CHAPTER 2

MATERIALS AND METHODS

2.1 OBJECTIVES AND SCOPE OF THIS STUDY

The cores of Offshore Sites C-B1 and O-A1 are of interest palynologically in that any preserved trilete spores, pollen grains, algae and fungal spores may contribute additional information on the makeup of the Cretaceous vegetation, and it's biostratigraphical and correlative importance.

The following outlines the primary objectives of this study:

- The identification to form genera and species level where possible of all the fossilized trilete spores, pollen grains, algae and fungal spores encountered in both Offshore Sites.
- Recording the range of each taxon.
- Show the qualitative and quantitative variations in the pollen / spore assemblages.
- Establish a biostratigraphy for Offshore Sites O-A1 and C-B1 by utilizing species range data, and then by establishing pollen zones based on the biostratigraphy.
- Compare the zones found in Offshore Site O-A1 to that found in Offshore Site C-B1 (and DSDP 360 / 361).
- Integrate the palynological data with information derived from other analyses undertaken for this thesis in order to build up a picture of not only the geochronology, but also the distribution of the sedimentary rocks between the Offshore Sites C-B1 (a shelf deposit) and O-A1 (a slope deposit).
- Conduct a palynodebris analysis on all the unoxidized slides provided for both offshore sites.
- Construct palaeoenvironmental interpretations from the palynofacies, dinoflagellate and lithological data.
- Confirm the age ranges previously assigned to each Offshore Site.

To achieve these objectives, a minimum of three slides were studied for each of the 33 samples taken from Offshore Site C-B1. The depth of Offshore Site C-B1 is less than half that of Offshore Site O-A1, therefore a lot less sampling was done in comparison to the minimum of two slides studied for each of the 116 samples taken from Offshore Site O-A1. A total of 326 microscope slides from 149 levels (see Appendix 9) were studied in detail.

2.2 MATERIALS

The samples used in this research were obtained from the Petroleum Agency SA, (ex-SOEKOR) and consisted of 326 already processed microscope slides from the two Offshore Sites C-B1 and O-A1. The characteristics of these offshore localities are summarized in Table 2.1.

PETROLEUM AGENCY, SA	**OFFSHORE SITE C-B1**	**OFFSHORE SITE O-A1**
POSITION IN THE CAPE BASIN.	Continental rise of the Cape Basin.	Abyssal plain of the Cape Basin.
DISTANCE FROM SHORE	66 km S of Cape Town.	297 km NW of Cape Town.
DEPTH OF BOREHOLE	1914 m	4181 m
AGE RANGE	Early Cretaceous to Tertiary.	Early Cretaceous to Tertiary.
TOTAL NUMBER OF SLIDES STUDIED	99	232

Table 2.1. Summarized characteristics of Offshore Sites C-B1 and O-A1.

2.3 SAMPLING AND SAMPLING PROCEDURES

The Petroleum Agency, SA conducted all the offshore exploration and drilling of Offshore Sites C-B1 and O-A1. Samples consisted of cuttings and sidewall cores (see Appendix 9), collected by

the Petroleum Agency SA's trained rig personal, following proper sampling protocols as part of a drilling schedule (McLachlan, *pers. comm.*). No samples were washed at the well site and most of the larger cuttings were sloughed from up-hole zones so as to minimize contamination.

Sampling intervals varied considerably in both wells, and depended on the presence of carbonaceous mudrock lithologies, and the state of preservation of the sedimentary strata. Not all the slides studied yielded microfossils. This is possibly due to either bad preservation or barren lithologies being sampled or to poor laboratory preparation. Offshore Site O-A1's slides were prepared from cuttings, sidewall core and core samples whereas Offshore Site C-B1 was prepared from sidewall cores and core samples.

2.4 LABORATORY TECHNIQUES

The Petroleum Agency SA's extraction procedure followed standard methods (McLachlan 1998, *pers. comm.*) and resulted in the rapid maceration of a wide variety of lithotypes. Two hundred and twenty six palynological residues were obtained for slide mounting by the standard palynological techniques of digesting sedimentary rock in hydrochloric acid, hydrofluoric acid, Schultz's solution and heavy liquid separation with zinc chloride. However, oxidation with Schultz's solution was excluded for those residues required for the study of palynodebris colouration because the natural colours were needed for interpretation. Seventy unoxidized slides were prepared for Offshore Site C-B1 and 176 unoxidized slides were prepared for Offshore Site O-A1.

2.4.1 CLEANING AND DISAGGREGATION

The objective was to ensure that the samples supplied were free from any surface contamination before processing began, as failure to do this could result in erroneous age determinations. Sidewall core samples required the surface drilling mud to be scraped off with a clean scalpel and then washed under running water. Cutting samples required careful handling because of drillhole contamination. These samples were placed in a beaker and covered with boiling water, which was later decanted, and the process repeated with cold water, until the supernatant was clear. The cleaned samples were placed on sheets of paper toweling and left to dry.

Physical disaggregation or sample crushing was undertaken to facilitate the rapid reaction of chemical agents on the sample. The samples were crushed with a pestle and motar until the fragments were 1 - 2 mm in size.

2.4.2 CHEMICAL EXTRACTION

Organic and inorganic materials were removed via chemical extraction as follows.

2.4.2.1 INORGANIC MATERIAL

- **HYDROCHLORIC ACID TREATMENT**

  The crushed material, usually inorganic in content, was digested in hydrochloric acid to remove any calcium and magnesium carbonates present. Failure to do this would result in the precipitation of fine insoluble secondary fluorides in the following step for hydrofluoric acid treatment. The procedure was carried out as follows:

  The crushed material was placed in a 250 ml beaker with enough 10 % hydrochloric acid solution to just cover each sample, which was then stirred carefully and frequently. The sample was then placed in a water bath at 50° C to initiate a reaction between the hydrochloric acid and any carbonate crystals present. If a reaction occurred, then a further 100 ml of 10 % hydrochloric acid solution was added to the sample and then left until the reaction had run to completion. If no reaction occurred then the acid was removed from the sample by diluting with distilled water and centrifuging at 3 500 rpm for one minute. Any resulting supernate was poured off and the residue was flooded with more distilled water and centrifuged. This process was repeated until all the hydrochloric acid was removed, and the sample was tested for a neutral pH using Litmus paper.

- **HYDROFLUORIC ACID TREATMENT**

  The remaining residue from the previous step was then digested in hot hydrofluoric acid, conducted in a fume cupboard to remove the silicates. The process was carried out as follows:

A 40 % hydrofluoric acid solution was added to the residues in a polyethylene beaker (because glass is soluble in HF), a little at a time, whilst stirring. This was continued until there was no visible reaction. The beaker with its contents was placed on a hot plate and boiled for approximately 30 minutes, stirring occasionally. Thirty minutes usually sufficed for total disaggregation and silicate dissolution. The hydrofluoric acid solution was poured off into a calcium oxide acid neutralizer and the remaining residue was decanted into plastic tubes and washed with distilled water during centrifuging. This step was repeated until all the hydrofluoric acid was removed. Litmus paper was used to test the pH until a neutral solution was obtained.

- **FLUOROSILICATE REMOVAL**

  During the hydrofluoric acid reaction, fluorosilicate complexes were formed. If these complexes were not removed and deposited onto a slide as part of the final palynodebris residue, they would obscure the microfossil fraction of the palynodebris. To eliminate these complexes, the residue from the hydrofluoric acid reaction was treated with a 10 % hydrochloric acid solution for two hours. This residue was centrifuged and washed with distilled water until all the hydrochloric acid was removed and the pH tested neutral using Litmus paper.

2.4.2.2 RESIDUE MOUNTING FOR UNOXIDIZED SLIDES

Unfortunately, the oxidation process alters the natural colours of the dispersed organic matter and may also destroy certain types of palynomorphs such as structureless amorphous material (Jaramillo & Oboh-Ikuenobe, 1999). One unoxidized slide per sample was therefore also prepared. The unoxidised residues from Offshore Sites C-B1 and O-A1 were deposited onto 1 mm thick glass slides, 75 mm x 25 mm in size as follows:

A uniformly thin spread of residue was pipetted onto a slide and allowed to dry. All of the unoxidized slides examined for Offshore Site C-B1 showed a uniformly thin dispersal of palynodebris and optimal viewing conditions were the result. However, the residue dispersal for some of the Offshore Site O-A1's slides were dense and this resulted in:

- A major overlapping of the palynomorph fraction with the surrounding debris.
- The palynodebris appearing at differing focal levels so requiring constant refocussing. These slides required a longer time to study.

2.4.2.3 EMBEDDING MEDIA FOR UNOXIDIZED SLIDES

The Petroleum Agency SA, laboratories used glycerine jelly as their mounting medium of choice (McLachlan, *pers. comm.*). Glycerine jelly can be subject to desiccation (Hill, 1983) and is prone to fungal and bacterial growth (Phipps & Playford, 1984). However, if moisture is driven off during preparation and slides are properly curated, glycerine jelly slides should keep their clarity indefinitely, provided that they are adequately sealed and stored horizontally (Wood *et al.*, 1997). Even though they have been carefully stored, some of the unoxidized slides from both Offshore Sites C-B1 and O-A1 have begun to show signs of desiccation.

After the residue was deposited onto a slide and allowed to dry completely on a warming tray, the glycerine jelly was applied to form a permanent seal as follows:

A glycerne jelly smear was spread onto a coverslip 40 mm x 22 mm in size leaving 3 mm clear all around the edge of the coverslip. The coverslip was then affixed to the slide and left on a warming tray for a few minutes to allow for all the palynodebris to settle onto one plane on the coverslip. The sides of the cover slip were then sealed to the slide with a clear varnish. A maceration number was etched onto all the slides and the same maceration number was written on the coverslip using an indelible ink pen. A paper label stuck to the slide was used to list the maceration number, the locality number, the site name and the interval sampled.

2.4.2.4 OXIDIZED ORGANIC MATERIAL

This step involved the transformation of excess organic matter into humic acids that are alkali-soluble to increase the abundance of palynomorph residues. This result was achieved by using the following two treatments:

- **POTASSIUM HYDROXIDE (KOH) TREATMENT**

  A cold 5 % potassium hydroxide solution was used to remove organic material such as cellular matter. The resulting residue was placed into a 250 ml beaker and 50 ml of KOH solution was added. The total reaction time was about 30 minutes. The residue was centrifuged and washed with distilled water until the solution was neutral and clear.

- **SCHULTZ'S SOLUTION TREATMENT**

  In some cases, so much organic material remained that palynomorphs were obscured. Such slides warranted oxidation with Schultz's solution. The Schultz solution consisted of a saturated potassium chlorite solution and a 70 % cold concentrated nitric acid solution combined in the ratio of 1: 3. The samples were treated with 100 ml of Schultz solution in a 250 ml beaker. The amount of time required for oxidation was dictated by the nature of the organic matter present. To ensure that the oxidation process had run to completion, heat was applied to the beaker and the contents were mixed with a constant swirling motion. Oxidation was usually indicated by a change in the colour of the residue from black / brown to a dark brown and the supernatant turned a golden colour. The residue was monitored throughout the oxidizing process to avoid over-processing.

- **REMOVAL OF HUMIC ACIDS**

  During the final slide preparation, a brown, cloudy effect often developed making microscope examination difficult. This was a result of the presence of humic acids. These humic acids were removed from the remaining residue of the previous oxidation process by adding a 10 % potassium hydroxide solution to the sample for $\pm$ 30 seconds. It is important not to leave the residue in the potassium hydroxide solution for too long, as palynomorph disintegration may occur.

2.4.2.5 GRAVITY SEPARATION

Since the aim of this entire process was to concentrate the palynomorph fraction and keep the organic debris interference to a minimum, a zinc chloride solution was used.

- **ZINC CHLORIDE ($ZnCl_2$) TREATMENT**

  The residue was placed in a 100 ml centrifuge tube and then washed with a 10 % hydrochloric acid solution to prevent the precipitation of a white zinc hydroxide during the next step. A small quantity of zinc chloride solution was then added to the washed residue and stirred into a muddy consistency.Additional zinc chloride was used to fill the test tube to 1 cm from its rim. For centrifuging purposes two test tubes containing residues and zinc chloride solution were balanced and centrifuged for 25 minutes at 2 500 rpm. A distinct floating interface usually developed and it was here that the paly-nomorphs fraction was found. A small amount of this concentrate was pipetted onto a slide and examined for palynomorphs. If palynomorphs were present, the remaining supernate was pipetted into a separate tube and washed with 10 % hydrochloric acid solution. After several washes with distilled water, no more zinc chloride remained.

2.4.2.6 FINAL RESIDUE PURIFICATION

The remaining residues were washed clean of any remaining acid or base impurities before mounting and storage as follows:

The residues were washed in ethanol of increasing concentration i.e. 30 %, 50 %, 75 % and 97 % ethanol concentrations. Each residue was washed twice at each increasing concentration. After the final wash, it was assumed that no water was present in the residue.

2.4.2.7 STAINING

Staining is a practice that has become less popular in recent years due to the greater availability of interference and phase contrast microscopy. The major problem with staining is that most palynomorphs will not stain equally i.e. acritarchs and dinoflagellates may not absorb the dye, whereas pollens and spores may readily stain. Safranin O was the stain of choice used to highlight the presence of palynomorphs. A drop of the stain was added to the residue during the final alcohol wash. If the specimens had darkened too much by staining, the dye could be removed with a wash of diluted hydrochloric acid.

2.4.2.8 RESIDUE MOUNTING FOR OXIDIZED SLIDES

The same methods and procedures used for mounting unoxidized residues onto slides were adopted for the mounting of oxidized residues onto slides.

2.4.2.9 EMBEDDING MEDIA FOR OXIDIZED SLIDES

The same methods and procedures used for the assembling of unoxidized slides were employed for oxidized slides.

2.5 ANALYTICAL PROCEDURES

All work was done on a Zeiss Axioskop Petrographic Microscope located at the Bernard Price Institute for Palaeontology, University of the Witwatersrand. On each slide are printed the following:

- The site designator i.e. Offshore Site C-B1 or O-A1.
- Either cuttings or sidewall core sample (SWC).
- Slide preparation and designation number i.e. 20454 A. The letter A indicates that it is the first in a series of two or three slides to have been prepared.
- The depth from which the sample was taken.

Two hundred and fifty to three hundred specimens were counted for each sample (both oxidized and unoxidized). When the number of specimens from a specific sample did not amount to at least 250 specimens, then all the specimens counted were recorded. Three hundred particles of palynodebris were point counted per unoxidized slide using transmitted light microscopy. A cutoff size for each component was 5 μm and have been classified and discussed in Chapter 4.

Counting was undertaken under the 40x objective. After counting 250 to 300 specimens, the slides were completely scanned to establish the presence of any rare species. The scanning is a very important part of the procedure, where the presence or absence of a trilete spore may be a critical factor in the zonation. The frequency of each species encountered in all 192 samples is recorded in Appendix 3.

Specimens were also studied using the 100x objective under oil immersion and photographs were taken using the Zeiss Axioskop Petrographic Microscope that was fitted with a 35 mm camera attachment. ILFORD ASA 50 PAN F black and white film was used. Recording first the vertical and then the horizontal coordinates on the mechanical stage indicates the exact position of all illustrated specimens.

2.6 DARKROOM TECHNIQUE

All the black and white film used was developed in the Bernard Price Institute darkroom according to the manufacturer specifications. All prints from negatives were made on Ilford, Grade 3, glossy photographic paper.

2.7 STORAGE AND PRESERVATION

The glycerine jelly slides are being stored horizontally when not in use and are kept away from any source of heat and light. This is important because specimens may change position if the glycerine medium becomes fluid.

2.8 ARCHIVING OF MATERIAL

The slides that I have studied belong to the Petroleum Agency, SA and will be returned to them in due course.

2.9 CLASSIFICATION OF SPECIMENS

2.9.1 NOMENCLATURE AND TAXONOMY FOR CRETACEOUS AND TERTIARY POLLEN AND SPORES

The classification that follows has been simplified from the first five volumes of the Synopsis der Gattungen der sporae dispersae (Potonié, 1956 – 1970) for pollen and spore classification depicted here in skeletal hierarchical form with members. Burger's (1966) system of combining Potonié's turmal classification system with the different shape-groups of van der Hammen (1954 & 1956) was also followed along with the additions of several other researchers in this field. The fossil epiphyllous fungi have been ordered following the classification system of Luttrell (1973).

2.9.1.1 POLLEN

Superdivision POLLENITES Potonié, 1931

Division VESICULATAE Iversen & Troels-Smith, 1950

Subdivision MONOSACCATAE Chitaley, 1951 emend. Potonié & Kremp, 1954

Zonalapollenites dampieri Balme, 1957

Zonalapollenites segmentatus Balme, 1957

Zonalapollenites trilobatus Balme, 1957

Zonalapollenites turbatus Balme, 1957

Division BISACCATAE Cookson, 1947

Podocarpidites ellipticus Cookson, 1947

Podocarpidities sp.

Division POLYSACCATAE Cookson, 1947 emend. Potonié & Kremp, 1954

Cedripites sp.

Lactoripollenites cf. *L. africanus* Zavada & Benson, 1987

Microcachryidites antarcticus (Cookson) Couper, 1953

Division AZONOLETES Luber, 1935 emend. Potonié & Kremp, 1954

Balmeiopsis limbatus (Balme) Archangelsky, 1977 ememd. Norvick & Burger, 1976

Division MONOPORATAE Iversen & Troels-Smith 1950

Exesipollenites tumulus Balme, 1957

Harrisipollenites annulatus Mildenhall & Crosbie, 1979 emend. Mildenhall, 1980

Division AEQUATORANNULATAE (non MONOPORATAE) Burger, 1966

Subdivision ENDOSTRIATAE Burger, 1966

Classopollis cf. *C. echinatus* Burger, 1965

Classopollis torsus (Reissinger, 1950; Balme, 1957) Couper, 1958 emend. Burger, 1965

Division DIPORATAE Iversen & Troels-Smith, 1950

Diporites aspis Pocknall & Mildenhall, 1984

Division TRIPORATAE Iversen & Troels-Smith, 1950

Luminidites sp.

Division TETRAPORATAE Iversen & Troels-Smith, 1950

Quadraplanus brossus Stover, 1973

Division PERIPORATAE Iversen & Troels-Smith, 1950

Buttinia andreevii Boltenhagen, 1967

Buxaceaepollenites cainozoicus Sah, 1967

Bytneripollis coronarius Konzalová, 1976

Division MONOCOLPATAE Iversen & Troels-Smith, 1950

Subdivision PSILAMONOCOLPATES Iversen & Troels-Smith, 1950

Ginkocycadophytus nitidus (Balme) De Jersey, 1962

Division POLYPLICATAE Erdtman, 1952

Ephedripites sp. 1

Ephedripites sp. 2

Ephedripites sp. 3

Ephedripites sp. 4

Ephedripites sp. 5

Ephedripites sp. 6

Steevipollenites sp.

Division POLYADAE Iversen & Troels-Smith, 1950

Acaciapollenites myriosporites (Cookson) Mildenhall, 1972 ex Jansonius & Hills, 1976

Division TRICHOTOMOSULCATAE Belsky, Boltenhagen & Potonié, 1965

Subivision POROTRICHOTOMOSULCATAE Iversen & Troels-Smith, 1950

Andreisporis mariae Belsky, Boltenhagen & Potonié, 1965

Constantinisporis jacquei Belsky, Boltenhagen & Potonié, 1965

Dorreenipites sp.

Victorisporis robertii Belsky, Boltenhagen & Potonié, 1965

Division TRICOLPORATAE Iversen & Troels-Smith, 1950

Crotocolopites sp.

Margocolporites sp.

Liliacidites trichotomosulcatus Singh, 1971

Orbiculapollis globosus Chlonová, 1961

Triangulorites pachyexinus Kar & Kumar, 1986

Division TETRACOLPORATAE Iversen and Troels-Smith, 1950

Tetracolporites ixerboides Pocknall & Mildenhall, 1984

Tetracolporites spectabilis Pocknall & Mildenhall, 1984

Tetracolporites sphericus Couper, 1960 emend. Pocknall & Mildenhall, 1984

2.9.1.2 SPORES

Superdivision TRILETES (Reinsch, 1881) Potonié & Kremp, 1954 emend. Dettmann, 1963

Division AZONOTRILETES Luber, 1935 emend. Dettmann, 1963

Subdivision PSILATRILETES and GRANULATITRILETES Burger, 1966

Biretisporites potoniaei Delcourt & Sprumont, 1955

Concavisporites obtusangulus (Potonié) Krutzsch, 1959

Cyathedites australis Couper, 1953

Cyathedites australis rimulis Balme, 1957

Cyathedites punctatus (Delcourt & Sprumont) Delcourt, Dettmann & Hughes, 1963

Cyathedites kerguelensis Cookson, 1947

Cyathedites major splendens Harris, 1965

Cyathedites minor Couper, 1953

Divisisporites divisus Pflug, 1953

Divisisporites euskirchenensis non Thompson; Cookson & Dettmann, 1958

Gleicheniidites apilobatus Brenner, 1963

Gleichenidites circindites (Cookson) Dettmann, 1963

Gleicheniidites feronensis (Delcourt & Sprumont) Delcourt & Sprumont, 1959

Gleicheniidites radiatus (Bolkhovitina) Krutzsch, 1959

Gleicheniidites rasilis (Bolkhovitina) Krutzsch, 1959

Gleicheniidites senonicus Ross, 1949

Gleicheniidites toriconcavus Krutzsch, 1959

Gleicheniidites sp.

Gleichenites limbatus Agranovskaja, 1960

Mediobaculisporis mediobaculus Krutzsch, 1959

Psilatriletes radiatus Brenner, 1963

Stereisporites electoides Krutzsch, 1963

Stereisporites stereoides (Potonié & Venitz) Pflug, 1953

Undulatisporites microcutis Pflug, 1953

Subdivision RUGUTRILETES and STRIATITRILETES Burger, 1966

Appendicisporites dentimarginatus Brenner, 1963

Appendicisporites matesovae (Bolkhovitina) Norris, 1967

Appendicisporites tricorinatatus Weyland & Greifeld, 1953

Appendicisporites tricuspidatus Weyland & Greifeld, 1953

Camarozonosporites cretaceus (Weyland & Krieger) Potonié, 1956

Cicatricosisporites australiensis (Cookson) Potonié, 1956

Cicatricosisporites hughesii Dettmann, 1963

Cicatricosisporites venustus Deâk, 1963

Contignisporites sp.

Ghoshiatriletes gondwanensis D'rozario & Banerjee, 1989

Hamulatisporites hamulatus Krutzsch, 1959

Nodosisporites costatus Deâk, 1964

Staplinisporites caminus (Balme) Pocock, 1962

Striatella seebergensis Mädler, 1964

Tigrisporites halleinis Klaus, 1960

Triplexisporites playfordii (de Jersey & Hamilton) Foster, 1979

Subdivision FOVEOTRILETES and RETITRILETES Burger, 1966

Foveogleicheniidites confossus (Hedlund) Burger, 1976

Foveosporites canalis Balme, 1957

Ischyosporites crateris Balme, 1957

Klukisporites varigatus Couper, 1958

Lycopodiumsporites reticulumsporites (Rouse) Dettman, 1963

Microreticulatisporites parviretis Balme, 1957

Scrobiculifoveotriletes sp.

Subdivision GEMMATRILETES and VERRUTRILETES Burger, 1966

Corrugatisporites sp.

Gemmatriletes morulus Pierce, 1961

Trilobosporites sp.1

Trilobosporites sp.2

Trilobosporites sp. 3

Trilobosporites sp. 4

Subdivision BACUTRILETES and CLAVATRILETES Burger, 1966

Osmundacidites wellmanii Couper, 1953

Subdivision ECHITRILETES and TUBERCULITRILETES Burger, 1966

Ceratosporites equalis Cookson & Dettmann, 1958

Luberisporites luberi Nakoman, 1976

Ornamentifera echinata (Bolkhovitina) Bolkovitina, 1966

Ornamentifera tuberculatus Bolkovitina, 1966

Raistrikia grovensis Schopf, Wilson & Bentall, 1944

Subdivision PERINOTRILETES Erdtman, 1947 emend. Potonié, 1956

Perotriletes granulatus Couper, 1953

Division ZONOTRILETES Waltz, 1935

Subdivision ZONOPSILATRILETES Burger, 1966

Cingulatisporites levispecoisus Pflug, 1953

Murospora florida (Balme) Pocock, 1961

Murospora truncata Singh, 1971

Undulatitriletes hertensis Klein, 1959

Subdivision ZONORUGUTRILETES and ZONOSTRIATRILETES Burger, 1966

Densoisporites microrugulatus, Brenner, 1963

Taurocusporites reduncus Bolkhovitina, 1962

Subdivision ZONOFOVEOTRILETES and ZONORETITRILETES Burger, 1966

Rouseisporites reticulatus Pocock, 1962

Zlivisporites blanensis Pacltová, 1961

Zvlisporites sp.

Subdivision ZONOGEMMATRILETES and ZONOVERRUTRILETES Burger, 1966

Asbeckiasporites wirthii von der Brelie, 1964

Foraminisporis asymetricus Krutzsch, 1959

Foraminisporis foraminis Krutzsch, 1959

Interulobites algoensis Scott, 1976

Nevesisporites tribullatus Nakoman, 1976

Nevesisporites vallatus De Jersey & Paten, 1964

Taurocusporites segmentatus Stover, 1962

Taurocusporites sp.

Subdivision ZONOBACUTRILETES, ZONOCLAVATRILETES and ZONOECHITRILETES Burger, 1966

Antulsporites baculatus (Archangelsky & Gamerro, 1966a) Archangelsky & Gamerro, 1966b

Cyatheacidities annulatus (Cookson) Potonié, 1956

Diatomozonotriletes sp.

Indotriletes explanatus (Luber) Playford, 1991

Undulatitriletes sp.

Zonalasporites arcusus Balme, 1957

Division PSEUDOSACCITITRILETES Potonié & Kremp, 1954

Subdivision POLYSEUDOSACCITI Potonié & Kremp, 1954

Balmeisporites sp.

2.9.1.3 MONOLETES

Superdivision MONOLETES Ibrahim, 1933

Division AZONOMONOLETES Luber, 1935 emend. Dettmann, 1963

Subdivision LAEVIGATOMONOLETES Dybová & Jachowicz, 1957

Laevigatosporites sp.

Division AZONOMONOLETES Luber, 1935

Subdivision SCULPTATOMONOLETI Dybová & Jachowicz, 1957

Ischyomonoletes sp.

2.9.1.4 ALGAE

Superdivision CHLOROPHYTA Pascher, 1914

Division CHLOROPHYCEAE Kutzing, 1843

Subdivision SPHAEROPLEALES Fritsch in West, 1927

Sphaeroplea sp.

Division CHLOROPHYCEAE Kutzing, 1843

Subdivision ZYGEMATALES Borge & Pascher, 1931

Ovoidites sp.

Schizosporis reticulatus Cookson & Dettmann, 1959

INCERTAE SEDIS (affinity Algal)

Chomotriletes sp.

2.9.1.5 FUNGI

Superdivision FUNGI van der Hammen 1954 & 1956

Division LOCULOASCOMYCETES Luttrell, 1973

Subdivision MICROTHYRIALES Luttrell, 1973

Microthyriacites sp.

2.10 NOMENCLATURE

Palynomorphs were identified from the literature, focusing on both northern and southern hemisphere Cretaceous and Tertiary palynology. As one of the primary aims of this research was to place the sedimentary rocks stratigraphically, a bottom-up approach was adopted. As it is the history of the southern Gondwana palaeofloras that was of immediate interest, comparison of the palynomorphs from the two Offshore Sites with other palynofloras of similar age from regions which previously occupied the Gondwana drift phases, was undertaken.

2.11 TABLE FORMAT USED TO DESCRIBE AND ILLUSTRATE PALYNOMORPHS

The descriptions and scanned-in images of each kind of palynomorph are presented in table format instead of text and plate methods (See Table 2.2 below). The main reasons for adopting this format are:

- The tables are clear and easy to refer to, as all the information concerning a particular palynomorph is located in one place as opposed to being described in one place and illustrated elsewhere.
- All hard-copy photographs are image processed and imported directly into the tables.

- The tables have been designed to form part of a database facilitating the addition of data from specimens produced by future research.

2.12 TECHNICAL TERMS

The palynomorphs were described according to the technical terms compiled primarily by Kremp (1965) and Punt *et al.,* (1994).

2.13 GLOSSARY

The glossary section (included with the Appendices) contains a compilation of the technical terms used in this thesis. The literature reference for each term is not necessarily the earliest publication in which it was used, but has been selected as a source for further information.

2.14 QUANTITATIVE STATEMENTS AND SPECIMEN FREQUENCIES

A quantitative statement concerning the distribution of each palynomorph type cannot be included as part of the description due to the immense time span covered, and the resulting fluctuations in palynomorph type. Therefore, the frequency of a palynomorph is discussed relative to the stages / zones it is found in. The specimen frequencies are expressed in the following terms:

- Very rare - The number of specimens found is stated.
- Rare - up to 10 % of a stage
- Common - up to 25 % of a stage
- Abundant - 25 – 50 % of a stage
- Dominant - over 50 % of a stage

Few age ranges were found where one palynomorph could be classified as either abundant or dominant. Actual abundance distribution is visually illustrated in the pollen diagrams (see Chapter 4). A drawback to this system occurs when contaminants are classified as very rare when they should be ignored altogether.

AFFINITY:	GENUS:	TYPE SPECIES:	THIS SPECIES:
OFFSHORE SITE:	SLIDE:	CO-ORDINATES:	DEPTH:
DESCRIPTION: AMB SHAPE:	SIDES:	ANGLES:	EQUATORIAL OUTLINE:
LAESURAE:	SCULPTURING: PROXIMAL FACE: DISTAL FACE:	RADIAL / INTERRADIAL / POLAR REGIONS:	EQUATORIAL REGIONS:
CINGULUM:	PORES:	COLPI:	SACCI:
EXINE:	EQUATORIAL DIAMETER:	PRESERVATION:	COLOUR:
STRATIGRAPHIC RANGE (LITERATURE):	LOCALITY AGE FOR THIS SPECIMEN:	AGE RANGE OF ALL SAMPLES:	FIGURE:
COMMENTS:			
SPECIMEN FREQUENCY:			
MICROFOSSIL SYSTEMATICS:		DISTRIBUTION:	
CONTINUED IN APPENDIX 2		CONTINUED IN APPENDIX 2	
OCCURRENCES IN WESTCOAST OFFSHORE SITE C-31:		OCCURRENCES IN WESTCOAST OFFSHORE SITE O-A1:	

Table 2.2. Table format used to describe and illustrate palynomorph types.

SEE APPENDIX 3 FOR GREATER DETAIL	SEE APPENDIX 3 FOR GREATER DETAIL
Figure	Figure

Table 2.2. con't. Table format used to describe and illustrate palynomorph types.

2.15 PRESERVATION

The following palynomorphs are classified according to their preservational quality (Figures 2.2 a - d that follow).

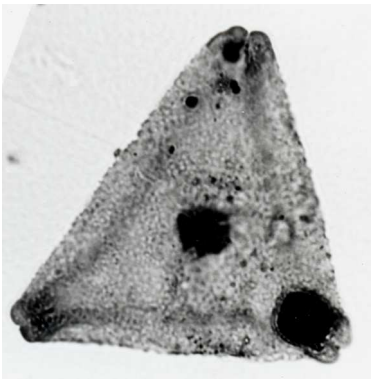

Figure 2. 2a. Very good preservation.

The body of the palynomorph is not damaged in any way and the shape has not been distorted. Surface texture is clearly discernable and the specimen is completely in focus i.e. lying in one plane only. There is minimal debris hiding the features.

Figure 2. 2b. Good preservation.

The body of the palynomorph has minimal damage and distortion to it. A section of the specimen is slightly out of focus but features are still clear. Debris is starting to become a problem with surface features being hidden. Surface texture is still clear.

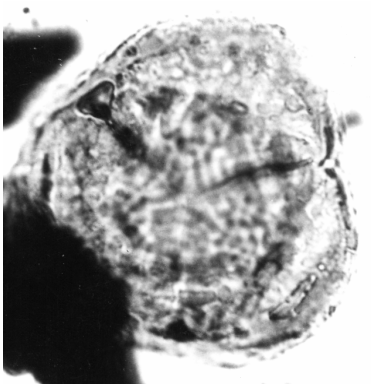

Figure 2. 2c. Fair preservation.

The body of the palynomorph is damaged and distorted. More than half of the palynomorph is out of focus and debris obscures more and more of the surface features. Surface texture is still discernable.

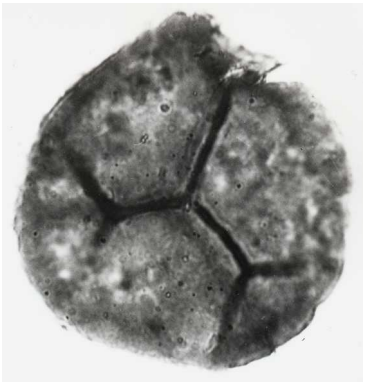

Figure 2. 2d. Poor preservation.

The spore body is damaged and the shape as a result has been distorted. The surface is badly eroded so that the surface texture is no longer discernable.

Figures 2. 2a – d. Palynomorph preservation ranging in quality from very good to poor.

The preservation of the palynomorphs present in the slides studied varied mostly between good and fair.

2.16 POLLEN DIAGRAMS

The data gathered from the quantitative microfossil investigations resulted in the composition of two different types of distribution diagrams. The first type of distribution diagram is a bar graph diagram, with each bar representing a separate species (see Figures 4.1 & 4.2). In such a format, the appearance and disappearance of each species is clearly visible. The bar graph has been divided into three major groups according to turma characteristics. Along the right side of the distribution diagram, which has been created by Tillia and Tillia Graph (Grimm, 1987) is a cluster analysis diagram generated by CONISS (Grimm, 1987). These diagrams reflects major zonations and designate the pollen zone boundaries by constraining the incremental sum-of-squares cluster analysis that is also generated by CONISS (Grimm, 1987) by using a square-root transformation and chord-distance dissimilarity measure for the spore and pollen taxa that occur at a value greater than 1% in abundance. The bar graphs are based on percentage calculations and set out using the same scale unless otherwise stated (see Chapter 4 for an in-depth discussion). Apart from the cluster analysis other multivariate techniques were also used to aid interpretation of the pollen diagrams (Table 2.3)

2.17 GENERATION OF DIAGRAMS

The following computer programs were used to generate the graphs and diagrams:

INFORMATION GENERATED	COMPUTER PROGRAMS USED
Typed chapters, references appendices and glossary.	Microsoft Word.
All photos scanned into the table format.	Photoshop Limited Edition 5.71
Pollen diagrams.	Tilia and tilia graphics programs with CONISS (Grimm, 1987).
Stratigraphic correlation of all studied sections.	Corel Draw Version 10.
Palynodebris diagrams	Tilia and Tilia Graph 2.0.b.5 CONISS (Grimm, 1987).
Principal Components Analysis	XLSTAT
Detrended Correspondence Analysis	PAST by Oyvind Hammer

Table 2.3. Computer programs used to generate information.