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STRATIGRAPHY AND PALEONTOLOGY OF COAL BEDS IN THE GHAZIJ SHALE, SOR RANGE-DAGHARI COAL FIELD QUETTA DIVISION, PAKISTAN

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STRATIGRAPHY AND PALEONTOLOGY OF COAL BEDS IN THE GHAZIJ SHALE, SOR RANGE-DAGHARI COAL FIELD, QUETTA DIVISION, PAKISTAN

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ABSTRACT

Coal mine tunnels and surface sections in the Ghazij Shale of early Eocene age in the coal field near Quetta, Pakistan, were sampled in detail in order to make a foraminiferal analysis. This analysis and consequent correlations suggest that the coal seams are lenticular and have little lateral continuity. The planktonic Foraminifera date the geologic age of the coal-bearing sequences as early Eocene. Other Foraminifera indicate the shallow-water environment of deposition of the coal. Evidence is presented to show that coal was deposited in a series of unconnected swamps or marshes.

INTRODUCTION

Purpose and scope of the report

Coal plays a very important role in the economy of Pakistan, as a major source of energy. Because information is needed on the coal deposits in the country, a comprehensive geological survey of the Sor Range-Daghari coal field near Quetta (fig. 1), the largest field in Pakistan, was begun in 1957 as a joint project of the U. S. Geological Survey and the Geological Survey of Pakistan under the sponsorship of the Agency for International Development (then known as the International Cooperation Administration), U. S. Department of State, and the Government of Pakistan. As part of that project, the present report summarizes the results of paleontologic and stratigraphic investigations of the Ghazij Shale, the formation that contains the coal in this field.1/

It was believed that detailed sampling of the claystone units in coal mine tunnels, or adits, and of nearby outcrops would furnish valuable information on the paleontology and stratigraphy of the Ghazij Shale, as a means of correlating and determining the areal distribution of the various coal beds in the formation. During 1963 and 1964, six coal mine adits and two surface sections were sampled. Samples in all sections were taken at 10-foot stratigraphic intervals. The index map of the Sor Range-Daghari area (fig. 2, insert map) shows the locations of the sections sampled.

1/ Information herein is based on data as of 1966.

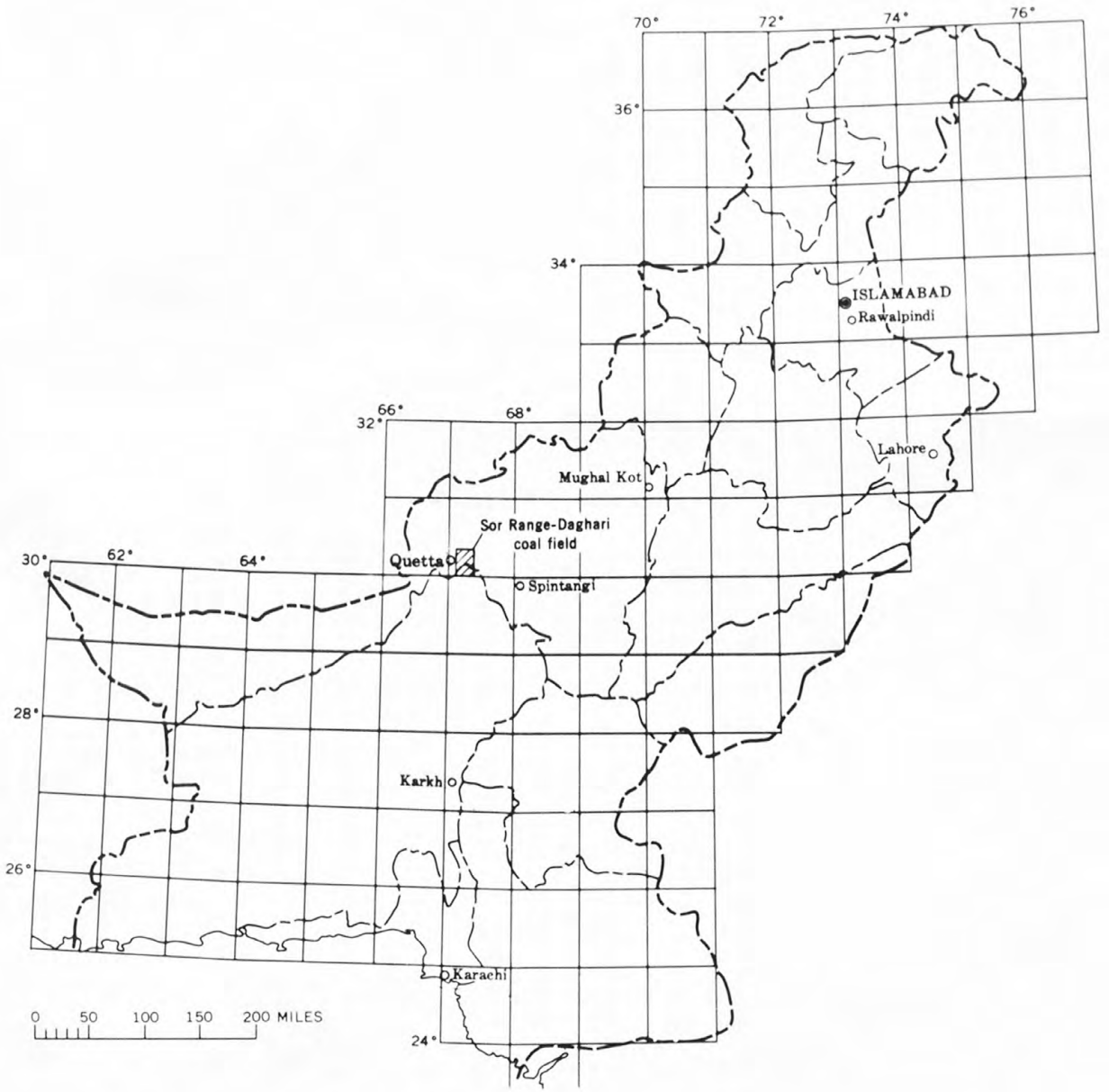

Figure 1.—Index map of Pakistan showing location of the Sor Range-Daghari coal fields

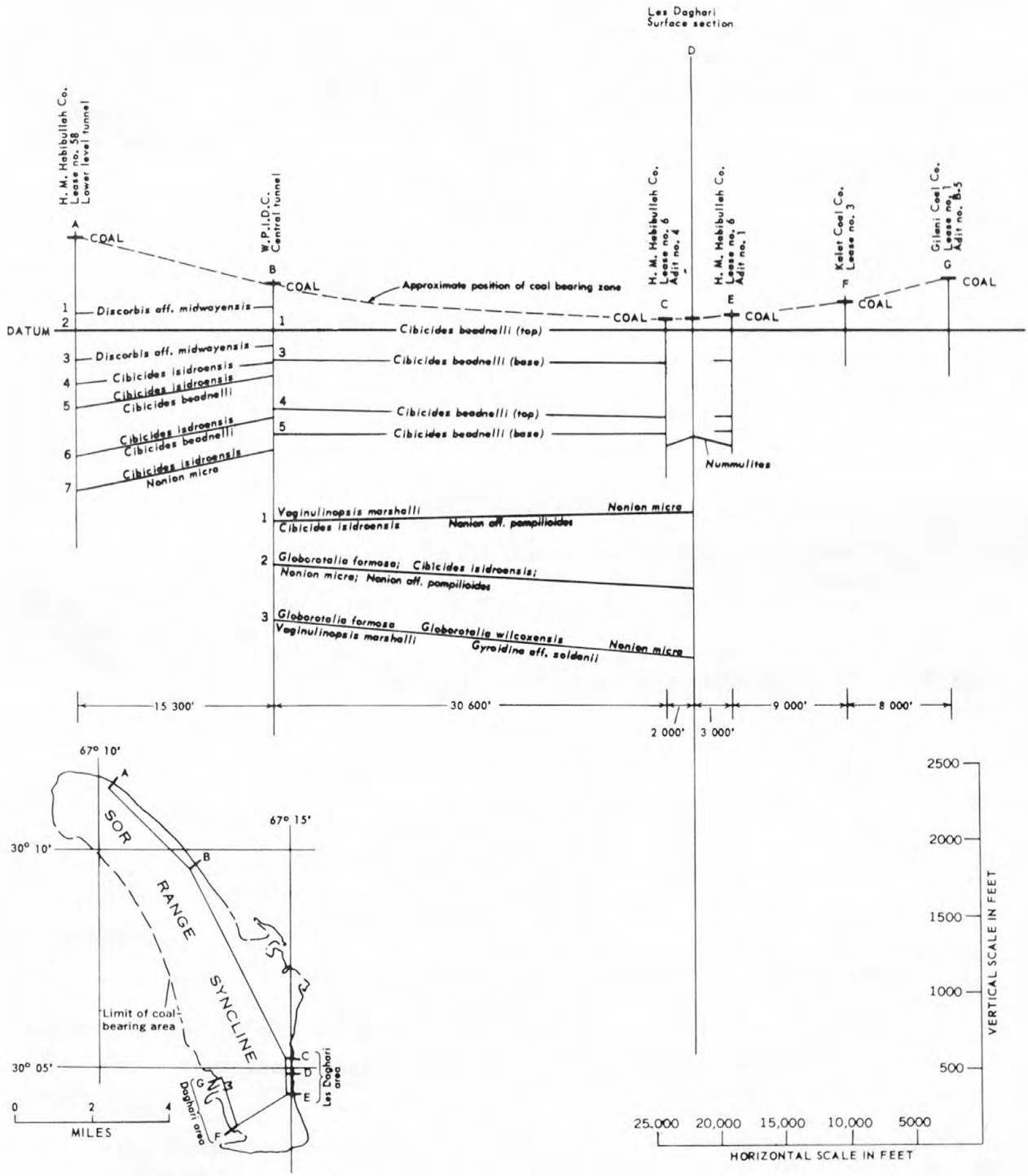

Figure 2.—Correlations of foraminiferal zones in the Sor Range-Daghari coal field

Location

The Sor Range-Daghari coal field is near the city of Quetta, Pakistan. The field trends northwesterly and is approximately 12 miles long. The area is east and southeast of Quetta, and the northernmost mines are about 5 miles from the city limits. The Daghari area of the field is approximately 12 airline miles southeast of Quetta, is about 2 miles long, and is south of the southern part of the Sor Range area.

Previous work

Before 1947, geologists of the Geological Survey of India studied the coal-bearing regions that now are within the boundaries of Pakistan. The results were summarized by Gee (1948). Since 1947, the Geological Survey of Pakistan has conducted investigations of the country's coal fields. Powell Duffryn Technical Services, Ltd. (1949) made studies of the mining methods and the chemical properties of coal in Pakistan. Gee (1950), Khan (1950), Crookshank and Heron (1955), Haque (1959), Hunting Survey Corp. Ltd. (1960), and Reinemund and Khan (1965) have reported on the geology and occurrence of the coal in the different regions of Pakistan.

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ment Corp. (WPIDC), for permission to sample the PIDC central tunnel; the Kalat Coal Co. and the Gilani Coal Co. for permission to sample their adits in the Daghari area.

GENERAL GEOLOGICAL SETTING

Stratigraphy [1]

The outcropping rocks in the area of investigation are sedimentary rocks of Jurassic to Pleistocene age, as follows:

Oligocene to Pleistocene

Urak Group*: sandstone, conglomerate, shale, shelly limestone.

Middle and late Eocene and Oligocene

Kirthar Formation: limestone, gray to light-gray, dense.

Early Eocene

Ghazij Shale: claystone, olive-green to gray, brown to yellow, hard; contains discontinuous beds of conglomerate, sandstone, siltstone, shale, limestone, and coal.

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[1] Formation names followed by asterisk (*) have not been formally accepted by the Stratigraphic Committee of Pakistan, but are believed to meet the requirements of the Stratigraphic Code.

Paleocene and Cretaceous

Dunghan Formation: limestone, gray to bluish-gray, dense; basal part yellow to brown or gray, sandy, hard.

Late Cretaceous

Parh Limestone : limestone, white, light-gray, or grayish green, dense, sublithographic.

Early and Late Cretaceous

Sembar Formation* and Goru Formation* (undivided): claystone and siltstone, gray to dark gray, with limestone bands. (These two units are difficult to distinguish lithologically, in the field, in the Quetta area.)

Jurassic

Chiltan Limestone*: limestone, gray, dense.

The oldest rock unit exposed in the vicinity of the Sor Range-Daghari coal field is the Chiltan Limestone* of Jurassic age, which crops out in the mountains west and south of the coal field. Rocks assigned to the Sembar Formation* and Goru Formation* (undivided), a claystone and siltstone unit containing limestone layers of Cretaceous (Albian-Cenomanian) age, overlies the Jurassic. These two formation names were introduced by Williams (1959, p. 385) to replace the old name of "belemnites beds" of Oldham (1890) which with subsequent usage became "Belemnites Shale." Conformably overlying the Sembar Formation* and Goru Formation* (undivided) is the Parh Limestone* of Late Cretaceous (Cenomanian-Maestrichtian) age. The Dunghan Formation of Late Cretaceous and Paleocene age is in conformable contact with the underlying Parh Limestone*. The basal (Cretaceous) part of this formation may be the equivalent of the Fort Munro Limestone Member* of the Mughal Kot Formation* of Williams (1959, p. 386) because it carries the same microfauna as the Fort Munro Limestone.

The Ghazij Shale, of early Eocene age, probably conformably overlies the Dunghan Formation, but the contact is covered in this area. The unit is conformably overlain by the Kirthar Formation, a thick-bedded light-colored limestone of middle Eocene to Oligocene age, which forms the tops of some of the hills in the Sor Range-Daghari coal field. The Urak Group* (Hunting Survey Corp. p. 312) Oligocene to Pleistocene in age, consists of sandstone, conglomerate, shale, and shelly limestone, and conformably overlies the Kirthar Formation.

Structure

The coal-bearing rocks in Sor Range-Daghari coal field are in a northwest-trending doubly plunging syncline, which is truncated by a fault along the west side and cut by many cross faults and folds.

At the northern end of the Sor Range syncline, the outcrop of coal and associated beds in the Ghazij Shale wraps around the synclinal nose and then extends southeastward along the eastern limb of the syncline. At the southern end of the syncline, the outcrop of coal-bearing rocks also extends around the nose of the structure and, in the Daghari area on the west limb, is broken by several large cross faults. The strata dip less than 15° in the northern part of the Sor Range and more than 50° in the southeastern part of the Sor Range and in the Daghari area.

Although that part of the Ghazij Shale usually containing coal beds is exposed on the southern end of the Sor Range syncline, no coal of commercial grade has been found there. Two test holes drilled in this area by the Geological Survey of Pakistan penetrated only thin beds of coal or carbonaceous shale. The reason for the absence of commercial coal is not known; probably it is depositional rather than structural.

GHAZIJ SHALE

Terminology

The term "Ghazij" was first used by Oldham (1890, p. 95) to designate a shale formation between the Dunghan (Paleocene) and Spintangi (middle Eocene) Formations. Oldham used it as "Ghazij group," a term that is incompatible with the rules of nomenclature of the Stratigraphic Code of Pakistan. Williams (1959, p. 389) described it under the name of Ghazij Formation*, and the Hunting Survey Corp. Ltd. (1960, p. 122), referred to it as the Ghazij Shale, the name used in the present report.

The type locality, designated by Oldham, is in Ghazij Rud, a stream valley southeast of the Spintangi railroad station (lat 29°54'N.; long 68° 09'E.), about 75 miles southeast of Quetta.

Areal extent and thickness

The Ghazij Shale is exposed in the central mountain areas of Pakistan (fig. 1). Beginning near Mughal Kot in the north (lat 31°30'N.; long 70°05'E.), the exposures curve to the southwest toward Quetta, and then south to Karkh (lat 27°45'N.; long 67°15'E) in the Kirthar Range. There are no reported surface exposures south of Karkh; however, the senior author found early Eocene Foraminifera in shale samples from several deep wells in the Karachi area and identified the shale as Ghazij. The thickness at the type section is 1,960 feet, and the greatest reported thickness is about 11,000 feet at Mughal Kot. In the report area, the measured thickness of the Ghazij Shale at the Les Daghari section is 6,550 feet.

Lithology

The dominant rock type in the Ghazij Shale is claystone; shale, sandstone, limestone, conglomerate, and coal are present in minor amounts. The claystone is gray to olive green, brown, yellow, maroon, or locally grayish blue. Red, blue, and yellow layers several feet thick are prominent in the upper third of the formation. Gypsum is conspicuous in the claystone as plates, thin partings, or small veins. The weathered claystone exposures form greenish-gray low rounded hills or small mounds. The surface of these exposures has a hard amorphous crust several inches thick in places. Slumping is a very common feature of the formation. The claystone has very low tensile strength, is hard and blocky, and bedding is rarely seen. However, in unweathered sections, such as in mine adits, bedding is commonly discernible.

The sandstone is coarse grained, pebbly, poorly sorted, and crossbedded. It is green, gray, or brown and weathers to a rusty brown. In places, fresh-water lamellibranchs and gastropods are found (Hunting Survey Corp., Ltd. 1960, p. 123). Fragments of leaves and some fossil wood are found in the sandstone adjacent to the coal. The sandstone may occur as resistant beds as much as 100 feet thick, but in the report area, these beds reach a maximum thickness of only 50 feet and are generally within 100 feet of the coal seams. A much higher percentage of sandstone is present in the upper one-third of the Ghazij Shale than in the lower two-thirds.

Very little limestone is present in the Ghazij Shale in the Sor Range-Daghari coal field.

Coal is found with either sandstone or claystone beds in the upper part of the Ghazij Shale. The aggregate thickness of the coal-bearing interval ranges from 10 feet to as much as 180 feet. The coal beds change greatly in thickness and in number from north to south in the field; Reinemund and Khan (1965) report that some of the adits have four, five, or six coal beds. Individual beds may range from a few inches to several feet thick within short distances. The continuity of beds is difficult to determine because of poor exposures, interruptions in mining, and inaccessibility of workings where coal beds could otherwise be observed. Coal of minable thickness is present everywhere along the outcrop except at the extreme south end of the field, where exploratory mining and drilling have revealed that the coal is generally less than a foot thick.

A persistent conglomerate bed is found above the uppermost coal bed or carbonaceous layer in the Sor Range-Daghari coal field. In the Sor Range part of the field this bed is locally almost 100 feet thick and is continuous for approximately 7 miles along the strike, except for dislocations caused by local faulting. In the Daghari area the thickness is no more than 40 feet and the conglomerate grades into sandstone locally. The pebbles of the conglomerate are composed mostly of chert and limestone from older formations. The conglomerate is found at different distances above the uppermost coal bed; it may be in contact with the coal or as much as 50 feet above it.

Paleontology

Foraminifera

The paleontologic study of the Ghazij Shale is based mainly on Foraminifera collected from the following coal mine tunnels and surface sections:

Section A: H.M. Habibullah Co. lease no. 58, lower level tunnel.

Section B: PIDC central tunnel.

Section C: H.M. Habibullah Co. lease no. 6, adit no. 4.

Section D: Les Daghari surface section

Section E: H.M. Habibullah Co. lease no. 6, adit no. 1.

Section F: Kalat Coal Co. lease no. 3.

Section G: Gilani Coal Co. lease no. 1, adit B-5.

The locations of these sampled sections are shown in Figure 2 (inset map).

Both benthonic and planktonic Foraminifera are abundant in the Ghazij Shale below the coal beds, but both types are very rare above the beds. Thirty-seven genera and approximately 100 species have been identified. The benthonic forms include the larger Foraminifera as well as the smaller ones. The genera Assilina, Discocyclina, Lockhartia, and Nummulites are the larger Foraminifera represented. No attempt was made to make species identification on the Assilina, Discocyclina, and Nummulites, as their identification depends on their internal structure, which can only be determined by studying thin sections.

The presence of the benthonic Foraminifera and the planktonic forms in the lower two-thirds of the Ghazij Shale indicates a marine origin for the formation. The presence of the planktonic forms points to an open-ocean depositional environment. The intermittent presence of the larger Foraminifera suggests shallow-water deposition from time to time before the coal beds were deposited.

In one surface section stratigraphically above the coal beds, the Ghazij Shale contains rare early Eocene indigenous forms, and a small number of reworked forms. Radiolaria are present throughout most of this interval, but whether or not they are reworked Late Cretaceous genera was not determined. The microfossils suggest that the upper third of the Ghazij Shale was deposited in a shallow marine environment which was not conducive to the existence of Foraminifera. The numerous small sandstone bodies in the upper third of the formation are coarse grained and crossbedded, which also suggests very shallow water conditions.

Nummulites zone.--Stratigraphically below the coal beds, in five of the six mine adits and also in the Les Daghari surface section, is an extensive zone of abundant Nummulites mixed with molluscan shell fragments. The thickness of the interval from the zone to the lowest coal bed differs from adit to adit, as the table below illustrates:

Section	Distance from base of Nummulites zone to lowest coal bed (feet)	Distance from top of Nummulites zone to lowest coal bed (feet)
A	520	10
B	600	250
C	150	40
D	100	not known
E	150	10
F	190	40
G	Absent	Absent

The Nummulites intervals show the very shallow water conditions existing during the time in which the Ghazij Shale was deposited prior to the deposition of the coal. The conglomerate bed above the coal also suggests shallow-water deposition at the end of the period during which the coal-forming material was deposited.

Depositional environment

Much Upper Cretaceous fossil foraminiferal material has been redeposited in the Ghazij Shale. However, no diagnostic Paleocene forms have been redeposited. The Late Cretaceous genus Globotruncana, represented by many specimens of several species, and the genus Pseudotextularia are present in many of the samples. Most of the reworked Upper Cretaceous material indicates that during the deposition of the Ghazij Shale, erosion of Upper Cretaceous rocks was taking place in nearby positive areas, which probably were to the north. The absence of reworked diagnostic Paleocene forms suggests that there were no positive areas of Paleocene rocks close by and that a depositional environment was continuous throughout the Paleocene into the early Eocene.

Although the reworked Foraminifera are commonly found within stratigraphic intervals approximating 100 feet in thickness, the intervals are not stratigraphically equivalent. In most places where the reworked forms are abundant, very few early Eocene fossils are found; conversely, where reworked forms are rare, early Eocene fossils are abundant. The most probable explanation for the above conditions is that uplift of the nearby Upper Cretaceous rocks caused rapid runoff and deposition of much sediment and detrital specimens of Foraminifera in the early Eocene sea. Most Foraminifera cannot exist in sediment-filled waters, but require clear water. After periods of sedimentation, there were periods when the waters again became clear, few Late Cretaceous forms were carried into the seas, and early Eocene forms again found an environment in which they could flourish.

The presence of the benthonic and planktonic Foraminifera indicates that the lower two-thirds of the Ghazij Shale was deposited under open-ocean conditions, in shallow warm water. The presence of larger Foraminifera (mostly Nummulites) further shows that just prior to the deposition of the coal, waters were very shallow and, from time to time, less than 100 feet deep.

The authors believe that the coal was deposited in a series of unconnected swamps or coastal marshes. Forest vegetation flourished for long periods before it was covered by sediment and changed to coal. Later, a new marsh or swamp formed with different dimensions from the previous one. When its vegetation was in turn covered with sediment, the resultant coal bed had no connection with the previous bed or others contemporaneous with it. Two or more swamps probably existed at the same time, in different areas, but not connected to each other during the interval of time when the coal was formed, and the areas of coal formation were unrelated to each other.

Using the top of the uppermost occurrence of Cibicides beadnelli LeRoy as a datum, the interval from that datum to the lower most coal bed ranges from a maximum of 600 feet to a minimum of 100 feet. The maximum interval is found in the northwest corner of the coal field in section A; the minimum interval is in the southeast in sections C, D, and E (fig. 2). The 600-foot interval in section A, in the northern end of the coal field, probably represents an area which was close to the shoreline where the sedimentation rate was highest. Conversely, sections C, D, and E in the area with the 100-foot interval, reflect an area which was more basinward, and in which the sedimentation rate was much slower.

Age and correlation

The following diagnostic planktonic Foraminifera were found in the Ghazij Shale below the coal:

Globorotalia formosa Bolli var. gracilis Bolli

Globorotalia quetra Bolli

Globorotalia rex Martin

Globorotalia wilcoxensis Cushman and Ponton

Based on these four Globorotalia species, the age of the Ghazij Shale below the coal beds is early Eocene.

Correlation of the sampled sections

Certain diagnostic species of Foraminifera can be used to correlate the six sections sampled, as shown on the correlation chart (fig. 2). The datum is taken at the uppermost occurrence of Cibicides beadnelli LeRoy, because this horizon is the only zone found to be continuous throughout the report area. The number of samples collected and the thickness of the stratigraphic interval sampled at each locality is as follows:

Section sampled	Number of samples	Thickness of stratigraphic interval (feet)
Section A	176	2,070
Section B	291	2,980
Section C	102	1,050
Section D	570	6,550
Section E	92	940
Section F	41	450
Section G	62	620
Kalat Coal surface (not on correlation chart)	143	

Detailed information on the correlations from section to section are presented as follows:

Correlation from sections A to B
(distance about 3 miles)

The thickness interval indicates the distance from the foraminiferal horizon to the lowest coal bed.

Correlation number	Thickness of interval (feet) Section A (fig. 2)	Section B (fig. 2)	Basis of correlation (Foraminiferal horizon)
1	520	160	Discorbis aff. midwayensis Cushman (bottom of horizon)
2	630	320	Cibicides beadnelli LeRoy (first occurrence)
3	790	430	Discorbis aff. midwayensis (base of horizon)
4	940	520	Cibicides isidroensis Cushman and Renz (top of horizon)

Correlation number	Thickness of interval (feet) Section A (fig. 2)	Section B (fig. 2)	Basis of correlation (Foraminiferal horizon)
5	1,100	610	Cibicides isidroensis (bottom of horizon)
6	1,410	870	Cibicides isidroensis (top of horizon), Cibicides beadnelli (bottom of horizon), Valvulineria peruviana Cushman and Stone, var. discrepans Cushman and Stainforth
7	1,660	1,100	Cibicides isidroensis (bottom of horizon); Spiroplectammina sp. (bottom of horizon); Nonion micra Cole

Correlation from sections B to C
(distance about 6 miles)

Correlation number	Thickness of interval (feet) Section B (fig. 2)	Section C (fig. 2)	Basis of correlation (Foraminiferal horizon)
1	320	30 60 (from second seam)	First occurrence of Cibicides beadnelli LeRoy
2	370	105	Sharp break in abundance of Cibicides beadnelli and Nummulites sp.
3	490	250	Base of horizon of Cibicides beadnelli
4	820	600	Top of an horizon of Cibicides beadnelli
5	990	720	Bottom of an horizon of Cibicides beadnelli

Correlation from sections B to D
(distance about 5 miles)

A set of correlations was made between the PIDC central tunnel and the Les Daghari surface section. The surface section was taken on H. M. Habibullah Co. lease no. 6 between adit no. 4 and adit no. 1. The PIDC central tunnel and the surface section are about 5 miles apart. Although only the lower two-thirds of the 6,650-foot surface section has been examined, enough information was collected to permit correlations as follows:

Correlation number	Thickness of interval (feet) Section B (fig. 2)	Section D (fig. 2)	Basis of correlation
1	1,560	1,250	Combined occurrence of *Vaginulinopsis marshalli* (Finlay), *Nonion micra* Cole, *N.* aff. *pompilioides* (Fichtel and Moll), *Cibicides isidroensis* Cushman and Renz
2	1,850	1,720	Zone of *Globorotalia formosa* Bolli var. *gracilis* Bolli, *Cibicides isidroensis*, *Nonion micra*, *N.* aff. *pompilioides*, *Parrella* sp., *Spiroplectammina* sp.
3	2,210	2,200	Zone of *Cibicides isidroensis*, *Globorotalia formosa* var. *gracilis*, *G. wilcoxensis* Cushman and Ponton, *Gyroidina* aff. *soldanii* d'Orbigny, *Vaginulinopsis marshalli* (Finlay), *Robulus* sp., *Nonion micra*, *N.* aff. *pompilioides*, and Radiolaria

In correlation no. 1, there is a difference of approximately 310 feet in the thickness from the two intervals to the first coal seam; in the next correlation there is a difference of only 130 feet. The differences may be due to minor faulting which could not be observed in the field, or more probably overlapping of the sampled interval.

Correlation from sections C to E
(distance about 1 mile)

Correlation number	Thickness of interval (feet) Section C (fig. 2)	Section E (fig. 2)	Basis of correlation
1	30	40	Top of horizon of Cibicides beadnelli LeRoy
2	105	90	End of a sequence of Cibicides beadnelli, Nummulites sp., and an occurrence of Lockhartia hunti Ovey
3	250	260 small	Zone of Cibicides beadnelli
4	620	630	Base of a zone of Gumbelina sp.
5	720	730	Top of a zone of Gumbelina sp.
6	830	860	Top of a zone of Nummulites sp.

Correlation six also was found in section D, the Les Daghari surface section, 780 feet from the first coal seam, and was the only foraminiferal correlation made between the surface section and sections C and E.

Correlation from sections E and F
(distance about 2 miles)

This correlation line crosses the axis of the Sor Range syncline. Only one correlation was possible between the two tunnels; however, it was possible to make this same correlation across all localities except the Les Daghari surface section.

Correlation number	Thickness of interval (feet) Section E (fig. 2)	Section F (fig. 2)	Basis of correlation
1	40	110	Top of sequence of Cibicides beadnelli LeRoy

Correlation from sections F to G
(distance about 1½ miles)

Correlation number	Thickness of interval (feet) Section F (fig. 2)	Section G (fig. 2)	Basis of correlation
1	110	320	Top of Cibicides beadnelli LeRoy

SUMMARY

Results of the examination of samples from six coal mine adits and surface section at Les Daghari show that the geologic age of the Ghazij Shale and the coal-bearing sequence is early Eocene, that the coal-bearing sequences and the Ghazij Shale deposited prior to the coal were deposited in very shallow water, and that much of the Ghazij Shale was deposited under marine conditions. It was not possible to correlate individual coal seams or to establish their lateral extent by use of Foraminifera.

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