheidites formosus*				1				
	33	*Cyatheidites orientalis*				2	1	1	4	4
	34	*Cyatheidites taiwanensis*	1		3	5	2	1		3
	35	*Cyathidites crassimarginatus*					1			1
	36	*Cyathidites formosus*	4	3	5	12	7	13	12	17
	37	*Cyathidites minus*		2	4	11	6	2	1	2
	38	*Cyathidites mundulus*	2		1	18	3	3	9	8
	39	*Cyathidites parvus*			3	14	2	1	4	4
	40	*Deltoidospora communis*	1	1			1			2
	41	*Deltoidospora parvus*		1			1	1	5	2
	42	*Echinatisporis taiwanensis*			1					
	43	*Gemmatriletes specious*								1
	44	*Gleicheniidites orientalies*					1			1
	45	*Hymenoreticulisporites taiwanensis*					1			1
	46	*Impardecispora apiverrucata taiwaniana*	1				2	1	1	2
	47	*Impardecispora delerminatus*				1				
	48	*Kewanaesporites rotundus*								1
	49	*Kewanaesporites taiwanensis*								1
	50	*Leiotriletes communis*		5	3	2	5	4	6	15
	51	*Leiotriletes menbranus*					2	1	6	5
	52	*Leiotriletes obovatus*			1					
	53	*Leiotriletes rotundus*	1		1		1	2	1	4
	54	*Leiotriletes sphaerotriangulus*	1		2	2	1	1	3	

Table. 6. continued.

		WELL:YTN-1	SAMPLE DEPTH (m)							
		TAXA	*3700.7	*3702.54	*3703.5 3703.6	*3708.93 3709.0	*3711	*3712.2 3712.3	*3718.03 3718.08	*3722.1 3722.3
Pteridophyte	55	*Leiotriletes wolffi brevis*			1	1	1	1	3	
	56	*Klukisporites specious*			1					
	57	*Klukisporites subrotundus*			2					
	58	*Klukisporites taiwanensis*	1		3		1		1	2
	59	*Osmundacidites orientalis*		3				1		1
	60	*Pilosisporites parvus*								2
	61	*Pilosisporites paucipilosus*								1
	62	*Pilosisporites taiwanensis*					2		1	2
	63	*Pilosisporites triplanatus*					1			
	64	*Pilosisporites versus formosensis*					5	2	1	4
	65	*Praemerosisporites taiwanensis*								1
	66	*Rarutuberisporites taiwanensis*								1
	67	*Retitriletes cretaceous*	1							1
	68	*Scabratisporites taiwanensis*						1		1
	69	*Staplinisporites taiwanensis*								3
	70	*Triangulatisporites taiwanensis*								2
	71	*Trilobosporites deltoidus*	1						3	1
	72	*Trilobosporites formosensis*								1
	73	*Trilobosporites rotundus*								1
	74	*Triplanosporites cretaceous*	1	7	2	47	3	5	12	14
	75	*Triplanosporites figuratus*	3	3	12	3	5	3	1	13
	76	*Triplanosporites minor*	3	5	3	39	4	1	20	12
	77	*Triplanosporites taiwanensis*	1	3	4	14	6	3	8	15
	78	*Triplanosporites tuberosus*			1					
	79	*Verrucosisporites cretaceous*		15						
		SUBTOTAL	43	185	79	201	184	215	184	232
		Concentricystes cretaceous		2	1				2	
		TOTAL	**51**	**218**	**93**	**217**	**228**	**225**	**229**	**247**

* CONVENTIONAL CORE, · SIDE-WELL CORE, OTHERS ARE CUTTING.

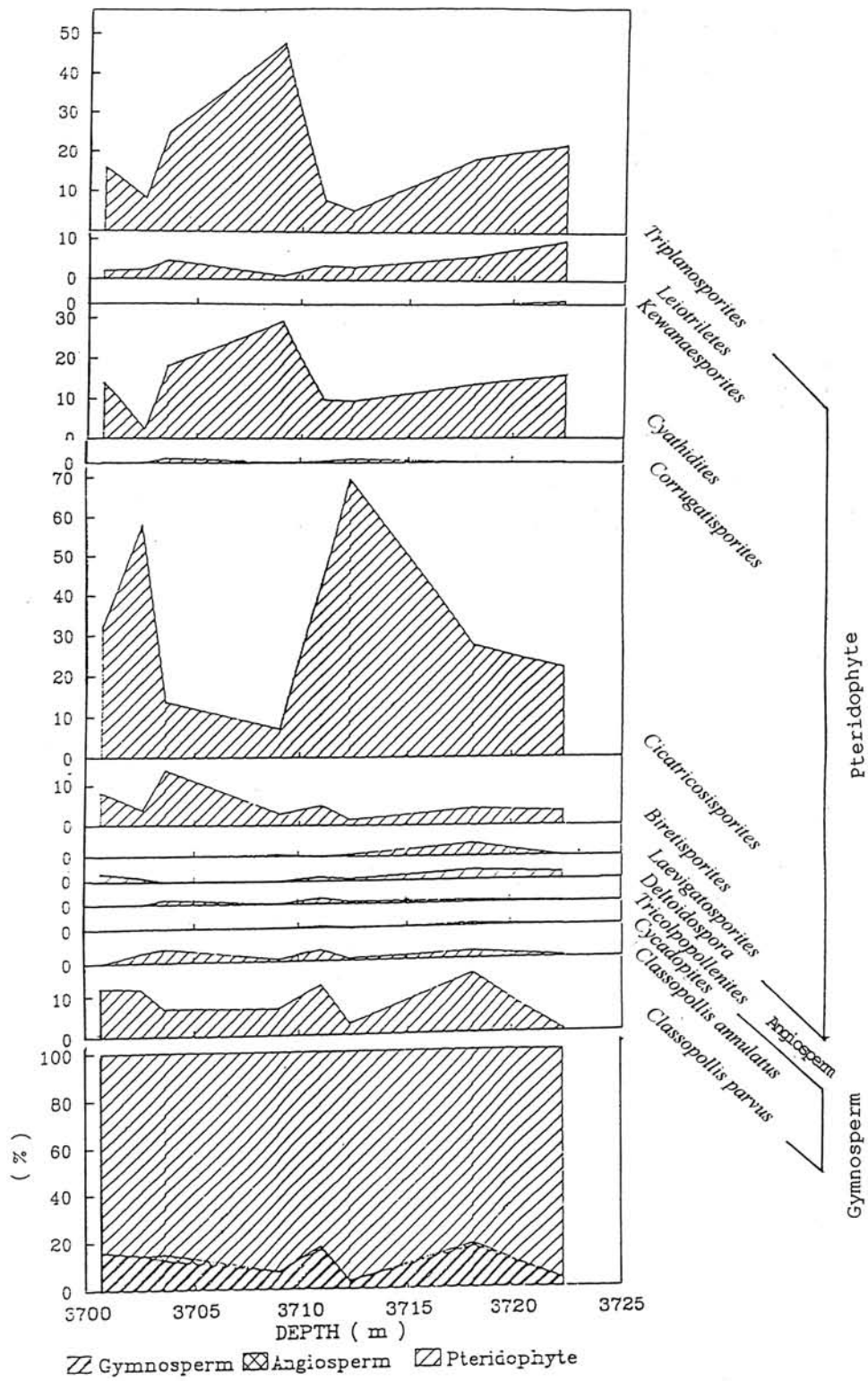

Fig. 3. Early Cretaceous Pollen diagram of YTN-1 well in offshore southern Taiwan.

Table. 7 Vertical stratigraphic distribution of palynomorphs in YPT-1 Well.

		WELL:YPT-1	SAMPLE DEPTH (m)								
		TAXA	· 3538.5	· 3561.0	· 3679.5	· 3745.0	· 3777.0	*3786.37 3786.4	*3790.48 3790.5	*3794.07 3794.1	*3797.26 3797.3
Gymnosperm	1	*Araucariacites australis*		1		4	1	1	7		
	2	*Callialasporites striatus*		1					1	1	2
	3	*Callialasporites taiwanensis*									1
	4	*Classopollis annulatus*	15	34	1	2	3	6	3	10	8
	5	*Classopollis classoides*		5				1			
	6	*Classopollis parvus*	50	77	5	32	7	25	6	12	25
	7	*Cycadopites attenuatus*						1			
	8	*Cycadopites lanceolatus*		1	1	1		1	1	13	1
	9	*Cycadopites ovalis*		1	4	3			1	14	1
	10	*Eucommidites formosus*								2	
	11	*Vitreisporites mediocris*								1	1
	12	*Vitreisporites pallidus*				1		1		2	
		SUBTOTAL	65	120	11	43	11	36	19	55	39
Angiosperm	1	*Confertisulcites cretaceous*							2		2
	2	*Confertisulcites formosus*					2		1		
	3	*Tricolpopollenites lepidus*								1	
	4	*Tricolpopollenites oblongus*			9	6	1	1	2	8	3
	5	*Tricolpopollenites peikangensis*			2						
	6	*Tricolpopollenites perprolatus*	1		3	1				1	
		SUBTOTAL	1	0	14	7	3	1	5	10	5
Pteridophyte	1	*Bacuinaperturites taiwanensis*			1	1		1			1
	2	*Echinatinaperturites spinulosus*									
	3	*Huangasporites parvus*				1					
	4	*Rubinella taiwaniana*							1		
	5	*Cicatricososporites taiwanensis*							1		
	6	*Laevigatosporites gracilis*	2		7	1	1	1	4	16	2
	7	*Laevigatosporites minor*			5	2	1			5	
	8	*Laevigatosporites nudum*			4	1				2	
	9	*Laevigatosporites sinensis*			3		3	2	1		1
	10	*Aequitriradites spinulosus taiwanensis*			2	1	1		1	1	1
	11	*Biretisporites crassimagosus*	1		4	12	1	7	1	4	2
	12	*Biretisporites cretaceous*			2	2	2	4	1	1	2
	13	*Biretisporites magnus*	6	13	1	1	7		2		

Table. 7 continued.

		WELL:YPT-1	SAMPLE DEPTH (m)								
		TAXA	· 3538.5	· 3561.0	· 3679.5	· 3745.0	· 3777.0	*3786.37 3786.4	*3790.48 3790.5	*3794.07 3794.1	*3797.26 3797.3
Pteridophyte	14	*Biretisporites parvus*		1		6	1		5	4	5
	15	*Biretisporites vulgaris*	5	6	1	2	11	3	4	3	5
	16	*Canaliculatisporites taiwanensis*			2						
	17	*Cibotumspora taiwaniana*	1					1		2	3
	18	*Cicatricosisporites communis*					3	1	1		
	19	*Cicatricosisporites minor Pocock*	2	3	1	6	25	4	4	5	7
	20	*Cicatricosisporites rarustriatus*	2	2	1	2	4	1	7	1	2
	21	*Cicatricosisporites taiwanensis*	1		1			2			
	22	*Cicatricosisporites tersus*	6	10	2	10	21	4	49	1	6
	23	*Cicatricosisporites vulgaris*	2	11	5	31	38	20	56	4	8
	24	*Concavissimisporites taiwanensis*				1	4				
	25	*Convolutispora formosana*								1	
	26	*Corrugatisporites formatus*								1	
	27	*Corrugatisporites taiwanensis*	8	5	1						
	28	*Crybelosporites taiwanensis*			1	1	1				3
	29	*Cyatheidites formosus*						2	1	3	9
	30	*Cyatheidites orientalis*			3	3	1	7	3	3	6
	31	*Cyatheidites taiwanensis*			1	1	1	1			
	32	*Cyathidites crassimarginatus*					1			1	1
	33	*Cyathidites formosus*	4	2	6	8	8	7	6	6	3
	34	*Cyathidites minus*	4	1	9	12	3	3	3	5	15
	35	*Cyathidites mundulus*			6	2	4	8	1	4	8
	36	*Cyathidites parvus*	1		3	17	4	8	2	9	3
	37	*Deltoidospora communis*		1			1				2
	38	*Deltoidospora parvus*	1	1	1	1	1		2	9	1
	39	*Echinatisporis taiwanensis*						1		1	
	40	*Gemmatriletes crassimaginatus*								3	
	41	*Gleicheniidites orientalies*	2	1	1	1		1	1	1	6
	42	*Gleicheniidites peikangensis*						1			1
	43	*Granulatisporites parvus*						1		1	1
	44	*Granulatisporites taiwanensis*						3		2	
	45	*Impardecispora apiverrucata taiwaniana*			1	2		1		1	1
	46	*Kewanaesporites formosus*	1	1		2	1			1	

Table. 7 continued.

		WELL:YPT-1	SAMPLE DEPTH (m)								
		TAXA	· 3538.5	· 3561.0	· 3679.5	· 3745.0	· 3777.0	*3786.37 3786.4	*3790.48 3790.5	*3794.07 3794.1	*3797.26 3797.3
Pteridophyte	47	*Kewanaesporites rarigranulatus*	1		3	5		1	1		5
	48	*Kewanaesporites rotundus*			4	17	2	1		1	3
	49	*Kewanaesporites taiwanensis*			2	10	2	2	1	1	16
	50	*Leiotriletes communis*	5	2	4	2	6	8	2	5	13
	51	*Leiotriletes menbranus*	3	3	5	1	5	1		5	2
	52	*Leiotriletes obovatus*					1				
	53	*Leiotriletes rotundus*	1	2	3	4	1	2	5	8	5
	54	*Leptolepidites taiwanensis*								1	
	55	*Klukisporites specious*								8	
	56	*Osmundacidites orientalis*	1	1		1		1	1	2	3
	57	*Pilosisporites parvus*									1
	58	*Retitriletes aerolatus*								2	
	59	*Scabratisporites taiwanensis*							1	1	
	60	*Staplinisporites taiwanensis*						2		1	
	61	*Triangulatisporites taiwanensis*			1	1					
	62	*Triassisporis taiwaniana*		1							
	63	*Triplanosporites cretaceous*	1	2	3	1	2	22	1	8	2
	64	*Triplanosporites figuratus*		5	1		5	1		4	
	65	*Triplanosporites minor*	4	7	56	32	13	38	8	28	11
	66	*Triplanosporites taiwanensis*	3	1	20	8	15	7	2	15	19
	67	*Undulatisporites parvirotundus*								1	
		SUBTOTAL	68	82	177	212	201	181	179	192	185
		Concentricystes cretaceous			2		1	1			
		TOTAL	**134**	**202**	**204**	**262**	**216**	**219**	**203**	**257**	**229**

* CONVENTIONAL CORE, · SIDE-WELL CORE, OTHERS ARE CUTTING.

I. The YTP-1 Well

Two conventional cores and twelve side-wall-cores were collected from the well. Quantitative analysis of the core and side-wall-core samples indicates that pollen are generally present from the samples between 1717m and 2942.5m (Table 8). The Table 8 also shows that the pollen assemblages are comprised of 35-74% of *Classopollis,* belonging to conifers and are associated with *Cicatricosisporites* (1.5-26%), *Cyathidites* (1.4-20.3%),

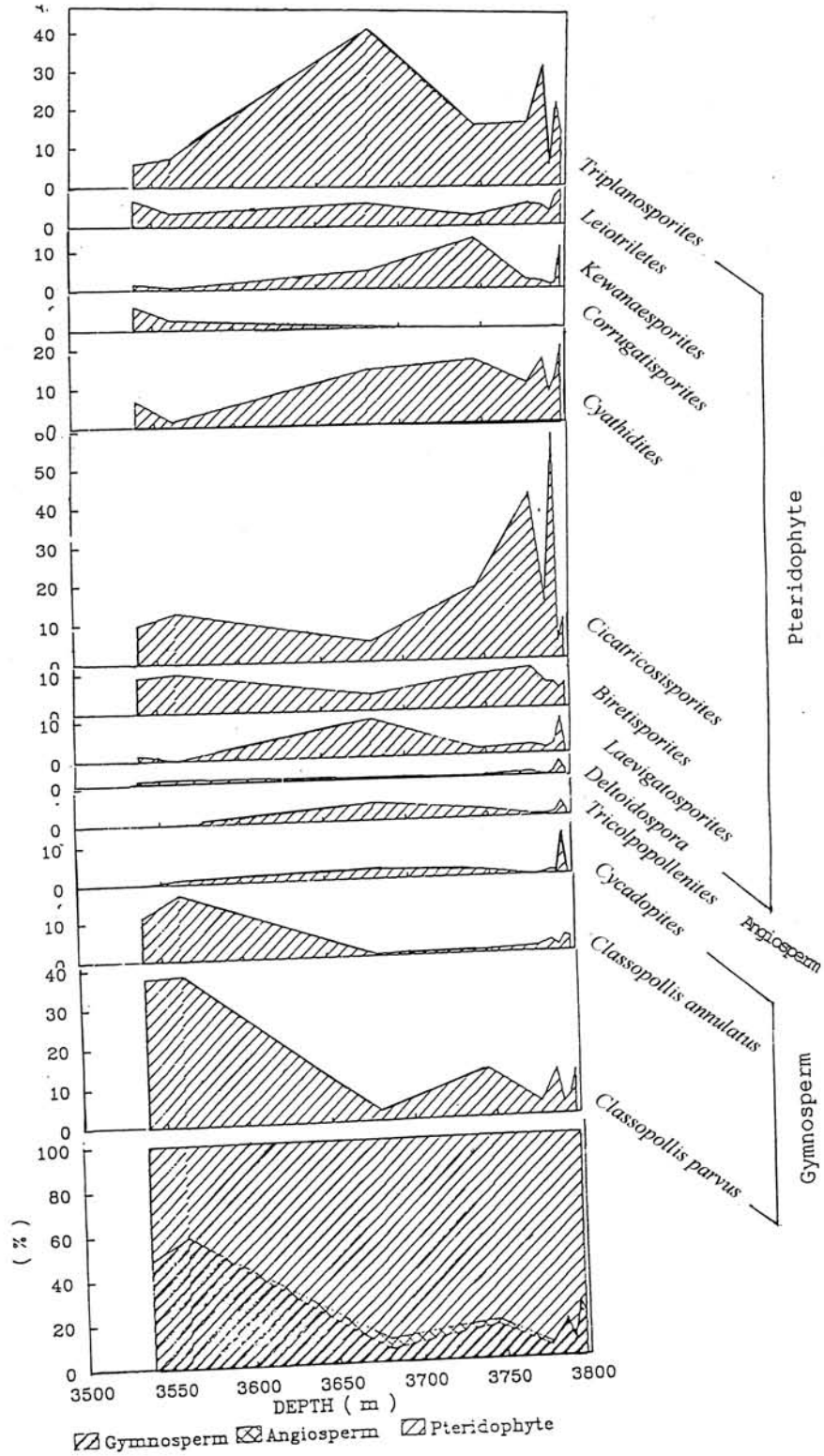

Fig. 4. Early Cretaceous Pollen diagram of YTP-1 Well in offshore southern Taiwan.

Triplanosporites (1.4-12.5%) and *Lavigatosporites gracilis* (0-13.6%). Angioisperm is only represented by *Tricolpopollenites* (<3%) (Fig. 5).

The pollen assemblages of YTP-1 Well suggest a tropical-subtropical climate at that time and the vegetation was dominated by coastal shrub-type *Classopollis* community with local occurrence of herb-type community of pteridophytes.

J. The YKL-1 Well

Twelve cutting samples were collected from the well. Quantitative analysis of the samples indicates that pollen are generally present from the samples between 1305m and 2315m (Table 9). The Table 9 also shows that the pollen assemblages are comprised of 15.5-73% of *Classopollis*, belonging to conifers and are associated with *Cyathidites* (1-19.3%), and *Triplanosporites* (4.1-17.2%). Angioisperm is only represented by *Tricolpopollenites* (<2%) (Fig. 6).

The pollen assemblages of YKL-1 Well suggest a tropical-subtropical climate at that time and the vegetation was dominated by coastal shrub-type *Classopollis* community with local occurrence of herb-type of pteridophytic *Triplanosporites*.

K. The YKL-2 Well

Five side-wall-cores samples were collected. Results show that spores and pollen are present from the samples between 2116.5m and 2518.0m; but the samples of 2136.5m and 2767.5m, there are no spores and pollen recovered. The Table 10 also shows that the pollen assemblages are fair in abundance, and are comprised of 19.2-60% of *Classopollis*, and are associated with *Cyathidites* (0-26%), and *Triplanosporites* (1.3-4.6%). No angiosperm pollen was recovered from the kerogen in these samples (Table 10).

The pollen assemblages of YKL-2 Well suggest a tropical-subtropical climate at that time and the vegetation was dominated by coastal shrub-type *Classopollis* community with local occurrence of herb-type community of pteridophytes.

L. Other wells.

No pollen was recovered from the samples of uncertain Cretaceous age(?) in the wells of YML-1, YCI-1, YCI-2, TL-1 and YKL-3.

DISCUSSION

Fifty eight form genera, one hundred and thirty four species of fossil palynomorphs were reported from the early Cretaceous strata based on materials from seventeen exploration wells in Taiwan. Among these, there are fourty-five genera and ninety eight species of genera and ten species of angiospermous grains. These early palynomorphic assemblages are pteridophytic spore, eleven genera and twenty six species of gymnospermous grains, and two predominated by gymnosperms in quantity but by pteridophytes in species diversity. Angiospermous species are only represented by primitive monocolpate and tricolpate pollen.

The appearance of the early primitive angiospermous pollen, such as *Confertisulcites and Tricolpopollenites* and the presence of several pteridophytic index species such as *Impardecispora apiverrucata* var. *taiwaniana, Aequitriradites spinulosus* var. *taiwanensis, Pilosisporites verus* var. *formosensis, Cicatricosisoprites* spp.,and *Vitreisporites* spp. with

Table. 8 Vertical stratigraphic distribution of palynomorphs in YTP-1 Well.

		WELL:YTP-1	SAMPLE DEPTH (m)						
		TAXA	· 1717.0	· 1862.0	· 1901.0	*2003.7 2004.50	*2004.5 2005.6	· 2108.0	· 2942.5
Gymnosperm	1	*Araucariacites australis*	1		1	1	1		
	2	*Araucariacites taiwanensis*	1						
	3	*Camerosporites tuberosus*			1				
	4	*Classopollis annulatus*	10	40	3	10	4	1	14
	5	*Classopollis classoides*	6	7	3	1	1		1
	6	*Classopollis parvus*	53	107	67	63	18	4	36
	7	*Cycadopites lanceolatus*	1						
	8	*Cycadopites lanceolatus var. scabratus*				1			
	9	*Cycadopites yunlinensis*				2			1
	10	*Ephedripites spp.*	1						1
	11	*Pityosporites longicorpus*							1
	12	*Taxodiaceaepollenites taiwanensis*	3	2		5			
		SUBTOTAL	76	156	75	83	24	5	54
Angiosperm	1	*Tricolpopollenites medieus*							1
	2	*Tricolpopollenites oblongus*				2	1		1
	3	*Tricolpopollenites peikangensis*				2			1
		SUBTOTAL	0	0	0	4	1	0	3
Pteridophyte	1	*Laevigatasporites irregularis*		1	1	2			
	2	*Membranosphaera taiwaniana*	8	1		2			
	3	*Laevigatosporites gracilis*	4	1	1	29	2		
	4	*Laevigatosporites minor*	1	2		16			
	5	*Aequitriradites spinulosus taiwanensis*			1				
	6	*Biretisporites crassimagosus*			4	5			
	7	*Biretisporites cretaceous*	2	1		1	1		
	8	*Biretisporites magnus*			1				
	9	*Biretisporites parvus*	1	3	2	5	2		
	10	*Biretisporites vulgaris*	1		1		1		1
	11	*Cibotumspora taiwaniana*				1			
	12	*Cicatricosisporites communis*			1				
	13	*Cicatricosisporites minor Pocock*		2	14				
	14	*Cicatricosisporites rarustriatus*	2	2	1	6			
	15	*Cicatricosisporites taiwanensis*						1	
	16	*Cicatricosisporites tersus*	5	3	13	4	1		
	17	*Cicatricosisporites vulgaris*	6	2	14	1			1
	18	*Concavissimisporites lepidus*				1			
	19	*Concavissimisporites speciosus*		1		2			
	20	*Concavissimisporites taiwanensis*				2			
	21	*Corrugatisporites formatus*				1			

Table. 8 continued.

		WELL:YTP-1	SAMPLE DEPTH (m)						
		TAXA	· 1717.0	· 1862.0	· 1901.0	*2003.7 2004.50	*2004.5 2005.6	· 2108.0	· 2942.5
Pteridophyte	22	*Corrugatisporites taiwanensis*		1	4				
	23	*Costatisporites taiwanensis*	2						
	24	*Cyatheidites taiwanensis*				2			
	25	*Cyathidites formosus*	1		1	2			
	26	*Cyathidites minus*	3	1		5	3		1
	27	*Cyathidites mundulus*	4			2	4		
	28	*Cyathidites parvus*	1	5	1	4	4		
	29	*Deltoidospora parvus*		1		1	1		
	30	*Gleicheniidites peikangensis*				1			
	31	*Granulatisporites peikangensis*	2						1
	32	*Granulatisporites taiwanensis*				1			
	33	*Impardecispora delerminatus*							1
	34	*Leiotriletes communis*	2		1	3		1	
	35	*Leiotriletes menbranus*				2			
	36	*Leiotriletes obovatus*	1				2		
	37	*Leiotriletes rotundus*	1		1	1			
	38	*Leiotriletes sphaerotriangulus*	1		1				
	39	*Leiotriletes taiwanensis*	2	2	1	5	2		
	40	*Leiotriletes wolffi brevis*		7	2				
	41	*Klukisporites specious*	1	2	1				
	42	*Klukisporites taiwanensis*		1					
	43	*Osmundacidites orientalis*							1
	44	*Retitriletes aerolatus*			1				
	45	*Triplanosporites cretaceous*	4	4		11	4		
	46	*Triplanosporites figuratus*	1	1					
	47	*Triplanosporites minor*	1	5	4	6	3		1
	48	*Triplanosporites taiwanensis*	4	2		4		1	
		SUBTOTAL	61	51	72	128	30	3	7
		Unidentified	12	11	10	10	3		9
		Dinoflagellate	1			2			2
		TOTAL	**150**	**218**	**157**	**227**	**58**	**8**	**75**

* CONVENTIONAL CORE, · SIDE-WELL CORE, OTHERS ARE CUTTING.

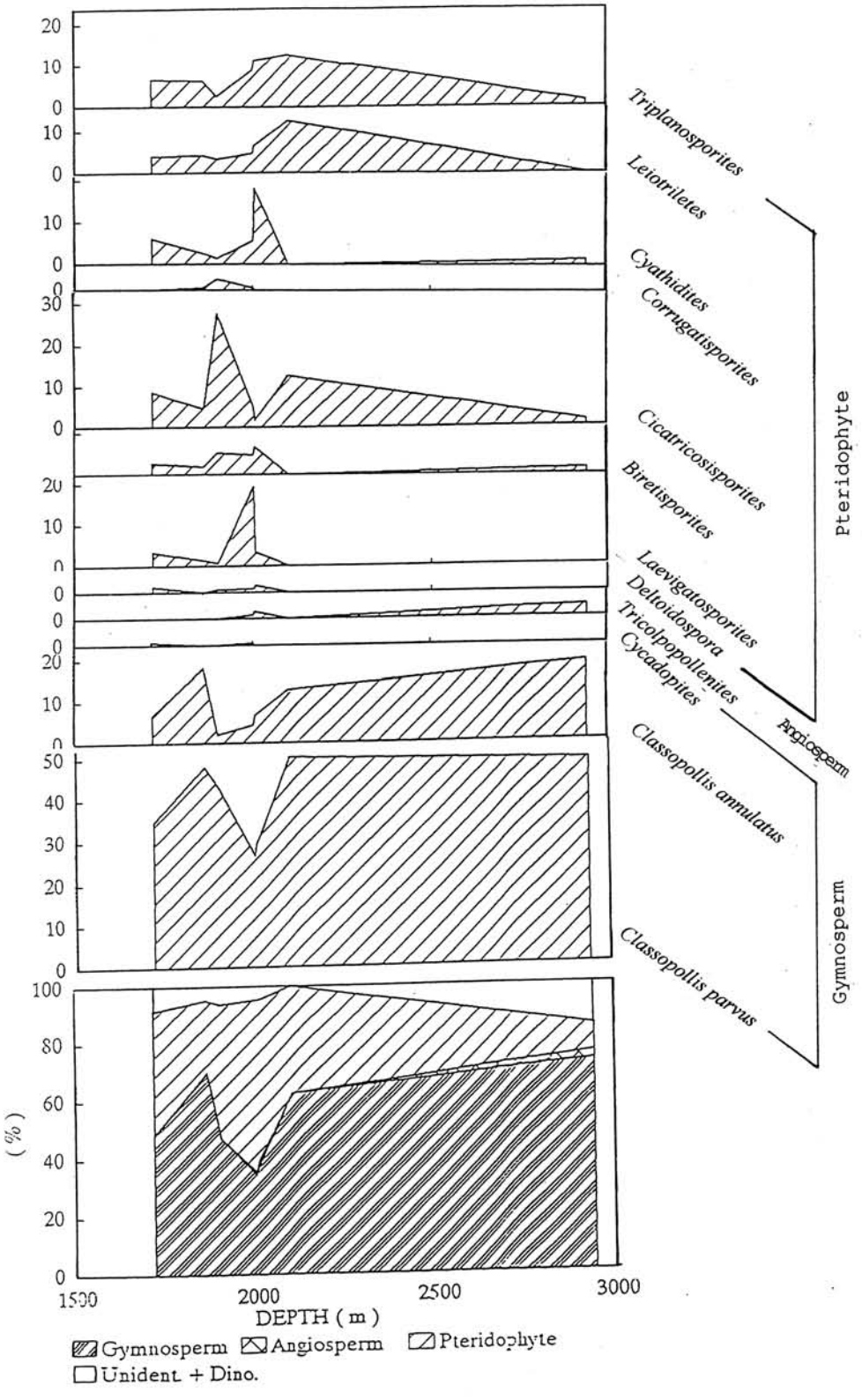

Fig. 5. Early Cretaceous Pollen diagram of YTP-1 Well in offshore northern Taiwan.

Table. 9 Vertical stratigraphic distribution of palynomorphs in YKL-1 Well.

		WELL:YKL-1	SAMPLE DEPTH (m)								
		TAXA	1305 1310	1395 1400	1475 1480	1615 1620	1890 1895	2080 2085	2155 2160	2235 2240	2312 2315
Gymnosperm	1	*Araucariacites australis*	5	3	2	5		1	12	11	2
	2	*Araucariacites taiwanensis*		2	2	1				1	
	3	*Camerosporites formosus*		1							
	4	*Camerosporites tuberosus*		1						1	
	5	*Classopollis annulatus*	30	46	48	26	1	5	7	7	9
	6	*Classopollis classoides*	8	5		8		1			1
	7	*Classopollis parvus*	115	67	127	118		16	46	25	36
	8	*Cycadopites attenuatus*			2	1					2
	9	*Cycadopites lanceolatus var. scabratus*			1						1
	10	*Cycadopites ovalis*									
	11	*Cycadopites yunlinensis*	1								
	12	*Ephedripites spp.*	1		2	1			3	1	1
	13	*Taxodiaceaepollenites taiwanensis*	6	1	2		1	1	3		4
	14	*Vitreisporites mediocris*							1		
	15	*Vitreisporites pallidus*			4						
		SUBTOTAL	166	126	190	160	2	24	72	46	56
Angiosperm	1	*Tricolpopollenites medieus*		1		1					
	2	*Tricolpopollenites oblongus*	3	2		1			1		
	3	*Tricolpopollenites orientalis*	2			1					
	4	*Tricolpopollenites peikangensis*	1								
		SUBTOTAL	6	3	0	3	0	0	1	0	0
Pteridophyte	1	*Echinatiaperturites spinulosus*				1				1	
	2	*Laevigatasporites irregularis*	1			1			9	3	2
	3	*Membranosphaera taiwaniana*	1	1	1	1				1	3
	4	*Laevigatosporites gracilis*	1		1		1	1	3	2	6
	5	*Laevigatosporites minor*	1								1
	6	*Laevigatosporites nudum*				1					
	7	*Laevigatosporites sinensis*						1		2	
	8	*Aequitriradites spinulosus taiwanensis*							1		
	9	*Biretisporites crassimagosus*	5		6	2			5		1
	10	*Biretisporites cretaceous*	1	1	1			1	3	1	1

Table. 9 continued.

		WELL:YKL-1	SAMPLE DEPTH (m)								
		TAXA	1305 1310	1395 1400	1475 1480	1615 1620	1890 1895	2080 2085	2155 2160	2235 2240	2312 2315
Pteridophyte	11	*Biretisporites magnus*									2
	12	*Biretisporites parvus*			2				2	3	
	13	*Biretisporites vulgaris*		3	1	2		4	5	7	8
	14	*Cicatricosisporites communis*				1					
	15	*Cicatricosisporites minor Pocock*				2			1	2	3
	16	*Cicatricosisporites mundulus*							1		
	17	*Cicatricosisporites rarustriatus*	1		1	1				2	1
	18	*Cicatricosisporites tersus*	1		2	3	1			1	4
	19	*Cicatricosisporites vulgaris*	6		2	2		2	10	2	3
	20	*Concavissimisporites lepidus*						1		2	1
	21	*Concavissimisporites speciosus*	1		1				1		
	22	*Concavissimisporites taiwanensis*							1	3	
	23	*Corrugatisporites formatus*				1				1	
	24	*Corrugatisporites taiwanensis*			1					2	
	25	*Cyatheidites formosus*							1	1	
	26	*Cyatheidites orientalis*							3	3	1
	27	*Cyatheidites taiwanensis*		1				1	1		1
	28	*Cyathidites formosus*	1			1		4	17	17	9
	29	*Cyathidites minus*	2	1	4	1			2	9	
	30	*Cyathidites mundulus*		3				3	15	10	8
	31	*Cyathidites parvus*			3	1		1	8	5	10
	32	*Deltoidospora parvus*				1					1
	33	*Echinatisporites taiwanensis*								1	
	34	*Gleicheniidites orientalies*								1	
	35	*Gleicheniidites peikangensis*					1	1			
	36	*Granulatisporites peikanensis*	1			1					2
	37	*Hymenoreticulisporites taiwanensis*									
	38	*Impardecispora apiverrucata taiwaniana*							1		
	39	*Leiotriletes communis*	1	5	2	3		3	6	8	4
	40	*Leiotriletes menbranus*		1	1	1		2	2	1	1
	41	*Leiotriletes obovatus*	2	2	1		3	3	2	2	6

Table. 9 continued.

		WELL:YKL-1	SAMPLE DEPTH (m)								
		TAXA	1305 1310	1395 1400	1475 1480	1615 1620	1890 1895	2080 2085	2155 2160	2235 2240	2312 2315
Pteridophyte	42	*Leiotriletes rotundus*	1	3		1		1		1	2
	43	*Leiotriletes sphaerotriangulus*				1					
	44	*Leiotriletes taiwanensis*			2		5	5	6	4	1
	45	*Leiotriletes wolffi brevis*	2						1		
	46	*Klukisporites specious*	1							2	
	47	*Klukisporites taiwanensis*	1	1							
	48	*Osmundacidites orientalis*		1	1						
	49	*Retitriletes aerolatus*								1	
	50	*Scabratisporites taiwanensis*									3
	51	*Triangulatisporites taiwanensis*				1					
	52	*Triplanosporites cretaceous*	8	6	10	5		2	8	8	9
	53	*Triplanosporites figuratus*		1				2	2	3	2
	54	*Triplanosporites minor*	1	2				1	6	15	3
	55	*Triplanosporites taiwanensis*	2	1	2	4	1	2	5	11	6
	56	*Triplanosporites tuberosus*									1
	57	*Tuberositriletes formosensis*							2	1	3
		SUBTOTAL	42	33	45	39	12	41	130	139	109
		Unidentified	20	12	14	19		21	28	21	23
		Dinoflagellate						158	39	14	31
		TOTAL	**234**	**174**	**249**	**221**	**14**	**244**	**270**	**220**	**219**

* CONVENTIONAL CORE, · SIDE-WELL CORE, OTHERS ARE CUTTING.

association of *Classopollis* in the PK-2, PK-3, HP-1, GH-1, YTN-1, YPT-1, YTP-1, YKL-1 and YKL-2 Wells might suggest the age of early Cretaceous(from Aptian to early Albian) strata in these wells.(Herngreen, 1947; Herngreen & Chlonava, 1981).

The flora assemblages of the early Cretaceous of Taiwan suggested a tropical to subtropical climate at that time and the plant community was dominated by coastal scrub plants such as *Classopollis*. More landwards, the flora was replaced by pteridophytic Cyatheaceae and gymnospermous *Classopollis* savanna plants in which local pteridophytic grassland was also common.

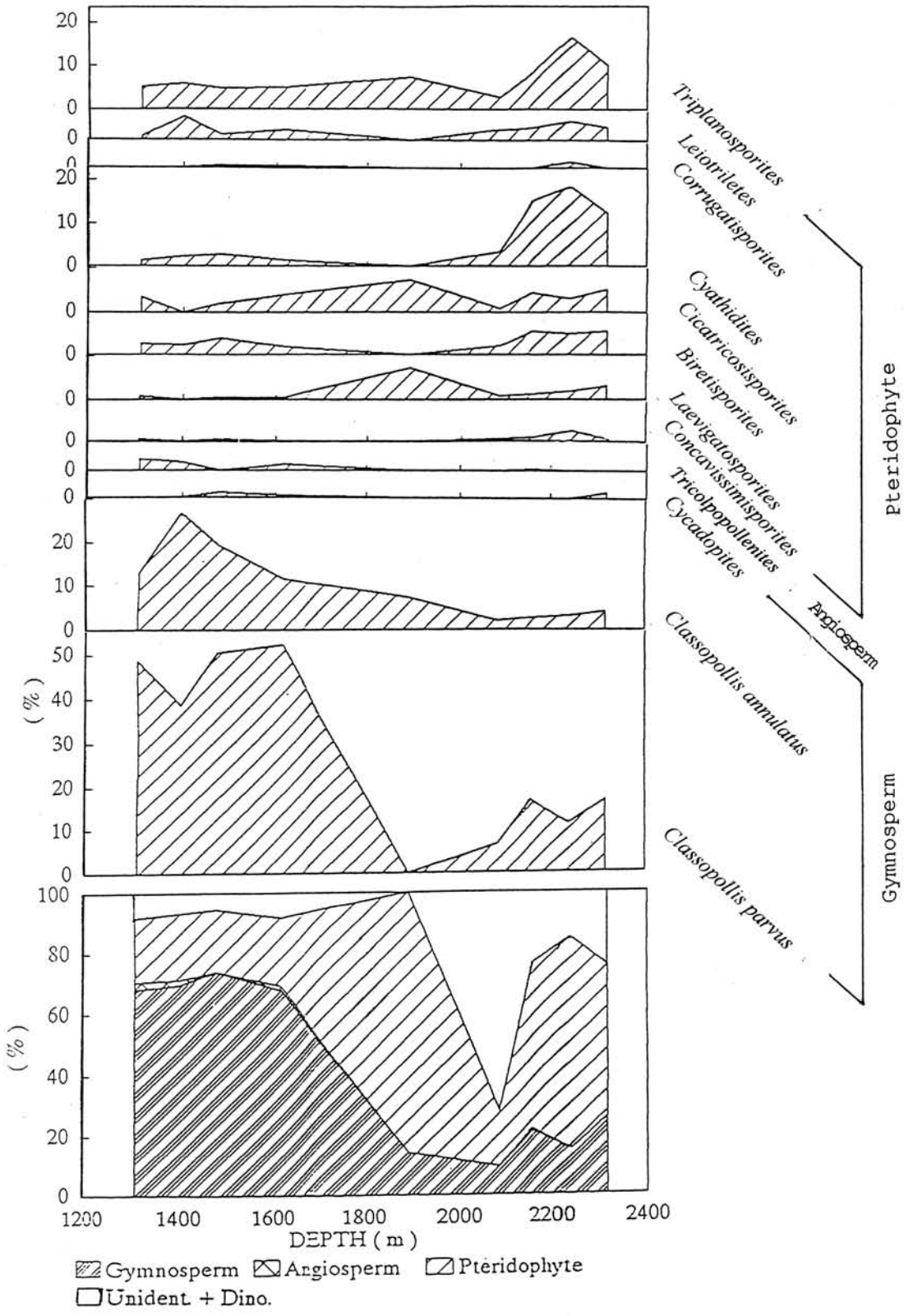

Fig. 6. Early Cretaceous Pollen diagram of YKL-1 Well in offshore northern Taiwan.

Table. 10 Vertical stratigraphic distribution and percentage of palynomorphs in YKL-2 Well.

		WELL:YKL-2	SAMPLE DEPTH (m)						
		TAXA	*2116.5	*2435	*2518		*2116.5	*2435	*2518
Gymnosperm	1	*Araucariacites australis*	3	1	1		1.73	3.33	1.47
	2	*Camerosporites tuberosus*	1		1		0.58	0.00	1.47
	3	*Classopollis annulatus*	42		17		24.28	0.00	25.00
	4	*Classopollis classoides*			1		0.00	0.00	1.47
	5	*Classopollis parvus*	52	5	21		30.06	16.67	30.88
	6	*Ephedripites spp.*	6				3.47	0.00	0.00
	7	*Pityosporites vulgaris*	8				4.62	0.00	0.00
	8	*Taxodiaceaepollenite taiwanensis*	1				0.58	0.00	0.00
	9	*Vitreisporites pallidus*			1		0.00	0.00	1.47
		SUBTOTAL	113	6	42		65.32	20.00	61.76
Pteridophyte	1	*Bacuinaperturites taiwanensis*	1				0.58	0.00	0.00
	2	*Huangasporites taiwanensis*	1				0.58	0.00	0.00
	3	*Membranosphaera taiwaniana*	4				2.31	0.00	0.00
	4	*Laevigatosporites gracilis*	4	3	1		2.31	10.00	1.47
	5	*Laevigatosporites minor*		1			0.00	3.33	0.00
	6	*Biretisporites crassimagosus*	1				0.58	0.00	0.00
	7	*Biretisporites cretaceous*	5				2.89	0.00	0.00
	8	*Biretisporites magnus*			2		0.00	0.00	2.94
	9	*Biretisporites parvus*	1				0.58	0.00	0.00
	10	*Cicatricosisporites rarustriatus*		1			0.00	3.33	0.00
	11	*Cicatricosisporites vulgaris*	2	4			1.16	13.33	0.00
	12	*Cyatheidites taiwanensis*			1		0.00	0.00	1.47
	13	*Cyathidites formosus*		2	1		0.00	6.67	1.47
	14	*Cyathidites minus*		1	2		0.00	3.33	2.94
	15	*Cyathidites mundulus*		2			0.00	6.67	0.00
	16	*Cyathidites parvus*		2			0.00	6.67	0.00
	17	*Leiotriletes communis*			1		0.00	0.00	1.47
	18	*Leiotriletes rotundus*			1		0.00	0.00	1.47
	19	*Leiotriletes wolffi brevis*	4	1	2		2.31	3.33	2.94
	20	*Scabratisporites taiwanensis*	4				2.31	0.00	0.00
	21	*Triplanosporites cretaceous*		1	2		0.00	3.33	2.94
	22	*Triplanosporites minor*	2		1		1.16	0.00	1.47
		SUBTOTAL	29	18	14		16.76	60.00	20.59
		Concentricystes cretaceous	1				0.58	0.00	0.00
		Unidentified	30	6	12		17.34	20.00	17.65
		TOTAL	**173**	**30**	**68**		**100.00**	**100.00**	**100.00**

* CONVENTIONAL CORE, · SIDE-WELL CORE, OTHERS ARE CUTTING.

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臺灣白堊紀之孢粉分析[1]

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摘　　要

本論文於十七口地下探井，白堊紀早期地層中共發現孢粉化石五十四屬一百二十種，其中蕨類孢子計有四十五屬九十五種，裸子植物花粉計有七屬十九種；被子植物花粉計有二屬六種。由早期白堊紀之孢粉化石群聚，顯示裸子植物花粉爲其中顯著的一個組成份子；蕨類孢子種類多趨異性極大亦爲其中顯著的植物群；而被子植物花粉僅有單溝及三溝的原始型花粉。於台灣陸海域白堊紀地層，由其孢粉組合反映當時的氣候均爲熱帶到亞熱帶之氣候，其植物社會爲由濱海一帶的*Classopollis*爲主之灌叢林，逐漸往內陸演替爲以蕨類植物桫欏科爲主，裸子植物*Classopollis*爲輔的灌叢疏林，於林內或林間局部生長著草本的蕨類植物。

關鍵詞：台灣、白堊紀、孢粉分析。

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