SOURCE ROCK PALYNOLOGY OF SUBATHU SEDIMENTS OF SIMLA HILLS*

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Abstract

The paper embodies results of palynofacies and thermal viz., alteration studies (TAI) carried out in three energy sequences, viz., Dharmpur, Kumarhatti and Makreri exposed in Talheri Ki Nadi, Nora Khondal Chakli khud, Barog Kumarhatti, Koshalia River and Kasauli-Dharmpur travarses of Simla Hills.

Sapropelic organic matter constitutes the dominant type in Dharmpur and Kumarhatti energy sequences, while Makreri is dominated by humic matter. TAI values of 2.5 to 2.75+ suggest that the sediments are within the hydrocarbon generation phase.

Introduction

The results of palynofacies have been presented with a view to evaluate organic matter typing, facies and thermal alteration studies carried out on the Subathu Groups of sediments exposed in Simla Hills.

Raiverman (1972) and Raiverman *et al.* (1976) proposed a time stratigraphic classification based on the principle of Energy Sequence for the Cenozoic strata in the foothills of Himachal Pradesh and subsequently these units are correlated (Raiverman *et al.*, 1983) with the Himalayan foot-hills and Gangetic plains of Uttar Pradesh and Bihar. The eight Enegy Sequences in Himachal Pradesh are :

En. Seq. I	—	Dharmpur
En. Seq. II	—	Kumarhatti
En. Seq. III	—	Dharmsala/Makreri
En. Seq. IV	—	Jawalamukhi
En. Seq. V	—	Kalidhar
En. Seq. VI	—	Garchandi
En. Seq. VII	—	Kamlagarh
En. Seq. VIII	—	Neogal

The terrace deposits in the hills and thick alluvium covering the Indo-Gangetic plains constitute nineth and the youngest unit. The material studied was collected from three Energy Sequences, viz., En. Seq. I (Dharmpur), En. Seq. II (Kumarhatti) and En. Seq. III (Makreri) of Talheriki Nadi, Nora Khondal Chakli Khud, Barog Kumarhatti, Koshalia River and Kasauli-Dharmpur traverses in Bilaspur-Surajpur area in Simla region (Text-fig. 1). The outcrop samples studied here are mainly shales intercalated with hard shaly microcrystalline limestone and siltstone.

The En. Seq. I (Dharmpur), En. Seq. II (Kumarhatti) and En. Seq. III (Makreri/Dharmsala) are dated as Palaeocene to Middle Eocene, Middle Eocene to Late Eocene and Oligocene to Early Miocene, respectively by Raiverman *et al.* (1983). However, based on palynofloral evidences En. Seq. III (Makreri/Dharmsala) is assigned Oligocene (Mathur in Raiverman *et al.*, 1976) and tentatively a Late Eocene age by Sharma *et al.* (1987).

Methods of study

The Technique for recovery of organic matter, spores and pollen involves treatment with hydrochloric and hydroflouric acids. The macerate is washed repeatedly and the residue is floated in Heavy Liquid (an

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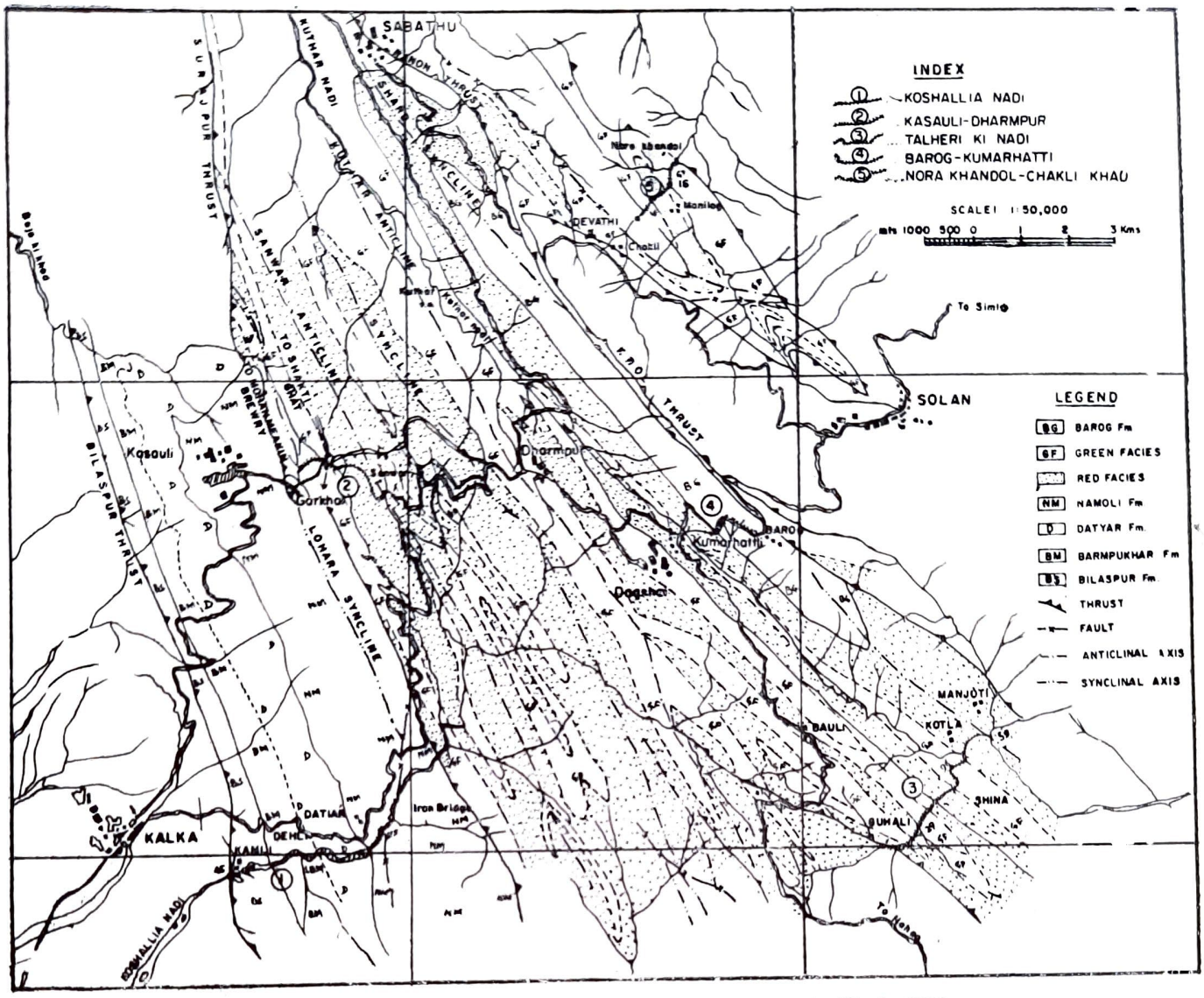


Text-figure 1—Location map of EN-SEQ traverses in Simla Hills.

iodide mixture of Potassium, Cadmium and Zinc) of specific gravity Ca 2.0. The macerate is throughly washed and smeared on a cover glass and mounted on the slide with polyvinyle alcohol or canada balsam.

For palynofacies studies, the total organic matter is classified into three main types depending on the degree of microbial and bacterial biodegradation (Masran & Pocock, 1981; Venkatachala, 1981a, b, 1984).

1. Humic organic matter, comprising of biodegraded terrestrial and woody material (Pl. 1, figs. 1-9; text-figs. 1, 2) with TAI values of 2.5 or more is considered mostly gas prone.

2. Sapropelic organic matter, composed of finely divided and amorphous organic matter (Pl. 1, figs. 1-9; Text-figs. 3,4,5), maturing at comparatively low thermal alteration values (TAI-2.25+) and is considered mostly oil-prone.

3. Sapropelic/humic or humic/sapropelic organic matter of mixed potential indicating transitional facies. The conclusions drawn in this study are based on above parameters.

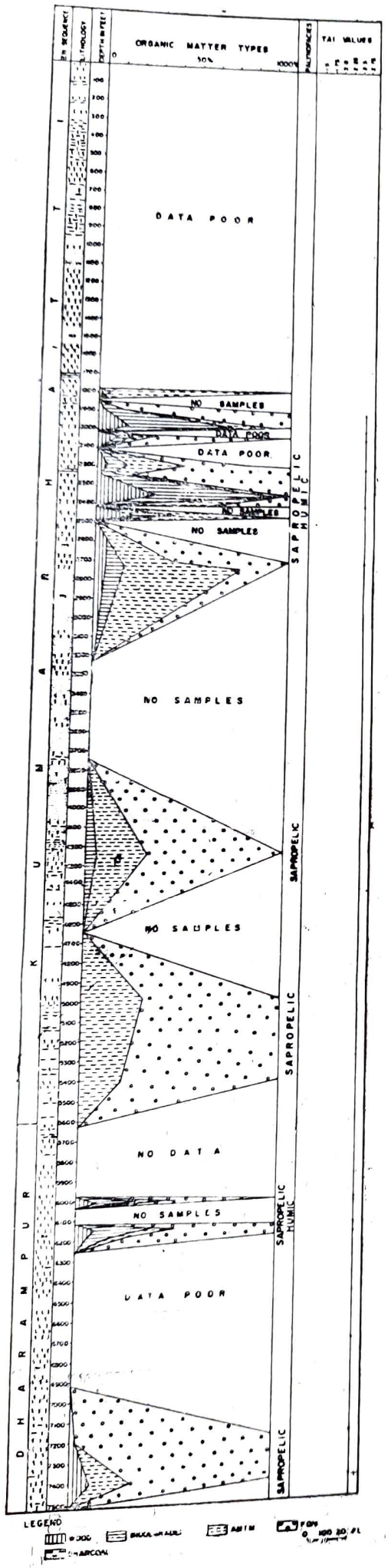
Quantitative visual examination analysis is carried out according to the method Terry and Chilinger (1955). The Thermal Alteration Index (TAI) values are evaluated on 1-5 scale of Staplin (1969) based on colour of the palynomorphs.

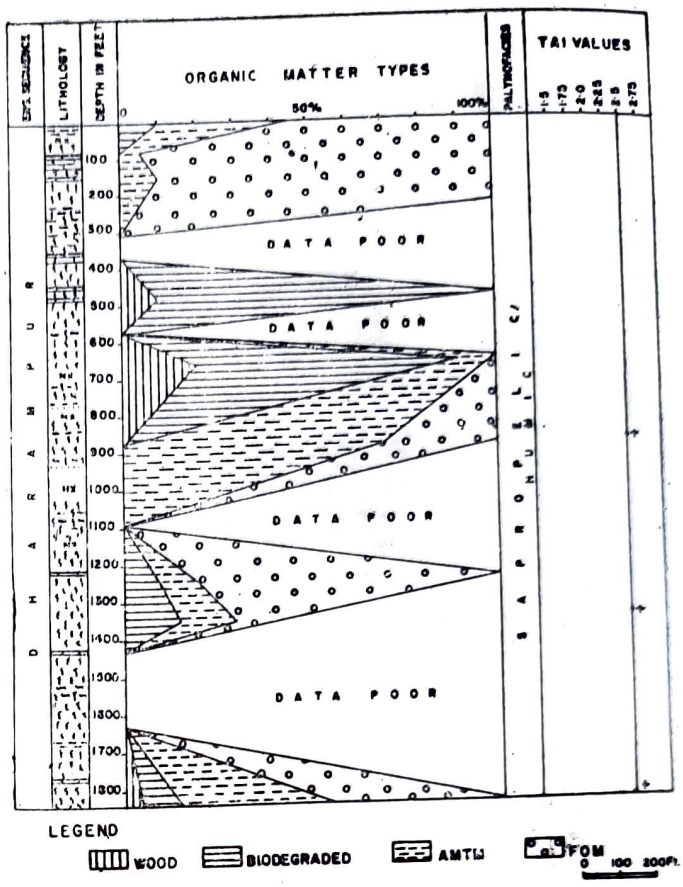
Source rock palynology

Energy Sequence I : Dharmpur (Palaeocene to Middle Eocene) (Figs. 2,3, 5a, b)

Talheri-Ki-Nadi Traverse

Organic matter Type—Sapropelic-finely divided organic matter dominates





Text-figure 3—Type of organic matter and palynofacies in Nora Khandol Chakli Khud traverse (Subathu).

the sequence (60-90%). Amorphous organic matter is significant (10-30%). Biodegraded terrestrial organic matter and woody organic matter are present (5-10%). Marine phytopalankton, spores, pollen and fungal hyphae are recorded in good number. *Pediastrum*, a fresh-water alga is also recorded.

Thermal maturation value—The TAI values estimated are 2.75 to 2.75+.

Source Potential—Sapropelic organic matter constitutes bulk of the total organic matter. The facies is mature (TAI 2.75+) and possesses good source potential for hydrocarbon.

Kasauli Dharmpur Traverse

Organic matter type—The total organic matter is composed of finely divided matter

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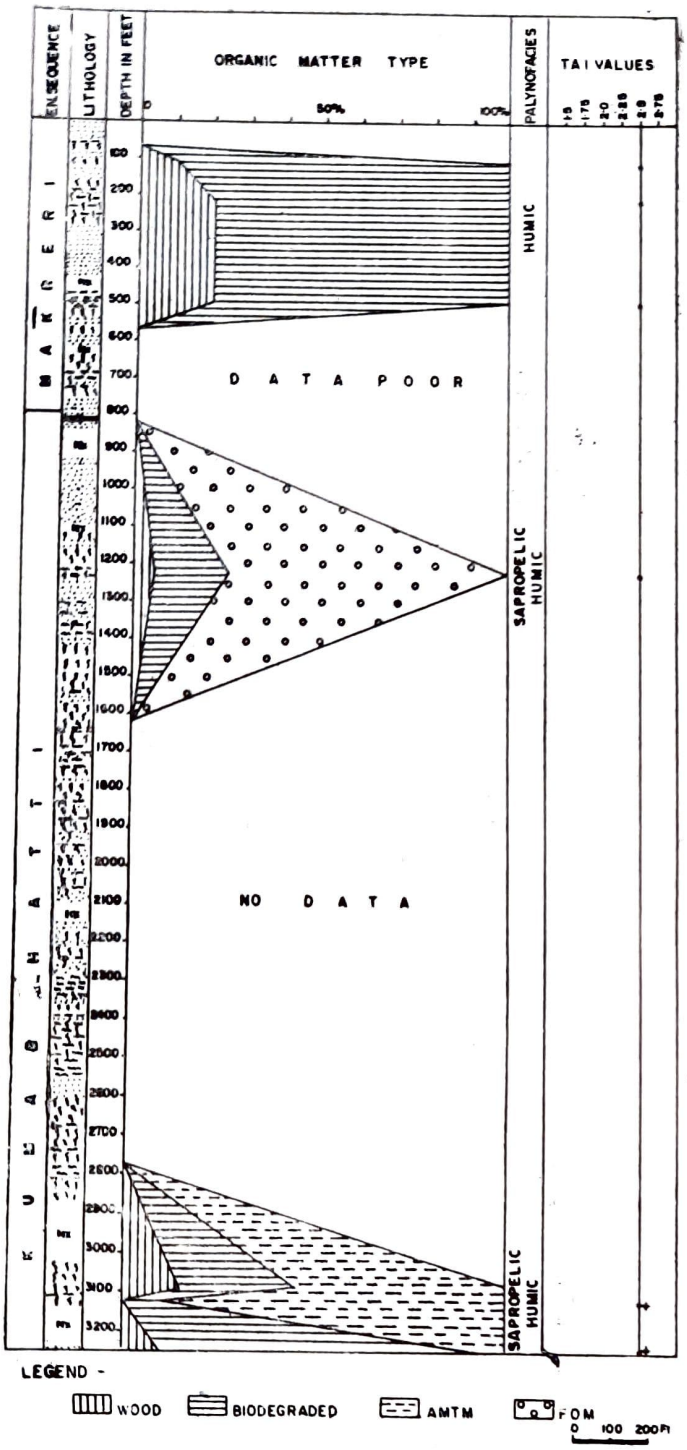
Text-figure 2—Type of organic matter and palynofacies in Telheri-ki-nads traverse (Subathu).



Text-figure 4—Type of organic matter and palynofacies in Barog Kumarhatti traverse (Subathu).

(5-90%). Amorphous organic matter is significant (5-25%) in most of the samples but dominant in a few samples (60%). Wood is rarely present (5%). Biodegraded terrestrial organic matter ranging) from 5-60% is recorded in some of the samples. Spores, pollen, marine phytoplanton, fungal hyphae and algal remains are well represented. *Pediastrum* is also present.

Thermal maturation values—The TAI values range from 2.5 to 2.75.

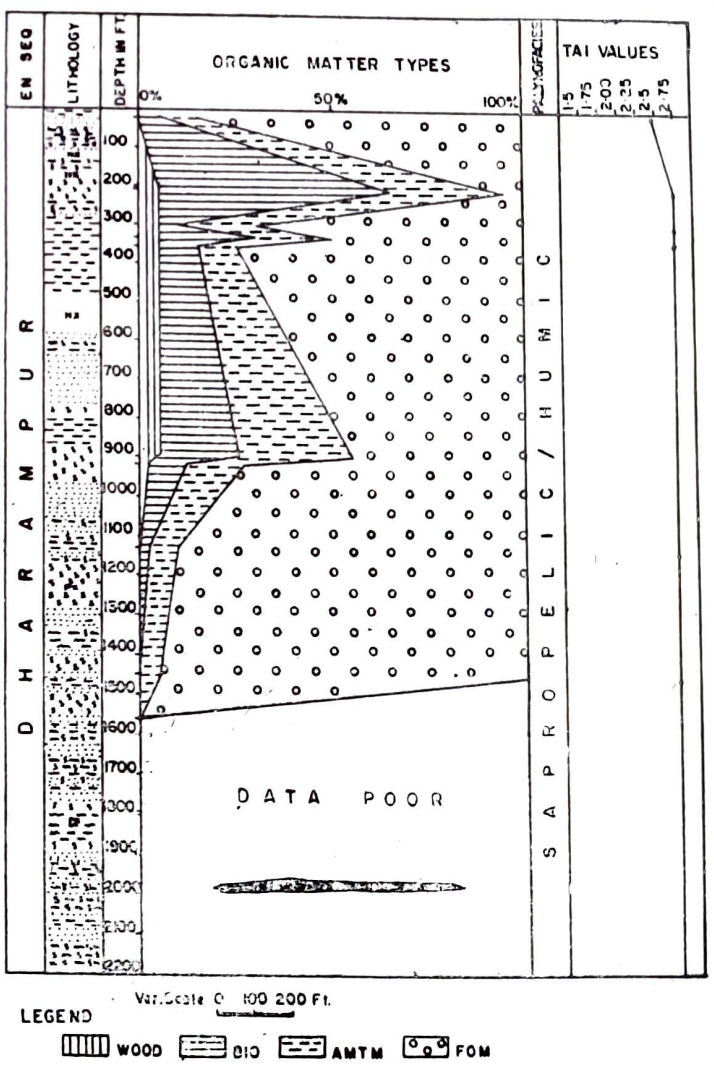
Source potential—Sapropelic organic matter is dominant type, though humic matter is also present. the organic facies is considered adequately matured to have sourced hydrocarbons.

Nora Khondal Chakli Khud Traverse

Organic matter type—Sapropelic organic matter composed of finely divided organic matter (40-90%) and amorphous organic matter (5-60%) forming bulk of the total organic matter. Land derived-biodegraded organic matter is abundant in few samples and form 70-75 per cent of the total organic matter whereas in others it is woody components which are low in percentage (0-20%). Algal filaments, marine phytoplankton and poorly preserved spores and pollen are recorded in a few samples.

Thermal maturation values—The TAI values of 2.5+ are estimated.

Source potential—The vegetal organic matter is of a mixed type (sapropelic/humic)



Text-figure 5a—Type of organic matter and palynofacies in Kasauli Dharampur traverse (Subathu).

and mature. A good source development is postulated.

Koshalia River Traverse

Organic matter type—Samples this travers are not rich from in organic matter. The total organic matter recorded consists of finely divided organic matter (10-25%), amorphous organic matter (5-20%) and biodegraded terrestrial organic matter (20-50%). Woody matter is rare (0-5%). Algal filaments, fungal spores, marine phytoplankton, spores and pollen are recorded.

Thermal maturation values—The TAI values estimated are 2.5+.

Source potential—The vegetal matter is of a mixed Sapropelic/humic type and mature (TAI 2.5+), showing a good source potential of hydrocarbon.

Energy Sequence II: Kumarhatti (Middle Eocene to Late Eocene) (Figs. 2 & 4)

Talheri-Ki-Nadi Traverse

Organic matter type—Sapropelic organic matter comprising of finely divided organic matter (10 90%) and amorphous organic matter (10-70%) constitutes the sequence. Biodegraded terrestrial organic matter is abundant but dominant (10-60%) in few samples. Wood and traces of charcoal are also recorded. Spores, pollen, algal filaments and marine phytoplankton are present.

Thermal maturation values—The TAI values are 2.75.

Source potential—The organic matter is predominantly of sapropelic type and mature. It indicates good source potential for hydrocarbon.

Koshalia River Traverse

Organic matter type—The organic matter is present in a few samples. Sapropelic organic matter composed of finely divided organic matter (30-80%) and amorphous organic matter (10-60%). Terrestrially biodegraded organic matter is present in low percentage (0-10%). Fungal remains, spores and pollen are present.

Thermal maturation values—The TAI values recorded are 2.5.

Source potential—Sapropelic organic matter continues to be dominant type and is considered to acquire maturation to generate hydrocarbon.

Barog Kumarhatti Traverse

Organic matter type—Finely divided organic matter (75%), amorphous organic matter (10-90%) and biodegraded terrestrial organic matter (10-70%) constitute the total organic matter of the sequence. Woody organic matter is common (20%). Spores, pollen, marine phytoplankton and algal filaments are sporadic.

Thermal maturation values—The TAI values range from 2.5 to 2.5+.

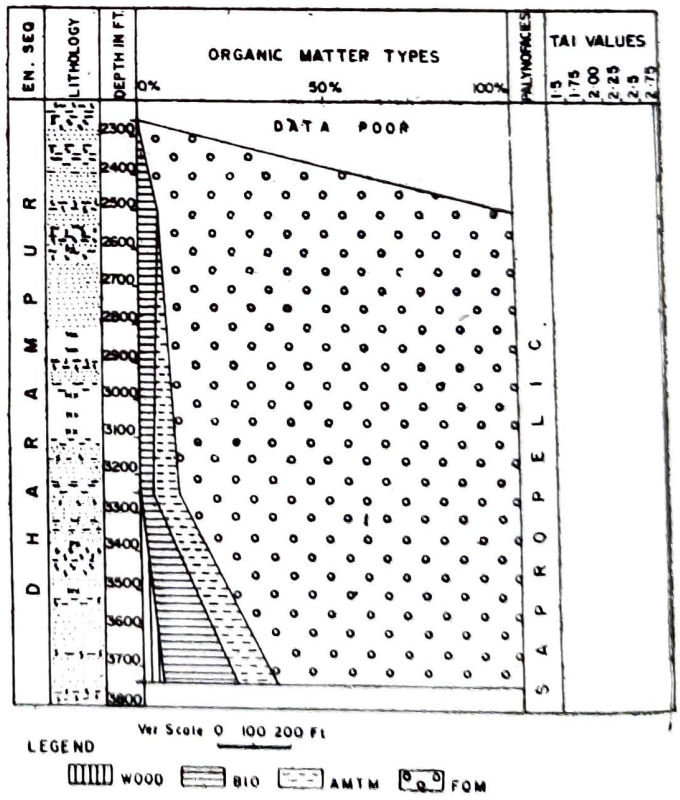
Source potential—The total organic matter is of a mixed typesapropelic/humic and mature (TAI 2.5 to 2.5+.) The source potential to generate hydrocarbon is good.

Energy Sequence III : Makreri (Tentatively Late Eocene)

(Fig. 4)

Barog Kumarhatti Traverse

Organic matter type—Terrestrially sourced biodegraded organic matter (80-90%) constitutes the total organic matter. Woody



Text-figure 5b—Type of organic matter and palynofacies in Kasauli Dharampur traverse (Subathu).

organic matter is meagre (10-20%). Algal filaments, marine phytoplankton, spores and pollen are scanty.

Thermal maturation values—The TAI value is estimated to 2.5.

Source Potential—Humic organic matter forms the major organic matter type. A good degree of biodegradation is visible. The humic and mature facies (TAI 2.5) show that the sediments can generate gaseous hydrocarbon.

Discussion

The total organic matter recovered in En. Seq. 1 (Dharmpur) and En. Seq. II (Kumarhatti) is dominantly sapropelic to sapropelic/humic. However, En. Seq. III (Makreri) contains only humic organic matter, though a good degree of biodegradation is recorded in some of the samples.

The Talheri-ki-nadi and Kasauli-Dharmpur traverses of En. Seq. I contain dominantly sapropelic matter whereas a mixed sapropelic/humic type of organic matter is recorded in Nora Khondal Chakli Khud and Koshalia River traverses of the En. Seq. I (Table 1). The Koshalia River and Talheri-ki-nadi traverses of En. Seq. II contain mainly sapropelic organic matter while the Barog Kumarhatti traverse has mixed-sapropelic/humic type. (Table-1).

Humic organic matter is recovered only from the Barog Kumarhatti traverse of En. Seq. III (Makreri) (Table 1).

The maturation values vary from 2.5 to 2.75+ in all the studied Energy Sequences.

En. Seq. I (Dharmpur)

TAI values of 2.75+ are estimated in Talheri ki Nadi, 2.5+ in the Nora Khondal Chakli khud and the Koshala River traverse and 2.5 to 2.75+ in Kasauli Dharmpur traverse (Table 1).

En. Seq. II (Kumarhatti)

TAI values of 2.75 are measured in Talheri ki nadi; 2.5 to 2.5+ in Koshalia River and Barog Kumarhatti traverses (Table 1).

En. Seq. III (Makreri)

TAI values 2.5 are estimated in Barog Kumarhatti traverse (Table 1).

This shows the sediments belonging to En. Seq. I, II and III have attained sufficient maturity thereby suggesting a good source potential for hydrocarbon.

Conclusions

1. *Organic matter type*

The vegetal dispersed organic matter recovered in the three energy sequences units I, II and III exposed in Talheri-ki-nadi, Nora Khondal Chakli Khud, Barog Kumarhatti, Koshalia River and Kasauli-Dharmpur traverses are dominantly sapropelic to sapropelic/humic and humic types.

2. *Thermal maturation*

The values range from 2.5 to 2.75+ as given belows:

En. Seq. I (Dharmpur) : TAI=2.5-2.75+
En. Seq. II (Kumarhatti) : TAI=2.5 to 2.75
En. Seq. III (Makreri) : TAI=2.5

3. *Source potential*

Dominant occurrence of sapropelic facies with sufficient maturity in En. Seq. Units I and II of the studied sequence indicate a good source development for hydrocarbon. However, humic dominant facies with TAI of 2.5 in En. Seq. III studied in Barog Kumarhatti traverse is considered to possess low potential.

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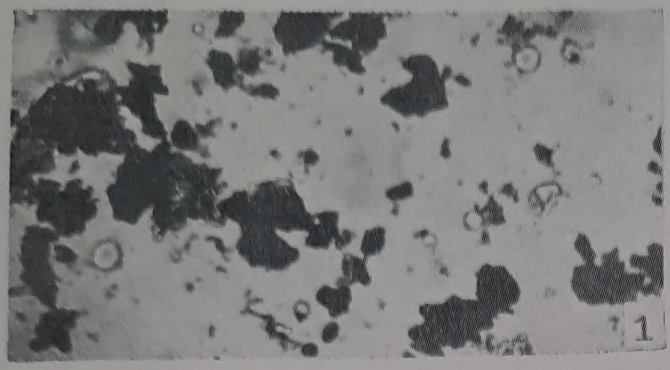
Explanation of Plate

Plate 1

(All photomicrographs magnified, × 250)

1. Woody organic matter
2. Biodegraded terrestial organic matter
3. Amorphous organic matter
4. Amorphous organic matter and finely divided organic matter
5. Finely divided organic matter
6. *Hystrichosphaeridium* sp. A
7. *Hystrichosphaeridium* sp. B
8. *Hystrichosphaeridium* sp. C
9. *Pediastrum* sp.
10. *Hystrichosphaeridium* sp. D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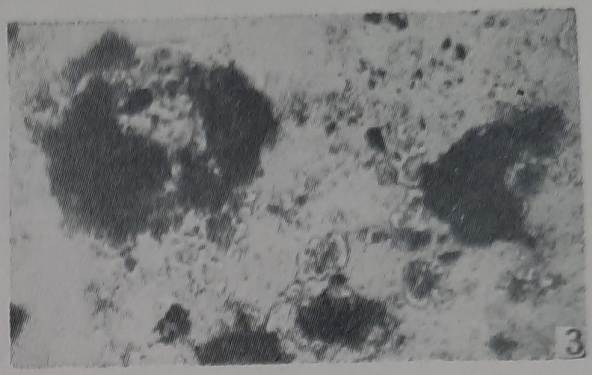
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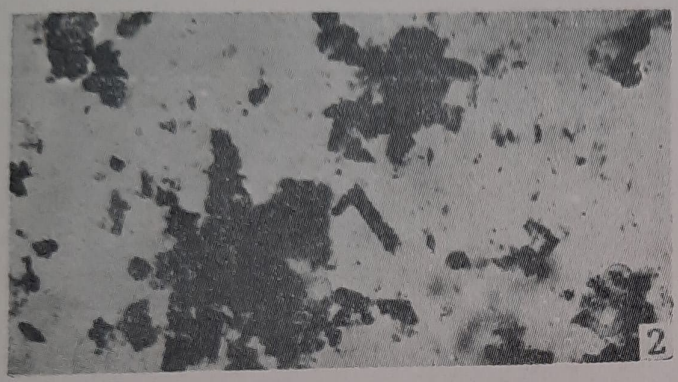
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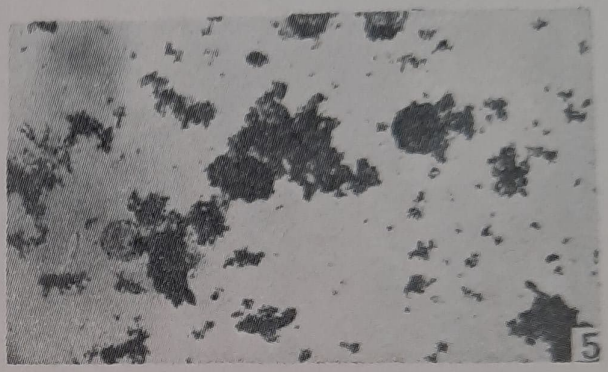
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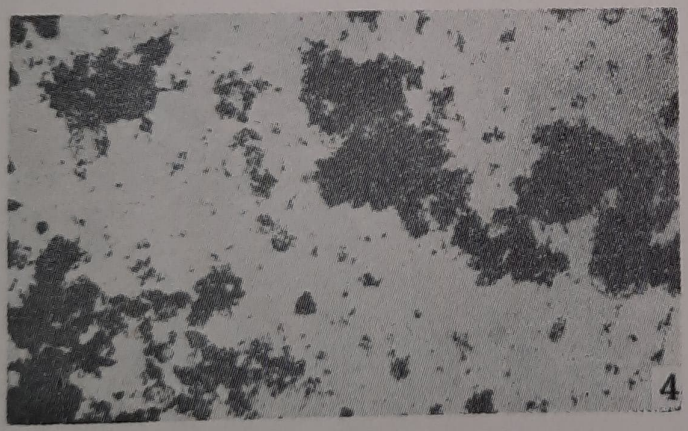
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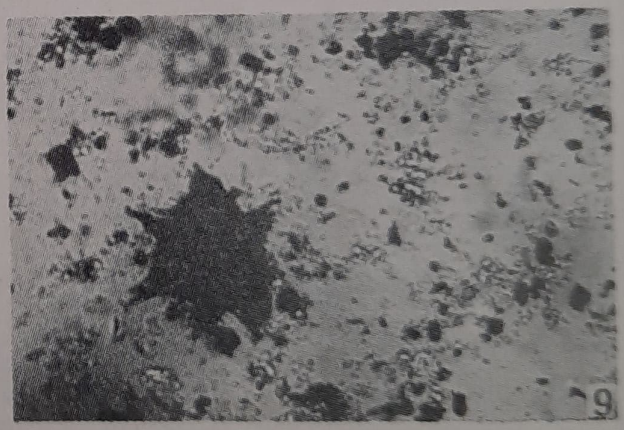
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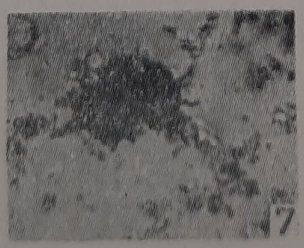
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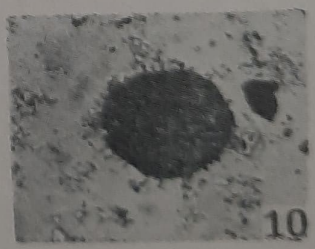
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