ON THE NATURE AND COMPOSITION OF THE NEYVELI LIGNITE, SOUTH INDIA

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ABSTRACT

The paper deals with the description and analysis of the organic constituents of the Neyveli lignite which has proved to be of high economic value. The nature and composition of the lignite suggest some characteristic genetic types. Determination of such types in the lignite deposit is useful for proper evaluation of the lignites.

INTRODUCTION

During recent years, Neyveli lignite, the largest brown coal deposit so far known in India has drawn much attention from geologists, palaeobotanists, mining engineers and technologists for understanding the nature, composition, the extent of formation of the lignite deposit and its behaviour in mining and technology for successful utilization because of its commercial and industrial importance (BALASUNDER, 1968, C.F.R.I., 1954, LAKSHAMANAN & Levy, 1956, Navale; 1961, 1968a, b, 1969, 1970, 1972 & 1973; RAMANUJAM, 1963a, b, 1964, 1966; RAMANUJAM, & RAMACHAR 1963, RAO 1955, 58; SUBRAMANYAM 1969; THIERGART & FRANTZS, 1962). Yet the studies are very preliminary probably due to greater attention to industrially more important hard coals of India on which extensive information is available. Nevertheless, as mentioned earlier, a beginning has been made specially on Neyveli lignite because of its established utility for multipurpose industrial undertakings, and one may reasonably expect more details on physico-chemical properties of this lignite in due course of time.

GEOLOGICAL BACKGROUND

The lignite has been found to occur in association with the Tertiary sandstones known as Cuddalore Sandstones (Upper Miocene) and clays. The other common rock types in the area of the lignite are granitoid gneisses and dolerites of Archean Complex followed by Mesozoic rock types of small limestones and shells; the Cuddalore Sandstones, clays and lignites of Tertiary age followed by recent alluvium and Kankar. The rocks of the Cuddalore Series in which lie the lignite deposit comprise argillaceous sandstones, grits and clay beds. The sandstones are whitish, pinkish, reddish or of mottled colour.

The lignite bed is met with between 1.8—135.3 m m.s.l. (6′—444′ m.s.l.) within the field so far proved. The bed has a general dip varying from 1 in 60 to 1 in 100 in S.65°E to S.82°E direction. The thickness of the deposit varies from 1 decimetre to 23 metres (1 to 75' within the field). The surface of the lignite is uneven although there are no structural disturbances. The clay bed which immediately underlies the lignite bed is carbonaceous in places. It is rich in allumina and the colour varies from white to pink and red. Beneath the lignite bed there are two aquifers within a depth of 107 m (350′)

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separated by a bed of clay. The lignite is generally compact, massive and devoid of impurities. It has deep brown or black colour often forming different layers due to the difference in the source material. It is associated with woody and fibrous material. Microscopic examination reveals abundance of plant tissues, woody material and exines of spores and pollen material.

COMPOSITION OF THE LIGNITE

Based on the classification proposed by SPACKMAN AND THOMSON (1963), the source material of the Neyveli lignite may broadly be grouped into *Lignogene Suite* and *Liptogene Suite*. The former comprises *Maceral Series* that are formed through the coalification of lignified cell walls and related organic material and the later (Liptogene Suite) includes entities derived from coalification of waxy and resinous plant secretions which are resistant to the decomposition and alteration.

The Lignogene Suite of the Neyveli lignite comprises genetically related Maceral Series such as *Tissuinite* or *Textinite*, *Detrinite*, *Gelinite*, *Fusinite* etc. In each of these series maceral groups of similar macerals are included. Likewise Liptogene Suite of the lignite comprises genetically related *Exinite* and *Resinite* Maceral Series. In these series similar macerals classed in maceral groups are included. The table-1 shows the groupings made of various organic entities (petrologically termed as macerals) recognised in the Neyveli lignite, and a general description is made on the broad groups of macerals.

TABLE—Classified Macerals (Organic entities) recognized in the Neyveli lignite

Maceral Suite	*Maceral Series*	*Maceral Groups*	*Macerals*
Lignogene Suite	*Textinite* or *Tissuinite*	*Xylinoids*	*Vesselinite*, *Parenchyminite*, *Rayinite*, *Fibrinite*
		Exylinoids	*Epiderminite*, *Parenchyminite*, *Collenchyminite*, *Sclerenchyminite*, *Corkinite*, *Barkinite*
	Huminite	*Detrinoids*	*Eudetrinite*, *Humodetrinite*, *Textodetrinite*
		Gelinoids	*Eugelinite*, *Detrogelinite*, *Textogelinite*
	Fusinite	Fusinoids	*Fusinite*, *Semifusinite*
		Sclerotinoids	*Textosclerotinite*, *Sporosclerotinite*
		Carbinoids	*Homocarbinite*, *Heterocarbinite*

Liptogene Suite	*Exinite*	*Exinoids*	—	*Sporinite* *Cutinite* *Alginite*
	Resinite	*Resinoids*	—	*Resinite* *Suberinite* *Latexinite* *Butiminite* *Chlorophyllinite*

LIGNOGENE SUITE

Textinite or *Tissuinite Series*—It includes all the organic tissues in the lignite composition. These tissues may be grouped into xylinoid and nonxylinoid tissues. The xylinoid group of tissues are those organic parts or entities derived from woody tissues. Some of them seen in the woody lignite are vessel pores, wood parenchyma, fibres and rays. The Exylinoids are nonwoody tissues occurring as part or wholly in the lignite composition. The nonxylinitic tissues seen in the deposit are of epidermis, collenchymat parenchyma, cork, and bark. Petrologically these tissues are designated on the plan, part itself ending with 'inite' (International convention) as given in the table. Some of the xylinoid group of tissues are identifiable into modern taxa. So far, the woody tissues of Guttiferae, Dipterocarpaceae, Ebenaceae, Combretaceae, Leguminosae, Euphorbiaceae and Palms have been recognised (NAVALE, 1972). However, they are not as common as nonxylinoid tissues. The later occur quite frequently in the lignite composition. By and large both xylinitic and nonxylinitic tissues are derived mostly from angiospermic plants. Few gymnospermic remains are also seen in the composition. Dispersed tissues form an important genetic group in the coalification of the lignite.

Huminite Series—Humous complex organic and inorganic components petrologically known as *Huminite* form the basic composition of the Neyveli lignite. It includes Detrinoid and Gelinoid Group of macerals derived from organic detritus and gellified substances. The former is invariably composed of small fragments of detached plant parts made up of humous matrix, constituted by granular colloidal particles with pores and cell fragments. It forms the ground mass of the lignite. Soft lignites are entirely filled with humous detritus. The interpore space between individual particles appears black. The ground mass may either be of detritus particles or humous detritus particles known as *Eudetrinite* or *Humodetrinite*, and others may be formed of fragments of tissues termed as *Textoderrinite*. All these macerals form a dominant composition in the huminitic group of macerals. Gelinoid components are derived from various gellified micro-components that originated in the process of gellification of detritus or tissue entities of lignite composition. On the basis of the genetic composition of the gelinites, terms have been given to various components. Among which, a few identified ones in the composition are *Eugelinite, Humogelinite, Detrogelinite* and *textogelinite*. Gellified substances are commonly seen in Huminite assemblage of the composition.

Fusinite Series—It includes those macerals or organic components which were formed from "fusinization" or partial oxidation of lignified plant parts in the diagenic stage of coal formation. The fusinitic components are inert in the "Carbonification process" and hence they are technologically known as "Inert". The term has been retained in the coal nomenclature although it does not imply that the constituents are totally inert. The constituents of Fusinite Series are either derived from tissues or humous clastics and therefore, included in the Lignogene Suite of the lignite. As shown in the table; Fusinoid, Sclerotinoid and Carbinoid group of macerals have been recognized in the lignite. Fusinites have well defined cell structure of wood or sclerenchyma. The cell cavities vary in size and shape. They are either round, oval or elongated. The cell cavities are generally empty. This may also occur as fragments or lenticles. Tissues of fibre cells and vessels have been highly fusinized. The intermediate constituent between *xylinite* and *Fusinite* having the above details and known as *Semifusinite* is common. The remains of resting fungi or sclerotia which constitute *Sclerotinite* maceral are commonly seen in the lignite. This maceral includes structures of fungal hyphae, sclerotia and spores. Sclerotia are formed of hard substance known as *Chitin* which has good preserving capacity. Morphographically few characteristic sclerotia may be separated (NAVALE, 1970). Few known sclerotia types in the lignite are *Sclerotites crassitesta, S. brandonianus, S. multicellulatus, Coronasclerotes africanus*. Fungal spores which form one of the components in the Fusinite Series are commonly seen in the lignite. They have a definite shape, size and form. They are largely comparable to Myxomycetes group of Fungi. Teleutospores are frequently seen in the lignite indicating the role of Basidiomycetes group of Fungi in the degradation of tissues. Teleutospores are sporogeneous bodies, moderately thick walled, dark brown in colour and have one to few chambers divided by septa, having narrow opening to contact each chamber. Teleutospores may be round, oval or slipper shaped. By maceration, spores comparable to those of urediospores of *Milesia*, teliospores of *Puccinia*, telial heads of *Ravenelia*, and *Triphragmium* and teliospores of *Uromyces* and *Xenodochus;* thyriothecia of Asterineae of Microthyriaceae have also been recorded (RAMANUJAM & RAMACHER, 1963; RAMANUJAM, 1963a, b).

LIPTOGENE SUITE

Exinite Series—This series includes macerals which can be recognised as material derived from exines of spores, cutin and suberinin during the "Coalification process" It has been found during the coalification process that the spore material proceeds along a distinct path known as "Exinization path" quite dissimilar from that of Lignogene Suite of material (SPACKMAN & THOMSON, 1963), Spores and pollen grains which are resistant to the chemical process are the main constituent of *Sporinite* maceral. This constituent is less represented in the Neyveli lignite composition. By maceration method the source material of the above maceral may be resolved and compared to some modern taxa (RAMANUJAM, 1964, 1966; NAVALE, 1971), the important ones are listed below:

Ferns—Polipodiaceae, Schizeaceae, Osmundaceae, Hymenophyllaceae, Gleicheniaceae, Lycopodiaceae.

Angiosperms—Leguminoseae, Lecythidaceae, Meliaceae, Nympheaceae, Cruciferae, Lentibulariaceae, Halorrhagaceae, Labiatae, Euphorbiaceae, Ericaceae, Sapotaceae, Oleaceae, Liliaceae, Palmae and Grasses.

The *Cutinite* maceral formed from dispersed cuticles is seen as very thin, long strands. Some of the cuticles show resemblances to the cuticles of angiospermic leaves. (JACOB, 1954; NAVALE, 1971). They are mostly seen in the detrital potaion of the lignite along with other exinitic material. Likewise, algal forms like *Botryococus* and other filamentous structures (RAMANUJAM, 1966) forming *Alginite* maceral are also seen in the exinitic group of the organic remains. These entities are rarely distributed in the lignite composition. Even considering "*Exinite Series*" as a whole their entities are less common compared with other groups. Yet their presence, recognition of source material and relative distribution are of considerable value in understanding the genesis and correlation of the lignite types.

Resinite Series—It is confined to coalified product of resinous material formed by plants. This series includes macerals of *Resinite, Suberinite, Butiminite, Latexinite* and *Chlorophyllinite* derived from the same substances on which it is termed. Although Exinite and Resinite Series exhibit certain similarities yet petrographic observation suggests that they have formed from different coalification paths. Because of the lack of data on proper evaluation of coalfield gum, latex, xylem ray inclusions and other plant substances, the Resinite Series appear to be heterogenous. At present all the plant inclusions are grouped in this category. Generalising, Liptinite Suite of the source material in the Neyveli lignite is rather poor nevertheless their local abundance, resolution of source material to modern taxa are of importance in the utilization and determination of coal types. This group is closely mixed with huminoid groups of organic material. The relative abundance in the composition, characterizes the type of lignite, such as peaty lignite, durainy lignite or xyloidal lignite.

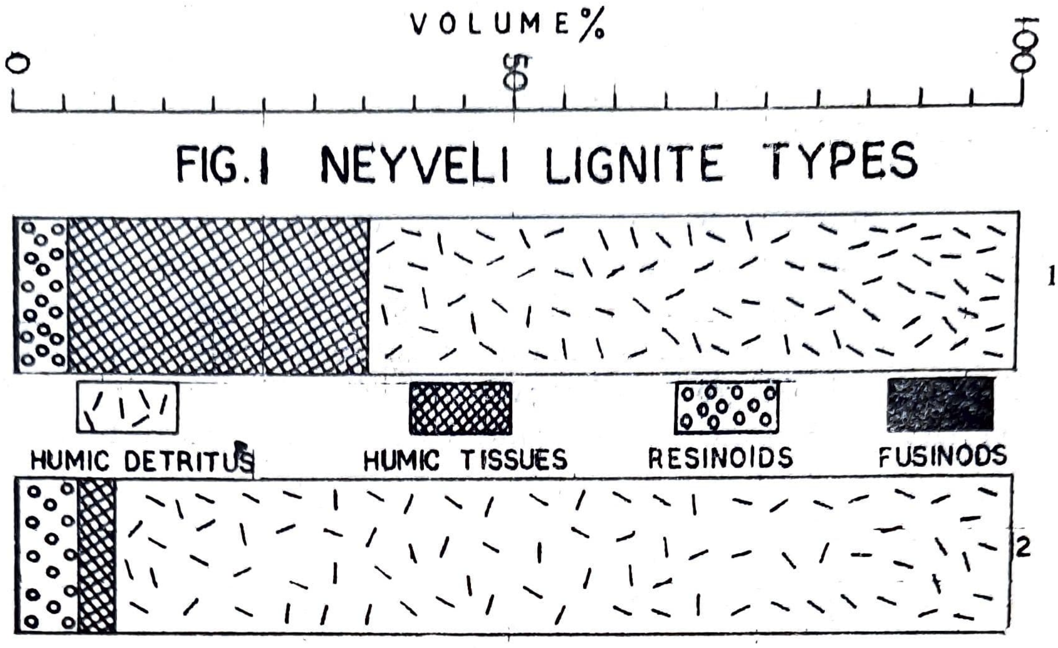
EVALUATION OF THE LIGNITE

Lithotypes of the lignite—Examination of the lignite seam with the unaided eye provides physical description which is useful in relating microscopical observations with gross geological characteristics of the lignite. Although many proposals have been made to formulate adequate definition and classification of microscopic constituents (NAVALE, 1969), yet no standard mtehod is available for megascopic description. In recent years the International Committee on Coal Petrology has undertaken to standardize lithotype description of lignites.

Neyveli lignite does not show marked variety in the lithology of the seam. By and large the seam is characterised by brownish dark lignite. However, between these broad benches of lignite one finds thin layers of brownish yellow lignite. Further categorization may also be made on the above lithotypes such as xyloidal or stratified, in the brownish black lignite, and whitish brown or yellowish brown types in the brown lignite. It may be said here that minor differentiation is not practical as they are uncommon in the present mining area.

Distribution of the organic components' group or Maceral groups—An analysis of the physical constituents of the lignites investigated reveals that they are mostly composed of *Detrinoid* and *Tissuenoid* group of macerals. As already mentioned, they are derived from detritus and tissues of coal forming swamp. They form the basic ground substance of the lignite. The samples investigated show two distinct pattern of distribution of humic detritus components. One has an average of 65% and the other has an average of 90% in the overall composition of the lignite (Fig. 1). Similarly humic tissues have two distinct pattern of distribution in the composition. One has an average of 4.1% and the other has an average of 30% (Fig. 1). The exinoid, resinoid and fusinoid groups of the lignite derivatives are not common. Nevertheless, the exinoids and resinoids are of considerable value in correlation and evaluation of the lignite deposit. The exinoids have 6% in one group of samples where as resinoids have 5% in other group of samples. Fusinoids are of local importance. Some xylinitic and nonxylinitic entities reveal fusinitic nature. This group forms an "inert" component during the carbonisation process.

Lignite types—The distribution pattern of the microcomponents in the samples investigated reveals two sets of primary assemblage of the macerals. The majority of samples which form one group have the following distribution:



Humic Detritus (64%), Humic Tissues (30%), Resinoids (5%), Fusinoids (1%)

The other group is characterized by Humic Detritus (90%), Humic Tissues (3.6%), Exinoids (6%) and Fusinoids (4.1%).

Thus it is apparent that the lignite is derived from two types of source material, one is chiefly constituted by humic detritus and tissues and the other mostly by humic detritus. On comparison with the lithotype analysis, the first assemblage corresponds with dark brown lignite layer, the second equates well with yellowish brown lignite layers.

Assessment—From the above data it is reasonable to assess that the lignite under investigation may be differentiated into coaly lignite and peaty lignite. The seam examined is mostly of coaly lignite nature. Nevertheless, peaty lignite occurs characteristically as thin layers among broad layers of coaly lignite.

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