MIOCENE PALYNOFLORAS FROM SUBSURFACE SEDIMENTS IN THE BUNDABERG DISTRICT

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Well-preserved palynofloras extracted from fluvial sediments of the Cainozoic Elliott Formation in the Bundaberg Trough, central-eastern Queensland enable dating the formation, the age of which hitherto has been poorly constrained. Representation of the pollen taxon, *Canthiumidites bellus* (Stover & Partridge) Mildenhall & Pocknall, in association with spores referable to *Polypodiidites usmensis* (van der Hammen) Khan & Martin, both of which are restricted to Early Miocene and younger sediments in the Capricorn Basin, confirm an age no older than the Early Miocene, and enable correlation of the Bundaberg sequence with Early Miocene fluvio-deltaic sediments penetrated by GSQ Sandy Cape 1-3R on Fraser Island. Records of *Polypodiidites usmensis* in the Fairymead beds, which underlie the Elliott Formation, indicate that the Fairymead beds are also no older than Early Miocene. ❒ *Elliott Formation, palynofloras, Miocene, Capricorn Basin.*

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Subsurface sediments in the Bundaberg area, southeastern Queensland (Fig. 1), contain an important aquifer, which is tapped as a source of groundwater, principally for sugar-cane irrigation. Fossil fruit-stones including the recently reported *Spondylostrobus symthii* F.Muell. (Dettmann & Clifford, 2002), having been recovered during the course of water-bore drilling by the Department of Natural Resources and Mines. The fruits came from a sequence of unconsolidated coarse to fine sands, silts, and interbedded clays capped by a thin sequence of Quaternary sands. The sand/silt/clay sequence is lithologically similar to the Elliott Formation, the type section of which occurs in the region (Robertson, 1979). This formation, based on its stratigraphic relationships with weathering and erosional surfaces of underlying and possibly penecontemporanous sediments, has been reported to comprise Eocene and Oligocene to Miocene sediments (Grimes, 1988). With the aim of resolving the subsurface stratigraphy and age of the important aquifer a continuously cored section, DNR 1360 0253 (Fig. 2), was drilled south of Bundaberg. Sediments sampled from this section have been palynologically analysed for age assessment and the results are detailed herein.

GEOLOGICAL SETTING

The Cainozoic history of southeastern Queensland has been one of basic volcanism associated with Paleocene break-up of the Australian plate followed by intermittent sedimentation and periods of deep weathering (Grimes, 1988). In the Bundaberg region subsurface sections penetrated basalts believed to be of Paleocene age and overlying fluvial sediments referred to the Fairymead beds that were tentatively dated as Eocene (Ellis, 1968; Foster, 1978; Robertson, 1979; Grimes, 1988) (Table 1). Outcrops of fluvial sediments believed to be younger and mapped as Elliott Formation occur in an area between the Kolan and Elliott Rivers within the Bundaberg Trough (Robertson, 1979; Day et al.,1983); the type area on the banks of the Elliott River southeast of Bundaberg has a flat to gently

TABLE 1. Stratigraphy of Upper Mesozoic and Cainozoic sediments in the Bundaberg Trough as currently recognised (Robertson, 1979; Grimes, 1988).

Age	Formation	Lithology
Pleistocene and Holocene		Estuarine, lagoonal, and fluvial sands
Early Pleistocene	Hummock Basalt	Olivine basalts
?Oligocene-Miocene	'Elliott Formation' (younger)	Sandstone, claystone
?Eocene	Elliott Formation (older)	Sandstone, claystone
?Eocene	Fairymead beds	Sandstone, claystone
?Paleocene	Pemberton Grange Basalt	Olivine basalts
Albian	Burrum Coal Measures	Coals, shales and silts

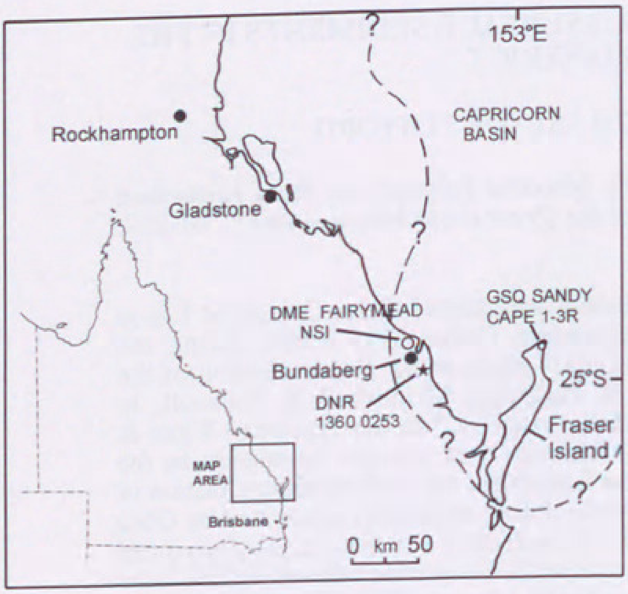

FIG. 1. Map showing location of DNR 1360 0253, 20km south of Bundaberg, Queensland.

sloping surface. To the west of the type area, the surface buries deeply weathered Mesozoic and older rocks, but it is uncertain whether or not the surfaces are contemporaneous. In places a younger, lithologically similar unit is thought to be represented (Grimes, 1988) and this 'later Elliott Formation' may be of Oligocene to Miocene age (Grimes, 1988, p.69). Overlying Pleistocene and Holocene sands are restricted to alluvial terraces and coastal plains (Grimes, 1988).

MATERIAL AND METHODS

The sequence encountered in DNR 1360 0253, situated adjacent to Foleys Road, 20km south of Bundaberg, comprises coarse to fine sands, silts, and clays beneath Quaternary sands (Fig. 2). Several horizons were sampled and prepared for palynological analysis using standard procedures (Phipps & Playford, 1984). All samples yielded abundant fungal remains and small-to-medium-sized wood fragments were recovered from the coarse sands. Two samples (24.6 m and 56.8 m) provided well preserved assemblages of palynomorphs including diverse spores and pollen grains (Table 2). Strew slides were examined in transmitted light and photographed at magnifications up to ×1250.

Illustrated specimens are housed in the palaeontological collection of the Queensland Museum. Registered numbers (QMF) refer to the catalogue of that repository and are listed in Table 3 together with slide numbers and co-ordinates derived from a standard 'England Finder' slide.

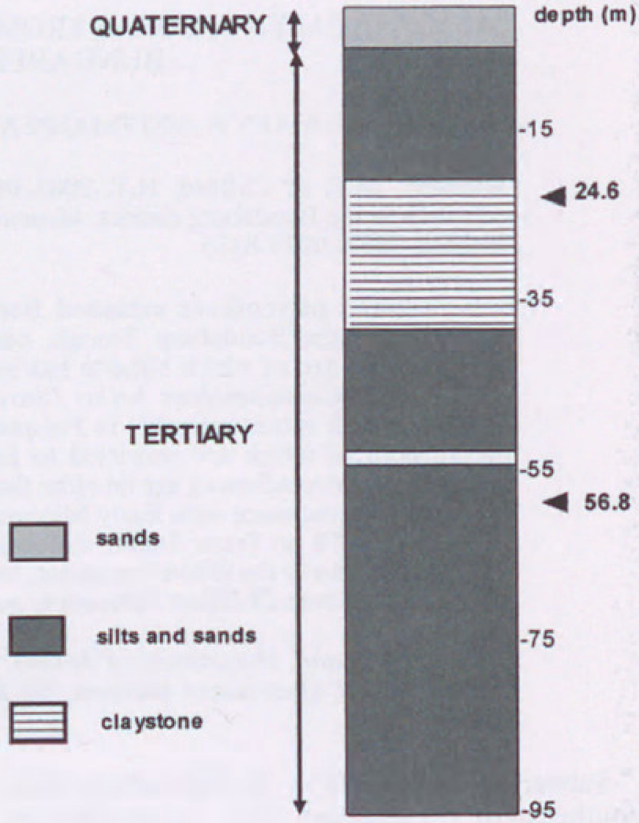

FIG. 2. Lithologic log of section cored by DNR 1360 0253 showing sampling horizons.

BIOSTRATIGRAPHY AND AGE

The diverse, well-preserved palynomorph assemblages recovered from DNR 1360 0253 are dominated by angiosperm pollen with significant contributions from ferns and lesser frequencies of gymnosperm pollen (Table 2). A Tertiary age is clearly indicated by the association of *Haloragicidites harrisii*, *Nothofagidites emarcidus*, *N. asperus*, *Malvacipollis* spp., and *Myrtaceidites* spp. Qualitative/quantitative attributes of the assemblages are in accord with those reported (Wood, 1986) from an Early Miocene section penetrated by GSQ Sandy Cape 1-3R located on Fraser Island and some 100km E of Bundaberg (Fig. 1). Specifically, the Bundaberg palynofloras and those from between 421.65-433.5m in Sandy Cape 1-3R share high frequencies of fern spores, including significant representation (>10%) of *Cyathidites paleospora*, together with *Polypodiidites* spp. and *Crassoretitriletes vanraadshooveni*. The associated angiosperm pollen florules include common *Haloragicidites harrisii*, *Rhoipites*, and *Nothofagidites* coupled with infrequent *Clavastephanocolporites meleosus* and *Canthiumidites bellus* (Wood,

1986) (Table 2). This Sandy Cape 1-3R section includes fluvio-deltaic sediments containing rotaliid and miliolid foraminifers at 425m; overlying calcareous sandstones and calcarinites contain foraminiferal associations of Early Miocene age (Palmieri, 1984). The fluvio-deltaic beds are believed to express deposition early in a transgressive episode initiated during the Early Miocene; correlative sediments occur in several sections to the north in the Capricorn Basin, offshore from Rockhampton (Palmieri, 1984). Two of the Capricorn Basin sections, AGO Aquarius 1 and AGO Capricorn 1, yielded diverse palynofloras (Hekel, 1972) that share many of the features of those from the Sandy Cape and Bundaberg sections. They contain moderate frequencies of *Haloragicidites harrisii*, *Nothofagidites*, *Rhoipites*, and fern spores. Amongst the fern taxa are rare *Crassoretitriletes vanraadshooveni* and common *Polypodiidites*, including *P. usmensis*, which has first appearances in Miocene sediments (Hekel, 1972).

The Sandy Cape 1-3R fluvio-deltaic sediments overly two basalt flows, the lower of which is underlain by marine sediments containing foraminiferids of late Oligocene age (Grimes, 1982; Palmieri, 1984). Between the two basalt flows are deltaic sediments; palynofloras from these sediments (537-539.4 m) differ from those at 421.65-433.5 m above the basalts in containing high frequencies of *Haloragicidites harrisii*, low frequencies of fern spores, and *Malvacearumpollis mannanensis* (Wood, 1986).

In summation, evidence from marine sections in the Capricorn Basin reveals that *Polypodiidites usmensis* and *Canthiumidites bellus* are restricted to Early Miocene and younger sediments. The association of these two taxa in terrestrial sediments between 24.67 and 56.83 m in DNR 1360 0253 near Bundaberg argues for an age no older than Early Miocene.

The only other Cainozoic sediments in the region from which palynological data have been published are from the Fairymead beds in DME Fairymead NS 1 (Robertson, 1979) (Fig. 1, Table 1). A sample from 61.7m in this well provided common *Haloragicidites harrisii*, infrequent *Nothofagidites* and proteaceous grains in association with *Polypodiidites usmensis* (Foster, 1979). Occurrence of the last mentioned taxon implies an age no older than Early Miocene. Such a dating raises the question of whether or not the Elliott Formation and Fairymead beds were deposited contemporaneously. Foster (1979) had argued for a late Early Eocene age of the Fairymead palynoflora based on its broad similarity to palynofloras of the *Proteacidites asperopolus* Zone of southeastern Australia as defined by Stover & Partridge (1973). He also considered that palynofloras from the upper fluvio-deltaic sediments in GSQ Sandy Cape 1-3R were dominated by taxa restricted to Eocene sediments in southeastern Australia, but suggested these may have been reworked (Foster, 1978).

From present evidence, first appearances of *P. usmensis* and *C. bellus* in the Capricorn Basin may be earlier than in the more southerly basins of Australia. *C. bellus*, the nominate species for the *C. bellus* Zone of the Gippsland Basin and the *C. bellus* equivalent Zone in the Murray Basin has documented first appearances in those regions as late Early Miocene and last appearances in the *M. galeatus* Zone of Pliocene age (Stover & Partridge, 1973; Macphail, 1996). This contrasts to the appearances of the pollen taxon in foraminiferal Zone N4 (of Palmeiri, 1986) of earliest Miocene age in the Sandy Cape section. *P. usmensis*, a spore taxon with affinities with the fern *Stenochlaena* is known from the Murray Basin where it is restricted to sediments of the *C. bellus* Zone equivalent dated as late Early – Middle Miocene age (Macphail, 1996); in the Capricorn Basin the species ranges from earliest Miocene (foraminiferal Zone N4) to Pliocene age (Hekel, 1972). Wood (1986) advanced evidence for the disparate stratigraphic ranges of several palynomorph taxa in Tertiary sediments of Queensland and those of more southerly regions of Australia; further evidence has been subsequently detailed by Beeston (1994) and Dettmann & Clifford (2000).

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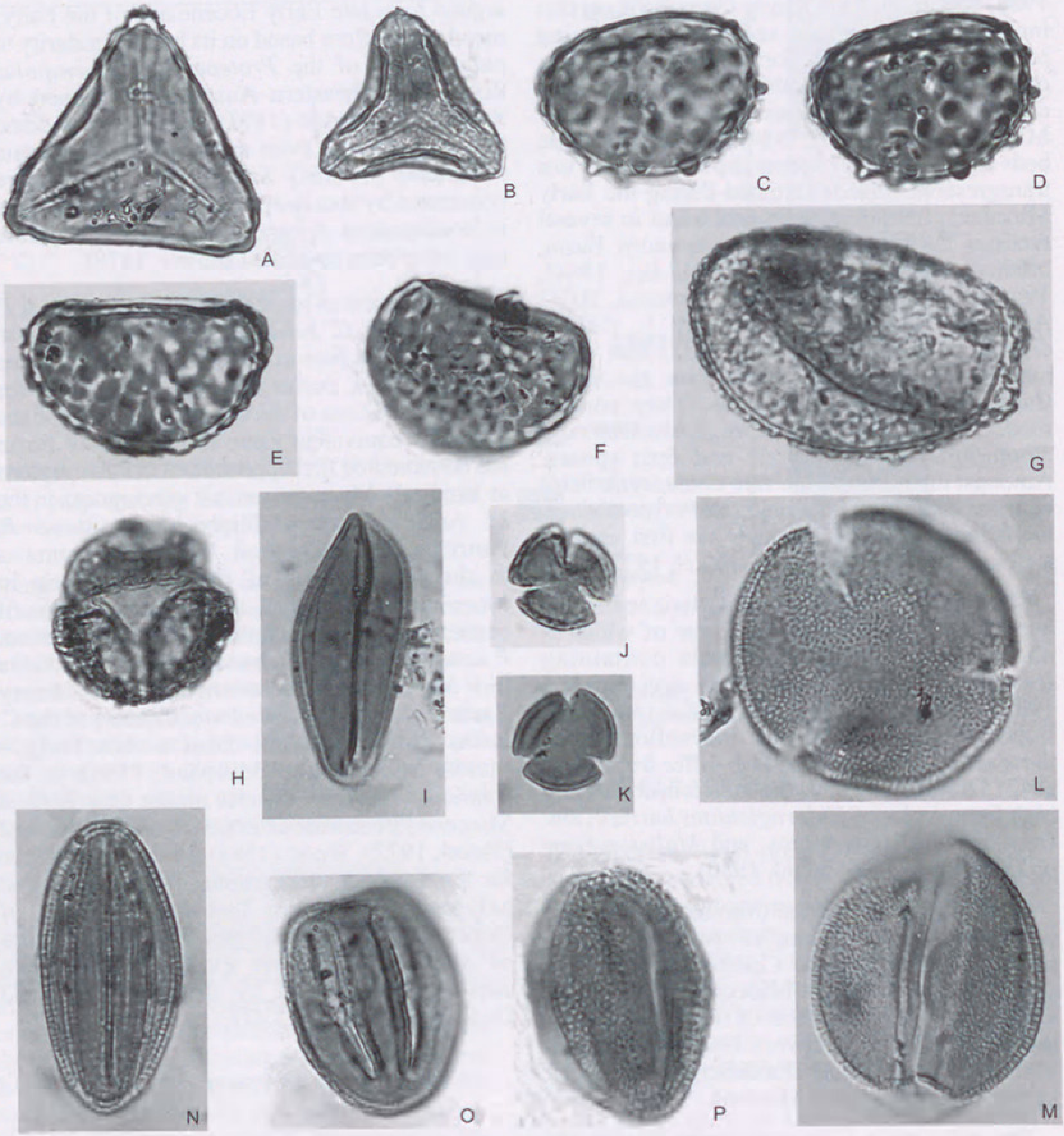

FIG. 3. A-G, spores, ×750 and H-P, pollen, ×1000 from DNR 1360 0253 borehole. A, *Gleicheniidites* sp.; B, *Dictyophyllidites arcuatus* Pocknall & Mildenhall; C, D, *Polypodiidites usmensis* (van der Hammen) Khan & Martin, optical section and high focus respectively; E, *Polypodiidites speciosus* (Harris) Khan & Martin; F, *Microfoveolatosporites* sp.; G, *Peromonolites* sp.; H, *Dacrycarpites australiensis* Cookson & Pike; I, *Arecipites* sp.; J, K, *Tricolpites* sp. 1 polar views of two specimes; L, M, *Tricolpites* sp. 2, specimens in polar and lateral aspect respectively; N, *Tricolpites* sp. 3; O,P, *Rhoipites sphaerica* (Cookson) Pocknall & Crosbie, lateral aspect, optical section and high focus respectively.

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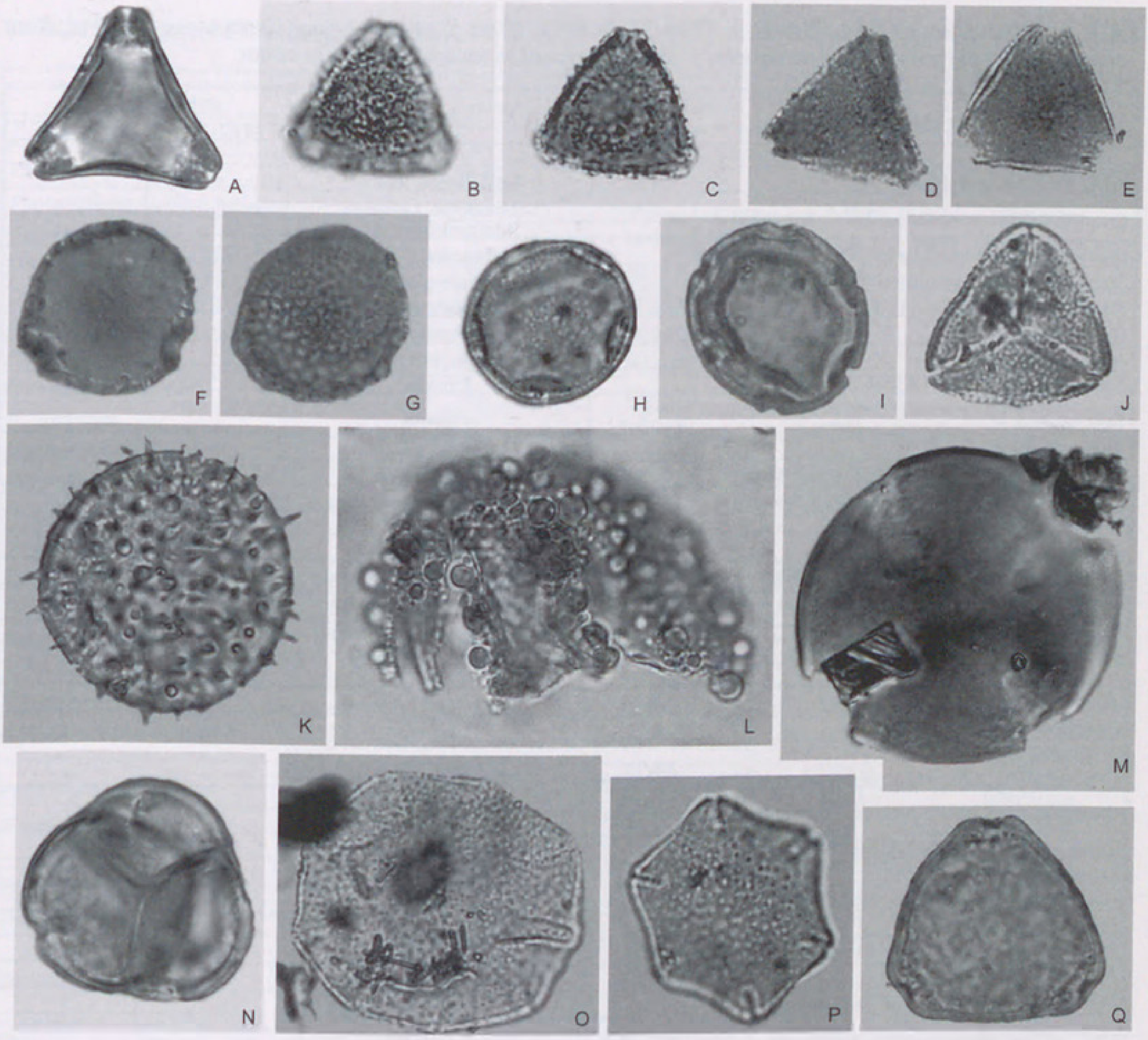

FIG. 4. Pollen, ×1000. A, *Proteacidites ivanhoensis* Martin; B, C, *Propylipollis pseudomoides* (Stover) Dettmann & Jarzen, high focus and optical section respectively; D, *Propylipollis pseudomoides* (Stover) Dettmann & Jarzen; E, *Lewalanipollis* sp.; F, G, *Canthiumidites bellus* (Stover & Partridge) Mildenhall & Pocknall, optical section and high focus respectively; H, *Polyorificites oblatus* Martin; I, *Haloragacidites suttorensis* Beeston; J, *Cupanieidites reticularis* Cookson & Pike; K, *Malvacipollis* sp.; L, *Clavastephanocolporites meleosus* Martin, Macphail & Partridge; M, *Tetracolporites* sp.; N, *Ericipites* sp.; O, *Nothofagidites asperus* (Cookson) Stover & Evans; P, *Nothofagidites emarcidus* (Cookson) Stover & Evans; Q, *Haloragacidites harrisii* (Couper) Harris.

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TABLE 2. Palynomorph distribution in DNR 1630-0253, 20km S of Bundaberg. Percentages derived from counts of 200 palynomorphs per sample; + denotes present in sample, but not in count.

Palynomorph Taxa	Affinity	Depth	
		24.67-.75m	56.8-.83m
Ferns:			
Azolla Lam., microsporangia	Salviniaceae, *Azolla*	+	
Crassiretitriletes vanraadshoovenii Germeraad et al.	Schizaeaceae, *Lygodium microphyllum*-type	+	
Cyathidites paleospora (Martin) Alley & Broadbridge	Cyatheaceae, *Cyathea*	12.5	16.5
Dictyophyllidites arcuatus Pocknall & Mildenhall	?Gleicheniaceae	3.5	2
Foveosporites sp. of Wood (1986)	?Ophioglossaceae		+
Gleicheniidites sp.	Gleichenianceae	+	
Ischyosporites sp.	Dicksoniaceae		+
Laevigatosporites ovatus Wilson & Webster	Filicales		10.5
Microfoveolatosporites sp. (=*Polypodiisporites* sp. of Wood, 1986, fig. 3.6)	Filicales		+
Peromonolites spp.	Filicales		+
Polypodiidites speciosus (Harris) Khan & Martin	Polypodiaceae	+	4
P. usmensis (van der Hammen) Khan & Martin	Blechnaceae, *Stenochlaena*	1	
Gymnosperms:			
Araucariacites australis Cookson	Araucariaceae		1
Dacrycarpites australiensis Cookson & Pike	Podocarpaceae, *Dacrycarpus*	2	2
Lygistepollenites florinii (Cookson & Pike) Stover & Evans	Podocarpaceae, *Dacrydium*	1	1
Podocarpidites ellipticus Cookson	Podocarpaceae, *Podocarpus*		3
Trichotomosulcites subgranulatus Couper	Podocarpaceae	1.5	
Monocotyledons:			
Arecipites sp.	?Arecaceae? Liliaceae	4.5	1
Cyperacaepollis sp.	Cyperaceae	+	
Dicotyledons:			
Canthiumidites bellus (Stover & Partridge) Mildenhall & Pocknall	Rubiaceae, *Randia*	+	+
Clavastephanocolporites meleosus Martin, Macphail & Partridge	Alangiaceae, *Alangium villosum*-type		+
Cupanieidites reticularis Cookson & Pike	Sapindaceae, Cupanieae	+	+
Ericipites sp.	?Epacridaceae		+
Haloragacidites cainozoicus Cookson & Pike	Casuarinaceae		+
H. harrisii (Couper) Harris	Casuarinaceae	36.5	12.5
H. suttorensis Beeston	Unidentified angiosperm	15.5	2.5
Polyorificites oblatus Martin	Unidentified angiosperm	+	
Ilexipollenites anguloclavatus McIntyre	Aquifoliaceae, *Ilex*		2
Lewalanipollis sp.	Proteaceae	+	+
Malvacipollis subtilis Stover & Partridge	Euphorbiaceae, *Austrobuxus*	5	3
Malvacipollis spp.	Euphorbiaceae	2	+
Myrtaceidites parvus-mesonesus (Cookson & Pike) Stover & Evans	Myrtaceae	1	1
Nothofagidites asperus (Cookson) Stover & Evans	Nothofagaceae, *Nothofagus Lophozonia*		5.5
N. emarcidus (Cookson) Stover & Evans	Nothofagaceae, *Nothofagus Brassospora*	2	17.5
Periporopollenites sp.	Unidentified angiosperm		+
Propylipollis pseudomoides (Stover) Dettmann & Jarzen	Proteaceae	6	3
Proteacidites ivanhoensis Martin	Proteaceae, *Helicia/Macadamia*		+
Proteacidites spp.	Proteaceae	2	2
Rhoipites sphaerica (Cookson) Pocknall & Crosbie	Unidentified angiosperm	2	5
Rhoipites microreticulatus (Harris) Macphail et al.	Unidentified angiosperm	2	5
Rhoipites spp.	Unidentified angiosperm	+	+
Tetracolporites sp.	Unidentified angiosperm		+
Tricolpites sp. 1	Unidentified angiosperm	+	+
Tricolpites sp. 2	Unidentified angiosperm	+	+
Tricolpites sp. 3	Unidentified angiosperm	+	