PALYNOFACIES AS A TOOL FOR THE INTERPRETATION OF DEPOSITIONAL ENVIRONMENTS IN THE WAIKATO AND TARANAKI BASINS, NEW ZEALAND

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The components of organic matter in sedimentary rocks provide a key to understanding the environment under which the rocks were deposited. In this study the total kerogen (acid-resistant organic matter) component in samples of Te Kuiti Group from onshore western North Island (Waikato Basin) and Kapuni Group from offshore western North Island (Taranaki Basin) has been assessed in palynological preparations and several distinct fluvial, paralic and neritic palynofacies are identified. These include fluvial channel, floodplain, peat swamp, lacustrine, lagoon, marginal marine, estuarine, shore related, and inner shelf, each named according to the depositional environment which they are inferred to represent. The various palynofacies occur in sediments deposited during the Eocene (Taranaki Basin) and the Upper Eocene and Oligocene (Waikato Basin).

Combining palynofacies with lithofacies analysis of the Kapuni Group in Kiwa-1 (offshore Taranaki Basin) a cyclic alternation of fluvial, and paralic sequences, capped by marine facies is documented. This allows landward and basinward translations of the shoreline during the Eocene to be plotted, enabling greater precision in a regional paleogeographic synthesis.

INTRODUCTION

The use of palynology in geological studies has hitherto been focused on determining the age of rocks (palynostratigraphy) and on giving vegetational and climatic interpretations based on comparison of fossil palynofloras with those of extant vegetation (paleoecology and paleoclimatology). During the past two decades there has been increasing attention paid to analysing the total kerogen (acid-resistant organic matter) component of sediments, particularly in marine sediments (Batten, 1982, 1987; Boulter and Riddick, 1986). The subdiscipline of palynofacies analysis (sensu Combaz, 1964) has enabled palynologists to provide detailed environmental interpretations that have proven useful in coal and petroleum geology. Palynofacies interpretation can be applied in the context of sequence stratigraphy to facilitate a greater understanding of the development of sedimentary sequences.

In New Zealand, detailed paleoenvironmental interpretations have only been made for marine sediments (based on foraminifera; Hayward, 1986). Palynofacies analysis has not previously been undertaken to any extent. One recent exception is the study of Pocknall and Turnbull (1989) who identified three facies associations in the Upper Eocene Beaumont Coal Measures and Orauea Mudstone in the Waiau Basin, Southland, comparing the distribution of plant communities with their sedimentary environments. In that study, only land-derived palynomorphs (spores and pollen) were employed in the interpretation, and not the total kerogen component of the sediments. A comparable study, but also including dinoflagellates, is that of Bint and Helby (1988) who defined seven palynofacies in sediments deposited in a delta plain to shallow marine sequence in Upper Triassic sediments in the Carnarvon Basin, offshore Western Australia.

This paper applies palynofacies analysis to Eocene to Early Oligocene sequences from the Waikato and Taranaki basins (Fig. 1). Study of samples from an opencast mine and a coal exploration drillhole in the Upper Eocene to Oligocene Te Kuiti Group in the Waikato Basin, and an oil exploration well in the Eocene Kapuni Group in the Taranaki Basin has resulted in the recognition of nine palynofacies representing fluvial, paralic and neritic environments. The basis by which these palynofacies are defined is outlined below, followed by discussion of the examples. Throughout the paper ages are given as New Zealand stages; see Edwards *et al.* (1988) for correlations to the international time scale and inferred absolute ages.

PALYNOFACIES

Samples for palynofacies analysis are prepared in a standard manner. The sediment sample is broken down with hydrochloric and hydrofluoric acids which digest the inorganic component of the sample and release the organic material. For routine palynostratigraphic studies an oxidation phase is

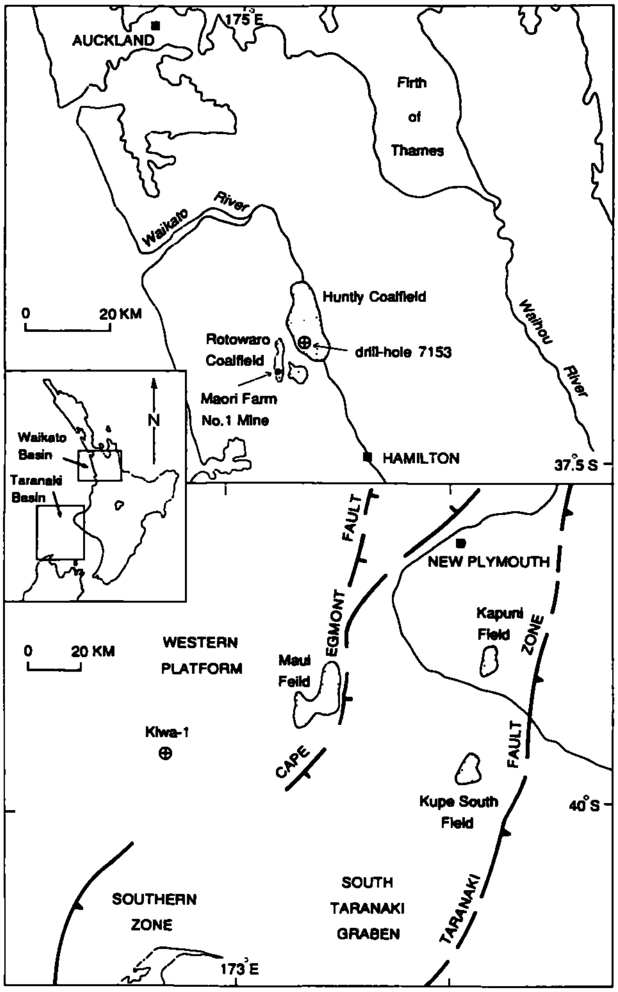


Fig. 1: Taranaki and Waikato regions showing location of study sites. Inset: North Island showing general extent of study area.

required to isolate the palynomorphs from the organic material. Slides prepared after both stages of preparation are examined for palynofacies determinations.

Palynofacies are recognised on the basis of the type, relative proportions, size, shape, colour, and state of preservation of the kerogen components, and lithology of the enclosing sediments. Broad descriptions of nine palynofacies are given below and the characteristics of each are summarised in Table 1. It should be noted that the palynofacies definitions given here are preliminary and that further refinement will follow with future work. It is also important to realise that kerogen types are not necessarily exclusive to a particular palynofacies. Palynofacies are named according to the environment they are inferred to represent and have not yet been tested against studies of kerogen distribution in Recent environments.

In this study the term kerogen is used in its broadest context as defined by Burgess (1974). It includes all finely disseminated organic material freed from sedimentary rock after acid treatment, such as identifiable palynomorphs (both marine and nonmarine), leaf cuticle, wood, fungal spores and hyphae, and resin, as well as a host of unidentifiable organic debris.

Fluvial and paralic systems

Fluvial channel (fl-c) This palynofacies is characterised by a low diversity association of spores and pollen that show variable preservation, and it contains abundant quantities of degraded and amorphous plant matter, much of it small and dark. Among the palynomorphs, spores outnumber pollen, and other kerogen components include angular fragments of wood and leaf cuticle. The characteristics of all the kerogen components of this palynofacies reflect selective sorting and abrasion in a high energy channel environment.

Floodplain (flp) A highly diverse and intermixed association of spores and pollen, together with abundant wood and leaf cuticle which is mostly transparent and well preserved, is characteristic of this palynofacies. It is generally associated with fine-grained lithologies (carbonaceous mudstone and siltstone) that were deposited in low energy, quiet water situations and is transitional between fluvial and paralic environments. The state of preservation of the various components indicate that deposition took place in a reducing (waterlogged) environment in which there was only minimal sediment reworking.

Peat swamp (sw) A high yield of well preserved palynomorphs is characteristic of the swamp palynofacies. The total kerogen composition is variable, often containing large fragments or coagulated packets of degraded amorphous kerogen, as well as fungal spores and hyphae, wood, black debris, and sometimes high abundances of pollen or spores from plants that were growing on the swamp. The presence of dinoflagellates in some coal samples may represent peat development in a backbarrier situation, subject to occasional flooding by marine waters.

Coal samples generally vary in their kerogen components as a result of changing depositional conditions (particularly changes in peat and groundwater chemistry) throughout the history of the swamp. In some samples fungal material (spores and hyphae) is common, suggesting that biodegradation may have taken place; in these instances organic matter is finely particulate. Many samples contain mostly woody material indicating waterlogged (reducing) conditions, while occasional samples contain high levels of black, angular debris apparently indicating oxidation of the swamp surface during periods of lower water table. Petrographic studies of coal from the Waikato Coal Measures (Sykes, 1987, 1988) show that the incidence of the coal macerals fusinite and semifusinite is low indicating that dry periods were rare during the deposition of the peat swamp. However, coal petrographic sampling techniques involve taking composites of a substantial stratigraphic thickness which may not resolve some subenvironments, such as relatively short-lived periods when the peat body was elevated above the water table.

Lacustrine (lac) An abundance of the freshwater alga *Botryococcus* characterises the lacustrine palynofacies. Land-derived palynomorphs are generally sparse, although spores are occasionally common, suggesting their selective deposition and/or preservation in the lake environment. Pollen, when present, is often poorly preserved indicating that mechanical abrasion has taken place during recycling of the water mass and subsequent redeposition of the sedimentary load within the lake. Also present are epidermal tissues, often degraded, and amorphous organic particles which are

Palynofacies	Kerogen components	Lithology
Fluvial and paralic		
Fluvial channel (fl-c)	Low diversity and yield of spores and pollen, variably preserved; degraded plant tissue and black debris common; tissue mostly dark colour and small.	Sandstone
Floodplain (flp)	High diversity and yield of spores and pollen; plant tissue, including leaf cuticle, generally abundant and well preserved.	Carbonaceous mudstone and siltstone
Peat swamp (sw)	High yield of spores and pollen, variable diversity; plant tissue often abundant and degraded appearing amorphous in structure, black debris and fungal material (spores and hyphae) often common.	Coal
Lacustrine (lac)	Low yield of spores and pollen, spores generally outnumbering pollen, variably preserved, *Botryococcus* common; amorphous matter common and mostly degraded.	Claystone
Lagoon (lag)	Average yield of spores, pollen and dinoflagellates, variably preserved, *Botryococcus* present; allocthonous black debris, degraded plant tissue and specked amorphous matter common.	Claystone, some carbonaceous content
Marginal marine (m-m)	Generally low yield of spores and pollen, dinoflagellate and plant tissue fragments common; mangrove pollen sometimes present.	Siltstone and sandstone
Estuarine (est)	Pollen and spores common, especially mangrove pollen; occasional dinoflagellates and varying quantities of structured plant tissue which is variably preserved.	Mudstone and siltstone
Neritic		
Shore related (sh-r)	Small fragments of unstructured plant tissue and inertinite common; low yield of spores and pollen and dinoflagellates which are poorly preserved; spores are generally more diverse than pollen.	Sandstone
Inner shelf (in-s)	High yield of mostly well preserved dinoflagellates, low spores and pollen content and poorly preserved; various types of amorphous matter including comminuted debris and specked amorphous matter.	Siltstone and sandstone

Table 1: Summary of palynological and lithological characteristics for palynofacies defined herein.

small (20-30 μm) and often clumped. The lithology typical of this palynofacies is fine grained claystone.

Lagoon (lag) The distinctive lagoonal palynoflora has a good yield of land-derived palynomorphs of generally low diversity, as well as dinoflagellates, and *Botryococcus*, although the latter is not as common as in the lacustrine palynofacies. The presence of *Botryococcus* and dinoflagellates is indicative of brackish water or weakly saline conditions. An allochthonous component consists of black debris, specked amorphous matter, and abraided plant tissue; all appear to have been transported to the site of deposition.

Marginal marine (m-m) Finely dispersed particulate matter (predominantly black debris) varying quantities of plant tissue, dinoflagellate fragments, and a low abundance of land-derived palynomorphs characterise this palynofacies. The components suggest a moderate energy level at the site of deposition and are considered to represent deposition in a tidal mud flat environment where sediment is being constantly reworked within the tidal zone. This palynofacies is often hosted by interbedded mudstone and sandstone units.

Estuarine (est) The estuarine palynofacies is characterised by the presence of mangrove pollen of the genus *Nipa* (*Spinizonocolpites prominatus*), with varying quantities of structured plant material. The state of preservation of the components is variable reflecting the varying energy levels within the estuarine system. The abundance of mangrove pollen varies and may be used to predict where in the estuarine system the sampled sediments were deposited. Based on modern mangrove occurrence, within a coastal embayment, the greater the abundance of *Nipa* pollen the more landward the site of deposition.

Nipa inhabited parts of New Zealand during the Early to Middle Eocene when New Zealand's climate was as warm as any in period of the Cenozoic (Pocknall, in press). By late Middle Eocene time the onset of cooler climatic conditions resulted in the near extinction of *Nipa* and an increase in the distribution of rainforest communities dominated by southern beech (*Nothofagus*).

Extant *Nipa* occurs within the tropical and subtropical latitudinal zone, growing in areas where there is some freshwater influence. Within the Early to Middle Eocene in New Zealand the presence of *Nipa*, and hence the identification of the estuarine palynofacies, can be a useful guide to the relative location of an ancient shoreline, because estuarine systems generally develop with a rise in relative sea level following a period of valley incision during a sea level lowstand. When mangrove pollen is not recorded the estuarine palynofacies may not be able to be discriminated from the marginal marine palynofacies (see above).

Marine systems

Shore related (sh-r) The high energy environments of an oceanic shoreline, including shoreface, beach, back-barrier washover, and even delta-mouth bar sands have a characteristic palynofacies. It contains small angular fragments of unstructured woody material, black debris, land-derived palynomorphs, and dinoflagellates, all of which are poorly preserved and dark in colour. Generally, land-derived palynomorphs and dinoflagellates are rare, but in a relative sense spores may be more common than pollen, indicating high energy selection.

Inner shelf (in-s) The inner shelf palynofacies is characterised by a high proportion of mostly well preserved dinoflagellates and a low abundance of land-derived palynomorphs. The spores and pollen that are present are generally poorly preserved and mostly derived from plants whose pollen is wind dispersed (e.g. conifers, *Nothofagus*) and thus able to be transported large distances. The plant material present is usually much smaller (size-wise) than that found in palynofacies deposited nearer to the shore and the source. Structureless organic matter (of possible bacterial origin) is often abundant.

In marine environments the distribution of organic matter can be related to the distance from land at the time of deposition. Spores from ferns and pollen from wind pollinated plants are generally the only land-derived palynomorphs found in offshore environments. Their relative abundance in marine sediments is dependent on the energy of the environment and the preservational characteristics of the palynomorph concerned. As a general rule spores seem to be better preserved than most pollen types and are therefore better represented in sediments deposited in high energy environments. With other debris there may be a correlation between size of the particle and distance from shore such that larger debris (e.g. leaf cuticle) be deposited near to shore and that smaller particles (e.g., black debris) be deposited further out to sea. More detaile examination of nearshore marine and offshore marine sediments is needed to confirm this relationship. Future work will also compare marine palynofacies to paleoenvironmentally interpreted foraminiferal assemblages from the same samples.

PALYNOFACIES IN THE WAIKATO AND TARANAKI BASINS

The Upper Eocene to Oligocene Te Kuiti Group sequence in the Waikato Basin, as defined by Kear and Schofield (1959), consists of basal coal measures passing upwards through non-calcareous estuarine and shallow-water deposits, to calcareous marine beds culminating in the widespread Otorohanga Limestone (Kear and Schofield, 1978). The respective units within the Te Kuiti Group that have been examined during the course of this study include all those between the Waikato Coal Measures (both Lower and Upper) and the Whaingaroa Siltstone (see Figs. 2 and 3). For stratigraphic definitions, lithological descriptions, and notes on distribution within the Waikato Basin refer to Kear and Schofield (1978), Nelson (1978) and Edbrooke *et al.* (in prep.).

The material examined from the Waikato Basin has been obtained from surface exposures (opencast mine face) at Maori Farm No. 1 Mine in the Rotowaro Coalfield and the

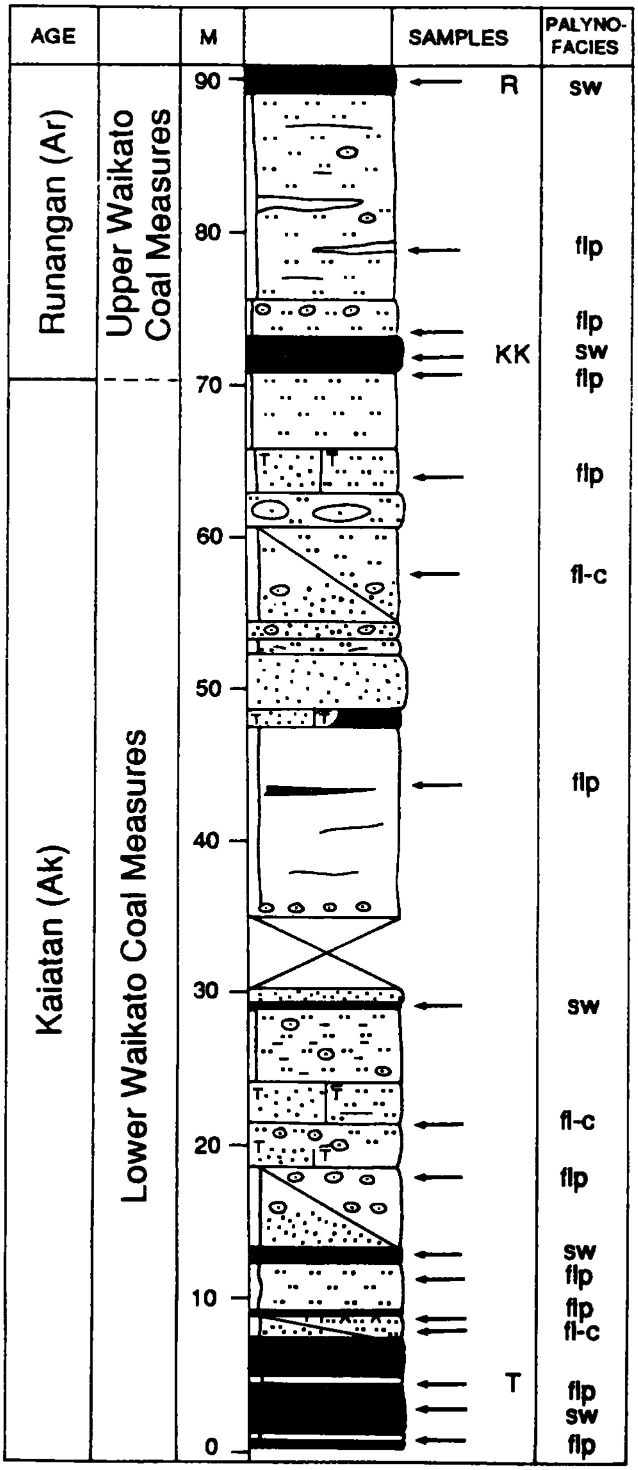


Fig. 2: Lithostratigraphic sections for the Maori Farm No. 1 Mine in the Rotowaro Coalfield showing the distribution of palynofacies (see Table 1 for key to abbreviations). Coal seams are abbreviated as follows: T=Taupiri seams, KK=Kupakupa, and R=Renown.

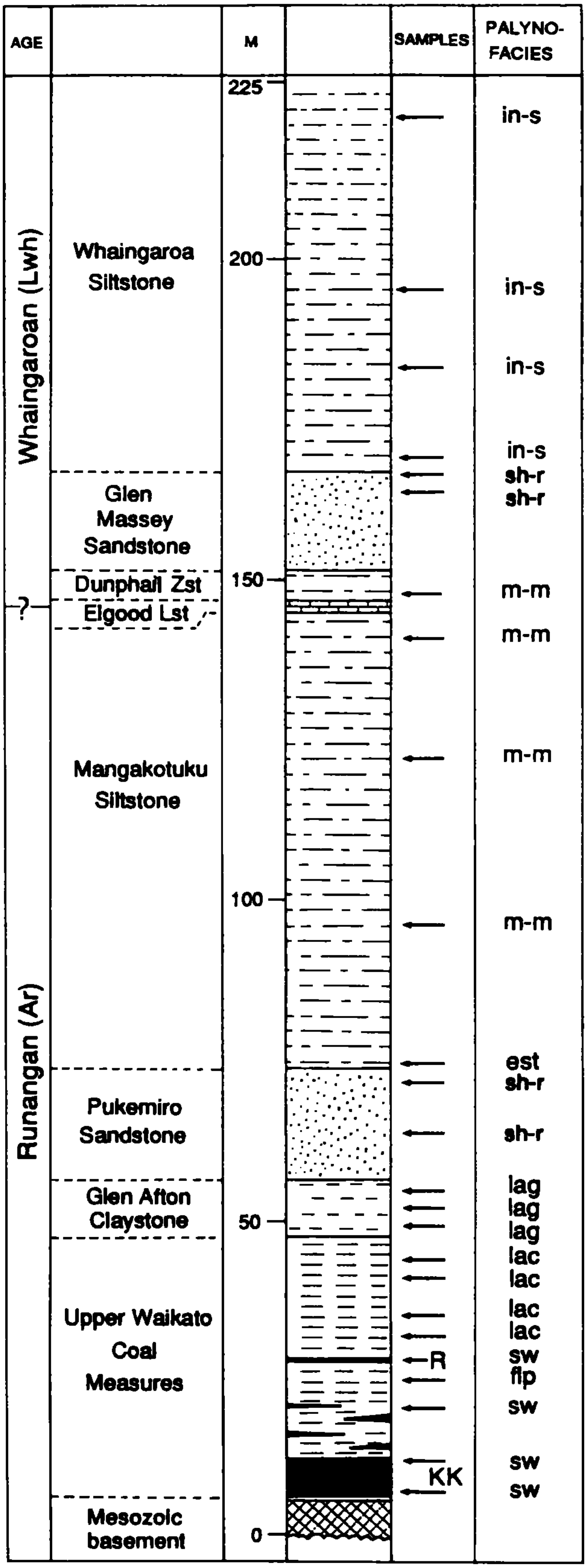


Fig. 3: Lithostratigraphic section for drillhole 7153 in the Huntly Coalfield, showing the distribution of the palynofacies (see Table 1 for key to abbreviations). See caption to Fig. 2 for coal seam abbreviations.

subsurface in drillhole 7153 in the Huntly Coalfield (Fig. 1). At Rotowaro all of the Lower Waikato Coal Measures and the Upper Waikato Coal Measures up to, and including, Renown Seam were sampled, and at Huntly the Upper Waikato Coal Measures, including Kupakupa Seam, and much of the overlying marine sequence was sampled.

Summary lithostratigraphic sections for the Rotowaro and Huntly sequences are presented in Figs. 2 and 3, respectively. On these sections the distribution of the various palynofacies is summarised. In the Lower Waikato Coal Measures at Rotowaro (Fig. 2) the alternation of paralic (peat swamp and floodplain palynofacies) and fluvial (fluvial channel palynofacies) facies is interpreted to result from changes in base level. Variations in peat swamp palynofacies in the Lower and Upper Waikato Coal Measures indicate that depositional conditions varied during accumulation of the thick coals as a result of changes in peat and groundwater chemistry and the height of the water table. These observations are largely in accord with the interpretations of Sykes (1987, 1988). The uppermost Upper Waikato Coal Measures at Huntly (Fig. 3) accumulated in a lacustrine environment and is overlain by the Glen Afton Claystone. The presence of the freshwater alga *Botryococcus* and dinoflagellates in the Glen Afton Claystone confirm that deposition took place in a brackish water, lagoonal environment, as suggested by Kear and Schofield (1978). Palynofacies in the Pukemiro Sandstone indicate shore related deposition. A possible disconformity at the top of the Pukemiro Sandstone is marked by the onset of estuarine and marginal marine deposition (Mangakotuku Siltstone and Elgood Limestone) followed by a deepening with deposition of the Dunphail Siltstone, shore related sands of the Glen Massey Sandstone, and ultimately the inner shelf deposits of the Whaingaroa Siltstone. Palynofacies interpretations for the predominantly marine section of the Te Kuiti Group are in general agreement with the observations based on lithofacies and foraminiferal faunas cited by Kear and Schofield (1978). We believe that there is considerable scope for application of sequence stratigraphic principles to the further elucidation of depositional environments in the Te Kuiti Group.

Several exploration wells in the Taranaki Basin are currently being reappraised stratigraphically and palynofacies results obtained from one of these, Kiwa-1, are presented here. Kiwa-1 was drilled by Shell BP Todd Oil Services Ltd in 1981 on the Western Platform (Fig. 1). Samples from the Kapuni Group were dated by Mildenhall *et al.*, (1981) but with little or no attention to palynofacies determination.

Samples from Kiwa-1 are mainly sidewall cores, supplemented by cuttings over significant gaps. Palynofacies are better determined from sidewall core samples because they usually represent a single environment of deposition whereas cuttings may include several subenvironments. The quality of the results from well studies and the ability to draw comparisons between wells relies on good biostratigraphic control which in turn is dependent on the sidewall coring programme.

As Taranaki Basin wells have been re-examined the palynostratigraphy has been revised, providing a better time framework in which to interpret environments of deposition. For Kiwa-1 the revised ages are shown on Fig. 4.

The distribution of palynofacies in the Kapuni Group sediments in Kiwa-1 are shown on the stratigraphic section in Fig. 4 and the significance of these to the sequence stratigraphic interpretation of the well are discussed in the following sections of this paper.

FACIES SEQUENCE AND SEQUENCE STRATIGRAPHY

The concept of sequence stratigraphy developed as a result of the efforts of Vail and co-workers (e.g. Vail *et al.*, 1977; Haq *et al.*, 1987) to correlate, on a global scale, indications of eustatic sea-level variations in the stratigraphic record. The relationship between depositional facies sequence and eustatic sea level is complex and if understood can be a powerful predictor of three-dimensional basin stratigraphic architecture. The principles of sequence stratigraphy are described by Posamentier and Vail (1988) and Posamentier *et al.* (1988). We have applied these principles in interpreting the Eocene Kapuni Group section in Kiwa-1, integrating the lithologic data with new palynofacies data described above, and subdividing the section into eustatically-controlled depositional sequences (see Figs. 4 and 5).

An important corollary of sequence stratigraphy is that certain depositional facies are characteristic of particular parts of a eustatic sea-level cycle. For example, conditions for the aggradation (and hence permanent accumulation) of fluvial systems across a coastal plain are limited to the late part of a sea-level highstand; as sea level begins to fall the point to which stream profiles are graded moves basinward causing successive equilibrium profiles to move outward and create *accommodation* (sensu Posamentier *et al.*, 1988) above base level. During other parts of the eustatic cycle, fluvial systems are either in equilibrium or undergoing down-cutting, resulting in no net deposition.

Estuarine conditions, on the other hand, imply valley incision prior to subsequent filling with estuarine facies. Paralic estuarine and lagoonal facies are particularly characteristic of transgressive periods (rising sea level), even though they are landward of the shoreline. The principles of sequence stratigraphy enable us to recognise eustatic events in fluvial and paralic sequences such as the Kapuni Group, and to predict the relative spatial position of the shoreline and point of coastal onlap at any given point in time.

SEQUENCE INTERPRETATION OF KIWA-1 KAPUNI GROUP

The integration of lithofacies and palynofacies outlined above enables the Kapuni Group section in Kiwa-1 to be subdivided into a series of fluvial, paralic, and ultimately marine depositional facies. This facies sequence, however, is not a simple transgressive progression from fluvial through paralic and shore related to neritic facies. The Early Eocene (Waipawan to Heretaungan) section includes several alternations of fluvial, estuarine, and lagoonal facies, which are succeeded in the Middle Eocene (Bortonian) by neritic facies correlated with the Turi Formation of Palmer (1985). Elsewhere in the basin, fluvial and paralic conditions persisted until at least the end of the Eocene in the east (Palmer, 1985; King and Robinson, 1988), whereas marine conditions were already established by Paleocene times to the north.

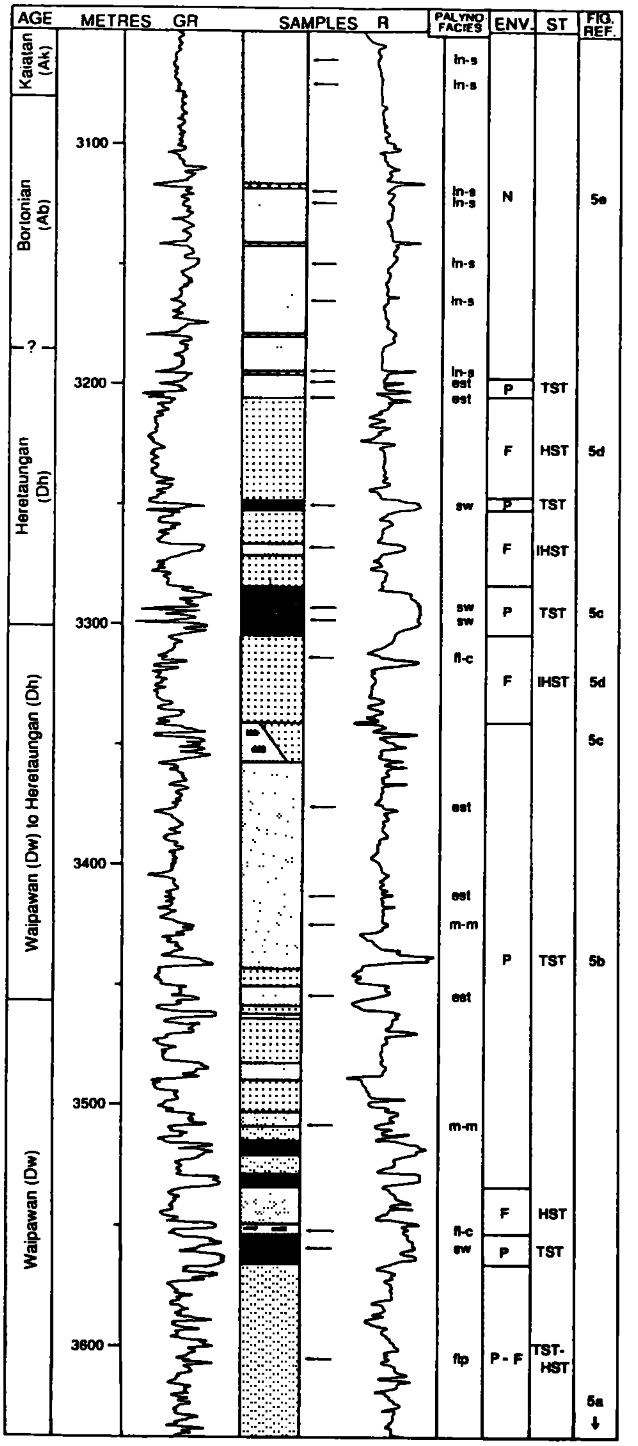
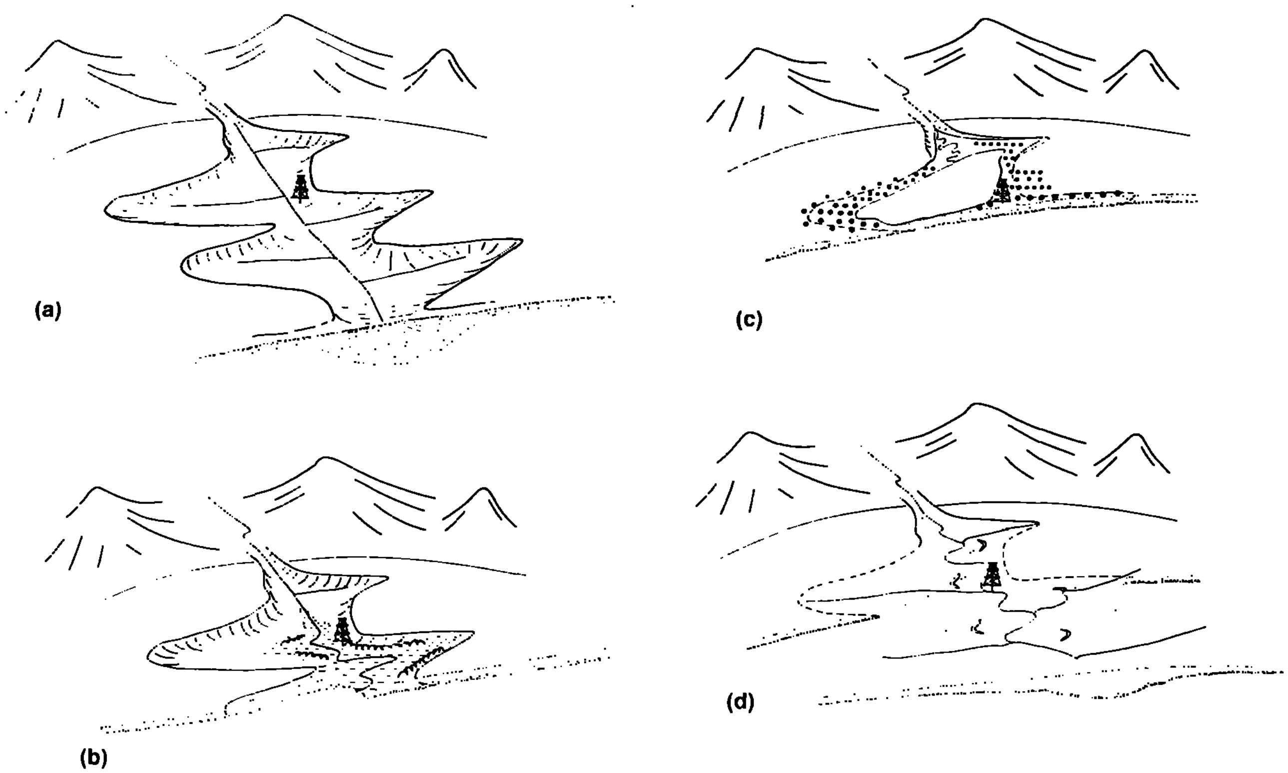


Fig. 4: Section through the Kapuni Group in Kiwa-1 with gamma-ray (GR) and resistivity (R) logs, sample locations, ages, palynofacies interpretation (see Table 1 for key to palynofacies abbreviations), environment of deposition (ENV) and systems tracts (ST). Systems tract (TST=transgressive systems tract, HST=highstand systems tract, lHST=late highstand systems tract) designations follow Posamentier et al. (1988); P=paralic, F=fluvial, N=neritic.

During deposition of the sequence at Kiwa-1 the Western Platform lay at the edge of a passive margin (King, this volume) suggesting that major changes in sediment supply were unlikely. At the same time subsidence at the site, as determined from foraminiferal data (Hayward and Wood,



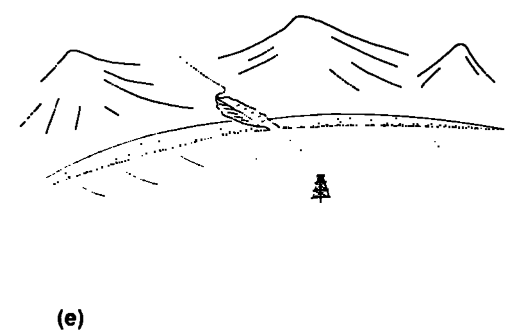


Fig. 5: Schematic evolution of depositional environments in Kiwa-1 (location marked by well symbol) related to eustatic sea level movements. (a) Lowstand system with no net accumulation at site of Kiwa-1. (b) Early stage of transgressive system with estuarine deposition infilling incised valleys cut during previous lowstand. (c) Late stage of transgressive system showing development of lagoon and coal swamps coincident with high base levels. (d) Late highstand system with aggradation of fluvial deposits and basinward translation of shoreline. (e) Transgressive system after shoreline has moved landward of Kiwa-1 site; deposition in inner neritic environment (Turi Formation).

1989), remained steady and consistent with the tectonic interpretation.

The base of the interval of interest in Kiwa-1 is at a measured depth of 3638 m (Fig. 4). This overlies an inferred sequence boundary representing a period of non-deposition associated with low sea level (e.g. Fig. 5a). The basal 71 m of the study interval (up to 3567 m) is predominantly fluvial sand with interbedded floodplain facies, overlain by a 12 m thick coal. The overlying 137 m (up to 3430 m) consists of sandstone, interbedded with carbonaceous siltstone, and a 6 m coal (between 3517 m and 3523 m). These intercalations of fluvial and swamp facies record 3rd or 4th-order fluctuations in sea level; fluvial facies aggrade as sea level begins to fall, followed by a period of non-deposition until the onlap of swamp facies during the subsequent transgression.

An 80 m thick shaley unit (between 3430 m and 3350 m), which becomes increasingly more carbonaceous upward represents a progression of paralic facies accumulation from estuarine to lagoonal (e.g. Figs 5b, c). There is no indication of marine facies in this interval of Kiwa-1, but a marine incursion occurred at this time (Heretaungan) in wells to the northeast (D1 shale of Maui Field; Omata Formation in onshore Taranaki; Palmer, 1985). Although paralic, the facies in Kiwa-1 are representative of a sea level rise (transgressive systems tract). In other words, the transgression recorded by the occurrence of marine facies in Maui Field and onshore Taranaki wells can be recognised even in wells which remained landward of the maximum incursion of the shoreline.

The thick carbonaceous shale is overlain by about 150 m of interbedded sandstones and coals (between 3350 m and 3206 m) deposited during the Heretaungan. This section records a series of 3rd or 4th-order eustatic cycles with fluvial deposition at the end of highstands (e.g. Fig. 5d), separated by sequence boundaries from overlying, onlapping coal swamp deposits. This is depicted diagrammatically in Fig. 6. This sequence stratigraphic interpretation of the fluvial and paralic cycles for the Heretaungan Kapuni Group in Kiwa-1 could be extended to the fluvial and paralic cycles in the Runangan Lower Waikato Coal Measures (see Fig. 2).

The overlying shale section, referred to the Turi Formation, is largely inner neritic (Fig. 5e) on the basis of palynofacies, but there is some indication of estuarine conditions (includ-

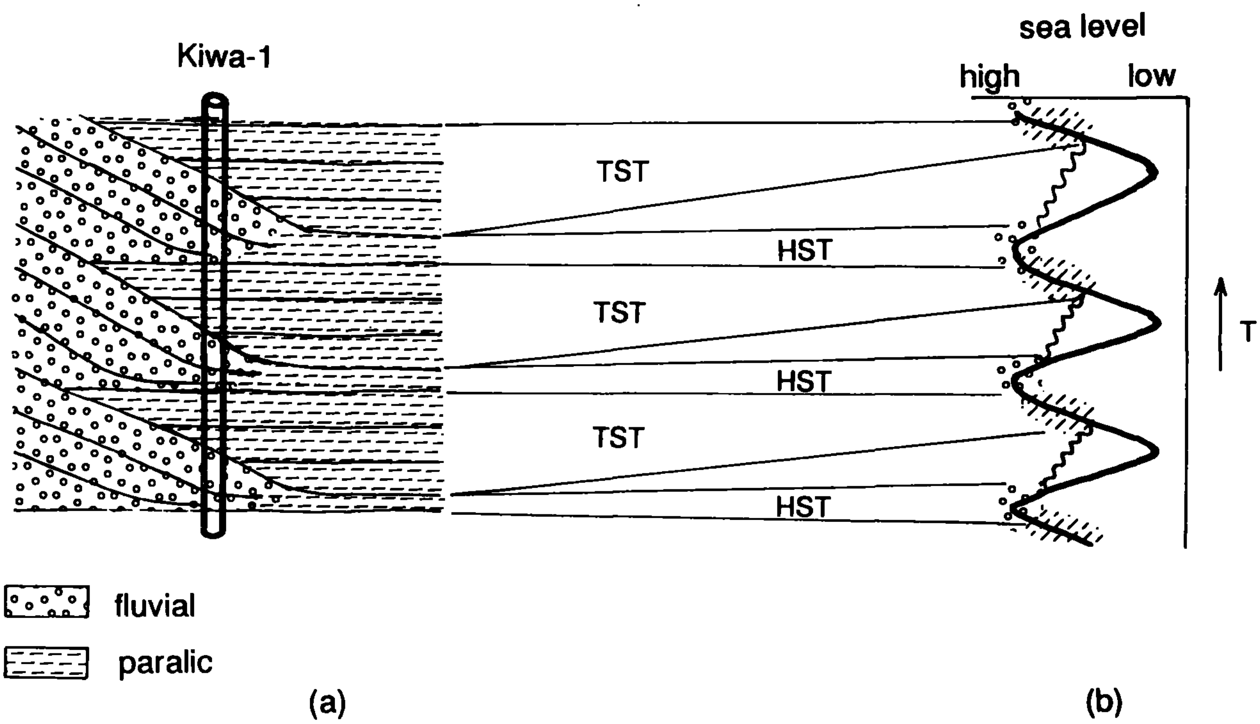


Fig. 6: Origin of fluvial/paralic cycles, for example in the Heretaungan section of Kiwa-1. (a) Stratal pattern: note onlap of transgressive (paralic) facies against fluvial wedges. (b) Sea-level versus time (schematic): during lowstands, there is no net deposition at the landward end of a depositional transect.

ing mangrove pollen) in the sample at 3195 m. This implies a period of drainage incision (a consequence of eustatic fall) followed by estuarine deposition during the subsequent transgression. There are no shoreface facies preserved, but that is not uncommon for a transgressive shoreline. Some of the wireline logs show several carbonate rich bands which may either be thin transgressive lags, or related to periodic exposure. Samples from 3165 m upward all contain neritic palynofacies, and foraminiferal assemblages (Hayward, 1985).

SUMMARY

The organic composition of sedimentary rocks is an important means by which the depositional history of the enclosing sediments can be understood. Palynofacies analysis permits us to interpret environments of deposition in fluvial, paralic, and neritic sediments, particularly in the subsurface where traditional means of investigation may not provide the resolution required. This level of environmental interpretation has previously only been made for marine sediments, using foraminifera (see Hayward, 1986).

In this study we have described several palynofacies that represent specific depositional environments in the Te Kuiti and Kapuni groups in the Waikato and Taranaki basins, respectively. A comparison of palynofacies and lithofacies in the Kapuni Group in Kiwa-1 in the Taranaki Basin has enabled us to document the facies sequence. Even though there are no marine facies throughout much of the Kapuni section in Kiwa-1 the influence of eustatic sea level fluctuations on deposition can still be identified. The results indicate that there is scope for further work on other wells in the Taranaki Basin which should enable us to reconstruct the movements of the shoreline during Kapuni time and to predict the location and geometry of high porosity shoreline reservoir sands.

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