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Palynology of Mesozoic and lower Tertiary samples
from northern, central, and southern Pakistan

By

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ABSTRACT

This report concerns:

1. Five samples from lower Lumshiwai Nala, Surghar Range, Punjab Province (one is probably Lower Cretaceous, one is barren, and three, from the Hangu Formation, are mid-Paleocene)
2. Three samples from the Baroch Nala section, Surghar Range (two are barren, and one, from the Hangu Formation, is mid-Paleocene)
3. Five samples from Nammal Pass, western Salt Range, Punjab Province (one is Jurassic to mid-Cretaceous, one is mid-Cretaceous, and three are barren)
4. Two samples from the Hangu Formation of Cherat drill holes, Northwest Frontier Province (samples were barren)
5. One sample from the Ghazij Formation (Eocene, Pir Ismail Ziarat coal field, Balochistan Province), which was barren
6. Two samples from the upper part of the Bara Formation and two from the lowermost part of this formation, in the principal reference section for the Bara Formation, Sindh Province (the upper two samples are probably lower upper Paleocene, the lower two may be lower Paleocene).

INTRODUCTION

The Geological Survey of Pakistan (GSP) and the U.S. Geological Survey (USGS) have been cooperatively investigating the coal resources of Pakistan under the sponsorship of the U.S. Agency for International Development (USAID). This report discusses the results of palynological research conducted in conjunction with the current coal resource exploration and assessment program (COALREAP) which began in 1985.

PALYNOLOGICAL METHODS

Palynological samples were prepared by means of standard acid maceration. All samples underwent heavy liquid separation using ZnCl_2 having a specific gravity of 1.45. This unusually low specific gravity was necessary in order to remove the abundant dark woody particles from the residues and to increase the richness of the residues in spores/pollen. The float fraction was screened on a 10 μm nylon sieve and mounted in glycerine jelly. When spores and pollen were present in a sample, they were usually fairly to very well preserved.

Table 4 presents an alphabetical list of species mentioned in the text and tables of this report.

SAMPLE ANALYSES

Lower Lumshiwai Nala Section, Makarwal Coal Field

This section is at lat $32^\circ 51' 00''$ N, long $71^\circ 08' 45''$ E (fig. 1, loc. 1), section measured by P. D. Warwick and T.

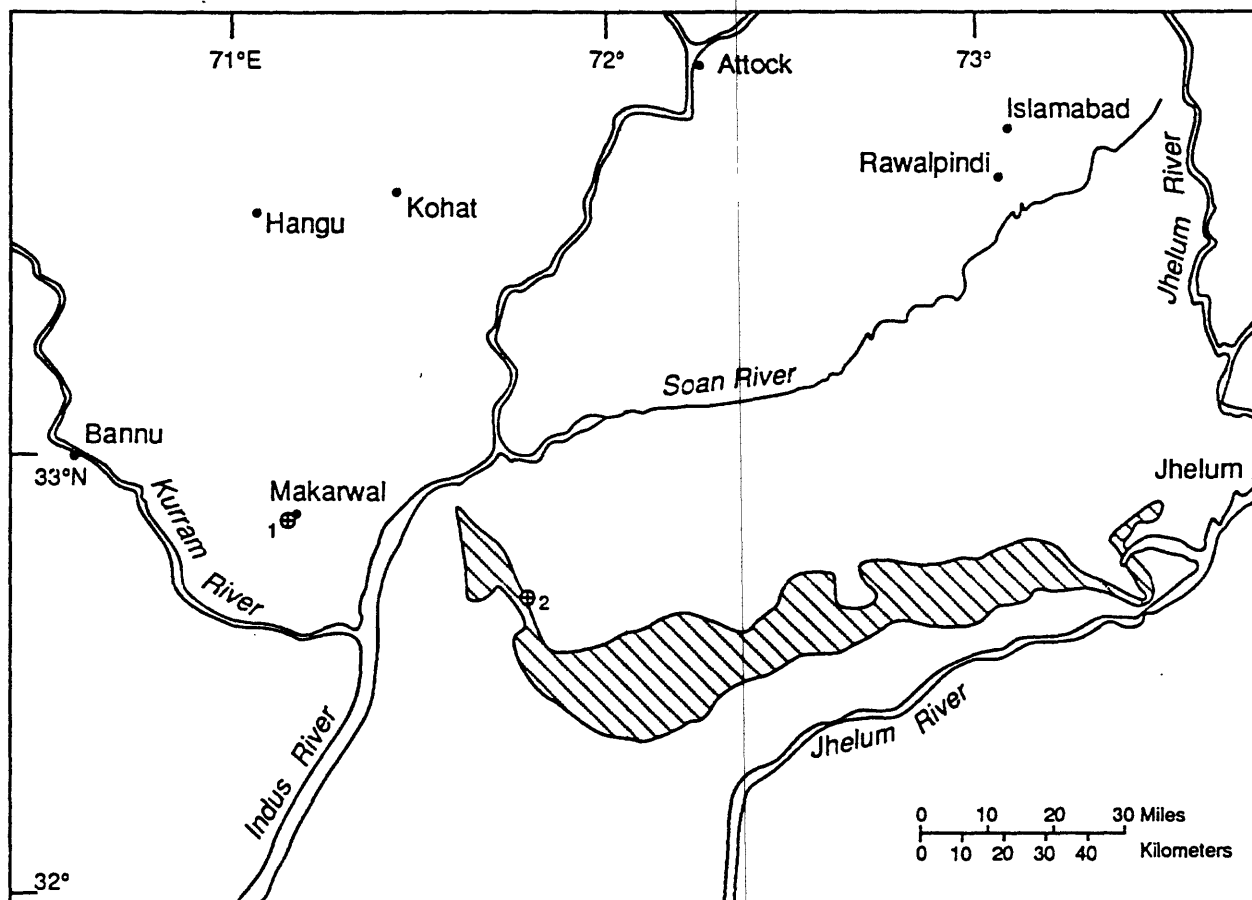


Figure 1. Map of localities from which pollen-bearing samples were obtained in northern Pakistan and are discussed in this report. Shaded area is the Salt Range.

1. Lumshiwal and Baroch Nalas, Makarwal Coal Field
2. Nammal Pass

Shakoor. "Section is located in Surghar Range, Lumshiwal Nala, below the working mine facilities. Section is in down faulted block of Lumshiwal and Hangu Formations. This is a remeasure of the section measured by Javed, Mashhadi and Khan in 1989" (P. D. Warwick, written commun., 1991).

Sample PW-90-1, R4470A (same location as sample K-SH-1 collected by Warwick and Javed in 1989), uppermost part of Lumshiwal Formation?

The following taxa were found:

Applanopsis ovatus
Araucariacites australis
Callialasporites dampieri
Callialasporites segmentatus
Callialasporites trilobatus
Cicatricosisporites aff. *C. ludbrookii*
Concavisporites cutchensis
Contignisporites glebulentis
Eucommiidites sp.
Exesipollenites sp.

Most of these range from Upper Jurassic to Lower Cretaceous. However, *Applanopsis ovatus* has only been reported from the Upper Jurassic, whereas *Cicatricosisporites ludbrookii*, *Concavisporites cutchensis*, and *Contignisporites glebulentis* are apparently known only from the Lower Cretaceous. The weight of the evidence is therefore that the sample is Lower Cretaceous. The acritarch *Veryhachium* sp. was seen, indicating that the sample was deposited in a brackish to marine environment.

Sample PW-90-2, R4470B (same location as sample T-SH-2 collected by Warwick and Javed in 1989), lowermost part of Hangu Formation?

This sample was barren of palynomorphs.

Samples PW-90-3, 4, 5, R4470 C, D, E, Hangu Formation.

These samples contained some taxa previously found in the upper part of the Bara Formation of Sindh Province (Frederiksen, 1990); these are listed in Table 1. Most species found in the sample are undescribed but appear to be Paleocene. Taking all the species together, the sample is thought to be mid-Paleocene in age.

Table 1. Pollen species in samples from the Hangu Formation of the lower Lumshiwal Nala Section, Makarwal Coal Field (R4470 C, D, E) and the Baroch Nala Section, Makarwal Coal Field (R4471C). This table includes only taxa that had previously been found in the upper part of the Bara Formation of Sindh Province (Frederiksen, 1990).

	3 - Psilodiporites hammenii	25 - Echnitriporites trianguliformis	35 - Proxapertites assamicus	37 - Proxapertites operculatus	41 - Assamiales emendatus	43 - Spinizonocolpites prominatus	45 - Spinizonocolpites sp. A	69 - Matanomadhiasulcites maximus	101 - Cupanieidites aff. C. flabelliformis	109 - Polygalacidites clarus	111 - New genus D sp. A	113-125 - Retistephanocolpites spp.	Spinizonocolpites baculatus	
R4470C	X	X	F	.	.	.	X	X	.	X	X	X	.	R4470C
R4470D	.	X	X	X	.	X	X	.	X	.	X	X	.	R4470D
R4470E	.	X	.	X	X	.	X	.	R4470E
R4471C	.	X	X	.	X	.	X	.	.	.	X	X	X	R4471C

Baroch Nala Section, Makarwal Coal Field

This section is at lat 32° 55' 35" N, long 71° 08' 50" E, (fig. 1, loc. 1), section measured by P. D. Warwick, S. Javed, and S. T. A. Mashhadi. "Section is located in the Surghar Range, Baroch Nala, north of Haji Maula Khan and Akbar Badshah Coal Mines" (P. D. Warwick, written commun., 1991).

Samples PW-90-6, 7, R4471 A, B, lowermost part of Hangu Formation?

These samples were barren of palynomorphs.

Sample PW-90-8, R4471C, lowermost part of Hangu Formation?

Like samples PW-90-3, 4, 5 (R4470 C, D, E, Hangu Formation from lower Lumshiwai Nala), this sample contained many undescribed taxa that are thought to be mid-Paleocene. Table 1 lists the taxa that had previously been found in the upper part of the Bara Formation of Sindh Province.

Nammal Pass Section, Western Salt Range

This section (fig. 1, loc. 2) was measured by P. D. Warwick and T. Shakoor. The location is at "lat 32 deg 40 min 30 sec. N., long 71 deg 47 min 10 sec E, about 0.4 km south of the Mianwali-Talagang road in a small canyon cutting the Jurassic to Tertiary section in the western Salt Range. Section starts in the upper part of the Jurassic Datta Formation and continues through to the Lockhart Limestone" (P. D. Warwick, written commun., 1991).

Sample PW-90-9, R4472A, Datta or Lumshiwai Formation

The following taxa were found:

Callialasporites dampieri
C. trilobatus
Matonisporites spp.

The sample contained abundant gymnosperm pollen, but the diversity of this pollen was low. Spores might have been more useful than gymnosperm pollen, but relatively few spores were found. No doubt Jurassic or Lower to mid-Cretaceous.

Sample PW-90-10, R4472B

The following taxa were found:

Callialasporites dampieri
Callialasporites aff. *C. segmentatus*
Gleichenia triplex

Matonisporites aff. *M. cooksoni*
Matonisporites spp.

Spores and pollen grains were rather rare in the sample. Taxa that were found have long ranges, except *Gleichenia triplex*, which has only been reported from the Aptian (of Siberia: Bolkhovitina, 1953).

Samples PW-90-11, 12, 13, R4472C, D, E, Lumshiwai and Hanqu Formations

All three of these samples were barren of palynomorphs.

Cherat Drill Holes, Northwest Frontier Province

Two core samples were examined from the Hangu Formation of the Cherat no. 1 drill hole, Northwest Frontier Province: R4432A, field no. AH-89-SH1, 100-103.75 m, and R4432B, AH-89-SH2, 103.75-105.00 m depth. Both samples were barren of palynomorphs.

One core sample was examined from the Hangu Formation of the Cherat no. 5 drill hole, Northwest Frontier Province: R4433, field no. AH-89-SH3, 97-100 m depth. This sample was also barren of palynomorphs.

Pir Ismail Ziarat Coal Field, Balochistan

I examined one sample from the middle part of the Ghazij Formation (Eocene), field number A-32-90, R4474, from the Pir Ismail Ziarat coal field, east of Quetta, Balochistan, collected by E. Johnson. This sample contained mainly smooth fern spores, which have no biostratigraphic value; pollen was rare. Therefore, no age determination can be made.

Principal Reference Section for the Bara Formation,
Sindh Province

Fourteen samples from the Bara Formation (Table 2) were collected by E. M. Brouwers for possible palynological analysis,

Table 2. Paleocene and lower Eocene formations of the
Lower Indus coal region, Sindh Province
(in descending stratigraphic order).

Laki Formation
Sohnari Formation
Lakhra Formation
Bara Formation
Khadro Formation

from exposures that form the principal reference section for the Bara Formation (Cheema and others, 1977). The outcrops are in the 35 0/13 (1:50,000) quadrangle, lat 25° 53' 15" N., long 67° 55' 00" E., Dadu District, Sindh Province (fig. 2, loc. R); the section was measured by C. Wnuk, J. R. SanFilipo, and A. H. Chandio along Ranikot Dhoru east of Amerikot, across a large anticline, to the cliffs below the Ranikot Fort wall. Seven of the collected samples were so weathered that they were not considered worth processing. The seven samples that were processed for palynomorphs were as follows; depths are below the base of the Laki Formation.

<u>Palynology no.</u>	<u>Field no.</u>	<u>Depth (m)</u>	<u>Scan analysis for palynomorphs</u>
R4453A*	90-EB-102	180.37	Good
B	90-EB-101	210.17	Good
C*	90-EB-99	258.47	Good
D	90-EB-97	295.37	Barren
E	90-EB-96	324.93	Barren
L*	90-EB-89	503.30	Good
M*	90-EB-88	509.93	Fair to poor

Four of the samples (marked by asterisks) were analyzed in detail, and the results are given in Table 3. However, taxa listed in the table are only those that had previously been found in the upper part of the Bara Formation in coreholes (Frederiksen, 1990). The new species found in samples R4453 L and M are not listed because they have not been described or named, and their stratigraphic significance is unknown. These new species have not been reported from the Paleocene of India, although work on the lower Paleocene pollen of that country is only beginning (R. K. Kar, oral commun., 1989). I have not done enough work on the Hangu Formation of the Salt and Surghar Ranges to be able to compare the Hangu pollen assemblages with those from the lower Bara of southern Pakistan.

The Lakhra Formation has been assigned to the planktic foraminiferal *Planorotalites pusilla pusilla* and *P. pseudomenardii* Zones, and thus it is late Paleocene (Selandian) in age (Mohan, 1982); the *P. pusilla pusilla* Zone forms the base of the Selandian. The underlying Bara Formation is of less certain age because it contains only sparse marine fossils (Cheema and others, 1977). The base of the Lakhra interfingers with the top of the Bara, and the 200 m of the upper Bara penetrated by coreholes contains pollen floras very similar to those of the Lakhra (Frederiksen, 1988, 1990); therefore, the upper part of the Bara Formation no doubt is Selandian.

Samples R4453 A and C are from the upper part of the exposed principal reference section for the Bara Formation and should be equivalent to the upper Bara of the cores. Sample R4453C contains *Cricotriporites* sp. A; in the cored sections, this appears to be one of the best guide species, and its known

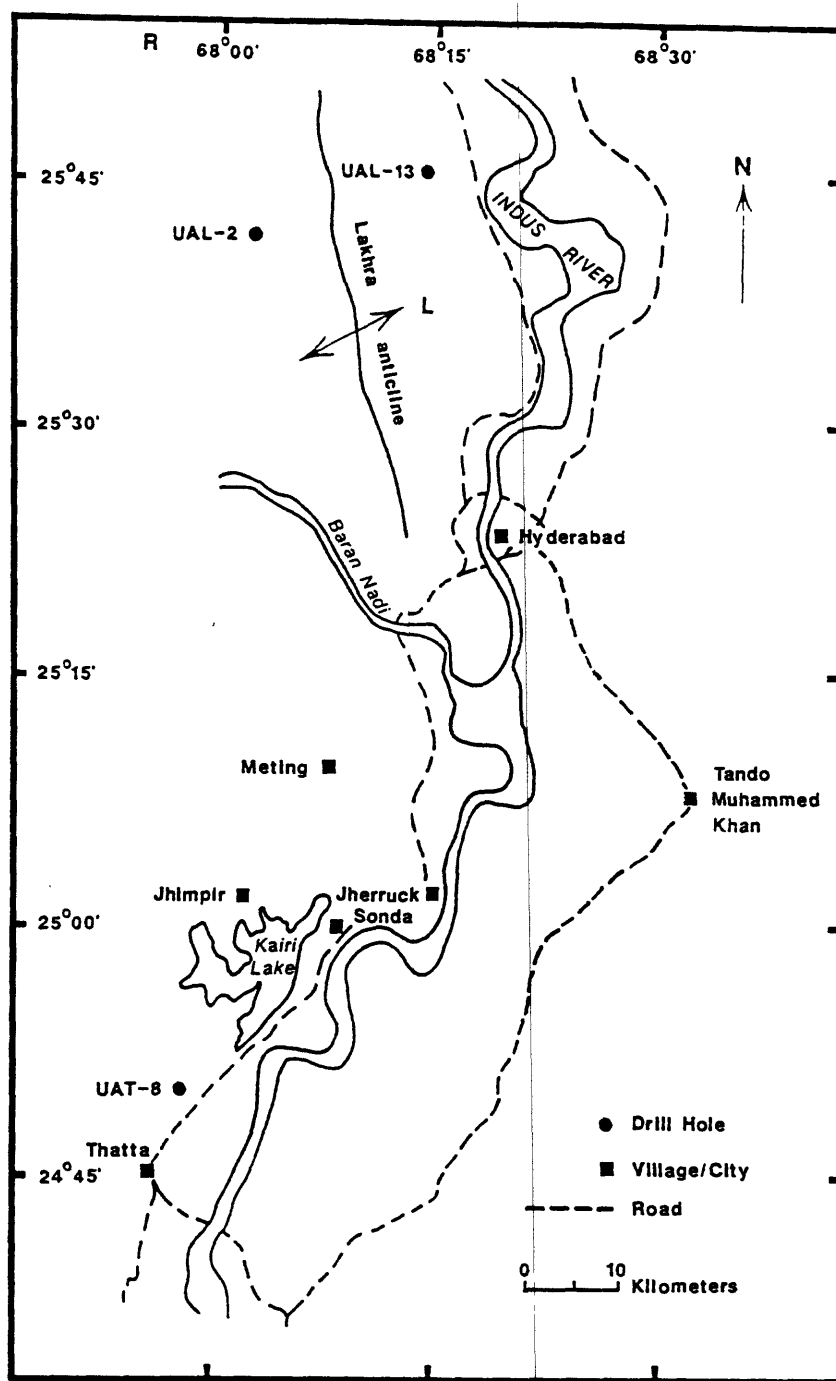


Figure 2. Map of southern Sindh Province showing location of the principal reference section for the Bara Formation (Ranikot area, locality R in the northwest corner of the map) and the three coreholes from which pollen samples from the upper part of the Bara Formation have been studied (Frederiksen, 1988, 1990). L = area where the best exposures of the Lakhras Formation are found.

Table 3. Pollen species in samples from the upper part of the Bara Formation (R4453 A and C) and from the lowermost part of the formation (R4453 L and M), in the principal reference section for the Bara Formation, Sindh Province. Taxa listed are only those that had previously been found in the upper part of the Bara Formation in coreholes (Frederiksen, 1990).

		R4453A	R4453C	R4453L	R4453M
1 -	<i>Milfordia minima</i> + <i>M. hungarica</i>	X	.	.	.
2 -	<i>Pseudodiporites hamenii</i>	X	.	.	.
21 -	<i>Cricotriporites</i> sp. A	X	X	X	X
25 -	<i>Echitriporites trianguliformis</i>	X	X	.	.
27 -	<i>Triangulorites triangulatus</i>	X	X	.	.
35 -	<i>Proxaperites asamicus</i>	X	X	X	X
37 -	<i>Proxaperites operculatus</i>	X	X	X	X
39 -	<i>Proxaperites curvus</i>	X	X	X	X
41 -	<i>Asamielates emendatus</i>	X	.	X	.
42 -	<i>Spinizonocolpites prominatus</i>	X	X	X	X
45 -	<i>Spinizonocolpites</i> sp. A	X	X	.	.
52 -	<i>Longaperites reticulatus</i>	X	X	X	X
53 -	<i>Longaperites</i> sp. C	X	X	X	.
62 -	<i>Longaperites</i> sp. E	.	.	X	.
65 -	<i>Longaperites</i> sp. F	X	X	X	X
69 -	<i>Katanomadhiasulcites maximus</i>	.	X	X	.
73 -	<i>Brevitricolpites</i> sp. A	.	X	X	.
75 -	<i>Intrareticulites brevis</i>	X	.	.	.
81 -	New genus A, sp. A	X	.	.	.
89 -	<i>Porocolpopollenites</i> aff. <i>P. olivaceus</i>	X	X	X	X
91 -	<i>Cf. Porocolpopollenites</i> , sp. A	.	X	.	.
101 -	<i>Cupanioides</i> aff. <i>C. flabelliformis</i>	X	.	.	X
103 -	<i>Cupanioides</i> sp. A	X	X	.	X
113-125 -	<i>Retistephanocolpites</i> sp.	X	X	X	.
	<i>Dandotiasspora telonata</i>	.	X	.	.

range base is in the uppermost part of the cored Bara (Frederiksen, 1990).

In most places, the Bara is underlain by the Khadro Formation, which is lower Paleocene (Danian) at least in its upper part (Cheema and others, 1977). However, near Fort Ranikot, the Bara rests on Deccan(?) trap. The two lower samples (R4453 L and M) from the principal reference section for the Bara Formation are from near the base of the section, approximately 500 m below the top of the Bara. These samples seem to contain about the same number of upper Bara species as the two upper samples (Table 3), suggesting that all four of these samples are not greatly different in age. On the other hand, the two samples from the lower Bara contain very many species that are unknown from higher in the formation; for this reason, the pollen assemblages from these two samples appear much older than the assemblages in samples R4453 A and C and in the cored Bara (Frederiksen, 1990), and thus the base of the Bara Formation at Fort Ranikot may be as old as Danian.

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Table 4. Alphabetical list of species mentioned in the text and tables of this report. * denotes an informal species name used by Frederiksen (1990).

Araucariacites australis Cookson 1947
Assamialetes emendatus Singh 1975 emend. Singh & Tripathi 1986
Brevitricolpites sp. A*
Callialasporites dampieri (Balme 1957) Dev 1961
Callialasporites segmentatus (Balme 1957) Dev 1961
Callialasporites trilobatus (Balme 1957) Dev 1961
Cicatricosisporites aff. *C. ludbrookii* Dettmann 1963
Concavisporites cutchensis Singh, Srivastava & Roy 1964
Contignisporites glebulentus Dettmann 1963
Cricotriporites sp. A*
Cupanieidites aff. *C. flabelliformis* Venkatachala & Rawat 1972
Cupanieidites sp. A*
Dandotiaspora telonata Sah, Kar & Singh 1971
Echitriporites trianguliformis van Hoeken-Klinkenberg 1964
Gleichenia triplex Bolkhovitinina 1953
Intrareticulitis brevis (Sah & Kar 1970) Kar 1985
Longapertites retipilatus Kar 1985
Longapertites sp. C*
Longapertites sp. E*, aff. *Quilonipollenites sahnii* Rao & Ramanujam 1978
Longapertites sp. F*
Matanomadhiasulcites maximus (Saxena 1979) Kar 1985
Matonisporites aff. *M. cooksoni* Dettmann 1963
Milfordia minima Krutzsch 1970 + *M. hungarica* (Kedves 1965) Krutzsch & Vanhoorne in Krutzsch 1970
New genus A, sp. A*
New genus D, sp. A*
Polygalacidites clarus Sah & Dutta 1966
Porocolpopollenites aff. *P. ollivierae* (Gruas-Cavagnetto 1976) Frederiksen 1983
cf. *Porocolpopollenites*, sp. A*
Proxapertites assamicus (Sah & Dutta 1966) Singh 1975
Proxapertites cursus van Hoeken-Klinkenberg 1966
Proxapertites operculatus (van der Hammen 1954) van der Hammen 1956
Psilodiporites hammenii Varma & Rawat 1963
Spinizonocolpites baculatus Muller 1968
Spinizonocolpites prominatus (McIntyre 1965) Stover & Evans 1973
Spinizonocolpites sp. A*
Triangulorites triradiatus (Saxena 1979) Kar 1985