TIME-HIATUS AT THE OLIGOCENE/EOCENE BOUNDARY IN SIND

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(Received October 15, 1966)

Evidence has been presented to show that, contrary to the earlier belief, the Khirthar Limestone is not wholly of Middle Eocene age but ranges up into the Oligocene. The Colombo Plan Survey has designated the Middle Eocene part of the Khirthar Limestone as Khirthar Member and the Oligocene part as the Gorag Member. The two Members are apparently conformable, but detailed faunal investigation has shown that there is a time-hiatus between the two as the faunas representing the greater part of the Auversian and the entire Bartonian Stages of Europe are missing.

Introduction

In Sind, which is the type area for the Tertiary succession of West Pakistan, the Middle Eocene and the Oligocene Epochs are represented by the Khirthar and Nari Limestones. The boundary between the two is taken at a place where the massive, hard, grey coloured Khirthar Limestone is replaced by the relatively soft, brownish coloured Nari Limestone. Until recently the Khirthar Limestone was regarded as wholly of Middle Eocene age. 2,4,5,6 During the course of examination of material from the Khirthar and Nari Limestones from a number of localities in Sind including the type Gaj River Section, the writer found that the Oligocene/Eocene boundary lies within an apparently conformable sequence of the Khirthar Limestone and does not conform with the litho-stratigraphic boundary between the Khirthar and Nari Limestones. The Khirthar Limestone, therefore, ranges in age from the Middle Eocene to the Oligocene. The Photographic Survey Corporation of Canada redesignated the Khirthar Limestone as Brahui Limestone and subdivided it into a lower Khirthar Member containing Eocene fauna and an Upper Gorag Member containing Oligocene fauna (Ref. 1, p. 96).

Further detailed study carried out by the writer at the British Petroleum Research Centre, Sunbury, England on collections made by Messrs Pakistan Petroleum Limited from the Gaj River Section and Badhra area, has shown that despite the apparent conformity of the Eocene and Oligocene parts of the Khirthar Limestone, faunal evidence suggests a time-hiatus between the two. In the Gaj River Section a large part of the Upper Eocene and Lower Oligocene are missing; while in the Badhra area the Middle Eocene is directly succeeded by the Middle Oligocene.

The Upper Eocene is not of widespread occurrence in West Pakistan. It has been recognised by Eames³ from the Rakhi Nala Zinda Pir area and from the Shirani area a little to the north. The writer recognised Limestone of Upper Eocene age from West of Marap, Baluchistan (Map ref. 34L/2), where it is about 40 feet in thickness and has been designated by Photographic Survey Corporation of Canada as Wakabi Limestone (Ref. 1, p. 175). The fauna in these localities includes, among others, the typical Upper Eocene genus *Pellatispira* which has not been reported from any locality in Sind. The presence of a break at the Oligocene/Eocene boundary in Sind has, therefore, been long suspected.

Faunal Evidence

A. Gaj River.—The fauna recorded from the Khirthar Limestone of Gaj River Section is shown in Fig. 1.

The basal 200 ft of the Khirthar Limestone (Sample Nos. FB.B. 5090—FB.B 5087) contains the typical Lutetian larger foraminifera as follows:

Assilina cancellata/subcancellata, Nuttall; A. papillata Nuttall; Nummulites perforatus (de Montfort); N. beaumonti, d'Archiac and Haime; Discocyclina dispansa, (Sowerbyi); D. sowerbyi, (Nuttall); D. undulata, Nuttall;

This fauna is succeeded by an assemblage of planktonic foraminifera (Sample Nos. FB.B. 5086 —FB.B. 5083) which indicates an uppermost Lutetian to basal Auversian age, and comprises the following species:

Porticulasphaera mexicana, (Cushman); Turborotalia centralis, (Cushman and Bermudez); T. crassata, (Cushman); Truncorotalides rohri, (Bolli); Globigerina linaperta, Finlay; G. yeguaensis pseudovenezuelana, Weinzierl and Applin; G. tripartita, (Koch); Globigerapsis cf. semiinvoluta, (Keijzer); Hantkenina cf. alabamensis, Cushman.

Sample FB.B. 5082, from 780 ft above the base of the Khirthar Limestone contains the first *Nummulites fichteli*, Michelotti indicating a Lattorfian age.

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Fig. 2.—Palaeontological Range Table. Grata Nala (Scale 1" to 50 ft.) Map ref, 35 $\,\mathrm{N}/\mathrm{12}$

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Fig. 3.—Palaentological Range Table. Nirani Nala (Scale:- 1" to 50 ft.) Map ref, 35 N/12

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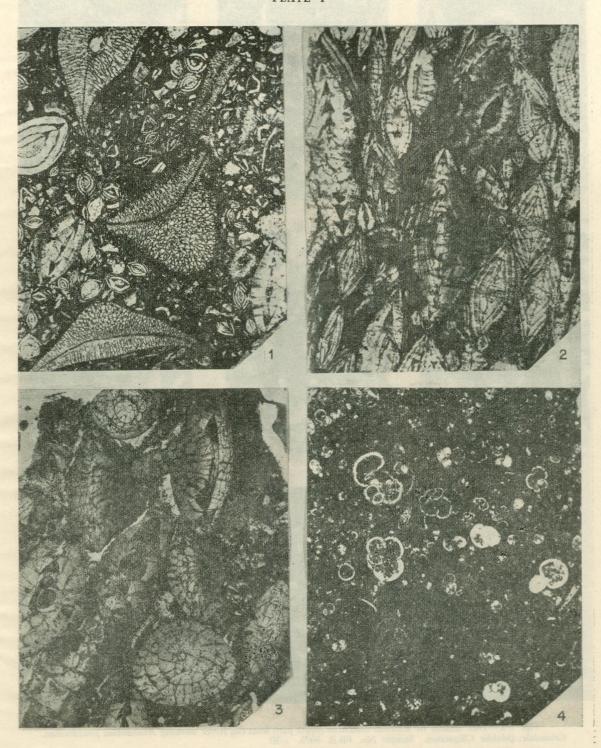
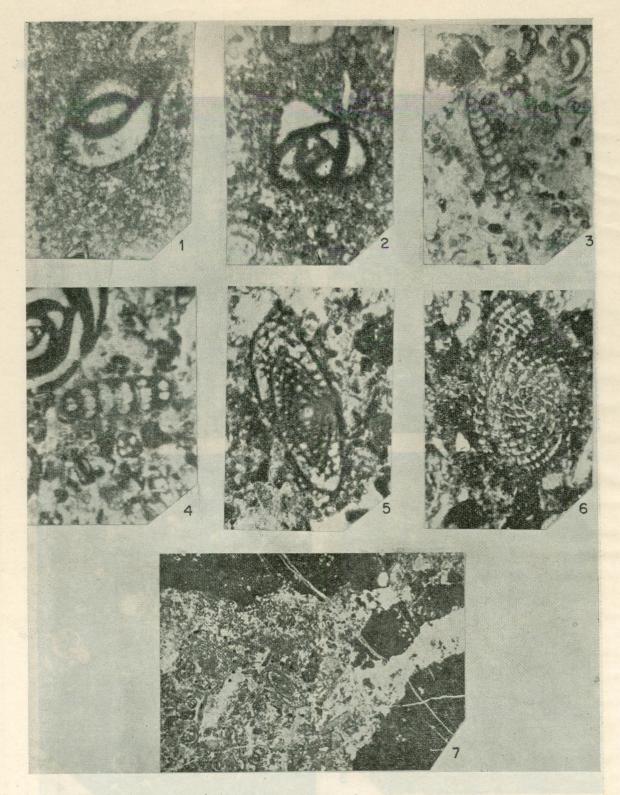


Fig. 1.—Thin section of Khirthar Limestone (lower part) from Gaj River with Discocyclina cf. dispansa, (Sowerbyi); Nummulites beaumonti, (meg.) d'Archiac and Haime; Assilina subcancellata, Nuttall; Nummulites sp; (Middle Eocene Sample No. FB.B.5110. \times 6

Fig. 2—Thin section of Khirthar Limestone (lower part) from Gaj River with Assilina cf. subpapillata, Nuttali; Nummulites subatacicus, Leymeri; (Middle Eocene). Sample No. FB.B. 5098. ×6

Fig. 3.—Thin section of Khirthar Limestone (lower part) from Gaj River with Assilina subcancellata, Nuttall; Nummulites perforata, (de Montfort); Aktinocyclina sp. (Middle Eocene). Sample No. FB. B. 5116. ×6

Fig. 4.—Thin section of Khirthar Limestone (upper part) from Gaj River with planktonic foraminifera *Turborotalia centralis*, (Cushman and Brmudez); *Sphaeroidinella senni*; Beckmann; (Middle Eocene). Sample No. FB.B. 5086, ×25



Figs 1-2.—Thin section of Khirthar Limestone (upper part) from Gaj River showing Austrotrillina paucialveolata, Grimsdale; (Middle Oligocene). Sample No. FB.B. 5075. $\times 30$

- Figs. 3-4.—Thin section of Khirthar Limestone from Nirani Nala, Badhra anticline showing Praerhapydionina delicata; Henson; (Middle Oligocene). Sample No. FB.B. 5831. \times 30
- Fig. 5.—Thin section of Khirthar Limestone from Nirani Nala, Badhra anticline showing *Peneroplis glynnjonesi*, Henson; axial section (Middle Oligocene). Sample No. FB. B. 5833. $\times 30$
- Fig. 6.—Thin section of Khirthar Limestone from Nirani Nala, Badhra anticline showing *Peneroplis glynnjonesi*, Henson; oblique equatorial ection (Middle Oligocene). Sample No. FB.B. 5825. $\times 30$
- Fig. 7.—Thin section of Khirthar Limestone conglomerate from Niran Nala, Bahra anticline showing reworked pebbles of probable Middle Eocene age in matrix with *Archaias operculiniformis*, Henson and *Peneroplis glynnjonesi*, Henson (Dotted Circles) (Middle Oligocene). Sample No. FB.B. 5833. ×7



Figs. 1 and 3.—Thin section of Khirthar Limestone (upper part) from Gaj River with Nummulites fichteli, Michelotti; Lepidocyclina (Eulepidina) dilatata, (Michelotti); Middle Oligocene). Sample No. FB.B. 5061×6

Fig. 2.—Thin section of Khirthar Limestone (upper part) from Gaj River with Nephrolepidina tournoueri, Lemoine; Heterostegina sp; Operculina sp. (Middle Oligocene). Sample No. FB.B. 5065. ×15

Fig. 4.—Thin section of Khirthar Limestone (upper part) from Gaj River with *Nummulites fichteli*, Michelotti; *Paleonummulites incrassatus*, (Fichtell and Moll); and reworked *Nummulites perforatus*; (de Monfort); (Circled) showing disseminated iron ore, rugged edge and thick rim of calcite (Middle Oligocene). Sample No. FB.B. 5082. ×6

There is a sampling gap of about 350 ft between sample FB.B. 5083 containing basal Auversian planktonic foraminifera and sample FB.B. 5082 which is of Lattorfian age. Fortunately this gap has been sampled by Messrs Pakistan Shell Oil Company from a narrow gorge which the Gaj River cuts through the Khirthar Range. The fauna recorded by them consists of:

Nummulites spp., Alveolina spp., Lockhartia spp., Nummulites beaumonti, d'Archiac and Haime; Fabiana sp., Asterigerina rotula, Kaufmann; Operculinoides sp., Hantkenina sp., and is not younger than basal Auversian. A large part of the Auversian and the entire Bartonian, which elsewhere are represented by the beds containing Pellatispira, are missing (text Fig. A).

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Text Fig. A.—Gaj River and Badhra Areas. (Time-Hiatus between eocene and oligocene.

It may be mentioned here that a change in lithology occurs at the level of sample FB.B. 5082 and this sample contains *Nummulites perforatus* (de Montfort) with disseminated iron ore, rugged periphery and thick rim of calcite suggesting that it has been reworked (Plate III, Fig. 4).

B. Badhra Area.—The faunas identified from the Nirani and Garata Nalas from Badhra area are shown in Figs. 2 and 3.

In the Nirani Nala the lower 203 ft of the Khirthar Limestone (Sample Nos. FB.B. 5965—FB.B.5947, FB.B. 5839—FB.B. 5836) is of Lutetian age and contains Nummulites gizehensis, (meg.) (Forsk), N. pinfoldi, Davies; N. acutus, Sowerbyi, Assilina papillata, Nuttall; Alveolina oblonga, d'Orbigny; Orbitolites complanatus, Lamarck.

There is an unfossiliferous interval of about 14 ft and the next sample FB.B. 5833 is from a limestone conglomerate of Middle Oligocene age containing reworked pebbles of probable Middle Eocene age in a matrix with Archaias operculiniformis, Henson and Peneroplis glynnjonesi, Henson (Plate II, Fig. 7).

The succeeding samples FB.B 5882—FB.B. 5793 are all of Rupelian age and contain the following fauna:

Archaias operculiniformis, Henson; Peneroplis glynnjonesi, Henson; Autrotrillina paucialveolata, Grimsdale; Praerhapydionina delicata, Henson; Palaeonummulites incrassatus, (Fichtell and Moll); Borelis pygamaea, Hanzawa; Nummulites fichteli, Michelotti; Eulepidina dilatata, (Michelotti);

As compared to the Gaj River the time-hiatus in the Badhra area appears to be of even greater magnitude, as the Upper Eocene is entirely absent and a large part, if not the whole, of the Lower Oligocene is unrepresented.

The faunal succession in the Garata Nala is similar to that found in the Nirani Nala. The lower 165 ft of the Khirthar Limestone in this section is of Middle Eocene age and the remaining upper 124 ft contains Middle Oligocene fauna.

Acknowledgement.—The writer is indebted to Dr. F.E. Eames for a critical examination of evidence and for his valuable suggestions, and to Dr. W.H. Blow for determining the planktonic foraminifera. He is indebted to Managers of Pakistan Petroleum Limited and Pakistan Shell Oil Company Limited for permission to publish this work.

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