

Aspects of the Cenozoic stratigraphy of the Northern Sulaiman Ranges, Pakistan

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ABSTRACT – The results of micropalaeontological, nannopalaeontological and palynological analyses of Cenozoic sections from the Northern Sulaiman Ranges in Pakistan are discussed. They are in keeping with previously published results (though in some cases significantly more refined). They enable placement of most of the sampled lithostratigraphic units in a global bio- and sequence-stratigraphic framework. Limestones appear to be associated with essentially transgressive global sequences, shales with essentially regressive sequences. Palaeoenvironmental interpretations indicate a range of depositional settings from continental through shallow marine to basinal. A number of shallow marine carbonate platform sub-environments are recognized over the Palaeocene–Eocene section *J. Micropalaeontol.* 16(1): 51–58, May 1997.

INTRODUCTION

BP has recently undertaken a field survey of part of the Northern Sulaiman Ranges in Pakistan (Fig. 1). The primary objective of the survey was to log selected sections and to collect samples for geochemical, sedimentological and palaeontological analysis in order to identify any resource (source, reservoir and seal) potential. The secondary objective was to obtain enough structural geological information to construct a cross-section through the mountain-front to constrain appropriate source maturation and migration models. Structural aspects are discussed by Banks & Warburton (1986) and Jadoon *et al.* (1994)

Samples were made available for palaeontological analysis from the Dunghan, Ghazij, Baska, Kirthar and Chitarwata Formations and the Siwalik Group of the Zam Tower, Zor Shahr, Domanda, Toi River and Baska sections (Fig. 1). Particular emphasis was placed on the Eocene Baska and

Kirthar Formations (Fig. 2), which, by analogy with the Potwar Basin to the northeast (Brown & Dey, 1975; Khan *et al.*, 1986) were perceived to have the most resource potential.

Micropalaeontological analyses were undertaken by the author (calcareous algae and foraminifera) and John Athersuch (ostracods), nannopalaeontological analyses by Ted Finch and Julie Pearce, and palynological analyses by Bob Ravn, Paul Ventris and John Williams.

RESULTS AND DISCUSSION

Results are summarized on Fig. 3, and discussed in more detail (in ascending stratigraphic order) below.

Dunghan Formation

The dominant lithology was bioclastic limestone. Micropalaeontological analyses were undertaken on three samples (18, 44 and 45).

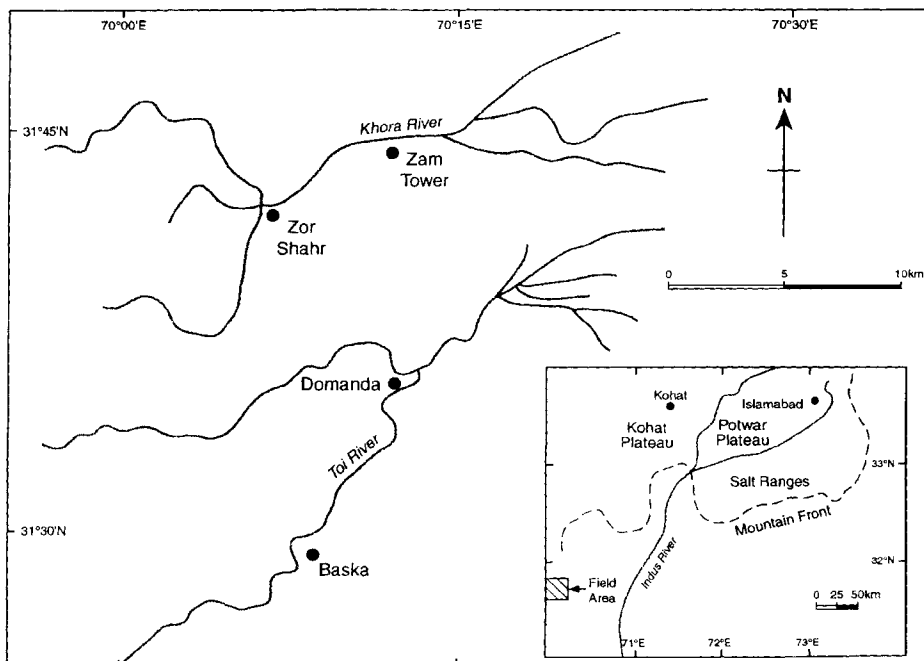


Fig. 1. Location map (1: 250 000 (inset 1: 2 000 000)).

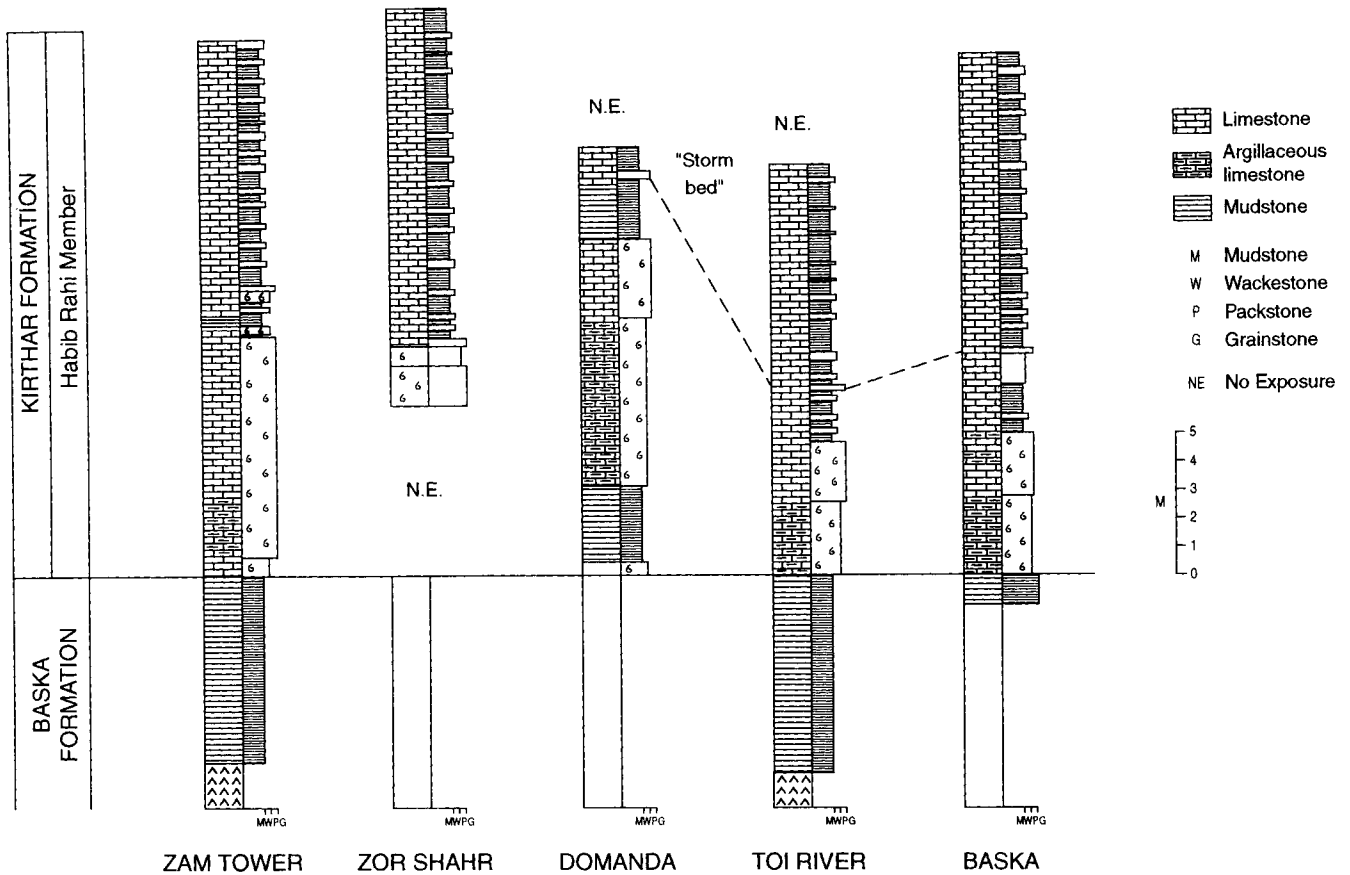


Fig. 2. Measured Baska and Lower Kirthar Formation sections. Samples 47–122 were collected from Zam Tower section, 131–143 from Zor Shahr, 150–158 from Domanda, 174–180 from Toi River and 181–195 from Baska (see Fig. 1). Samples were collected on average every 1 m.

Results. The microfauna is moderately rich and diverse, and included benthonic and planktonic foraminifera, calcareous algae, and bryozoan and miscellaneous macrofossil debris. The benthonic foraminifera include *?Dictyoconus* sp. and indeterminate miliolids and rotaliids. The planktonic foraminifera include *Globorotalia (Morozovella) ex gr. angulata/conicotruncata*, *G. (M.) ex gr. subbotinae* and *G. (M.) sp.* The calcareous algae include *Amphiroa*, sp., *Archaeolithothamnium*, sp., indeterminate codiaceans and dasycladaceans, *Distichoplax biserialis*, *Lithothamnium* sp., *Mesophyllum* and rhodoliths.

Discussion. Stratigraphy – A Late Palaeocene to Early Eocene age is indicated by the occurrences of the planktonic foraminifera *Globorotalia (Morozovella) ex gr. angulata/conicotruncata* (Zones P3–P5 of Blow, 1979) and *G. (M.) ex gr. subbotinae*

(P6–P8). Published information supports this interpretation (see, for instance, Samanta, 1972, 1973; Kureshy, 1978a, 1984).

Palaeoenvironmental interpretation – Micropalaeontological evidence points to a warm, shallow carbonate platform. The presence of codiacean, dasycladacean and rhodophytic algae indicates a setting within the euphotic zone (no deeper than 5–15 m).

Ghazij Formation

The dominant lithology was mudstone. Palynological analyses were undertaken on four samples (46, 120, 124 and 130).

Results. The *in situ* palynoflora is impoverished, and includes only rare pollen (flowering-plant (angiosperm) and grass (Gramineae) pollen) and spores (*Callialasporites*). Reworked

Fig. 3. Stratigraphic summary. Bio-, chrono- and sequence stratigraphy from Haq *et al.* (1987). Lithostratigraphy modified after Hemphill & Kidwai (1973). Dughan equivalent to Ranikot and Lower Laki of Eames (1952), Ghazij to Middle Laki, Baska to Upper Laki ('shales with alabaster'), Habib Rahi to 'platy limestone', Domanda to 'lower chocolate clays', Pir Koh to 'white marl band', Drazinda to 'upper chocolate clays', Chitarwata to Murree and Nari. Calibrated global (narrow band) and observed local (broad band) stratigraphic ranges of selected larger benthonic and planktonic foraminifera and calcareous nannoplankton are shown.

Early Cretaceous dinoflagellate cysts are also present.

Discussion. Stratigraphy – No conclusions can be drawn with regard to age. Published information indicates Early Eocene (see, for instance, Gill, 1953; Haque, 1956; Nagappa, 1959; Latif, 1961; Siddiqui, 1971; Samanta, 1972, 1973; Dorreen, 1974; Kureshy, 1978a,b, 1985a).

Palaeoenvironmental interpretation – The absence of marine palynomorphs provides negative evidence of a non-marine palaeoenvironment.

Baska Formation

The dominant lithology is mudstone. Micropalaeontological and palynological analyses were undertaken on eight samples (95, 106, 108, 113, 115–116, 119 and 181).

Results. The microfauna is moderately rich and diverse, and includes benthonic and planktonic foraminifera, ostracods, gastropods, and bryozoan, echinoderm and miscellaneous macrofossil debris. The benthonic foraminifera include Miliolida (?*Archaias* sp., ?*Peneroplis* sp., *Quinqueloculina* spp.), Buliminida (*Brizalina* spp.), smaller Rotaliida (anomalinids, discorbids, *Nonion* spp.) and larger Rotaliida (*Assilina maior punctulata*, *Dictyoconoides cooki*, *Nummulites* spp.). The planktonic foraminifera (Globigerinida) include '*Globigerina*' *lozanoi* and *Globorotalia* (*Acarinina*) ex gr. *pentacamerata*. The ostracods include *Alocopocythere* sp., bairdiids, cyprids, *Gyrocythere exaggerata*, *Krithe* sp., ?*Occulticythereis* sp., *Pontocythere* sp., trachyleberidids and *Xestoleberis* cf. *globosa*.

The palynoflora is also moderately rich and diverse, and includes marine dinoflagellate cysts and terrestrially derived pollen and spores. The dinocysts include *Achomosphaera* sp., *Areoligera* sp., *Cordosphaeridium* sp., *Diphyes* cf. *colligerum* (?*D. ficusoides*), ?*Impletosphaeridium* sp., *Phthanoperidinium* sp., *Systematophora placacantha* and *Thalassiphora* sp.

Discussion. Stratigraphy – An age in the range latest Early-earliest Middle Eocene is indicated by the occurrences of the larger benthonic nummulitid foraminifer *Assilina maior punctulata* (Cuisien Supérieur – Lutetien Basal of Schaub, 1981; calcareous nannoplankton Zones NP14–NP15 of Martini, 1971) and the planktonic foraminifera '*Globigerina*' *lozanoi* (Zones P8–P10 of Blow, 1979) and *Globorotalia* (*Acarinina*) ex gr. *pentacamerata* (P8–?P9). Published information supports this interpretation (see, for instance, Siddiqui, 1971).

The Baska Formation appears to be associated with the essentially regressive global third-order (?eustatically mediated) sequence TA3.1 of Haq *et al.* (1987).

Palaeoenvironmental interpretation – Microfaunal evidence points to a low-energy back-bank lagoon characterized by Miliolida. The presence of sea-grasses is indicated by the presence of epiphytic discorbids, the influence of the open ocean by rare globigerinids.

The depth of depositional environment is difficult to determine, because it would have been determined not by the foraminifera themselves but by the photosynthetic algal symbionts to which they acted as host. Modern *Archaias aduncus*, *Cyclorbiculina compressa* and *Peneroplis proteus* contain photosynthetic green algae which restrict them to between 0–15 m (e.g. Murray, 1973; Reiss & Hottinger, 1984; Hallock, 1988).

Habib Rahi Limestone Member (Kirthar Formation)

Lithology ranged from nummulitic and nummulithoclastic grainstone carbonate to laminated shale. Micropalaeontological, nannopalaeontological and palynological analyses were undertaken on 38 samples (58, 59, 68, 69, 80, 82, 83, 85–87, 91–94, 131, 132, 136, 141–143, 150, 152, 155–157, 174–177, 179, 180, 182–185, 188, 194 and 195). The majority of the micropalaeontological analyses were undertaken on random thin-section samples.

Results. The microfauna is moderately rich and diverse, and included benthonic and planktonic foraminifera, and bivalve, bryozoan and miscellaneous macrofossil debris. The benthonic foraminifera include Buliminida (*Brizalina* sp., *Loxostomum* sp., *Stainforthia* sp., *Uvigerinella* sp.), smaller Rotaliida (*Cibicoides* sp.) and larger Rotaliida (*Assilina maior punctulata*, *Dictyoconoides* sp., *Discocyclina* sp., *Lockhartia* sp., *Nummulites*). The planktonic foraminifera (Globigerinida) include indeterminate globigerinids.

The nanoflora is also moderately rich and diverse, and included *Braarudosphaera bigelowi*, *Chiasmolithus grandis*, *C. formosus*, *Coccolithus eopelagicus*, *C. pelagicus*, *Discoaster barbadiensis*, *D. binodosus*, *D. deflandrei*, *D. saipanensis*, *Helicosphaera lophota*, *H. seminulum*, *Lanternithus minutus*, *Markalius inversus*, *Micranolithus* spp., *Nannotetrina* spp., *Pemma angulatum*, *P.* spp., *Reticulofenestra dictyoda*, *Rhabdolithus tenuis*, *Sphenolithus moriformis*, *S. pseudoradians*, *S. radians*, *S. spiniger/orphanknollensis*, *S.* spp. and *Zygrabdlithus bijugatus*.

The palynoflora is also moderately rich and diverse, and includes marine dinoflagellate cysts and terrestrially derived pollen and spores. The dinocysts include *Achomosphaera* sp., ?*Cordosphaeridium* sp., *Diphyes colligerum* (?*D. ficusoides*), ?*Impletosphaeridium* sp., ?*Systematophora* sp. and *Thalassiphora* sp.

Discussion. Stratigraphy – An early Middle Eocene is indicated by the occurrences of the larger benthonic nummulitid foraminifer *Assilina maior punctulata* (Cuisien Supérieur – Lutetien Basal of Schaub, 1981; calcareous nannoplankton Zones NP14–NP15 of Martini, 1971) and the calcareous nanofossils *Discoaster saipanensis* (calcareous nannoplankton Zones NP15–NP20 of Martini, 1971), *Nannotetrina* spp. (NP14–NP15), *Sphenolithus pseudoradians* (NP15–NP23), and *S. spiniger/orphanknollensis* (Zones NP13–NP15). Published information suggests an essentially Middle–?Late Eocene age for the Kirthar Formation (see, for instance, Gill, 1953; Nagappa, 1959; Latif, 1961; Khan, 1967; Siddiqui, 1971; Samanta, 1972, 1973; Dorreen, 1974; Kureshy, 1978a,b, 1985b).

The Habib Rahi Member appears to be associated with the essentially transgressive global third-order (?eustatically mediated) sequences TA3.2–TA3.3 of Haq *et al.* (1987).

Palaeoenvironmental interpretation – Microfaunal evidence points to a range of carbonate platform and associated basinal sub-environments. Proximal high-energy bank and fore-bank (nummulitic and nummulithoclastic grainstone) sub-environments are characterized by Rotaliida (nummulitids and discocyclinids, respectively) (cf. Henson, 1950; Das Gupta, 1975; Ghose, 1977; Decrouez & Lanterno, 1979; Philobbos & Keheila, 1979; Benjamini, 1981; Luterbacher, 1984; Reiss & Hottinger, 1984; Serra Kiel & Regaunt, 1984; Singh, 1984; Moody, 1987; Pautal, 1987; Hallock, 1988; Buxton & Pedley, 1989). Distal

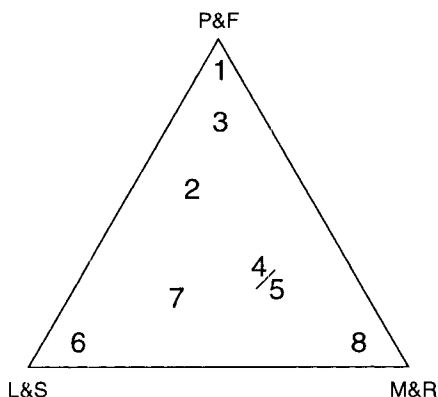


Fig. 4. Ternary plot of foraminiferal 'morphogroups' illustrating discrimination of standard facies (after Hallock & Glenn, 1986). M & R = Miliolida and smaller Rotaliida; L & S = lenticular and subspheroidal larger Rotaliida; P & F = planktonic foraminifera (Globigerinida) and flattened larger Rotaliida. 1-8 = standard facies of Wilson (1975) (1 = basin; 2 = open shelf; 3 = toe of slope; 4 = foreslope; 5 = ecologic reef; 6 = shelf sand; 7 = open platform; 8 = restricted platform). A-form dominated nummulitid populations from the Habib Rahi Member of the Kirthar Formation fall in the 'toe of slope' field.

basinal (laminated shale) sub-environments are characterized by stress-tolerant Buliminida (as in the Palaeogene of Tunisia (Bou Dagher, 1987), large-pored Rotaliida (again as in the Palaeogene of Tunisia (Keller, 1988) and Globigerinida.

The depth of depositional environment is again difficult to determine, because it would have been determined not by the foraminifera themselves but by the photosynthetic algal symbionts to which they acted as host. Modern nummulitids (e.g. *Amphistegina*, *Operculina*, *Operculinella*) contain photosynthetic B-2 and B-3 diatoms whose light requirements are non-specific and which therefore enable them to range down to the light floor (usually ± 130 m) (e.g. Murray, 1973; Reiss & Hottinger, 1984; Hallock, 1988). The optimum development of the modern nummulitids is between 50 and 70 m (Murray, 1973; Reiss & Hottinger, 1984; Hallock, 1988), whereas the optimum development of Eocene pustulose nummulitids in the Jaisalmer Basin in India has been estimated at around 20 m (Singh, 1984).

The nummulitid populations in the studied samples are characteristically dominated either by large B-forms or by small A-forms. Aigner (1982, 1983, 1985) has argued that this is a function of hydrodynamic sorting, and that B-form dominated populations are characteristic of autochthonous and A-form dominated populations of allochthonous accumulations. This has been disputed by various other authors (e.g. Wells, 1986). However, it seems reasonable to interpret A-form dominated assemblages associated with planktonic foraminifera as allochthonous. The latter fall in the 'toe-of-slope' field of a ternary plot of foraminiferal 'morphogroups' (Fig. 4). These assemblages are believed to have been transported along with fine clastic material on account of their high internal porosity and low threshold. Present-day populations of the nummulitid *Operculina bartschi* have been reported similarly transported into deep water off New Caledonia (Debenay, 1988).

Domanda Shale Member (Kirthar Formation)

Lithology ranged from mudstone to bioclastic limestone.

Micropalaeontological and palynological analyses were undertaken on two samples (56 and 57).

Results. The microfauna is impoverished, and includes only rare benthonic and planktonic foraminifera, ostracods, gastropods, and bivalve, echinoid and miscellaneous macrofossil debris. The benthonic foraminifera include Lituolida (lituolids), Miliolida (*Alveolina elliptica*, alveolinids, miliolids, soritids) and Rotaliida (anomalinids). The ostracods include *Cyprideis* sp.

The palynoflora is also impoverished, and includes only rare marine dinoflagellate cysts and terrestrially derived pollen and spores. The dinocysts include ?*Achomosphaera* sp., ?*Areoligera*, *Diphyes colligerum* (?*D. ficusoides*), *Glaphyrocysta* sp.

Discussion. *Stratigraphy* – A 'mid' Middle Eocene age was indicated by the occurrence of the larger benthonic alveolinid foraminifer *Alveolina elliptica* (Lutetian Basal – Moyen (2) of Schaub, 1981; calcareous nannoplankton Zones NP15–NP16/17 of Martini, 1971). Published information suggests an essentially Middle–Late Eocene age for the Kirthar Formation (see, for instance, Gill, 1953; Nagappa, 1959; Latif, 1961; Khan, 1967; Siddiqui, 1971; Samanta, 1972, 1973; Dorreen, 1974; Kureshy, 1978a,b, 1985b).

The Domanda member appears to be associated with the essentially regressive global third-order (?eustatically mediated) sequence TA3.4 of Haw *et al.* (1987).

Palaeoenvironmental interpretation – Microfaunal evidence points to a low-energy back-bank lagoon characterized by Miliolida. The depth of depositional environment is difficult to determine, because it would have been determined not by the foraminifera themselves but by the photosynthetic algal symbionts to which they acted as host. Modern *Alveolinella quoyi* contains photosynthetic B-3 diatoms which restrict it to between 15 and 75 m, with optimum development between 30 and 50 m (e.g. Reiss & Hottinger, 1984; Murray, 1973; Hallock, 1988).

Pir Koh Limestone Member (Kirthar Formation)

Lithologies ranged from laminated shale through mudstone to limestone. Micropalaeontological, nannopalaeontological and palynological analyses were undertaken on five samples (54, 55, 144, 147 and 149).

Results. The microfauna is moderately rich and diverse, and includes benthonic and planktonic foraminifera, calcareous algae, ostracods, radiolarians, and miscellaneous macrofossil debris. The benthonic foraminifera include Lituolida (*Clavulinoides* sp.), Miliolida (miliolids, soritids), Nodosariida (*Lenticulina* sp.), Buliminda (*Brizalina* sp., eouvigerinids), smaller Rotaliida (*Cibicidoides* sp., discorbids, *Gyroidina* sp., *Nonion* sp.) and larger Rotaliida (*Assilina exponens*, *A.* sp., *Asterocyclina* spp., *Dictyoconoides cooki*, *D.* sp., *Discocyclina* spp., *Linderina* spp., *Nummulites beaumonti*, *N. nanngoelani* (*N. mamilla* auctt.), *N. cf. obtusus*, *N.* spp., *Sphaerogypsina* sp.). The planktonic foraminifera (Globigerinida) include *Globigerina* (*Subbotina*) ex gr. *linaperta*, ?*Globigerinatheka* sp., globigerinids/tenuitellids, *Globorotalia* (*Acarinina*) ex gr. *bullbrookii*, *G.* (*A.*) spp., *G.* (*Morozovella*) *spinulosa*, *G.* (*M.*) spp., *G.* (*Turborotalia*) *centralis*, *Hantkenina* spp., *Orbulinoides beckmanni* and *Truncorotaloides topilensis*. The calcareous algae include *Distichoplax biserialis*. The ostracods include *Alocopocythere* sp., bairdiids, cyprids, *Cytherella* sp., *Krithe* sp., *Occulticythereis* sp. and

trachyleberidids.

The nannoflora is also moderately rich and diverse, and includes *Braarudosphaera bigelowi*, *Chiasmolithus grandis*, *Coccolithus pelagicus*, *Discoaster barbadiensis*, *D. saipanensis*, *Helicosphaera* sp., *Sphenolithus moriformis*, *S. predistensus* and *S. spp.*

The palynoflora is also moderately rich and diverse, and includes marine dinoflagellate cysts and terrestrially derived pollen and spores. The dinocysts include *Achomosphaera* sp., *?Areoligera* sp., *Cordosphaeridium* sp., *?Diphyes* sp., *Impleto-sphaeridium* sp., *?Leptodinium* sp., *?Nematosphaeropsis* sp., *Phthanoperidinium* sp., *Spiniferites* sp. and *Wetzeliella* sp.

Discussion. Stratigraphy – A ‘mid’ Middle Eocene age is indicated by the occurrences of the larger benthonic nummulitid foraminifera *Assilina exponens* and *Nummulites beaumonti*, (Lutetien Moyen – Biarriatzen of Schaub, 1981; calcareous nannoplankton Zones NP15–NP18 of Martini, 1971), the planktonic foraminifera *Globorotalia (Acarinina) ex gr. bullbrookii* (Zones P8b–P12 of Blow, 1979) and *Orbulinoides beckmanni* (P13), and the calcareous nannofossils *Chiasmolithus grandis* (calcareous nannoplankton Zones NP11–NP17 of Martini, 1971) and *Sphenolithus predistensus* (NP17–NP24). Published information suggests an essentially Middle–?Late Eocene age for the Kirthar Formation (see, for instance, Gill, 1953; Nagappa, 1959; Latif, 1961; Khan, 1967; Siddiqui, 1971; Samanta, 1972, 1973; Dorreen, 1974; Kureshy, 1978a,b, 1985b).

The Pir Koh Member appears to be associated with the essentially transgressive global third-order (?eustatically mediated) sequence TA3.5 of Haq *et al.* (1987).

Palaeoenvironmental interpretation – Microfaunal evidence points to a range of carbonate platform and associated basinal sub-environments.

Drazinda Shale Member (Kirthar Formation)

The dominant lithology is mudstone. Micropalaeontological and palynological analyses were undertaken on five samples (47, 49, 51, 164 and 165).

Results. The microfauna is moderately rich and diverse, and include benthonic and planktonic foraminifera, ostracods, gastropods, and bryozoan, echinoderm and miscellaneous macrofossil debris. The benthonic foraminifera include Miliolida (*Dentostomina* sp., *Pyrgo* sp., *Quinqueloculina* sp.), Nodosariida (*Fissurina* sp.), Buliminida (*Brizalina* sp., *Stainforthia* sp.), smaller Rotaliida (*Anomalinoides* sp., discorbids, elphidiids/nonionids, *Eponides* sp.) and larger Rotaliida (*Assilina* sp., *Heterostegina* sp., *Nummulites beaumonti*, *N. nanngoelani* (*N. mamilla* auctt.), *Operculina* sp., *Rotalia*). The planktonic foraminifera (Globigerinida) include *Chiloguembelina cubensis*, *Globigerina praebulloides*, *G. (Subbotina) cf. inaequispira*, *Globorotalia (Acarinina) spp.*, *G. (Turborotalia) cf. opima nana* and *Truncorotaloides libyaensis*. The ostracods include *Alococythere transcendens*, brachycytherids, cyprids, *Cytherella* sp., *Cytherelloidea* sp., cytherurids, *Gyrocythere exaggerata*, *Krithe* sp., *Paijenborchella* sp., *Pontocypris* sp., *Quadracythere (Hornbrookella)* sp., *Stigmatocythere luminaria*, thaerocytherids, trachyleberidids and *Xestoleberis cf. globosa*.

The palynoflora is also moderately rich and diverse, and includes marine dinoflagellate cysts and terrestrially derived pollen and spores. The dinocysts include *Achomosphaera* sp.,

Areoligera sp., *Cordosphaeridium* sp., *Selenopemphix nephroides*, *Spiniferites* sp. and *Wetzeliella* sp.

Discussion. Stratigraphy – A late Middle Eocene age is indicated by the occurrences of the larger benthonic nummulitid foraminifer *Nummulites beaumonti* (Lutetien Moyen – Biarriatzen of Schaub, 1981; calcareous nannoplankton Zones NP15–NP18 of Martini, 1971) and the planktonic foraminifera *Globigerina praebulloides* (no older than Zone P14 of Blow, 1979) and *Truncorotaloides libyaensis* (P10–P14). Published information suggests an essentially Middle–?Late Eocene age for the Kirthar Formation (see, for instance, Gill, 1953; Nagappa, 1959; Latif, 1961; Khan, 1967; Siddiqui, 1971; Samanta, 1972, 1973; Dorreen, 1974; Kureshy, 1978a,b, 1985b).

The Drazinda Member appears to be associated with the essentially regressive global third-order (?eustatically mediated) sequence TA3.6 of Haq *et al.* (1987).

Palaeoenvironmental interpretation – Microfaunal evidence points to a range of carbonate platform and associated basinal sub-environments.

Palynofloral evidence (the prevalence of the cinocysts *Selenopemphix* and *Wetzeliella*) points to a proximal or regressive environment (see, for instance, Harland, 1983; Islam, 1984; Wrenn & Kokinos, 1986; Bohacs, 1993).

Chitarwata Formation

The dominant lithology was mudstone. Palynological analyses were undertaken on two samples (166 and 173).

Results. The *in situ* palynoflora is impoverished, and included only rare freshwater algae (*Pediastrum*) and terrestrially derived pollen (alder (*Alnus*), hazel (*?Corylus*), hemlock (*Tsuga*), pine (*Pinus*) and sundry flowering-plant (angiosperm) and grass (Gramineae) pollen) and spores (*Deltoidospora*, *Laevigatosporites*, *Verrucosiporites*).

Discussion. Stratigraphy – No conclusions can be drawn with regard to age. Regional evidence indicates Oligocene.

Palaeoenvironmental interpretation – Palynological evidence points toward a continental environment characterized by a forested (?montane) hinterland. Published information indicates a shallow marine environment for the essentially age-equivalent Muree Formation (Bossart & Ottiger, 1989). These formations collectively can be regarded as representing a diachronous foreland basin megasequence younging from northeast to southwest.

Siwalik Group

The dominant lithology was mudstone. Palynological analyses were undertaken on two samples (159 and 163), both of which were barren. No conclusions can be drawn with regard to age or depositional environment. Published information indicates a Neogene–Pleistogene age and a range of continental depositional environments (see, for instance, Gill, 1953).

CONCLUSIONS

The results of palaeontological analyses of samples from sections from the Northern Sulaiman Ranges in Pakistan are in keeping with previously published information (though in some cases, including that of the prospective Kirthar Formation, significantly more refined). They enable placement of most of the sampled lithostratigraphic units in a global bio- and

sequence-stratigraphic framework. The limestones appear to be associated with essentially transgressive global sequences, the shales with essentially regressive sequences.

Palaeoenvironmental interpretations indicate a range of depositional settings from continental through shallow marine to basinal. A number of shallow marine carbonate platform sub-environments are recognized over the Palaeocene–Eocene section (essentially back-bank lagoon, bank and fore-bank).

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