MINERALOGICAL STUDIES OF GONDWANA SEDIMENTS FROM KORBA COALFIELD, MADHYA PRADESH— I. X-RAY MINERALOGY OF THE BULK SAMPLES, AND OPTICAL MINERALOGY OF THE SIEVE FRACTION (0.1-0 2 mm).

INDRA BIR SINGH* AND KRISHNA KUMAR SHARMA**

ABSTRACT

Mineralogical investigation of core samples of Lower Gondwana sediments from Korba Coalfield, Madhya Pradesh shows that the sediments are derived from metamorphic provinance with abundant garnet-bearing rocks. There are some changes in heavy mineral assemblages from lowermost part of the succession to the top. Plagioclase felspars are present only in lowermost Talchir deposits of glacial origin. Rest of the succession shows only alkali felspars; plagioclases are absent. Except for lowermost part, which is deposited by glacial agencies, deposition is typically fluvial in nature. Thick sandstone bodies are channel deposits, shale-coal successions are flood plain deposits.

INTRODUCTION

The sediments belonging to Gondwana System make a characterisitic succession of fresh-water terrestrial deposits. They are thick coal-bearing sedimentary deposits. They form a rather continuous sequence of sedimentary deposits starting from Middle Carboniferous through most of the Mesozoic. In general Gondwana sediments were laid down in isolated, faulted basins in the peninsular shield, where thick sedimentary successions were laid down in sinking basins. Classical studies on the Gondwana System are those by OLDHAM (1893), FOX (1931), and PASCOE (1959).

The Gondwana sediments are considered to be deposited mainly under fluvial conditions; only lowermost part, i.e. Talchir sediments are supposed to be deposited under glacial environment. Gondwana sediments are exceptionally rich in floral remains, thus detailed floral studies of these sediments have been done. During last decades sedimentological studies of Gondwana sediments have been extensively carried out. More recently, CASSYAP (1970), and SENGUPTA (1970) have studied sedimentary structures of the Gondwana rocks. However, detailed systematic mineralogical studies of Gondwana sediments are still lacking. In the present study core samples of a borehole from the Korba Coalfield (Borehole no. NCKB-19) are investigated mineralogically. Korba Coalfield is located within the basins of Mahanadi Valley, in Chhatisgarh region.

The main aim of this study was to investigate lithological and mineralogical variation in the succession. Moreover, as a detailed palynological study of this succession has been also done (BHARADWAJ & SRIVASTAVA, 1973) where some vegetational and climatic changes have been recorded, it was tempting to see whether or not such changes left their effect on mineralogical and lithological composition. A detailed profile like the one available provided a good opportunity to study such changes.

Selection of samples was based on the palynological zones and lithological units.

*Department of Geology, Lucknow University, Lucknow
**Institut f. Mineralogie, Lehrstuhl f. Kristallographie der Ruhr-Universität, D-463 Bochum, Postfach 2148. West Germany.

From each palynological zone samples of different lithology were taken. A total of 42 samples were selected from a sequence of a 690 m of sedimentary succession.

METHOD OF STUDY

A small portion of a sample was crushed and finely powdered so that no grains were felt when rubbed between the fingers. Sample powder was mounted on a slide and a X-ray diffractogram was prepared. Each peak was observed, and its d-spacings were calculated, and the mineral was identified. A rough semi-quantitative estimate of relative abundance of various minerals was done by comparing the peak heights of the maximum intensity lines.

The uncrushed part of the sample was disintegrated, and sieved through a set of sieves and various size fractions were separated. Grain slide was prepared out of the fraction 0.1-0.2 mm, and studied under polarisation microscope for the various minerals.

Aim of this paper is to provide some preliminary data on mineralogy of the Gondwana sediments of Korba Coalfield. More detailed studies of the heavy minerals, quartz surface morphology, silt fraction, and clay fraction were also carried out and shall be published in due course.

DESCRIPTION OF BOREHOLE PROFILE

The borehole no. NCKB-19 penetrates through a sequence of sedimentary rocks of Lower Gondwana age. Total thickness encountered in the borehole is 690 m.

BHARADWAJ and SRIVASTAVA (1973) have studied in detail the mioflora from this sequence and were able to establish three major palynological zones, each of which was further divided into two subzones. Each subzone is characterized by a definite miofloral assemblage, and climatic conditions (see table 1).

Table 1—Six zones recognized by miofloral studies and inferred palaeoclimate of each zone (After BHARADWAJ & SRIVASTAVA, 1973)

Zone No.	Core depth	Climate
Zone III B	271— 0 m	Cool and very humid (warm temperate with increased humidity)
Zone III A	472—271 m	Cool and humid (warm temperate)
Zone II B	519—472 m	Cool and dry
Zone II A	576—519 m	Very cold and humid (very cold temperate)
Zone I B	668—576 m	Cool and humid (Cold temperate)
Zone I A	690—668 m	Very cold and dry (Glacial conditions)

The lowermost 20 m thickness of the succession shows marked characteristics of glacial origin. Sediments are poorly sorted, angular gravel of metamorphic rocks are abundant, and content of matrix is high. Rocks are greenish in colour in lower part, becoming dark-grey in upper part. They belong to the Talchir Stage.

On the top of Talchir sediments follows a sequence of sandstones, shales and coal. Thick sandstone horizons are interbedded with thin shale and coal layers. The whole profile is built up in a cyclic fashion. Thick, medium to coarse-grained sandstones are overlain by relatively thin shale-coal-sandstone alternation. Such cycles are characteristic of fluvial sediments. Thick coarse-grained sandstone bodies can be regarded as channel deposits, whereas, fine-grained shale-coal-sandstone succession seems to represent flood-plain deposits, including both natural levee and flood-basin deposits. It is in the flood-plain deposits that the coal seams are formed. Lithology of borehole is shown in text-figure 1.

A short account of the lithology of each subzone is given below :

Zone I A (690-668 m)—Sediments of lowermost part of this zone are greenish in colour. Metamorphic rock fragments are abundant. In upper part, the colour changes to dark-grey. In the lowermost part, pollen and spores are sporadic and few, while they are significant in upper part. However, they belong to same mioflora. This suggests that the climatic conditions during deposition of upper part of Talchir became rather mild as to allow abundant vegetation to supply large quantities of spores and pollen.

Zone I B (668-576 m)—This zone consists of interbedded thin standstone and shale layers near the base, followed by thick sandstones with shale and coal layers at the top of each sandstone layer.

Zone II A (576-519 m)—This zone starts with an almost 50 m thick standstone body with a 10 m thick sequence of shale, coal and standstone intercalations at the top.

Zone II B (519-472 m)—This zone is made up of mostly standstone with few thin coal layers.

Zone III A (472-271 m)—This zone starts with a hundred metre thick sandstone accompanied by a 5 m thick shale-coal-sandstone horizon on the top. Rest of it also contains thick sandstone and thin shale-coal layers.

Zone III B (271-0 m)—In the lower part, this zone contains thick sandstone bodies with few metre thick shale-coal intercalations. In the upper part, thick coal seams are developed. Thickest coal seam is 35 m in thickness. On the top a 60 m thick coarse-grained sandstone caps the sequence.

MINERALOGY OF SAMPLES

In the following account, the results of mineral determination of bulk samples by X-ray and mineral grain studies of fraction 0.1-0.2 mm are given. Various minerals identified here are listed in decreasing order of abundance.

Sample no. 1 (Core depth—18.28 m) Coarse-grained standstone.

X-ray determination: Quartz—abundant, kaolinite—abundant, felspar—common.

Optical determination: Quartz—abundant, mostly angular grains, few grains are rounded; felspar—alkali felspar, both orthoclase and microcline. Grains strongly weathered, only few grains are fresh; mica—muscovite, light green to pale in colour, partly colourless; biotite—only few grains are present; accessory minerals—zircon.

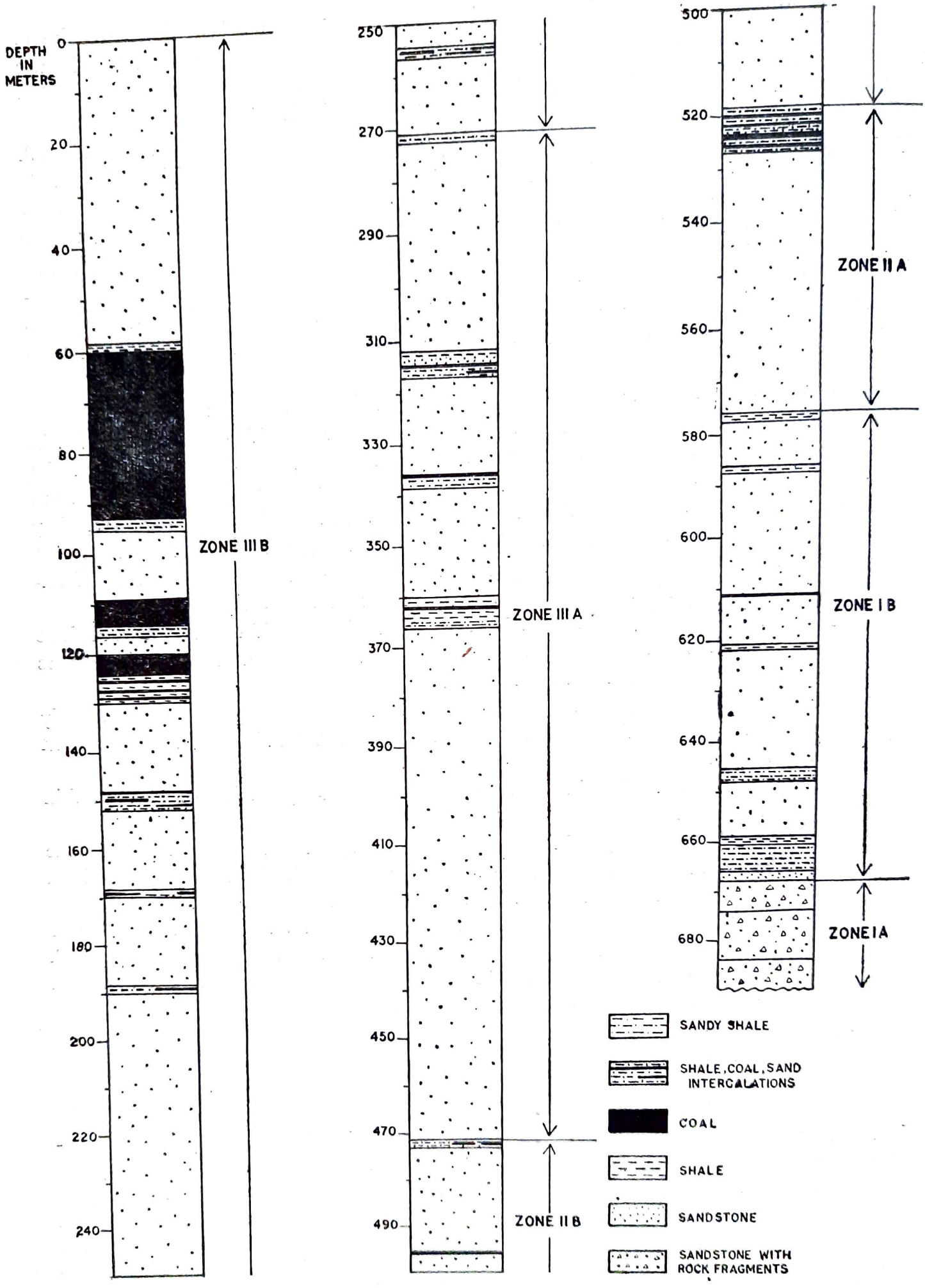

FIG.1 LITHOLOGICAL SUCCESSION OF THE BOREHOLE NO.NCKB-19, KORBA COALFIELD. (M.P.)

Sample no. 4 (Core depth—39.20 m) Coarse-grained sandstone.

X-ray determination: Same as sample no. 1.

Optical determination: same as sample no. 1; accessory minerals—tourmaline, hematite, epidote, apatite.

Sample no. 6 (Core depth—44.57 m) Coarse-grained sandstone.

X-ray determination: Quartz—abundant, kaolinite—abundant, felspar—common.

Optical determination: Same as sample no. 1, accessory minerals—garnet, biotite, chlorite, zircon, apatite, tourmaline, epidote.

Sample no. 9 (Core depth—95.30 m) medium grained sandstone; all characteristics same as in sample no. 6.

Sample no. 10 (Core depth—97.00 m) Medium grained sandstone.

X-ray determination: Quartz—very abundant, felspar—abundant, kaolinite—common.

Optical determination: Quartz—abundant, angular to subangular grains, few grains rounded; felspar—very little in amount, only alkali felspar (both orthoclase and microcline); mica—mostly muscovite, few grains of biotite; accessory minerals—zircon, tourmaline, epidote, chlorite.

Sample no. 12 (Core depth—114.50 m) Sandy shale.

All characteristics same as sample no. 10, except that heavy minerals are absent, only few opaque grains are present.

Sample no. 14 (Core depth—117.50m) Coarse-grained sandstone.

X-ray determination: Quartz—very abundant, felspar—common to little, kaolinite—very little.

Optical determination: Quartz—mostly angular grains; felspar—microcline-orthoclase, partly fresh, partly altered grains; mica—mostly muscovite, few grains of biotite; accessory minerals—tourmaline, baryte, garnet, zircon, andalusite.

Sample no. 15 (Core depth—129.84 m) Shaly coal.

X-ray determination: Quartz—very abundant, kaolinite—little, felspar—little.

Optical determination: Quartz—abundant, angular elongated grains; felspar—alkali felspar (microcline), strongly altered grains; mica—mainly muscovite, few grains of biotite; accessory minerals—tourmaline.

Sample no. 20 (Core depth—148.84 m) Medium grained sandstone.

X-ray determination: Quartz—very abundant, kaolinite—little, felspar—very little.

Optical determination: Quartz—abundant, angular to rounded grains; felspar—orthoclase and microcline; mica—muscovite, few grains of biotite; accessory minerals—tourmaline, garnet, opaques, barytes, chlorite.

Sample no. 21 (Core depth—150.90 m) Shaly coal.

X-ray determination: Quartz—abundant, kaolinite—very little, felspar—absent.

Optical determination: Quartz—mostly angular grains, few rounded grains; mica—muscovite and subordinate biotite; accessory minerals—chlorite, zircon, garnet, epidote, opaques, hornblende.

Sample no. 28 (Core depth—189.80 m) Shaly coal.

X-ray determination: Kaolinite—abundant, quartz—little.

Optical determination: Quartz—abundant mostly sub-rounded grains; felspar—only few grains of microcline; mica—muscovite, few grains of biotite; accessory minerals—opaques, chlorite, hematite, garnet.

Sample no. 35 (Core depth—229.61 m) Medium grained sandstone.

X-ray determination: Quartz—very abundant, kaolinite—little, felspar—little.

Optical determination: Quartz—abundant, elongated, angular grains, felspar—orthoclase-microcline, grains are slightly altered; mica—muscovite, few grains of biotite; accessory minerals—garnet, tourmaline, zircon.

Sample no. 40 (Core depth—257.27 m) Medium-grained sandstone.

X-ray determination: Quartz—abundant, kaolinite—abundant, felspar—little.

Optical determination: Quartz—abundant, mostly angular grains; felspar—few grains of altered microcline; mica—muscovite, few grains of biotite; accessory minerals—garnet, chlorite, barytes.

Sample no. 42 (Core depth—271.32 m) Sandy shale.

Characteristics same as in sample no. 40, except that of relative abundance of accessory minerals—opaques, chlorite, epidote, garnet.

Sample no. 48 (Core depth—298.50 m) Coarse-grained sandstone.

X-ray determination: Quartz—very abundant, felspar—common, kaolinite—little.

Optical determination: Quartz—dominantly angular to rounded grains; felspar—altered grains of orthoclase—microcline; mica—mainly muscovite, few grains of biotite; accessory minerals—chlorite, tourmaline.

Sample no. 52 (Core depth—312.80 m) Sandy shale.

X-ray determination: Kaolinite—abundant, quartz—very little.

Optical determination: Sample consists of mainly dark-coloured aggregates, quartz, mica, and opaques.

Sample no. 55 (Core depth—316.00 m) Shaly sandstone.

X-ray determination: Quartz—abundant, kaolinite—little, felspar—little.

Optical determination: Quartz—angular to sub-rounded grains; felspar—very little, altered microcline grains; mica—muscovite and biotite; accessory minerals—tourmaline, hornblende.

Sample no. 56 (Core depth—316.80 m) Sandy shale.

Most of the characteristics similar to that of sample no. 55. Accessory minerals—tourmaline, garnet.

Sample no. 57 (Core depth—318.50 m) Medium grained sandstone.

X-ray determination: Quartz—very abundant, kaolinite—little, felspar—little.

Optical determination: Quartz—dominantly angular to rounded grains; felspar—orthoclase-microcline; mica—muscovite; accessory minerals—chlorite, opaques, garnet.

Sample no. 61 (Core depth—337.60 m) Sandy shale.

X-ray determination: Quartz—abundant, kaolinite—common, felspar—very little.

Optical determination: Quartz—abundant, mostly rounded grains, few angular grains; felspar—orthoclase-microcline, very few grains, highly altered; mica—greenish muscovite; accessory minerals—opaques, garnet.

Sample no. 66 (Core depth—360.25 m) Coarse-grained sandstone.

X-ray determination: Quartz—abundant, felspar—abundant, kaolinite—common.

Optical determination: Quartz—abundant, angular grains; felspar—common, orthoclase-microcline, partly fresh, partly altered; mica—muscovite; accessory minerals—garnet.

Sample no. 68 (Core depth—360.95 m) Shale.

X-ray determination: Quartz—very abundant, kaolinite—little, felspar—very little.

Optical determination: Quartz—abundant, brownish grains; felspar—few grains, strongly altered; mica—muscovite; accessory minerals—absent.

Sample no. 71 (Core depth—365.50 m) Medium grained sandstone.

X-ray determination: Quartz—very abundant, felspar—common, kaolinite—very little.

Optical determination: Quartz—both rounded and angular grains; felspar—strongly altered grains of orthoclase-microcline; accessory minerals—tourmaline.

Sample no. 77 (Core depth—413.70 m) Medium grained sandstone.

X-ray determination: Quartz—abundant, felspar—abundant, kaolinite—very little.

Optical determination: Quartz—abundant, angular to rounded grains; felspar—microcline, partly fresh grains; mica—muscovite, few grains of biotite; accessory minerals—absent.

Sample no. 83 (Core depth—443.50 m) Coarse-grained sandstone.

X-ray determination: Quartz—very abundant, felspar—little, kaolinite—very little.

Optical determination: Quartz—abundant, angular, elongated grains; felspar—strongly altered grains of microcline; mica—muscovite; accessory minerals—garnet, tourmaline, zircon, opaques.

Sample no. 91 (Core depth—472.30 m) Shaly sandstone.

X-ray determination: Quartz—very abundant, kaolinite—little.

Optical determination: Quartz—abundant, angular grains coated with iron-oxide; mica—muscovite, few grains of biotite; accessory minerals—garnet.

Sample no. 93 (Core depth—473.00 m) Shaly sandstone.

X-ray determination: Kaolinite—very abundant, quartz—abundant, felspar—little.

Optical determination: Quartz—abundant, angular to rounded grains; felspar—altered grains of microcline; mica—muscovite; accessory minerals—opaques, chlorite.

Sample no. 95 (Core depth—474.90 m) Medium grained standstone.

X-ray determination: Quartz—very abundant, felspar—little, kaolinite—very little.

Optical determination: Quartz—abundant, angular and rounded grains; felspar—strongly altered microcline; mica—muscovite, few grains of biotite; accessory minerals—garnet, opaques, chlorite.

Sample no. 100 (Core depth—517.75 m) Medium grained sandstone.

X-ray determination: Quartz—abundant, felspar—little, kaolinite—very little.

Optical determination: Quartz—abundant, mostly elongated, angular grains; felspar—microcline-orthoclase, partly fresh, partly altered grains; mica—muscovite; accessory minerals—garnet, chlorite.

Sample no. 103 (Core depth—519.20 m) Shale.

X-ray determination: Kaolinite—very abundant, quartz—very little.

Optical determination: Quartz—many grains show rounding; mica—muscovite, some biotite; accessory minerals—chlorite, opaques.

Sample no. 107 (Core depth—523.39 m) Gray shale.

X-ray determination: Quartz—very abundant, kaolinite—little, felspar—very little.

Optical determination: Quartz—abundant, mostly rounded grains, only few grains angular; felspar—strongly altered grains; mica—muscovite; accessory minerals—opaques.

Sample no. 111 (Core depth—525.99 m) Medium grained sandstone.

X-ray determination: Quartz—very abundant, kaolinite—little, felspar—very little.

Optical determination: Quartz—abundant; felspar—strongly altered grains of microcline; mica—muscovite; accessory minerals—opaques, chlorite, tourmaline.

Sample no. 114 (Core depth—527.10 m) Shale.

X-ray determination: Kaolinite—very abundant, quartz—abundant.

Optical determination: Quartz—abundant, mostly rounded grains; felspar—few altered grains of microcline; mica—muscovite; accessory minerals—chlorite.

Sample no. 117 (Core depth—548.50 m) Very coarse-grained sandstone.

X-ray determination: Quartz—abundant, felspar—abundant, kaolinite—very little.

Optical determination: Quartz—abundant, angular grains; felspar—microcline, partly altered, partly fresh grains; mica—muscovite; accessory minerals—chlorite, garnet, zircon.

Sample no. 121 (Core depth—621.15 m) Shale.

X-ray determination: Quartz—abundant, felspar—common, kaolinite—little, chlorite—little.

Optical determination: Quartz—both rounded and angular grains are present; felspar—microcline; mica—muscovite; accessory minerals—chlorite, opaques, garnet, zircon.

Sample no. 127 (Core depth—649.10 m) Medium grained standstone.

X-ray determination: Quartz—very abundant, kaolinite—very little.

Optical determination: Quartz—mostly rounded grains, only few angular grains; felspar—few grains of altered microcline; mica—muscovite; accessory minerals—opaques, garnet.

Sample no. 130 (Core depth—660.50 m) Shale.

X-ray determination: Quartz—very abundant, felspar—little, kaolinite—very little.

Optical determination: Quartz—both angular and rounded grains; felspar—microcline, altered grains; accessory minerals—chlorite, opaques.

Sample no. 132 (Core depth—666.15 m) Sandy shale.

X-ray determination: Quartz—very abundant, felspar—little, kaolinite—very little.

Optical determination: Quartz—abundant, both rounded and angular grains; felspar—microcline, altered grains; mica—muscovite, few grains of biotite; accessory minerals—opaques, garnet.

Sample no. 134 (Core depth—668.90 m) Black shaly sandstone.

X-ray determination: Quartz—abundant, calcite—little, felspar—very little, kaolinite—traces.

Optical determination: Quartz—both rounded and angular grains; calcite—almost 10% of the sample; felspar—microcline, one or two grains of plagioclase; mica—muscovite; accessory minerals—opaques, garnet.

Sample no. 136 (Core depth—674.55 m) Shaly sandstone.

X-ray determination: Quartz—very abundant, calcite—very little, felspar—very little, kaolinite—traces.

Optical determination: Quartz—mostly angular grains, calcite—little, felspar—microcline, strongly altered grains; accessory minerals—opaques, garnet.

Sample no. 142 (Core depth—685.05 m) Sandstone with pebbles.

X-ray determination: Quartz—very abundant, felspar—very little, kaolinite—traces.

Optical determination: Quartz—both rounded and angular grains; felspar—

altered grains, both alkali and plagioclase-felspars are present; mica—muscovite, few grains of biotite; accessory minerals—opaques, garnet.

Sample no. 144 (Core depth—688.00 m) Sandstone with pebbles.

X-ray determination: Quartz—very abundant, felspar—common, kaolinite—traces.

Optical determination: Quartz—abundant, both rounded and angular grains; felspar—both plagioclase and orthoclase are present, grains are partly fresh, partly altered; mica—muscovite, few grains of biotite; accessory minerals—garnet, opaques.

DISCUSSION AND CONCLUSION

The main mineralogical characteristics of each zone can be summarized as follows:

Zone IA—Quartz and felspar are abundant, kaolinite is present only in traces. Both plagioclases and alkali felspar are present. In the samples of the lowermost part, plagioclase grains are more in number and rather fresh. Some calcite is present in samples 136 and 134; it has been formed most probably due to an alteration of plagioclases during diagenesis.
Garnet and opaques are the accessory minerals.

Zone IB—Quartz, felspar and kaolinite are the major minerals present in varying abundance. However, felspar is always a subordinate mineral. Felspars are represented only by alkali felspars. They are mostly altered grains of microcline. Accessory minerals are garnet and opaques; few samples contain chlorite and zircon.

Zone IIA—Quartz, felspar and kaolinite are present in varying amounts. Felspars are represented by microcline; and grains are mostly altered. A few samples totally lack the felspars.
Opaques, chlorite, garnet, and zircon are the accessory minerals. Chlorite is dominant in several samples.

Zone IIB—Quartz, felspar and kaolinite are present in varying abundance. Only alkali felspars are present.
Accessory minerals are garnet, chlorite and opaques. Chlorite is commonly present.

Zone IIIA—Quartz, felspar and kaolinite are major minerals present in varying amounts. Only alkali felspars are present.
Accessory minerals are garnet, tourmaline, zircon, opaques, chlorite, hornblende and epidote. Presence of tourmaline is rather characteristic.

Zone IIIB—Quartz, felspar and kaolinite are present in varying amounts. Only alkali felspars are present, which are represented by microcline and orthoclase.
Accessory minerals are garnet, chlorite, barytes, tourmaline, zircon, opaques, andalusite, apatite and epidote. Barytes is the mineral present only in this zone.

If we analyse the mineralogical results, we can conclude that source rocks for the whole succession were mainly metamorphic rocks of low to medium grade of metamorphism. In the provenance garnet bearing rocks were most abundant, and provide material throughout the sequence. There are some minor changes in the nature of heavy minerals.

Zone IA and IB contain almost exclusively garnet and opaques. Zone IIA and IIB are marked by the presence of chlorite along with garnet and opaques. Zone IIIA and IIIB are characterized by the presence of tourmaline; barytes, andalusite, and apatite are also present. Plagioclase felspars are present only in zone IA, suggesting thereby a lack of intense weathering in source area. This is justified by glacial climate during deposition of zone IA, as also indicated by mioflora.

Miofloral evidences suggested revival of very cold climate during deposition of zone IIA. However, this climatic change is not impressed upon lithology and mineralogy.

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