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Petrographic evaluation of the coal seams from Gundala area, Godavari Valley Coalfield, Andhra Pradesh, India

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ABSTRACT

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Gundala area represents the north-western extremity of Lingala-Koyagudem Coal Belt, Godavari Valley Coalfield, Andhra Pradesh. The sub-surface explorations from the virgin tracts of Gundala area revealed the existence of ten coal seams. Representative coal samples collected from seams III A, III (Top), III (Bottom), L-1, IV A, V (Top) and V (Bottom), pertaining to Bore hole No. SGK-124 and III (Top), III (Bottom), L-1, IV A and V seams of Bore hole No. SGK-128 have been critically analyzed for their maceral constitution and vitrinite reflectance measurements to understand the quality, rank, depositional environment, besides the economic and coal bed methane potentialities.

Based on the ternary mineral matter free (m.m.f.) maceral plotting, it has been inferred that, various coal seams intersected in Gundala area, in general contain mixed type of coal, barring V Top (Bore hole No. SGK-124) and III Top (Bore hole No. SGK-128) seams, which contain vitric type of coal. However, liptinite rich coal has been recorded from III Bottom seam of Bore hole No. SGK-124. The vitrinite reflectance (R_0 max %) has been recorded between 0.47 and 0.60%, which suggests that the coal has attained high volatile bituminous C stage of rank. Existence of low (8 to 21%) frequency of mineral matter indicates the better quality of coal, which may find its commercial utility. The maceral constitution suggests that the coal deposits of this basin have evolved with prolonged spell of cold climatic condition, besides a few dry oxidizing spells. The slowly sinking basin has received continuous input of vegetal resource. The facies model based on maceral and mineral matter contents of these coals have shown the development of alternate oxic and anoxic moor at the depositional site.

Key-words—Maceral, Reflectance, Palaeoenvironment, Rank, Gundala, Godavari Valley Coalfield.

भारत में आंध्र प्रदेश के गोदावरी घाटी कोयला क्षेत्र के गुण्डाला क्षेत्र से प्राप्त कोयला सीमों का सजातीय शैल मूल्यांकन

ओमप्रकाश एस. सराटे एवं एम. बासवा चारी

सारांश

गुण्डाला क्षेत्र आंध्र प्रदेश के गोदावरी घाटी कोयला क्षेत्र से लिंगला-कोयागुडेम कोयला बेल्ट की उत्तर-पश्चिमी छोर को निरूपित करती है। गुण्डाला क्षेत्र के प्राकृत क्षेत्रों से उपपृष्ठीय खननों से 10 कोयला सीमों की विद्यमानता प्रकट की गई। प्रतिनिधित्व कोयला नमूनों को वेध-छिद्र संख्या एस.जी.के-124 से संबंधित III ए, III (शीर्ष), III (तली), एल-1, IV-ए, V (शीर्ष) एवं V (तली) और वेध-छिद्र संख्या एस.जी.के.-128 से संबंधित III (शीर्ष), III (तली), एल-1, IV-ए एवं V सीमों से एकत्रित किए गए और गुण, कोटि, निक्षेपणीय पर्यावरण, आर्थिक विभव एवं कोयला संस्तर मिथेन शक्तियों को समझने हेतु उनके मसृणन संघटन एवं विट्रीनाइट परावर्तन मापों हेतु आलोचनात्मक रूप से विश्लेषित किया गया।

खनिज पदार्थ रहित (एम.एम.एफ.) त्रिकोणीय मैसरल आकृति के आधार पर यह अनुमान लगाया गया है कि विभिन्न कोयला सीमों को गुण्डाला क्षेत्र में विभाजित किया गया। साधारणतः मिश्रित कोयला पाया जाता है लेकिन इन V शीर्ष (वेध-छिद्र संख्या एस.जी.के-124) तथा शीर्ष (वेध-छिद्र संख्या एस.जी.के-128) सीमों में विट्रीक प्रकार का कोयला पाया गया है। यद्यपि लिप्टीनाइट प्रचुर कोयले को वेध-छिद्र संख्या एस.जी.के.-124 के III तली सीम से अंकित किया गया है। विट्रीनाइट परावर्तकता (R_0 max %) 0.47-0.60% के मध्य अंकित की गई है जो यह प्रस्तावित करता है कि इस कोयले ने उच्च परिवर्तनशील बिटुमिनस सी कोटि की अवस्था प्राप्त की है। खनिज पदार्थ की निम्न आवृत्ति (8-21%) की विद्यमानता से इंगित होता है कि कोयले के अच्छे गुणों के आधार पर इसकी व्यवसायिक उपयोगिता सिद्ध होती है। मैसेरल संघटन प्रस्तावित करता है कि इस द्रोणी के निक्षेपित कोयले को ठंडी जलवायवी अवस्थाओं के लम्बे अर्से तक होने के अलावा कुछ शुष्क ऑक्सीकरण दौरों के कारण विकसित किया गया है। धीरे-धीरे डूबती हुई द्रोणी ने नियमित रूप से वनस्पति संसाधन प्राप्त किया है। इन कोयलों के मैसेरल एवं खनिज पदार्थ अवशेषों के आधार पर रूप मॉडल के निक्षेपणीय स्थल पर एकान्तर ऑक्सीजन युक्त एवं आक्सीजन रहित मूरभूमि के विकास को दर्शाया गया है।

संकेत-शब्द—मैसेरल, परावर्तकता, पुरापर्यावरण, कोटि, गुण्डाला, गोदावरी घाटी कोयला क्षेत्र।

INTRODUCTION

EXISTENCE of coal in Godavari Valley has been reported by Walker (1841) and geological studies were carried out by King (1872a, b, 1881), Fox (1931), Rao (1971) and Raja Rao (1982). Qureshy *et al.* (1968) carried out the gravity analysis; where as Rizvi and Ramana Rao (1969) studied the resin contents of the coals from Kothagudem area. Ramana Rao (1962, 1965), Pareek *et al.* (1964), Navale *et al.* (1983) studied the petrological characteristic of the coals from Godavari Valley.

Recently, sub-surface drilling operations have been taken up in Gundala area to establish the continuity of coal seam succession of the Chilpur-Venkatapur-Parsa-Lingala belt in south-western part up to Kothagudem coal belt. The subsurface explorations have revealed the existence of ten coal seams in Gundala area of the Godavari Valley Coalfield. The present study has been taken up to understand constitution and rank of these coals and its bearing on the depositional set up.

GENERAL GEOLOGY

The Gondwana succession in Godavari Valley of Andhra Pradesh has been laid down on the Precambrian basement (Pakhal and Sullavai) following the coarse of the rivers Pranhita and Godavari. Structurally, it

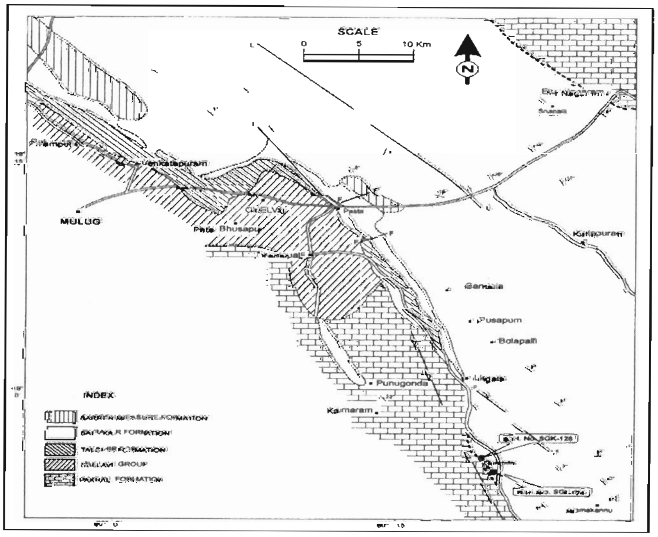

Fig. 1—Geological map of Gundala area showing location of B.H. Nos SGK-124 & SGK-128 (Courtesy, SCCL).

represents a rift Valley, having NNW-SSE trend and covering nearly 17, 000 sq km area with average width of 55 km, except the Palauncha-Kothagudem constriction where the width is reduced to 6 km. Godavari Valley Coalfield extends from the area north of Boregaon (Maharashtra) up to Eluru in the east coast of Andhra Pradesh and is marked between 16º38' and 19º32' latitudes and 79º12' and 81º39' longitudes (Raja Rao, 1982). This Coalfield has its own significance as it serves as the only major resource of coal supply for the entire Southern Indian Peninsula (Fig. 1). The gravity data suggests that the Gondwanas have been deposited in a number of block faulted troughs that developed during the Precambrian Pakhal sedimentation (Qureshy *et al*., 1968). However, during the Middle Proterozoic developed the NW-SE fault in the Archaean (Bhaskar Rao *et al*., 1971). The activation of boundary faults at different intervals caused the deposition of a thick pile of sediments right from the Precambrian up to the Lower Cretaceous periods, containing signatures of floral, faunal, sedimentary, as well as tectonic events which occurred during the entire Gondwana span. Godavari Valley has been structurally divided into Godavari, Kothagudem, Chintalapudi and Krishna-Godavari coastal sub-basins, each sub-basin displays its own depositional history. The coal horizons (coal

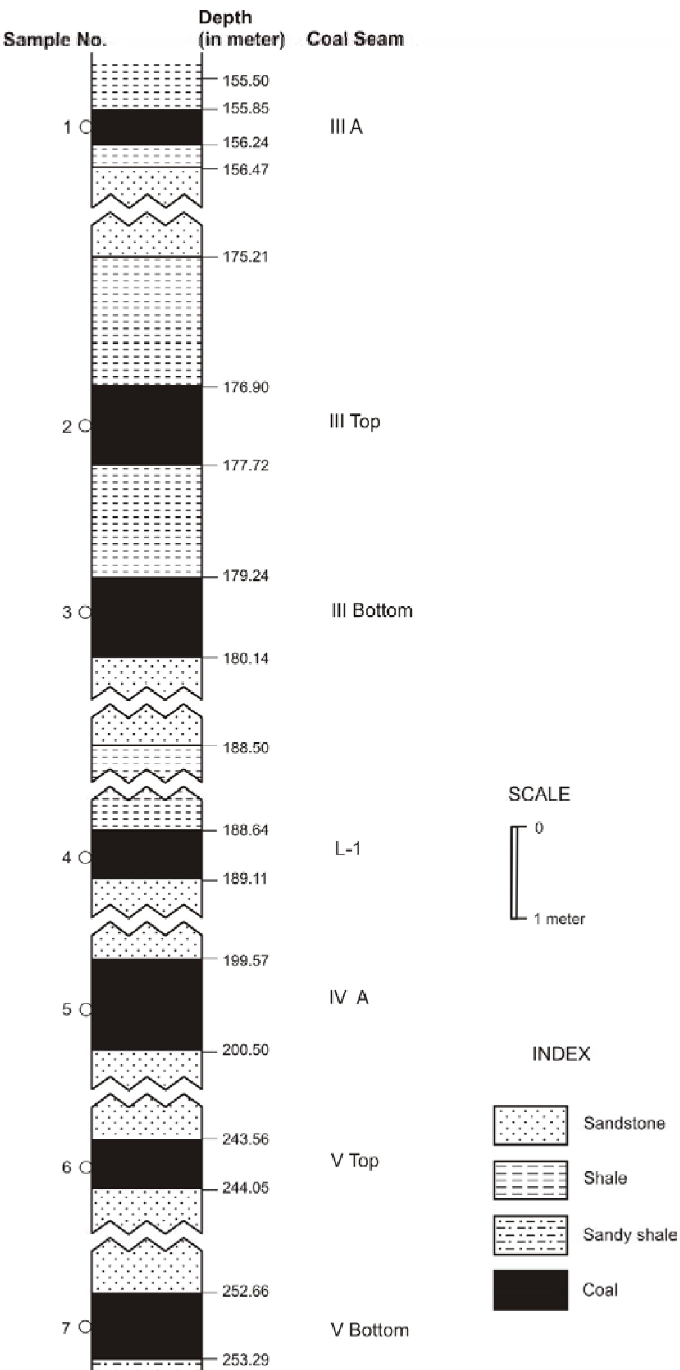

Fig. 2—Litholog of B.H. No. SGK-124 from Gundala area.

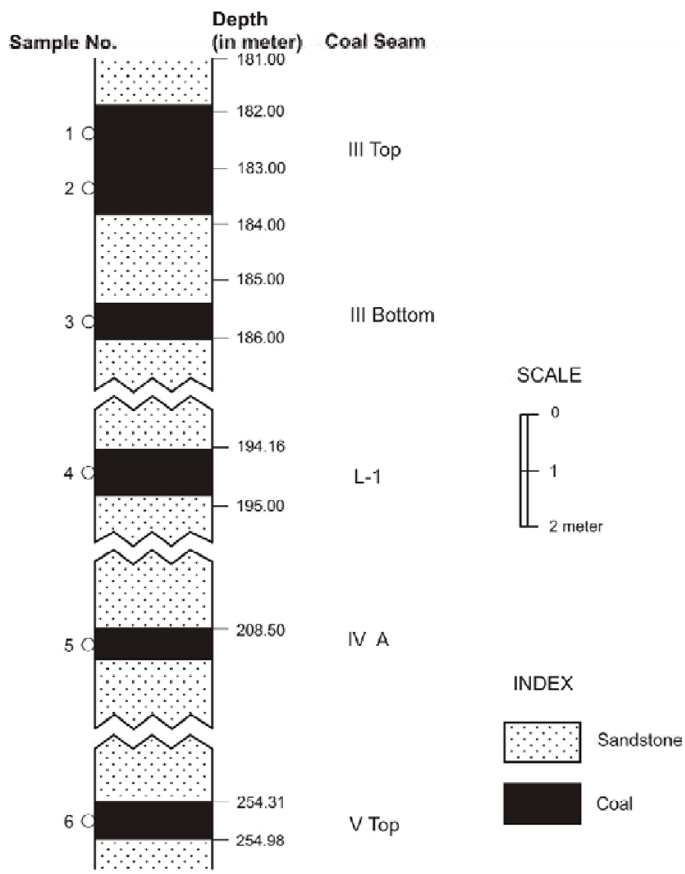

Fig. 3—Litholog of B.H. No. SGK-128 from Gundala area.

Sr. No.	Pellet Nos.	Coal Seam	Vitrinite (Vol. %)	Liptinite (Vol. %)	Inertinite (Vol. %)	Mineral Matter (Vol. %)	Reflectance R_o Max %
1	SGK 124/1	III A	38 (44)	37 (43)	11 (13)	14	0.56
2	SGK 124/2	III top	35 (43)	26 (32)	20 (25)	19	0.60
3	SGK 124/3	III bottom	21 (23)	52 (57)	19 (20)	08	0.52
4	SGK 124/4	L-1	21 (25)	26 (31)	38 (44)	15	0.51
5	SGK 124/5	IV-A	40 (47)	24 (28)	22 (25)	14	0.47
6	SGK 124/6	V top	48 (55)	17 (19)	23 (26)	12	0.60
7	SGK 124/7	V bottom	36 (45)	20 (25)	24 (30)	20	0.56
8	SGK 128/1	III top	36 (43)	27 (33)	20 (24)	17	0.52
9	SGK 128/2	III top	45 (57)	23 (29)	11 (14)	21	0.52
10	SGK 128/3	III bottom	37 (44)	25 (29)	23 (27)	15	0.52
11	SGK 128/4	L-1	36 (41)	32 (37)	19 (22)	13	0.53
12	SGK 128/5	IV-A	23 (31)	20 (27)	31 (42)	26	0.58
13	SGK 128/6	V	22 (27)	20 (25)	39 (48)	19	0.60

Fig. 4—Maceral constitution (in vol. %) and mean maximum vitrinite reflectance of samples from Bore hole Nos. SGK-124 and SGK-128. Note: The values mentioned in the bracket indicate mineral matter free (m.m.f.) percentage.

seams) confine mostly to the Barakar Formation. However, there are records for the occurrence of workable coal seams in the Kamthi Formation at Ramagundam Kundaram and Jaipuram areas (Ramanamurthy, 1976).

METHODOLOGY

The air dried coal seam samples were crushed to obtain ± 18 mesh sized particles, which were subjected to coal pellet preparation using a suitable mixture of

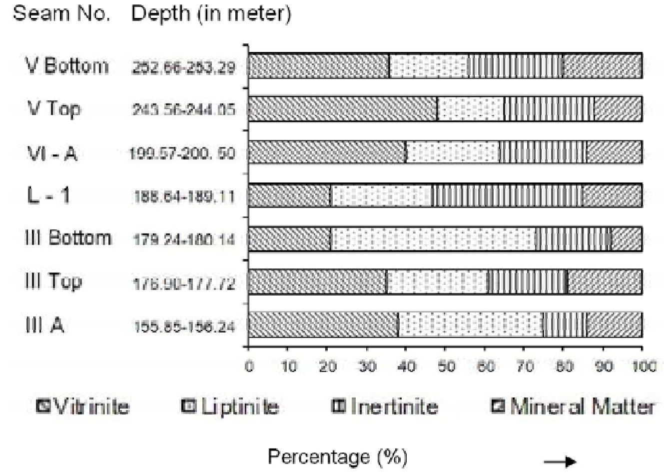

Fig. 5—Maceral composition of coal succession intersected in Bore hole No. SGK-124, from Gundala area.

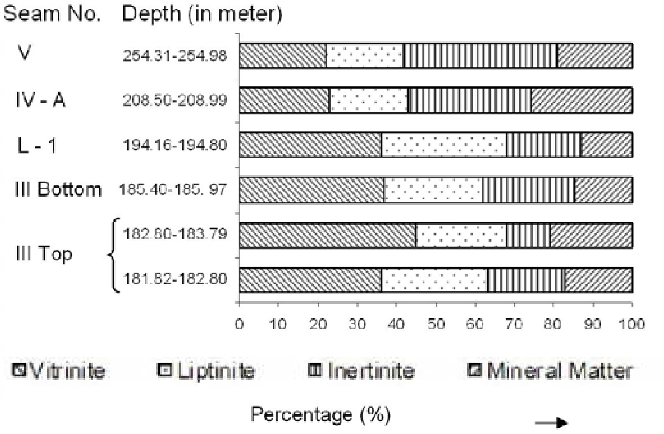

Fig. 6—Maceral composition of coal succession intersected in Bore hole No. SGK-128, from Gundala area.

PLATE 1 ⟶

1-4. Vitrinite bands.
5. Transition from Vitrinite to Semifusinite.
6, 9. Inertinite & Vitrinite bands.
10. Vitrinite bands with dispersed spores.
7, 8, 11. Dispersed Cutinite.
13, 14. Inertinite showing bogen structures.
12, 15, 16. Inertinite showing effect of compression.

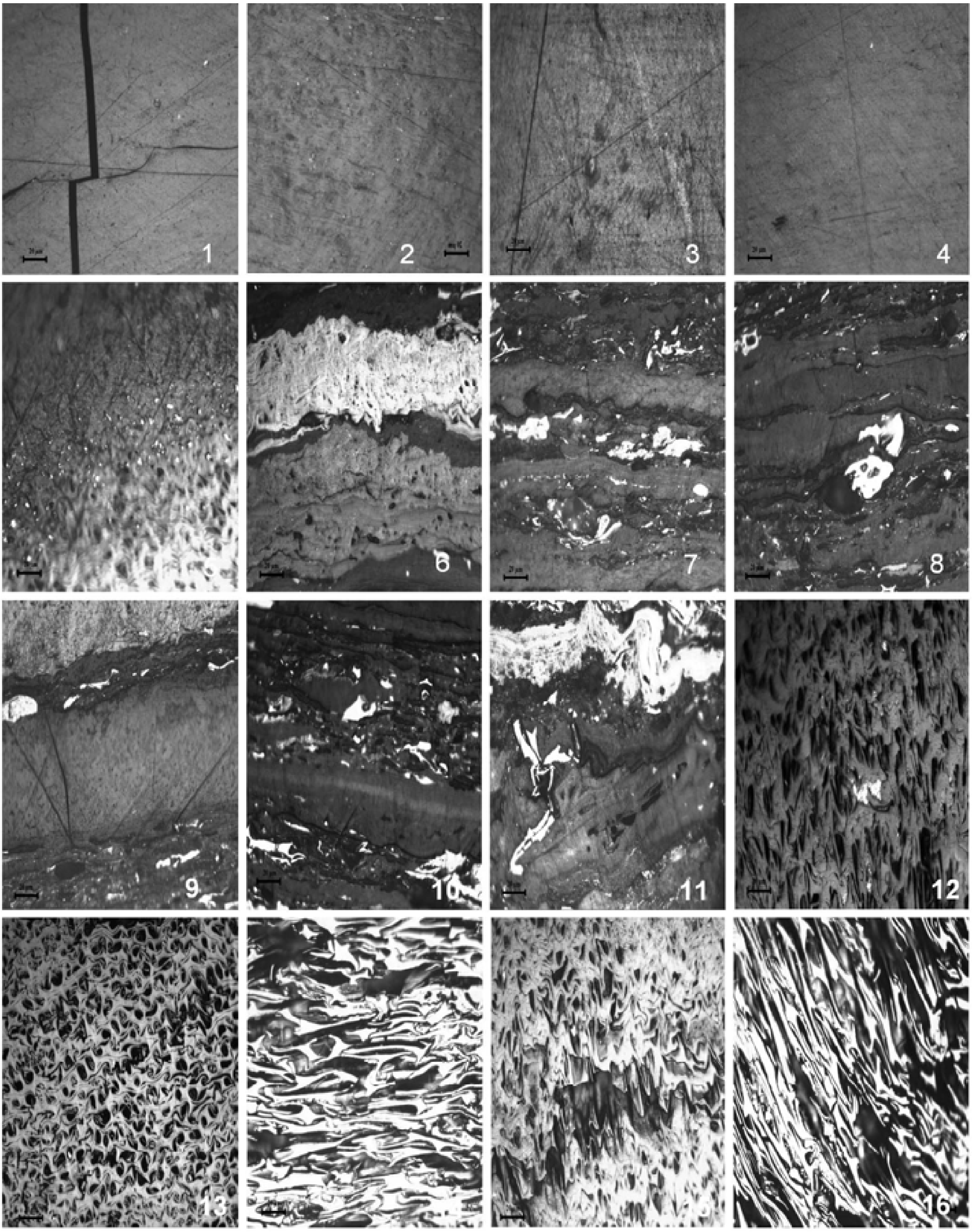

PLATE 1

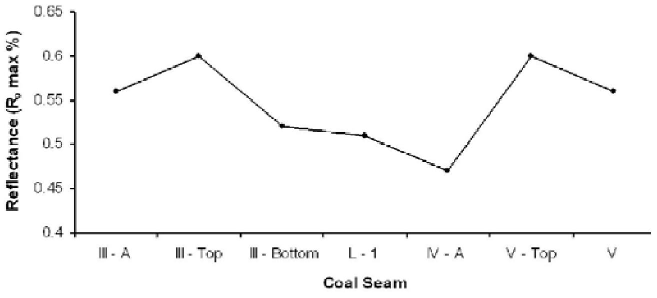

Fig. 7—Reflectance (R_o max %) analyses of the coals from B.H. No. SGK-124 from Gundala area.

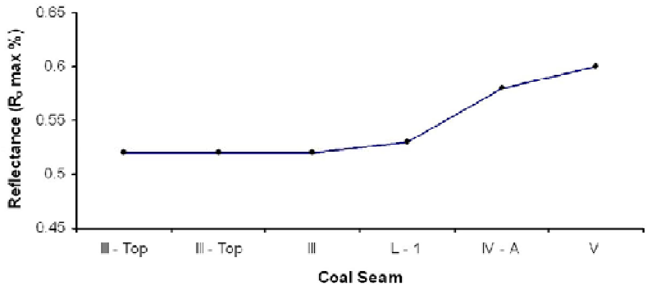

Fig. 8—Reflectance (R_o max %) analyses of the coals from B.H. No. SGK-128 from Gundala area.

Buehler Epo-kwick resin No. 20-8136-128 and Buehler Epo-kwick hardener No. 20-8138-032 following standard cold embedding technique. The coal maceral study and the reflectance measurements have been carried out on the Leitz MPV-1 microscope aided with photometric unit, mechanical stage and point counter. The recommendations of ICCP (1963, 1971, 1975, 1998, 2001) and Stach *et al.* (1982) have been considered for this analysis.

Collection Site—Bore hole No. SGK-124 has been drilled at a distance of about 2 km NW of Gundala Village, where as Bore hole No. SGK-128 is located at a distance of about 2 km SE of Gundala (Figs 1, 2, 3).

MICROSCOPIC CHARACTERISTICS OF THE MACERALS

Vitrinite—Vitrinite group of macerals have been recorded in the coals of Gundala area. They contain the dominance of telovitrinite followed by vitrodetrinite sub-group. Homogenous and structure less grey bands of collotenite usually exhibit fragmentary nature and occur more frequently than telovitrinite sub group. Telinite has darker cell walls and lower reflectivity than the collinite. Oval or spherical bodies of corpogelinite are also recorded in these coals. Collodetrinite and vitrodetrinite is generally found associated with the micro and macro-tenuisporinite besides, resinite (Pl. 1.1-4).

Liptinite—Sporinite is the dominating maceral represented by elongated thread or spindle-shaped

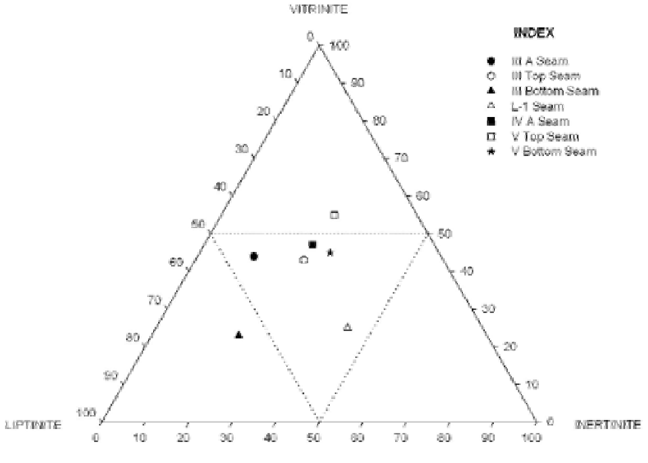

Fig. 9—Ternary diagram showing maceral (m.m.f.) constitution of the coal seams from B.H. No. SGK-124 of the Gundala area.

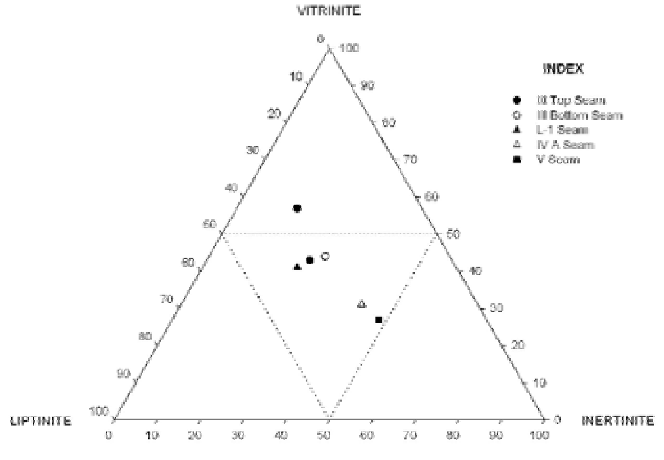

Fig. 10—Ternary diagram showing maceral (m.m.f.) constitution of the coal seams from B.H. No. SGK-128 of the Gundala area.

microspores, which are either thin walled tenuispores or thick walled crassispores (Pl. 1.10). The existence of cutinite, sporinite, suberinite and leptodetrinite group of macerals is also recorded. The frequency of megaspores is low, their walls are granular, therefore, they can be easily distinguished from the microspores by their large size and dark grey or black colour. Sporangia containing numerous spores have also been found. Dark grey coloured thick and thin walled cutinites with serrated margins are also recorded (Pl. 1.7, 8, 11). However, isolated circular to sub-circular bodies of resinite are rarely observed. Microsporinite occur frequently as linearly arranged elongated or spindle-shaped bodies.

Inertinite—Inertinite is mainly represented by highly reflecting and well preserved cellular structures of degradofusinites showing effect of compression (Pl. 1.12, 15, 16). Pyrofusinite however, exhibits bogen structure with higher reflectivity (Pl. 1.13, 14). Transition from semifusinite to fusinite is also very clearly demonstrated in these coals (Pl. 1.5). Large bands of vitrinite and inertinite are frequently noticed in these coals (Pl. 1.6, 9).

Mineral Matter—Mineral matter in Gundala area showed the existence of carbonate, sulfide and clay minerals. The sulfides mainly occur in the form of framboids, whereas, clay minerals generally occupy the space available in the cellular cavities, cracks and fissures of the vitrinite and inertinites.

Bore hole No. SGK-124 (Figs 4, 5)

The III A and III top seams encountered in this Bore hole have shown the dominance of vitrinite (35-38%) followed by liptinite (26-37%) group of macerals besides, inertinite (11-20%) and mineral matter 14-19%. The coal representing III bottom seam however, contains distinctly different coal constitution than its overlying III top and III A seams, as indicated by the dominance of liptinite (52%), the sub-dominating vitrinite (21%), followed by inertinite (19%). This seam also contains significantly low amount of mineral matter (8%), as compared to the overlying IIIA and III Top seams. The L-1 seam is represented by the dominant association of inertinite (38%), supplemented by liptinite (26%) and vitrinite (21%) group of macerals. Mineral matter is recorded to be 15%. The coal seams IV A, V top and V bottom are marked by the maximum concentration of vitrinite (36-48%) group of macerals besides, inertinite (22-24%), liptinite (17-24%) and mineral matter (12-20%).

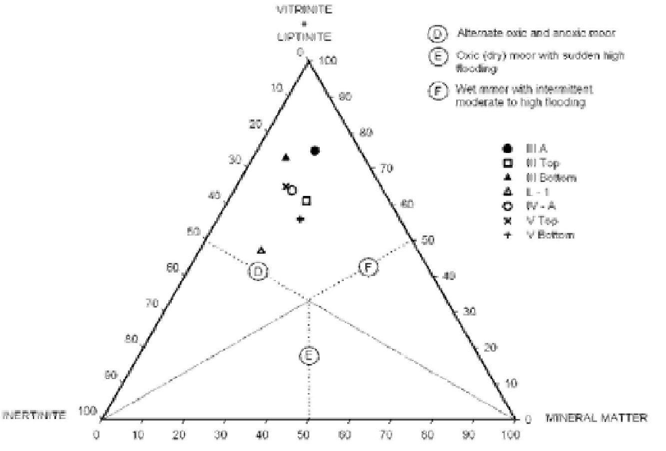

Fig. 11—Depositional conditions of the coal seams encountered in B.H. No. SGK-124 based on maceral and mineral matter content (after Singh & Singh, 1996).

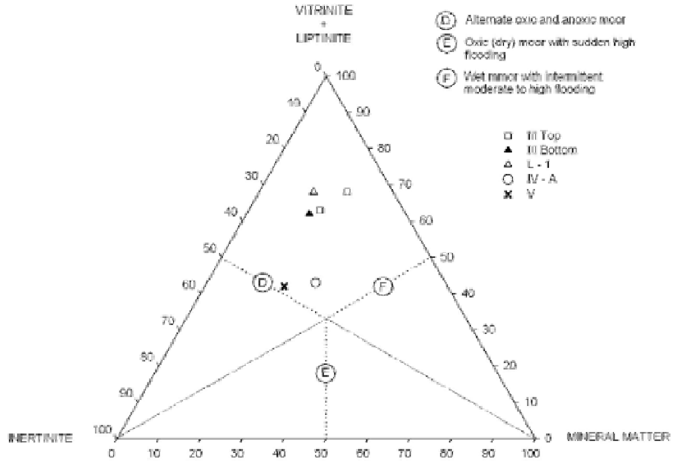

Fig. 12—Depositional conditions of the coal seams encountered in B.H. No. SGK-128 of Gundala area based on maceral and mineral matter content (after Singh & Singh, 1996).

Bore hole No. SGK-128 (Figs 4, 6)

The III top seam of this Bore hole is characterized by the dominant association of vitrinite (36-45%) macerals, followed by liptinite (23-27%) and inertinite (11-20%). Mineral matter in this seam is recorded between 17 and 21%. The III bottom and L-1 coal seams contain vitrinite (36-37%) as the dominating maceral, besides, liptinite (25-32%) and inertinite (19-23%). Mineral matter association in these seams has attained frequency range of 13 to 15%. The coal recovered from the IV A and V seams contain the dominant association of inertinite (31-39%) alongwith vitrinite (22-23%), liptinite (20%) and mineral matter (19-26%).

RANK ESTIMATION

Bore hole No. SGK-124

The vitrinite reflectance (R_o max %) value of the coals representing III A bottom seam is recorded to be 0.56%, whereas, the III top seam has indicated higher reflectance value (0.60%) than its overlying III A Seam. A gradually decreasing trend in the vitrinite reflectance has been observed in III Bottom (0.52%), L-1 (0.51%) and 0.47% in IV A seams respectively. The V top seam has shown the vitrinite reflectance of 0.60%, as recorded in the overlying III Top seam. The lowermost V bottom seam intersected in this Bore hole however, has indicated the reflectance of 0.56% (Fig. 7).

Bore hole No. SGK-128

The III Top and its underlying III bottom seams in this Bore hole have recorded the vitrinite reflectance 0.52%. A slightly higher reflectance i.e., 0.53% is observed in the coal of L-1 seam. IV A seam, however, has shown higher reflectance of 0.58%. The bottom seam of this Bore hole contains the maximum vitrinite reflectance (R_o max.) of 0.60%, which is higher than its overlying seams intersected in this Bore hole. Thus, the normal trend of increase in reflectance with respect to its depth is proved in this Bore hole (Fig. 8).

Based upon the reflectance measurements all the coal seams in both these Bore holes (SGK-124 & SGK-128) have attained high volatile bituminous C stage of the rank.

Ternary mineral matter free (m.m.f.) maceral plotting (Fig. 9) has revealed the existence of liptinite rich coal from III Bottom seam and vitrinite rich coal from V top seam. However, mixed type of coal has been recorded from III A, III Top, IV A, L –1 and V Bottom seams, intersected in Bore hole No. SGK-124. In Bore hole No. SGK-128 (Fig. 10) existence of both vitric and mixed coal types are recorded from III Top seam, where as, the coal seams III Bottom, L-1, IV A and V are characterized by the presence of mixed type of coal.

The facies model based on maceral and mineral matter constitution, as suggested by Singh and Singh (1996) has also depicted the prevalence of alternate oxic and anoxic moor in Gundala area (Figs 11, 12).

DISCUSSION

Majority of the seams intersected from Gundala area have indicated the dominant association of vitrinite along with sub-dominance of liptinite, e.g. III A, III top and IV A seams of Bore hole No. SGK-124 and III top and L-1 seams of Bore hole No. SGK-128. However, V top and V bottom seams of Bore hole No. SGK-124 though contain vitrinite dominance, the sub-dominance is occupied by inertinite. Similarly, IV-A seam of Bore hole No. SGK-124 and III bottom seam of Bore hole No. SGK-128 also contain vitrinite rich coal, but the sub-dominance is attained by liptinite. The seam L-1 of Bore hole No. SGK-124 has the dominance of inertinite, followed by liptinite group of macerals. The seams IV-A and V in Bore hole No. SGK-128 also contain inertinite rich coal constitution, however, the sub-dominance is attained by vitrinite.

Depositional Environment—Palaeogeographically, the present day Gondwanas were located nearby sub-artic region Plumstead (1962) and represent post glacial lacustrine or deltaic origin. The prevalence of cold temperate climatic condition during the deposition of the Gondwana succession is predicted by King

(1958) and Chandra and Chandra (1987). However, existence of alternate dry and rainy seasons is postulated by Kräusel (1961). Similar results have also been displayed by the facies model drawn for the study area. The forests presently growing in the sub arctic region, display the existence of broad leaved morphological feature. The Glossopteris forests of the Gondwanaland have also exhibited similar morphological feature of the leaves.

The coal of Gundala area in general has been of good quality, as it contains very low frequency of mineral matter association. Since the coal seams intersected are not very thick, therefore, it appears that these coal seams may not be commercially suitable for coal bed methane generation.

The genesis of the coal having the dominance of either vitrinite or liptinite maceral indicates the prevalence of cold climatic conditions at the site of deposition. However, inertinite rich coal constitution denotes the prevalence of oxidizing condition at the depositional site. Similarly, existence of low frequency of mineral matter association in these coals, suggests that the depositional site received continuous supply of vegetal rich resource from the luxuriantly growing dense swampy forests of the adjoining areas without much intervention of the agencies like flood.

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REFERENCES

Bhaskar Rao V, Murty VSN & Venkateswarlu PD 1971. Gravity anomalies and tectonics on a part of Lower Gondwana Basin. Symposium on Gondwana Systems, Aligarh Muslim University: 148-156.

Chandra S & Chandra A 1987. Vegetational changes and their climatic implications in coal-bearing Gondwana. Palaeobotanist 36: 74-86

Fox LC 1931. Coal in India – II. The Gondwana system and related formation. Memoir of the Geological Survey of India. 58 : 1-128.

ICCP (International Committee for Coal Petrology) 1963. International Handbook of Coal Petrology – Supplement to 2nd ed. Centre de Researche Scientifique. Qual. Antole Paris, unpaginated.

ICCP (International Committee for Coal Petrology) 1971. International Handbook of Coal Petrology – Supplement to 2nd ed. Centre de Researche Scientifique. Qual. Antole Paris, unpaginated.

ICCP (International Committee for Coal Petrology) 1975. International Handbook of Coal Petrology – Supplement to 2nd ed. Centre de Researche Scientifique. Qual. Antole Paris, unpaginated.

ICCP (International Committee for Coal Petrology) 1998. The new vitrinite classification (ICCP System, 1994). Fuel 77: 349-358.

ICCP (International Committee for Coal Petrology) 2001. The new inertinite classification (ICCP System, 1994). Fuel 80: 459-471.

King LC 1958. Basic palaeogeography of Gondwanaland during the deposition of Late Palaeozoic and Mesozoic eras. Quarterly Journal of the Geological Society of London 114: 47-77.

King W 1872a. Note on a new coalfield in south eastern part of the Hyderabad territory. Record of the Geological Survey of India 5: 41-74.

King W 1872b. Note on possible field of coal measures in Godavari District, Madras Presidency. Record of the Geological Survey of India 5: 109-128.

King W 1881. The geology of the Pranhita-Godavari Valley. Memoir of the Geological Survey of India 18: 150-311.

Kräusel R 1961. Palaeobotanical evidence of climate. *In:* Nairn Aem (Editor)—Descriptive Palaeoclimatology, Interscience: 227-254. New York.

Navale GKB, Misra BK & Anand-Prakash 1983. The microconstituents of Godavari coals, south India. International Journal of Coal Geology 3: 31-61.

Pareek HS, Deekshitulu MN & Ramana Murthy BV 1964. Petrology of Salarjung and Ross seam coals, Tandur area Godavari Valley Coalfield, Andhra Pradesh. Research Papers in Petrology by the officers of Geological Survey of India: 141-158.

Plumstead EP 1962. The Permo-Carboniferous coal measures of Transvaal, South Africa – an example of the constructing stratigraphy in the south and northern hemisphere. C. r. 4. Congr. Intern. Strat. Geol. Carbonifere. Maastricht., v. 2: 545-550.

Qureshy MN, Brahmam NK, Gadse SC & Mathur BK 1968. Gravity analysis and Godavari rift, India. America Bulletin. 79: 1221-1230.

Raja Rao CS 1982. Coal resources of Tamil Nadu, Andhra Pradesh, Orissa and Maharashtra. Bulletins of the Geological Survey of India, Series A., No. 45, Coalfields of

India Volume II, Chapter III, Coalfields of Andhra Pradesh: 9-40.

Ramanamurhty BV 1976. Report on the occurrence of a coal seam in the Kamthi Formation from Ramagundam area of the Godavari Valley Coalfield and its stratigraphic significance. Geological Survey of India. Miscellaneous Publication No. 45: 89-93.

Ramana Rao N 1962. Mikropetrographische Untersuchungen in den Gondwanokohlen von Tandur (India). Geol. Mitt. 3: 71-74.

Ramana Rao N 1965. Chemical characteristics of banded coal from Kothagudem Coalfield, Andhra Pradesh, India. Neues Jahrb. Geol. Palaentol., Monatsh., v. 1: 30-35.

Rao PV 1971. Godavari Valley Coalfield. *In :* Coal Resources of India. Memoir of the Geological Survey of India 88: 335-348.

Rizvi KS & Ramana Rao N 1969. Nature and distribution of resins in King Seam, Kothagudem coalfields, Andhra Pradesh. Proceedings of the National Institute of Sciences of India, 35A (Supplementary Volume), v. 2: 210-215.

SCCL. The Singareni Collieries Company Limited, Kothagudem, Khammam District, Andhra Pradesh.

Stach E, Mackowsky M-TH, Teichmüller M, Taylor GH, Chandra D & Teichmüller R 1982. Stach's Textbook of Coal Petrology, 3rd ed. Gebrüder Borntraeger, Berlin, Stuttgard, 535pp.

Singh MP & Singh PK 1996. Petrographic characterization and evolution of the Permian coal deposits of the Rajmahal Basin, Bihar. International Journal of Coal Geology 29: 93-118.