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Foraminiferal biostratigraphy of Yadgar area, Muzaffarabad Azad Kashmir, Pakistan

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Abstract

At Yadgar in Muzaffarabad Azad Kashmir, **t**he Late Paleocene to Middle Eocene shallow water marine sequence overlies unconformably on the Cambrian carbonate unit of the Abbottabad Formation and includes the Hangu Formation, the Lockhart Limestone, the Patala Formation, the Margala Hill Limestone, the Chor Gali Formation and the Kuldana Formation. The Paleogene sequence is overlain by the Miocene Himalayan molasse of the Murree Formation. The genera Lockhartia, Ranikothalia, Assilina and Nummulites include Lockhartia tipperi (DAVIES), Lockhartia conditi (NUTTALL), Ranikothalia sindensis (DAVIES), Ranikothalia nuttalli (DAVIES), Assilina spinosa DAVIES and PINFOLD, Assilina subspinosa DAVIES and PINFOLD, Assilina laminosa GILL, Nummulites atacicus (LEYMERIE) and Nummulites mamillatus (FICHTEL and MOLL) are described and illustrated for the first time from the Upper Paleocene and Early to Middle Eocene beds in this region. The analyses of these larger benthic foraminifers suggest that the deposition of the Paleogene sequence occurred in a Neotethys warm and shallow marine environment in the Yadgar area, Muzaffarabad.

1. Introduction

Geologically the Yadgar area lies in the apex of western limb of the Hazara Kashmir Syntaxis (Fig. 1) which mostly comprises of sedimentary rocks. These rocks range in age from Cambrian to Miocene forming Middle Himalayan Mountain Belt (Table 1). However, this study describes and illustrates stratigraphically significant larger benthic foraminiferal assemblages present in the Paleogene sequence exposed in the Yadgar, Muzaffarabad, Azad Kashmir area. This area belongs to the eastern Tethyian region and was classic for the tropical to sub-tropical marine sedimentary deposition. The stratigraphic nomenclature has been adopted here after Shah (1977) having close stratigraphic relations to the adjoining area of Hazara, Kala Chitta, Kohat and Salt Range (Upper Indus Basin) Pakistan.

Table. 1. Stratigraphic succession of Yadgar Muzaffarabad, Azad Kashmir

Age	Formation
Miocene	Murree Formation
----------Unconformity----------	
Middle Eocene	Kuldana Formation
Early Eocene	Chor Gali Formation
Early Eocene	Margala Hill Limestone
Late Paleocene	Patala Formation
Late Paleocene	Lockhart Limestone
Early Paleocene	Hangu Formation
----------Unconformity----------	
Cambrian	Abbottabad Formation

The Paleogene sequence of the Lockhart Limestone, the Patala Formation, the Margala Hill Limestone and the Chor Gali Formation consists dominantly of limestone, shale and marl. The upper part of this sequence consisting of Middle Eocene Kuldana Formation includes variegated clay, sandstone, siltstone, mudstone and fossiliferous limestone layers and lenses. The Paleogene sedimentary units of the study area are characterized by the development of foraminiferal assemblages (Fig. 2). The foraminifers have an important role in biostratigraphic studies. In comparison to most other organisms the amount and distribution of foraminiferal data in the study area are vast and the environment of deposition varies from upper slope to outer shelf (Plates 1-4). These larger benthic foraminiferal species belong to genera Lockhartia, Ranikothalia, Assilina and Nummulites include *Lockhartia tipperi* (DAVIES), *Lockhartia conditi* (NUTTALL), *Ranikothalia sindensis* (DAVIES), *Ranikothalia nuttalli* (DAVIES), *Assilina spinosa* DAVIES and PINFOLD, *Assilina subspinosa* DAVIES and PINFOLD, *Assilina laminosa* (GILL), *Nummulites atacicus* (LEYMERIE) and *Nummulites mamillatus* (FICHTEL and MOLL). The analyses of these benthic foraminifers suggest that the deposition of the Paleogene sequence occurred in a Neotethys an open sea upper slope to outer shelf shallow marine environments.

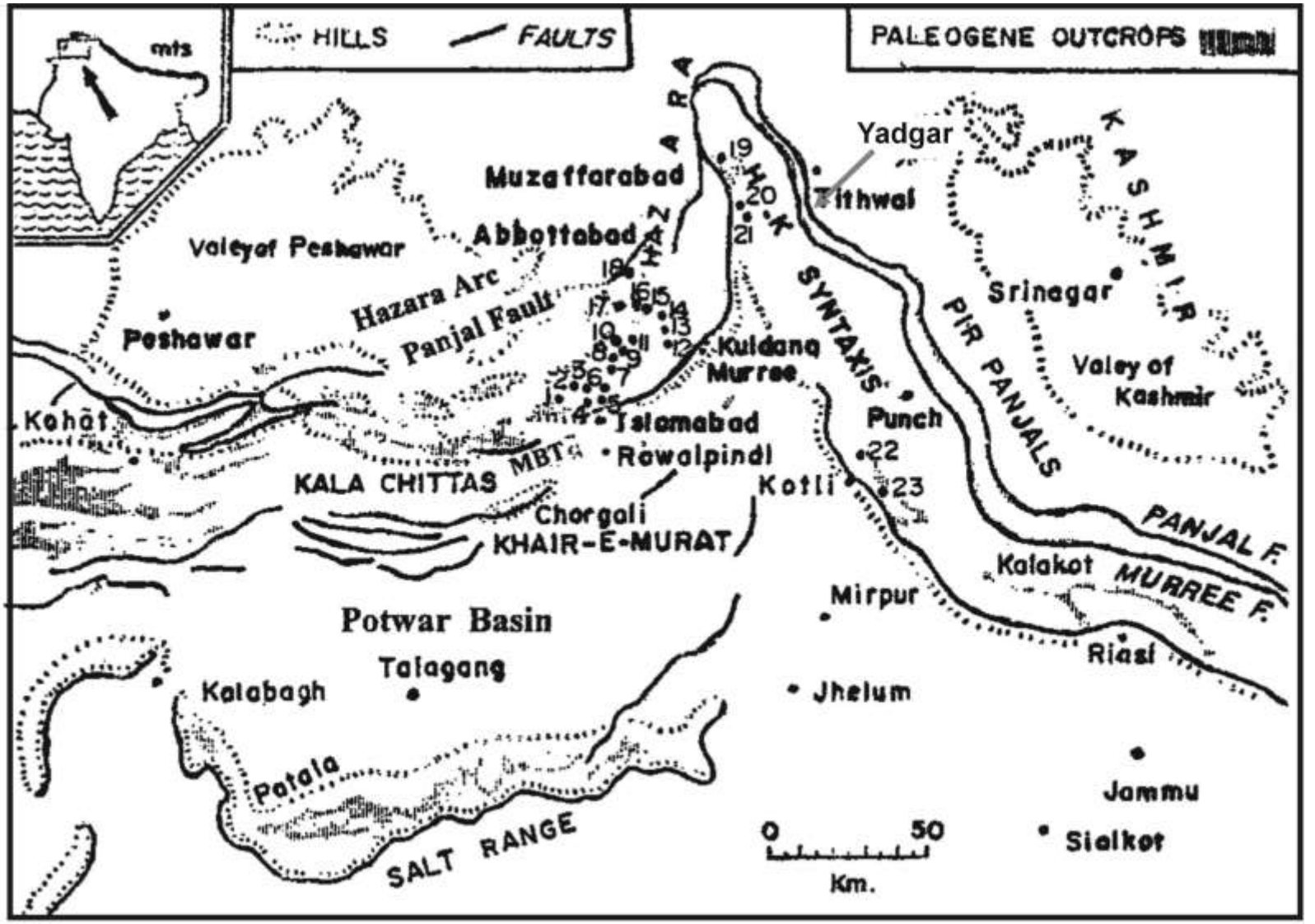

Fig.1. Location Map of Hazara Kashmir Syntaxis showing Yadgar Muzaffarabad area (modified after Wells and Gingrich, 1987).

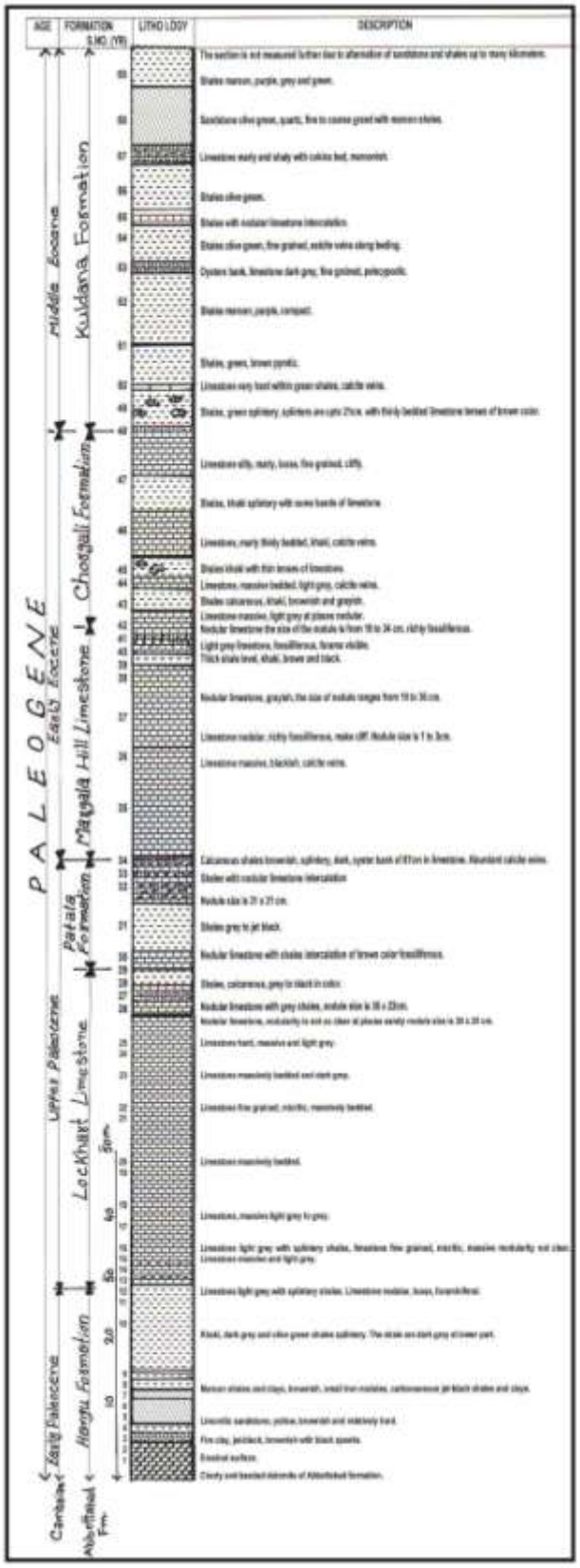

Fig. 2. Lithostratigraphic section of Yadgar, Muzaffarabad, Azad Kashmir.

Plate - 1

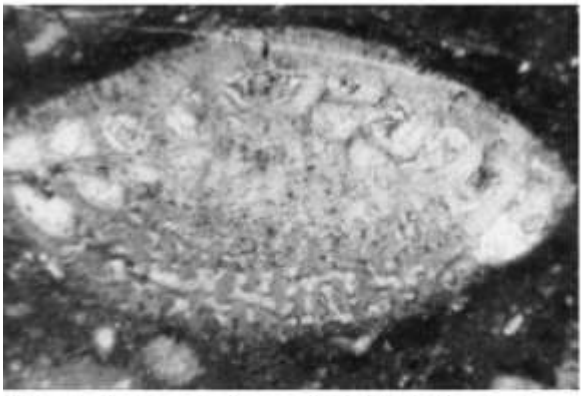

Plate 1a. *Lockhartia haimei* (DAVIES), Lockhart Limestone (X40).

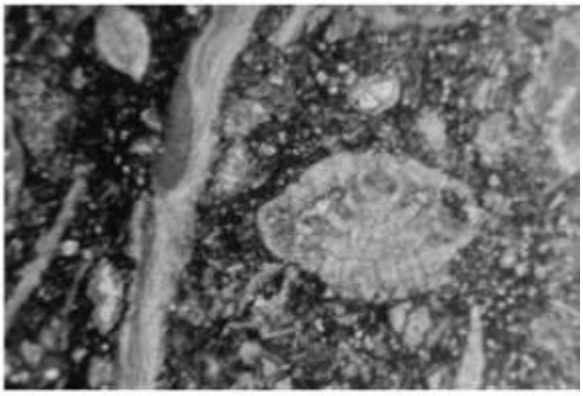

Plate 1b. *Lockhartia conditi* (NUTTALL), Lockhart Limestone (X40).

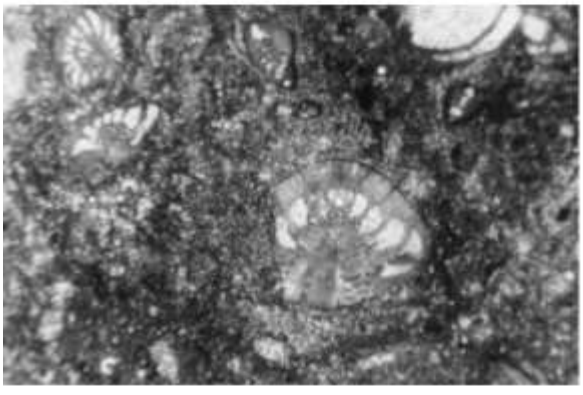

Plate 1c. *Lockhartia conditi* (NUTTALL), Patala Formation (X40).

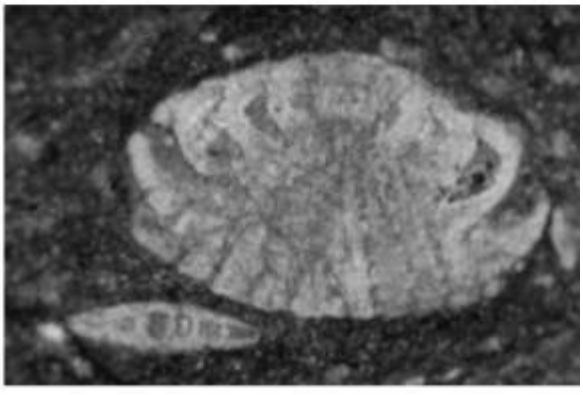

Plate 1d. *Lockhartia tipperi* (DAVIES), Margala Hill Limestone (X40).

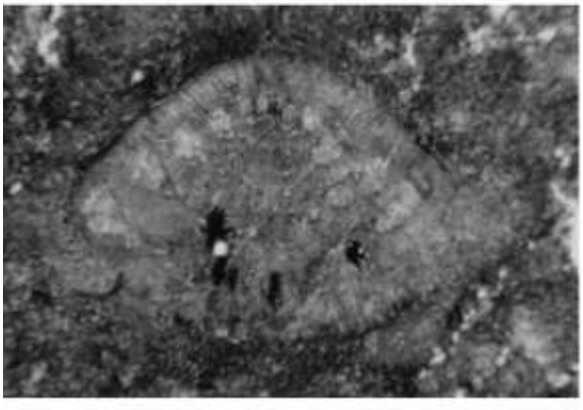

Plate 1e. *Lockhartia conditi* (NUTTALL), Patala Formation (X40).

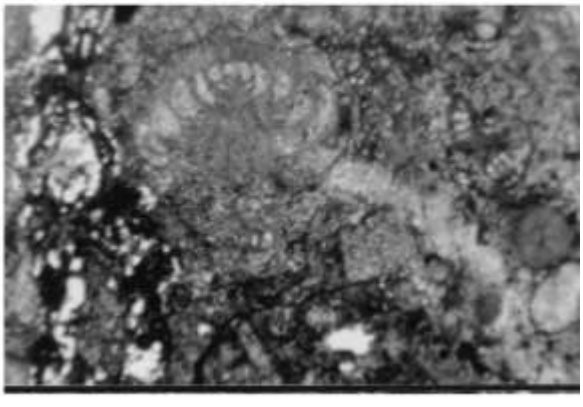

Plate 1f. *Lockhartia haimei* (DAVIES), Lockhart Limestone (X40).

Plate - 2

Plate 2a. *Ranikothalia sindensis* (DAVIES), Lockhart Limestone (X40).

Plate 2b. *Ranikothalia sindensis* (DAVIES) and *Miscellanea miscella* (d' ARCHIAC and HAIME), at the upper right corner, Lockhart Limestone (X40).

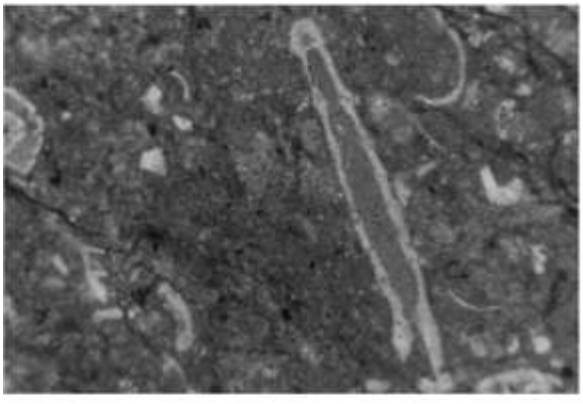

Plate 2c. *Ranikothalia sp.*, Lockhart Limestone (X40).

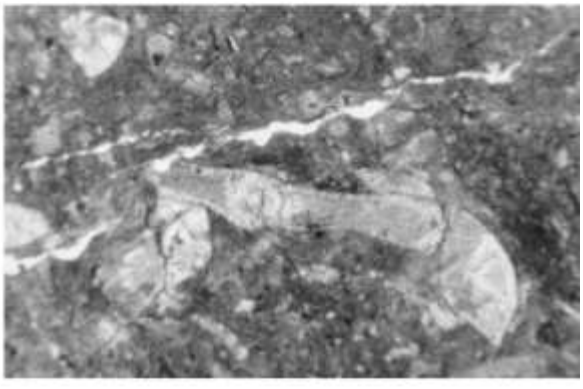

Plate 2d. *Ranikothalia sindensis* (DAVIES), Lockhart Limestone (X40).

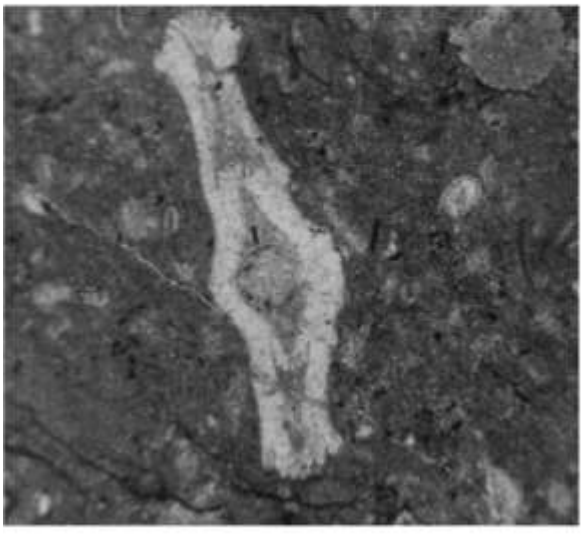

Plate 2e. *Ranikothalia sahni DAVIES*, Margala Hill Limestone (X40).

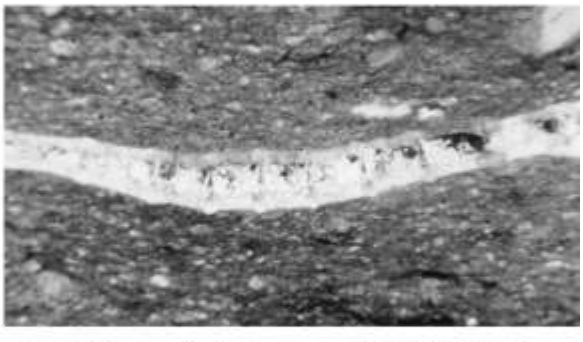

Plate 2f. *Ranikothalia sindensis* (DAVIES), Patala Formation (X40).

Plate - 3

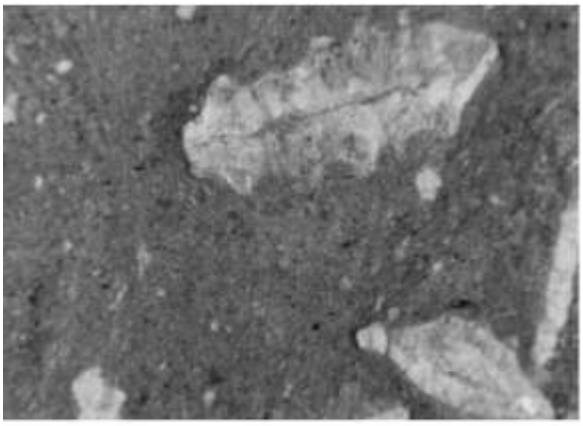

Plate 3a. *Assilina spinosa* DAVIES and PINFOLD, Margala Hill Limestone (X40).

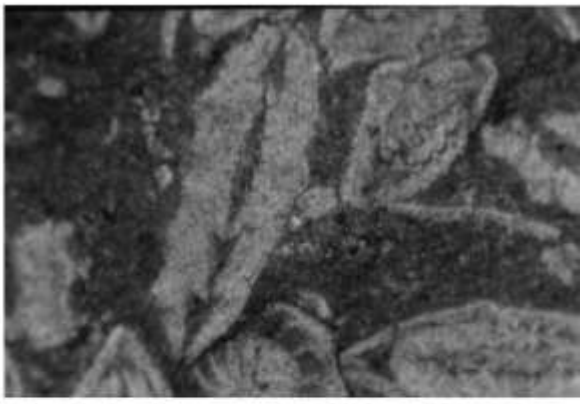

Plate 3b. *Assilina spinosa* DAVIES and PINFOLD, Margala Hill Limestone (X40).

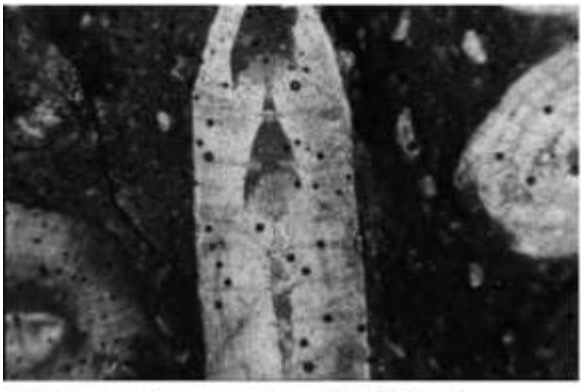

Plate 3c. *Assilina granulosa* (d' ARCHIAC), Margala Hill Limestone (X40).

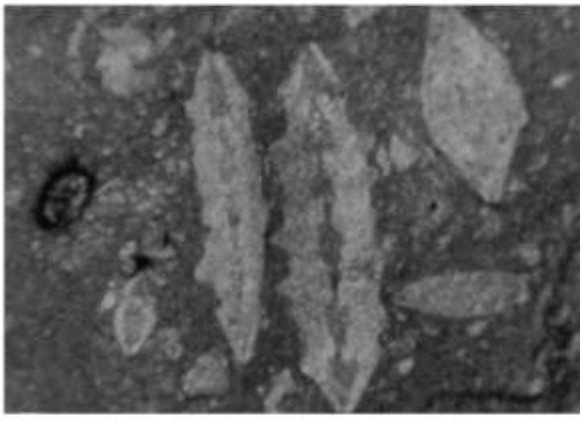

Plate 3d. *Assilina subspinosa* DAVIES and PINFOLD, Margala Hill Limestone (X40).

Plate 3e. *Assilina laminosa* (GILL), Margala Hill Limestone (YR41).

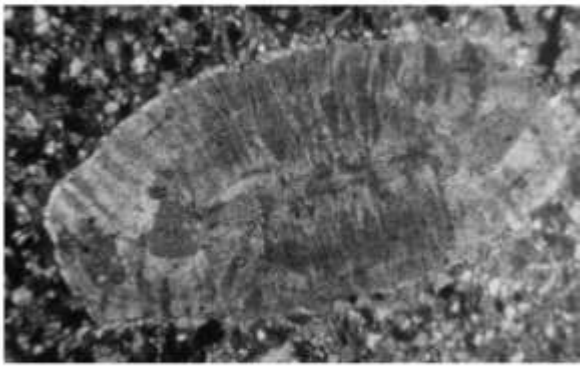

Plate 3f. *Assilina laminosa* (GILL), Chor Gali Formation (X40).

Plate - 4

Plate 4a. *Nummulites mamillatus* (FICHTEL and MOLL), showing the thick wall, numerous coils and umbilical pillars, Kuldana Formation (X40).

Plate 4b. *Nummulites atacicus* (LEYMERIE), Margala Hill Limestone (X40).

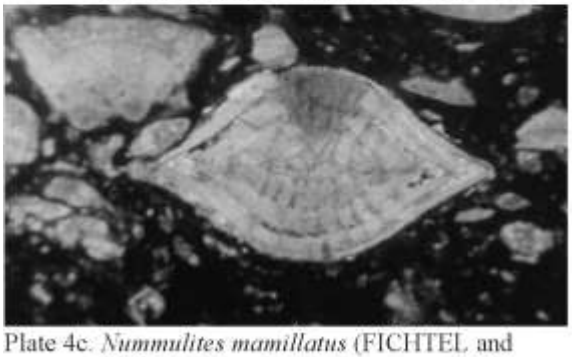

Plate 4c. *Nummulites mamillatus* (FICHTEL and MOLL), Margala Hill Limestone (X40).

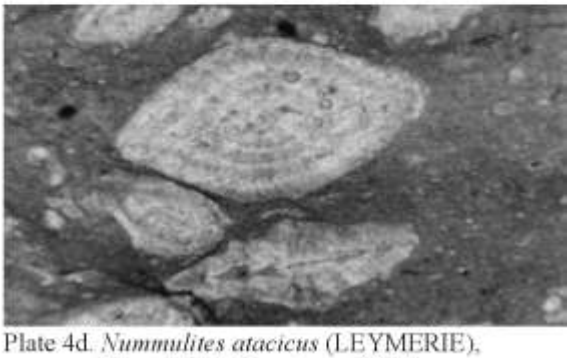

Plate 4d. *Nummulites atacicus* (LEYMERIE), Margala Hill Limestone (X40).

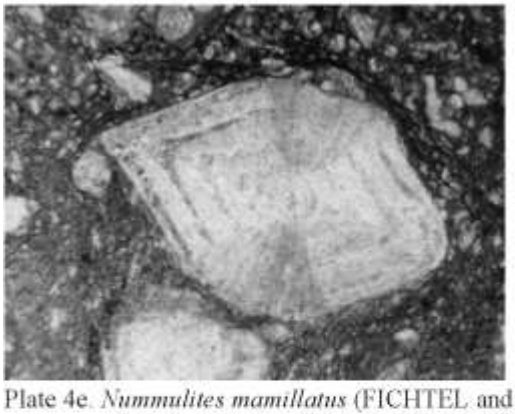

Plate 4e. *Nummulites mamillatus* (FICHTEL and MOLL), showing umbonal pillars, Kuldana Formation (X40).

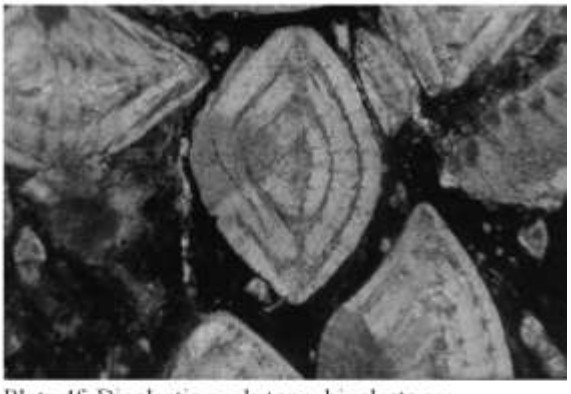

Plate 4f. Bioclastic packstone, bioclasts are *Nummulites sp.* Margala Hill Limestone (X40).

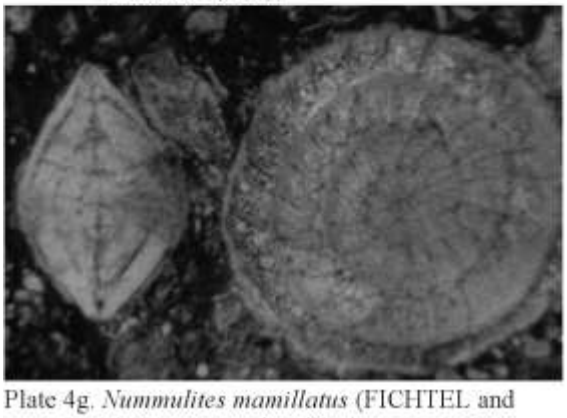

Plate 4g. *Nummulites mamillatus* (FICHTEL and MOLL), Margala Hill Limestone (X40).

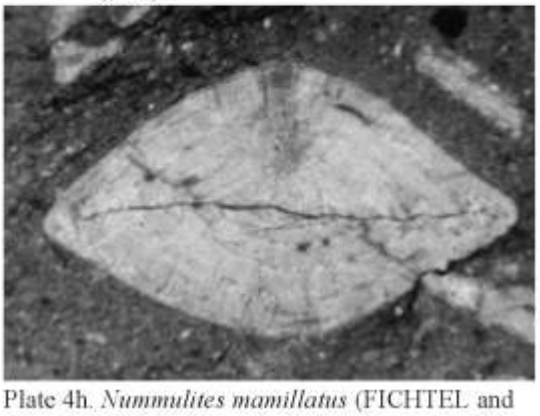

Plate 4h. *Nummulites mamillatus* (FICHTEL and MOLL), Margala Hill Limestone (X40).

2. Previous work

The study area has remained a site of deep interest for the geologists working on stratigraphy and tectonics since a long time (Vercher, 1867; Wadia, 1930; Nagappa, 1959; Ottiger, 1986). The geology and stratigraphy of this region was originally described by Medlicott in 1876 who gave the name as Hill Limestone to these rocks in this region. Wadia (1928) described the Tertiaries of Kashmir as "Subathu" of Eocene age alongwith Miocene Murree and Miocene-Pleistocene Siwalik Group having band at the Jhelum stretches eastwards through the Kashmir area, preserving all its geological characters and relations unchanged, to the Ravi and then to the Sutlij, where it merges into Kangra Himalayas. He correlated the Tertiaries of the Jammu hills to the corresponding rocks of the Kumaon and Simla Himalayas as "Hill limestone" and "Chharat" in the western Punjab, Kashmir Himalayas and northern part of Potwar as Eocene Subathu with Kumaon and Simla Himalayas. He placed the unconformity between the Eocene Chharat and Subathu strata and the Lower Miocene Lower Murree and Dagshai in Kashmir Simla Himalayas. The Swiss geologists Bossart et al. (1988), in collaboration with Institute of Geology Azad Jammu and Kashmir University and Ghazanfar et al. (1986) described the lithological, stratigraphic and structural features of Hazara-Kashmir Syntaxis. Greco (1991) described the stratigraphic and metamorphic features of the rocks of the Hazara-Kashmir Syntaxis. No work on the biostratigraphy was carried out by any above mentioned geologists in the area. This study is the first of its kind on the larger benthic foraminiferal Paleogene biostratigraphy of Yadgar area.

3. Material and methods

The description of the larger benthic foraminiferal species belong to genera Lockhartia, Ranikothalia, Assilina and Nummulites include Lockhartia tipperi (DAVIES), Lockhartia conditi (NUTTALL), Ranikothalia sindensis (DAVIES), Ranikothalia nuttalli (DAVIES), Assilina spinosa DAVIES and PINFOLD, *Assilina subspinosa* DAVIES and PINFOLD, *Assilina laminosa* (GILL), *Nummulites atacicus* (LEYMERIE) and *Nummulites mamillatus* (FICHTEL and MOLL) are based on 77 specimens recovered from 59 outcrop samples collected from stratigraphic section of Yadgar area (Figs. 1 and 2). All the species are represented by sufficient number of specimens for their proper identification. The aim of this study is to establish the paleogeographic setting of the Neotethys Ocean in the Yadgar area (Fig. 1) through the biostratigraphic approach. This will help to get an insight into the nature of the microfossil assemblages in the area and to provide a solid base for the correlation of Yadgar strata to reconstruct the depositional history of the basin for the Late Paleocene to Middle Eocene (Table 1). In three field trips to the section recorded the field information, measured the section and collected the samples from the top of Cambrian Abbottabad Formation to the base of Miocene Murree Formation (Fig. 2). The larger benthic foraminifers up to specific level were investigated from thin sections, oriented thin sections and in isolation. Conventional techniques were applied for the sample preparation. Trinocular stereo zoom microscope was used for identification and photography of the larger benthic foraminiferal population.

4. Biostratigraphy of the Paleogene sequence

The Paleogene sequence of Yadgar area is investigated for benthic larger foraminifers. For this purpose 59 rock samples are collected from the section. The distribution of 59 rock samples includes 11 from Hangu Formation, 17 from Lockhart Limestone, 6 from Patala Formation, 8 from Margala Hill Limestone, 6 from Chor Gali Formation and 11 from Kuldana Formation (Fig. 2). Samples are mainly from limestones and shales. The foraminiferal species are good index fossils for age determination of the rock units because these are restricted in stratigraphic ranges (Fig. 2). These species are quite common in the equivalent geological deposits of northern Pakistan and other parts of the world. This is the good criteria for the regional and inter-regional correlation of the strata using the age diagnostic species of foraminifers.

4.1. Lockhart Limestone

The Lockhart Limestone yields the following foraminiferal species (Plates 1-4). *Operculina salsa* DAVIES and PINFOLD, *Operculina subsalsa* DAVIES and PINFOLD, *Lockhartia haimei* (DAVIES), *Lockhartia tipperi* (DAVIES), *Lockhartia conditi* (NUTTALL), *Miscellanea miscella* (d'ARCHIAC and HAIME), *Ranikothlia sindensis* (DAVIES) and *Ranikothalia sp.*

The Lockhart Limestone is devoid of *Nummulites.* This confirms the studies of Cavelier and Pomerol (1983) that the *Nummulites* began to appear in the Eocene in various parts of the world and the Paleocene is marked by the absence of genus *Nummulites.*

The foraminiferal genus *Ranikothalia* also characterizes the Late Paleocene succession of Pakistan as well as in the world at many places. It sometimes extends into the Early Eocene. In addition, the strictly Late Paleocene species such as *Miscellanea miscella* (d'ARCHIAC and HAIME), *Daviesina langhami* (SMOUT), *Lockartia haimie* (DAVIES) and *Operculina subsalsa* (DAVIES and PINFOLD) also indicate the Late Paleocene age for Lockhart Limestone (Akhtar and Butt, 2000).

4.2. Patala Formation

The formation contains smaller foraminifers along with larger forams.

Operculina salsa DAVIES and PINFOLD, *Operculina subsalsa* DAVIES and PINFOLD, *Lockhartia haimei* (DAVIES), *Lockhartia tipperi* (DAVIES), *Lockhartia conditi* (NUTTALL), *Miscellanea miscella* (d'ARCHIAC and HAIME), *Daviesina langhami* SMOUT, *Ranikothlia sindensis* (DAVIES) and *Ranikothalia sp.* (Plates 1-4).

These species depict marine carbonate environments in hypersaline conditions and Late Paleocene age of the Patala Formation.

4.3. Margala Hill Limestone

The Margala Hill Limestone is highly fossiliferous. The formation contains foraminifera, mollusks and echinoids. The authors have carried out detailed work on the foraminiferal assemblage of the unit. For this purpose thin sections were studied from Yadgar area. The cumulative study of the thin sections has indicated the occurrence of the following foraminifers: *Nummulites atacicus* (LEYMERIE), *Nummulites mamillatus* (FICHTEL and MOLL), *Assilina granulosa* (d' ARCHIAC), *Assilina spinosa* DAVIES and PINFOLD, *Assilina laminosa* GILL, *Assilina subspinosa* DAVIES and PINFOLD, *Ranikothalia sindensis* (DAVIES), *Operculina patalensis* DAVIES and PINFOLD, *Lockhartia tipperi* (DAVIES) and *Lockhartia conditi* (NUTTALL).

On the basis of above mentioned microfossil assemblage an Early Eocene age is assigned to the Margala Hill Limestone (Plates 1-4).

4.4. Chor Gali Formation

The Chor Gali Formation is fossiliferous particularly in the lower part. It contains foraminifers, ostracods and smaller better mollusks. The foraminifera have been studied in detail from the formation. Their preservation is poor in many parts of the relevant areas. The following foraminifers are reported from the section of Yadgar area.

Assilina granulosa (d'ARCHIAC), *Assilina spinosa* DAVIES and PINFOLD, *Assilina subspinosa* DAVIES and PINFOLD, *Assilina laminosa* GILL, *Nummulites atacicus* (LEYMERIE), *Nummulites mamillatus* (FICHTEL and MOLL), *Lockhartia conditi* (NUTTALL) and *Lockhartia tipperi* (DAVIES).

On the basis of these microfossils assemblage an Early Eocene age is assigned to the Chor Gali Formation (Plates 1-4).

4.5. Kuldana Formation

The authors have identified foraminifera from the formation which include: *Assilina dandotica* (DAVIES), *Assilina granulosa* (d' ARCHIAC), *Assilina sp., Nummulites atacicus* (LEYMERIE), *Nummulites mamillatus* (FICHTEL and MOLL), *Nummulites sp.* and *Quinqueloculina sp.*

On the basis of above mentioned faunal assemblage a Middle Eocene age is assigned to the Kuldana Formation.

5. Conclusion

The genera of larger benthic foraminiferas observed in the Yadgar area are typical of Late Paleocene to Middle Eocene. The warm shallow water indicative genera *Miscellanea Operculina, Lockhartia, Assilina* and *Nummulites* of larger benthic foraminiferas observed in the Yadgar area are typical of Paleogene. The foraminiferal species *Miscellanea miscella* (d' ARCHIAC and HAIME), *Lockhartia haimei* (DAVIES) and *Operculina salsa* DAVIES and PINFOLD are restricted to Late Paleocene Lockhart Limestone and Patala Formation while *Lockhartia tipperi* (DAVIES), *Ranikothalia sindensis* (DAVIES), *Ranikothalia nuttali* (DAVIES) and *Assilina subspinosa* DAVIES and PINFOLD are of both Late Paleocene and Early Eocene age. The *Assilina spinosa* DAVIES and PINFOLD, *Assilina laminosa* (GILL), *Nummulites atacicus* (LEYMERIE) and *Nummulites mamillatus* (FICHTEL and MOLL) recorded from Margala Hill Limestone and the Chor Gali Formation are typical of Early Eocene age while the Kuldana Formation represent the age of Middle Eocene. The Paleocene-Eocene Boundary is placed by the disappearance of *Operculina salsa* DAVIES and PINFOLD and *Miscellanea miscella* (d' ARCHIAC and HAIME) and the appearance of *Nummulites atacicus* (LEYMERIE) and *Nummulites mamillatus* (FICHTEL and MOLL) in the upper part of the Patala Formation and the basal Margala Hill Limestone.

The whole succession from Late Paleocene to Middle Eocene was deposited by single cycle of transgression and regression in the Yadgar area.

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