

PaperID **AU191**

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Paleo-depositional conditions and hydrocarbon potential of lignite deposits of Bikaner-Nagaur Basin, Western Rajasthan, India

Abstract

In Bikaner-Nagaur Basin lignite bearing horizons occur within Late Paleocene–Earliest Eocene age of Palana formation and located in Bikaner district. Petrographic study entails lignites of Bikaner-Nagaur Basin dominated by huminite followed by inertinite and liptinite. The concentration of mineral matter also recorded in these lignite deposits which reveals carbonate mineral matters are dominating over the pyrite and argillaceous mineral matter. The huminite reflectance (%Ro) indicates that lignite samples of the Bikaner - Nagaur Basin are thermally immature in nature and lignite to sub-bituminous B in rank. The organic petrographic indices reveal that these lignite deposits originated in the bog forest under ombrotrophic to mesotrophic hydrological conditions. Gelification Index (GI) and the Tissue Preservation Index (TPI), suggests an accumulation of peat in the wet forest swamp. The result from the rock-eval pyrolysis reveals lignites of Bikaner-Nagaur Basin contained Type III kerogen and grading to mixed Type III–II kerogens and considered that it can generate the hydrocarbons on maturation.

Keywords: Bikaner-Nagaur Basin, Petrography, Geochemistry, Paleoenvironment, Maturity, Hydrocarbon potential

Introduction

In the current scenario, coal has been an important primary source of energy and lignite is one of the low-rank coal type. The lignite sequences are found worldwide, including China and other Asian developing countries (Singh and Kumar, 2017a). As increase, the price of high-rank coals people's approaches the low-rank coal as an important resource. The numbers of researcher have made efforts to understand the properties of lignites for its better utilization (Singh et al., 2016; Singh et al., 2017; Singh and Kumar 2017a & b). The lignite deposits of the Bikaner - Nagaur Basin is one of the major lignite resources in India & located in the western part of the Rajasthan. These lignite horizons deposited during Late Paleocene–Earliest Eocene age of Palana formation (Singh and Kumar, 2017a). The lignite deposits of Bikaner-Nagaur Basin are industrially very important because of its vast reserves in the region. Hence, in the present paper, an attempt has been made to study about the Paleo-depositional environment as well as hydrocarbon potential of lignite deposits of the Bikaner-Nagaur Basin, Rajasthan using organic petrography and geochemistry.

Method of study

To achieve the above mention objectives, lignite samples have been collected from all the working and exposed lignite seams from Barsingsar and Gurha lignite mines from Bikaner following the pillar sampling method. The petrographic study has been done following the International Committee for Coal and Organic Petrology (ICCP-94 system; 2001, 2005 & 2017) and ISO norms (ISO 7404-5, 2009). The Rock-Eval pyrolysis was performed on Rock-Eval 6 analyzer.

Result & Discussion

The petrographic study indicates that the lignite of Bikaner-Nagaur Basin mainly comprises macerals of different groups and a considerable amount of mineral matter. The lignite deposits of Bikaner-Nagaur Basin are dominated by maceral of huminite group (13.7-91.5%) followed by Inertinite (1.9-76.0%) and liptinite (2.2-16.8%) group macerals. The mineral matters represented by pyrite, carbonate and clay

minerals and which varies between 3.8% and 33.6%. The huminite reflectance is low and varies from 0.22 to 0.36 %R_{om}. The Rock Eval pyrolysis shows that the value of S₁ peak ranges from 0.7–4.5 mg HC/g Org C, S₂ from 51.6–142.1 mg CO₂/g OrgC, for S₃ peak form 6.5–21.8 mg CO₂/g OrgC, TOC from 21.14–59.89 % and Tmax from 415 °C and 432°C. Hydrogen index (HI) and oxygen index (OI) values range from 98–366 (mg HC/g Org) and 27–43 mg CO₂/g TOC respectively.

Petrographic constituents of coals are widely used to infer the paleoenvironmental condition. Various coal facies diagrams and indices derived from maceral ratios by Diessel (1986) and Calder et al. (1991) modified by Kalkreuth et al. (1991) which provides the key information about the coal facies and paleoenvironmental condition during peat accumulation. In order to assess further information about peat-forming conditions and predominant peat forming vegetation in the study area, TPI vs. GI and GWI vs. VI have also been used. These indices gelification index (GI), vegetation index (VI), groundwater index (GWI) and tissue preservation index (TPI) were derived from the macerals ratios use to identification of depositional and environment. GI vs TPI plot, suggests an accumulation of peat in the wet forest swamp (Figure 1a), whereas GWI vs VI showing that these lignites deposits originated in the bog forest under ombrotrophic to mesotrophic hydrological conditions (Figure 1b).

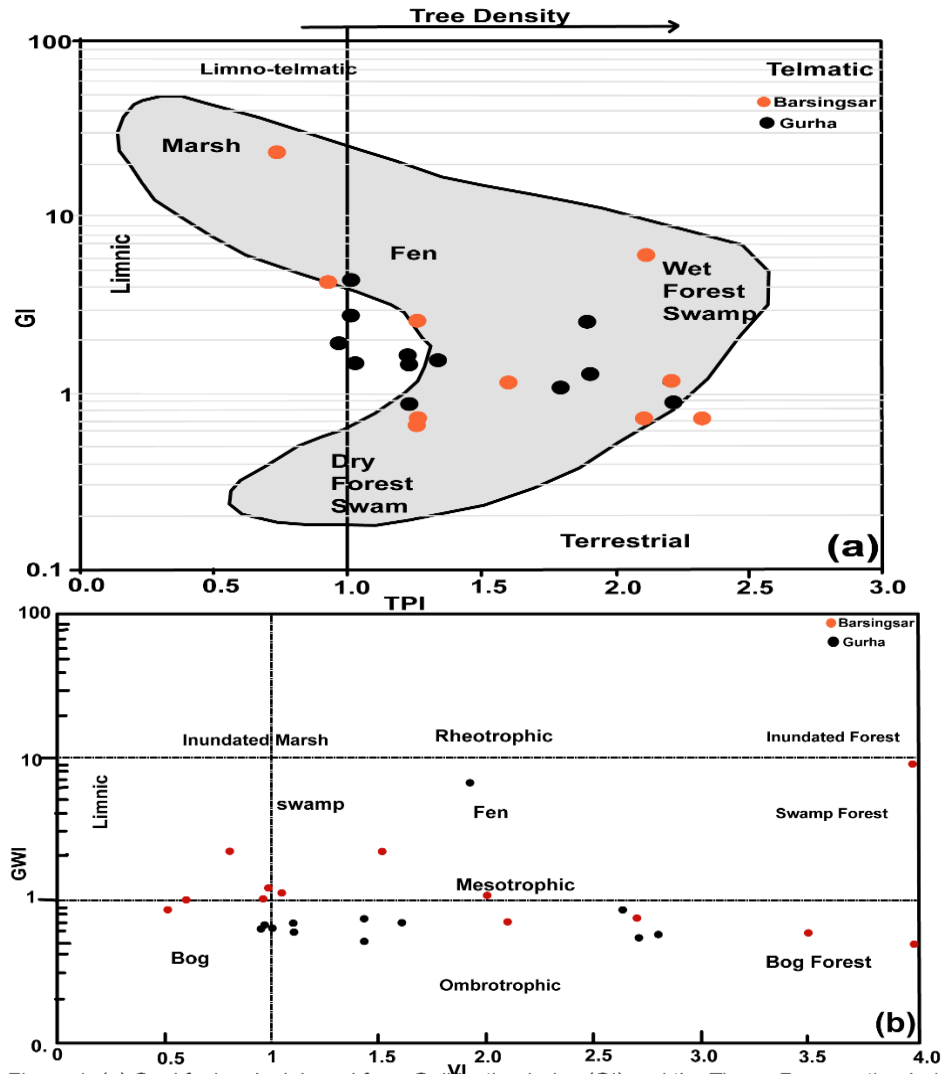


Figure 1. (a) Coal facies deciphered from Gelification Index (GI) and the Tissue Preservation Index (TPI) in relation to depositional setting and type of mire for the lignite deposits of Bikaner-Nagaur Basin (Kalkreuth et al. 1991), (b) GWI/VI mire paleoenvironment diagram (modified after Calder et al. 1991)

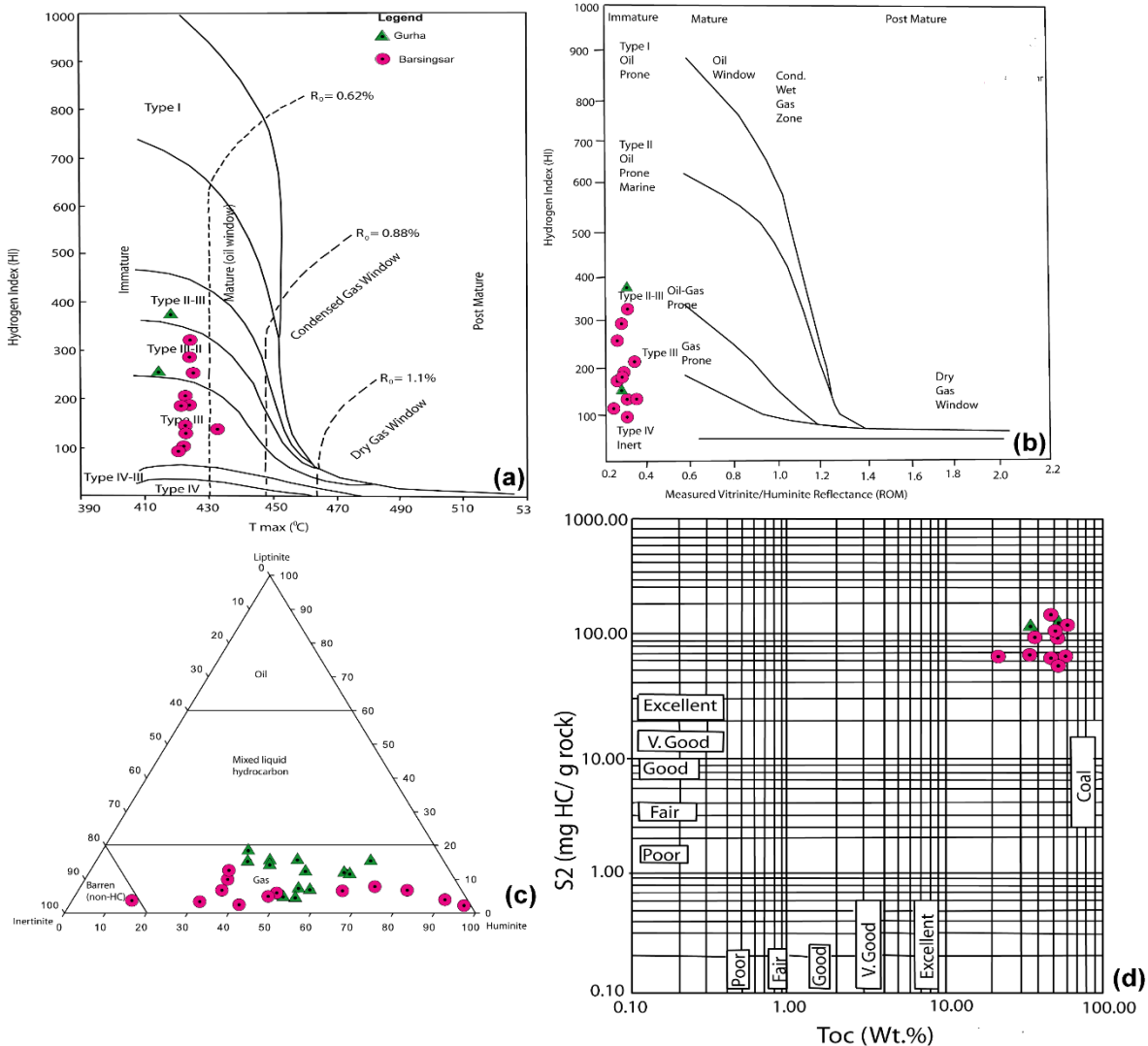


Figure 2. Plots of classification of kerogen type based on Rock Eval-pyrolysis (a) HI vs T_{max} and (b) HI vs %ROM showing Type III and mixed Type III-II kerogens and thermally immature organic matter (c) ternary diagram based on maceral composition indicating the hydrocarbon potential (d) (TOC) vs (S2) showing lignites of Bikaner-Nagaur Basin good source for hydrocarbon

To determination of type of organic matter, thermal maturity and hydrocarbon potential of organic Rock-Eval Pyrolysis is widely used method (Peters et al., 2005). The total organic content (TOC) provides the source rock richness for hydrocarbon generation (Peters et al., 2005). Hydrogen Index (HI) plot with the T_{max} entails lignites of Bikaner-Nagaur Basin contains Type III kerogen and grading to mixed Type and thermally immature to marginally mature in nature (Figure 2a) which is also supported by HI vs % R_0 plot (Figure 2b). In addition maceral concentration entails these lignite generate hydrocarbon mostly gases on maturation (Figure 2c) & excellent source rock for hydrocarbon generation (Figure 2d).

Conclusion

Petrographic investigation entails that of lignites of Bikaner-Nagaur Basin dominated by huminite group of maceral followed by inertinite and liptinite with significant concentration of mineral matters. Petrographic indices indicate the accumulation of peat in the wet forest swamp and these lignites originated in the bog forest under ombrotrophic to mesotrophic conditions. Geochemical study reveals these lignite deposits thermally immature in nature, mainly contains type III kerogen and excellent source rock for hydrocarbon.

Acknowledgement

The authors are thankful to the Director, Rajiv Gandhi Institute of Petroleum Technology, Amethi, India, for extending all the necessary facilities. Financial support from Department of Science & Technology (Project No. SB/S4/ES- 681/2013), Government of India is thankfully acknowledged.

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