Chapter-3

Background of Study Area

3.1 Description of Singrauli Coalfield

India's coal deposits are present in two different geological horizons: Permian (lower Gondwana) and the Cenozoic. Lower Gondwana hosts about 99.9% of the reserves. The Gondwana basins are situated along the river valleys. They are present on two sides of a large triangular area, the third part formed by the northern part of India's East Coast. The Damodar-Koel and Satpura river basins have an E-W trend, whereas the Mahanadi and Godavari basins have a roughly NW-SE trend. The Singrauli basin occupies a significant position within the Gondwana coalfield of India and the Son Valley Coalfield in particular. The thickness of the strata is about 150 meters, ranging in age from the Permian to the Lower Triassic. Under different climatic conditions, the sediments and coal are deposited in fluviatile and lacustrine environments.

The present study region, Singrauli, is located across the state boundary of Uttar Pradesh and Madhya Pradesh state runs along Ballia Nala to the west and along the road connecting Paratwar and Belwatia villages to the south. The coalfield is located between located at the latitude of 24°11'57.16"N and longitude of 82°39'52.37"E, respectively. The coalfield is structurally divisible into the Moher sub-basin on eastern and main basin on the western part and the seam of the Moher sub basin has been studied by Mukhopadhyay et al.(2010) in Singrauli and suggested the dominance of both deltaic as well as estuarine condition of deposition for Lower Gondwana sediments. The Barakar coal seams present in the Singrauli Moher sub basin were collected for this study.

3.2 Administration: Singrauli has a total area of 2200 km^2, approximately 80 km^2 of which is situated in Uttar Pradesh. It has a maximum length of 30 km and a breadth of about 16 km. The northeastern part falls in the Sonbhadra district of Uttar Pradesh, while the significant portion of the Gondwana basin is included in the Singrauli district of Madhya Pradesh. The coalfields have been divided into two parts by the river Kachni viz. The central basin contains the significant western and southern portions, and the Moher sub-basin in the northeastern portion, the division along longitudes of 82°30'. The Moher sub-basin coal seams are being exploited, and the detailed geographical accounts have been described in the Survey of India toposheets 63L/12 and 63L/16. The entire region is well connected by the national highway NH 135C, connecting with the state capital of Bhopal and the Jabalpur district. Varanasi, the nearest city, is 120-kilometers away and has air connectivity.

3.3 Topography: The Singrauli district is situated on a high plateau rising above the surrounding alluvial plains covered by Talcher soil sediments. Barakar sediments are present over the Talcher formation. In the north, the Gondwana sediments abut on Precambrian rocks, which form a continuous series of east-west trending ridges. The Singrauli plateau rises to 500-m above sea level from the southern plains, with an average rise of about 275-m above MSL.

The plateau has a step-like scarp that faces southerly. The steps emerge to represent different peneplanation stages. The various platforms are remnant types arising from the erosion of gently sloping sedimentary sequences of different resistances. Physiographically, the eastern portion of the coalfield in the UP is represented by a cluster of hills, a plateau in the north, and an undulating plain in the south. The western portion of the coalfield also comprises a platform inclining toward the east and south with an elevation drop of 50–60 m. Different high peaks, such as

Popari (508 m) and Burma (564 m), are significant topographic features in the southwest.

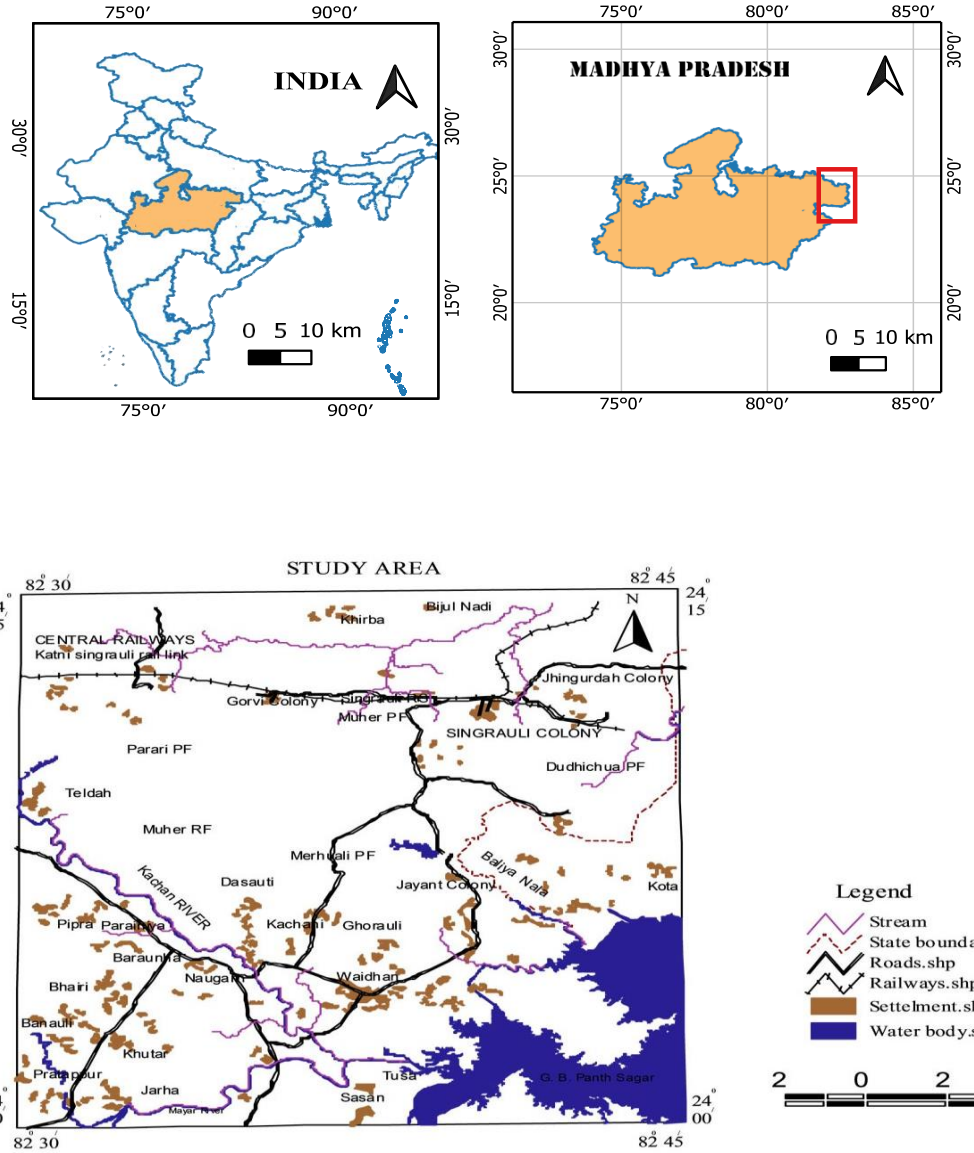

Figure 3.1. Location map of Singrauli district and drainage pattern showing the parts of coalfields (Moher sub-basin region).

3.4 Drainage Pattern: The Singrauli coalfield is situated in the drainage region of the Son and Rihand rivers. The north-flowing streams in the Moher scarp area connect the Bijul River, a tributary of the Son, and the south-flowing streams connect Kachani, a

tributary of the Rihand. Some flow directly into the Rihand reservoir, while others flow into the perennial stream, Ballia Nala. The Mehrauli Nala is the most important north-flowing stream, with a perennial flow (Figure 3.1). Most other Nalas in the plateau, such as Turra, Murwani, and others, are seasonal. In the Amelia area, the primary drainage comprises the Parawar and Bandha Nalas with the semi-perennial flow. Dendritic-type drainage morphology is developed, and controlled by lithological and topographic features in the south-eastern portion of Rihand Dam, a reservoir of GBP Sagar that covers nearly 50 km^2 of the area; the drainage area receives mining effluents from various projects.

3.5 Climate and Vegetation: The Singrauli coalfield experiences a tropical monsoonal climate. The winter temperatures range from 5 to 10 °C and summer temperatures can reach 46 °C in the shade. However, the nights are pleasantly cool, even on the days when the temperature is high. The entire region enjoys a good monsoon season, and annual rainfall amounts to 125 and 150 cm. The maximum and minimum relative humidity is 86% and 45% in the area during the winter and summer, respectively.

In the region, the elevated portions, is mainly covered with open mixed forests in all geological formations and almost all types of topography. The main species are Salai (*Boswelliaserrata*), Tendu(*Diospyrosmelanoxylon*), Anola(*EmblicaOfficinalis*), and Gunja *(Lanneagrandis)*. The bamboo *(Dendrocalamusstrictus*) mixed forest is more or less uniform in the area except in some compartments where it supports Haldu *(Adina cordifoiia*). All age classes of trees are present, but middle-aged trees predominate. Most of the mixed forest is patchy, having a density of between 0.4 and 0.6. The flat topography is deforested for agriculture and mining activities. Mango is the dominant plant committee, along with thorny and bushy plants.

3.6 Geological Setting of Singrauli Coalfields

3.6.1 Structure of the Basin: The Singrauli coalfield is located at the Son-Mahanadi master Gondwana basin's northern extremity, stretching from Orissa's coast to the heart of the Indian peninsula. This coalfield is situated at the junctional position between the east-to-west treading Tatapani Damodar and Koel basin and the NW-SE trending rift zone of the Son Mahanadi valley (Figure3.2 and Figure3.3). Thus, the stratigraphic and tectonic framework of the Singrauli basin shows characteristics of both the Damodar valley and the Son-valley of Gondwana basin. Singrauli stratigraphic sequence is similar to that of the neighboring Gondwana Tatapani, Humtar, and Karanpura basins. On the other hand, the sedimentary organization of the lithic piles shows a predominance of sandstone-dominated cycles typical of the Son Valley basin belt. Furthermore, the Gondwana sediment in Singrauli was deposited by the Son Valley basin's north-westerly draining fluvial network. Thus, many geological peculiarities of the basin can be attributed to its peculiar location at the junction of the rifts. The regional strike of Gondwana sediment is more or less west, with a slight variation from north to the southwest. The bed has a low northerly dip of 10 to 15 degrees in the southern part but shows a variable dip in the northern part due to faulting, and it is predominantly restricted to the Central Indian Tectonic Zone (Raja Rao, 1983).

The lower portion of the Gondwana formation of the Singrauli basin is separated from the main stretch of coal measures of the Sohagpur-Sunhat master basin by an extensive track covered by supra Barakar sediments. In the absence of geophysical and borehole data, it is hard to guess whether there is an interconnection between the coal measures of these two beneath the cover of a thick pile of upper Barakar rocks. It is, however, reasonable to infer that, with the shifting of the basin axis during

sedimentation, the younger sequence of the Gondwana pile might have been laid down directly on the Precambrian basement. Significant parts of the Singrauli coalfield are covered by the Barakar, Karahabari, and Talchir formations. The coal seams are uniformly distributed in the gently inclined Gondwana basins.

The northern portion of the Singrauli is delineated by a prominent east-west boundary fault, which is perhaps an offset of the Narmada Son lineament. The Talcher sediment rests unconformably on the Precambrian rocks along the eastern region of the coalfield. Towards the west, the upper Gondwana sediments are juxtaposed against the Bijawar sandstone of the Proterozoic period. Proterozoic period (Khan et al., 2020; Saxena et al., 1990)

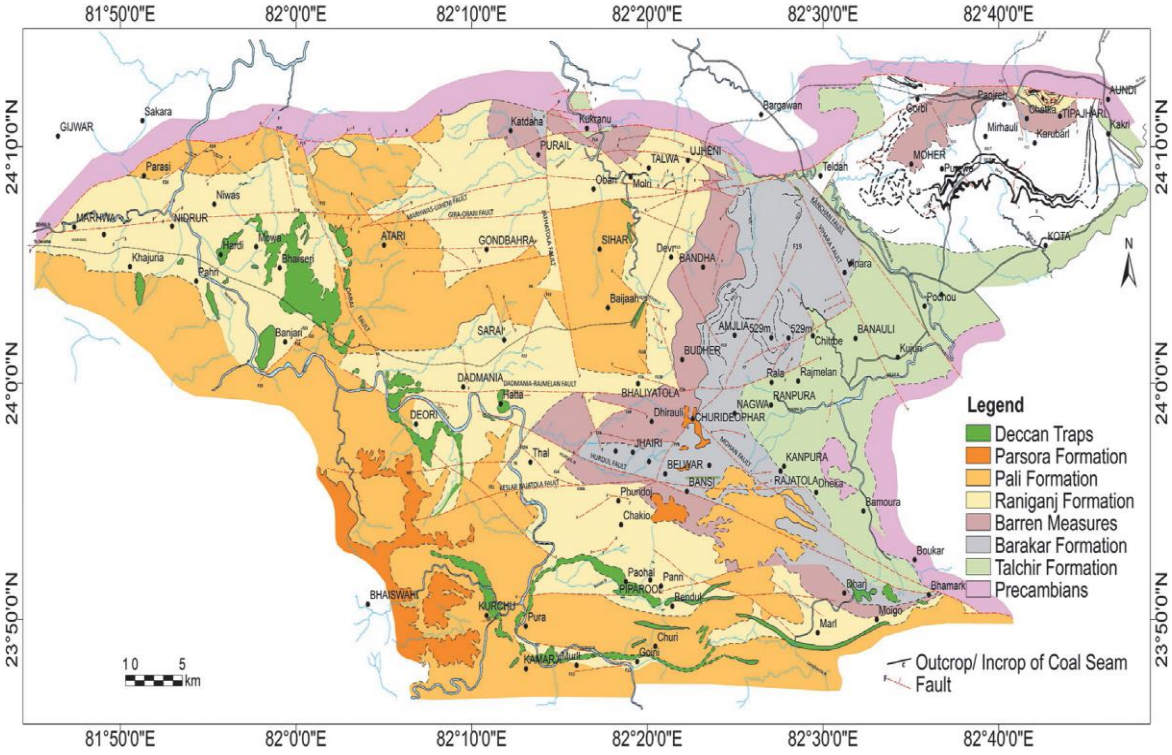

Figure 3.2. Regional geological map of the Singrauli coalfield, showing the part of Moher sub-basin in the northeast portion (Mukhopadhyay and Bhattacharyya, 2019).

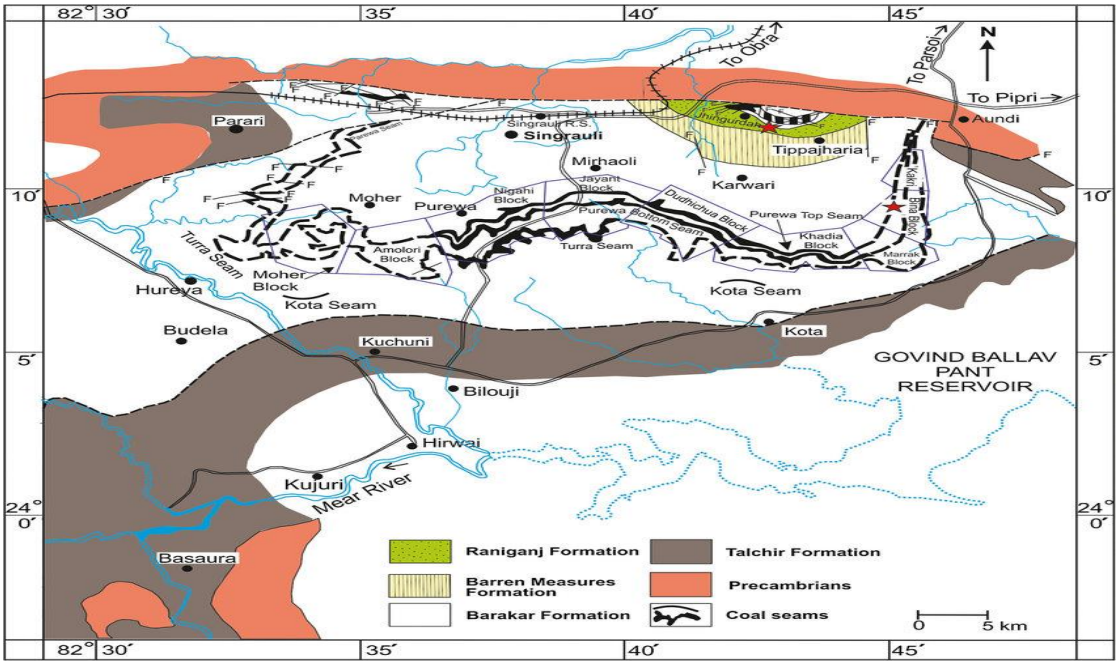

Figure 3.3. The geological map of coal hosting the Moher sub-basin (part of the Gondwana basin), Singrauli, India (Singh et al., 2017)

Table 3.1. Generalized geological sequences developed in the Singrauli basin

Age	Formation	Lithology
Cretaceous	Intrusive	Dolerite dykes and sills
Upper Permian to Triassic	Parsora	Fine to medium grained, well sorted quartzose sandstone with reddish shale/silty shale
----------Unconformity----------		
Lower Triassic	Pali	Coarse to fine grained, cross bedded and laminated, quartzose to feldspathic and ferruginous sandstone at places pebbly, white, green, buff, grey mudstone, palaeosols (as bed)
Upper Permian	Raniganj	Coarse to fine grained, feldspathic cross bedded and laminated sandstone, carbonaceous shale and regional and local coal seams
Middle Permian	Barren Measure	Medium to very coarse grained quartzose to feldspathic sandstones with pebbles and clasts/drapes; occasional shale and clay beds
Lower Permian	Barakar	Medium to coarse grained arkosic to sub-arkosic and quartzose sandstone, pebbly at places, shale, clays, coal seams and frequent bands of greenish mudstone
----------Disconformity----------		
Upper Carboniferous	Talchir	Dark greenish grey to green needle shale/siltstone, fine to very fine grained calcareous sandstone with thin interbeds of limestone, diamictite including pebbly sandstone and boulder bed.
----------Unconformity----------		
Precambrian	Mahakoshal and Surguja Crystalline Complex	Granite, gneiss, quartzite, phyllite, schist, migmatite, pegmatite

Table 3.2. Geological age and lithology of coal bearing formations of India (After G SI1998).

Coalfields	Geological Age	Localities
Cenozoic	Early Pleistocene to Late Pliocene	Lignite in the Karewa Formation, Kashmir Valley
	Miocene	Lignite in the Cuddalore Series Arcot, Chennai and Kerala
	Oligocene to Late Eocene	Lignite in the Barail Series in Nazira, and Assam.
	Middle Eocene	Lignite of Palana, Rajasthan,
	Early Eocene	Coal in Jaintia Series of Assam and Jammu
Upper Gondwana	Late Jurassic	Chikialia and Kota in Kota Stage, Maharashtra, M.P.
Lower Gondwana	Late Permian	Raniganj, Jharia,Bokaro, Karanpura, Damodar,Valley
	Early Permian	All Lower Gondwana Coalfields of the Peninsula India, Damodar, Son, and Pench valley.

3.6.2 Geological Descriptions

Pre Cambrian Basement: The Precambrian basements on which the Gondwana sediments are found have one prominent unconformity, with gneiss and schist in the south and phyllite and quartizes in the north. A series of ridges with meta-sediments demarcated the basin's northern boundary in the north-eastern part. Gondwana rocks are juxtaposed against the metamorphics of the Mahakoshal Group of rocks (Figure 3.2)**,** mainly along an east-west trending shear zone(Roy and Prasad, 2001).

Talcher Formation: In a narrow strip around Parari village in the northern part of the coalfield, the rocks belonging to the Talcher formation are mainly exposed over large areas of the plain in the eastern and southern parts of the Singrauli coalfield. The Talchir formation is present in the northern parts of the coalfield; near Parari village, a narrow strip of Talchir rocks exists. These rocks are devoid of coal. The Damuda

formation rests over the Talchir rocks.

Barakar Formation: The sediments of the Barakar formation cover a wide tract in the eastern part of the coalfield. The Barakar formation signifies prominent landmarks because of the rigid and compact nature of the strata, the sediments having a rugged and compact lithology and extending over a large area (515.18 km^2) with lateral variation in thickness. The maximum thickness of the Barakar sediments ranges from 585 to 600 meters in the eastern part, which reduces to 325 to 400 meters in the western part.

Damuda Formation: This Formation rests over the Talchir rocks. The Damuda is the most developed and valuable series in the area. The Karharbari series is not developed in this area. The major litho-units in this formation consist of medium to coarse-grained, pinkish, white, light grey, and arkosic sandstone. Fine-grained sandstone is also seen within the formation, but its proportion to the coarse-grained is relatively low. The occurrence of a high percentage of sedimentary garnet in sandstone gives it a pinkish color. The sandstone is occasionally loosely cemented with good porosity and usually acts as an aquifer when it is sandwiched between multistoried sandstone, which has attained a thickness of 50 m to 60 m. The shale beds are also inter-bedded with coal and comprise most of the grime band inside the seams. The shale is grey and usually sandy. The occurrences of some thick coal seams break the continuity of sandstone. However, the total thickness of coal is much lower than non-coal-bearing horizons. In the western part, the average coal/non-coal ratio of the Barakar formation is 1:11.6, while in the east, it is 1:10.6. The Barakar Formation comprises six major coal seams locally known as Kota, Turra, Purewa, Khadia, and PaniPahari seams from bottom to top. Inter-seam parts separate them, most of sandstone and shale.

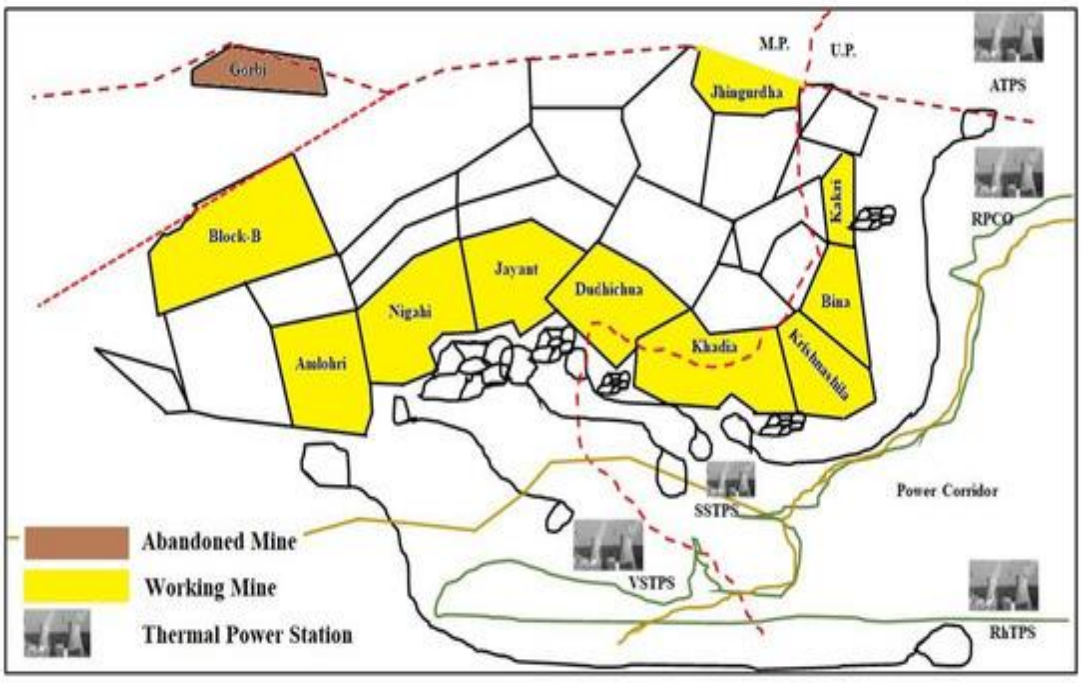

Figure 3.4. Productive coal mines (Bina, Kakri, Krishnshila, Dudhichua, and Jayant) of Northeastern Coalfields Limited(NCL) (Shirin et al., 2021).

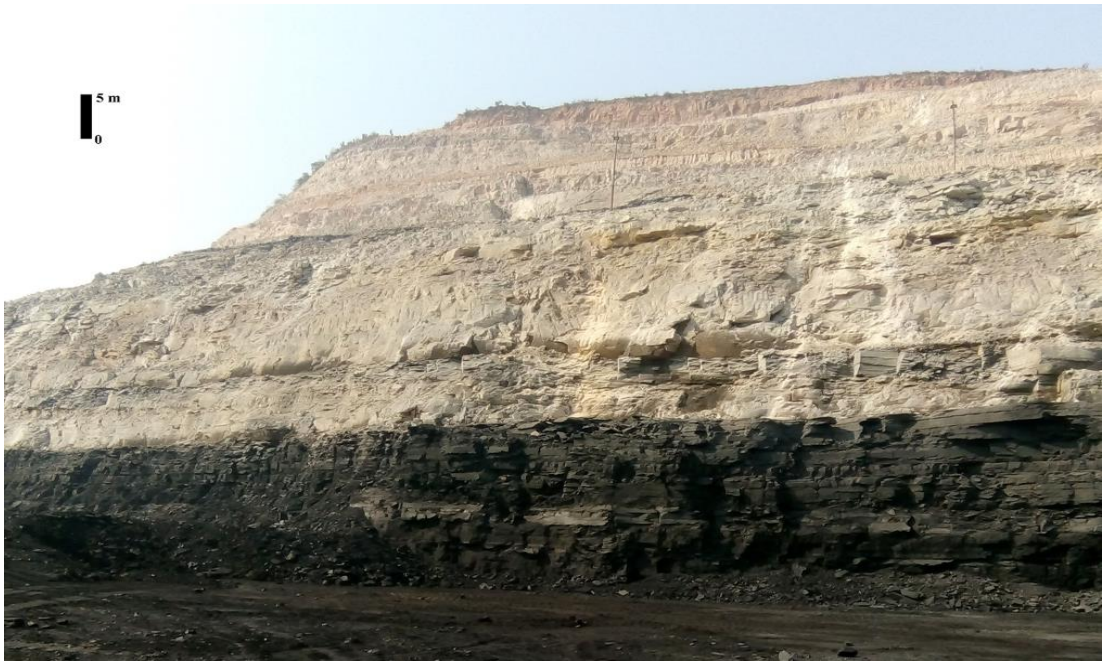

Figure 3.5. Vertical profile of working face of Dudhichua Mine showing exposure of Turra seam.

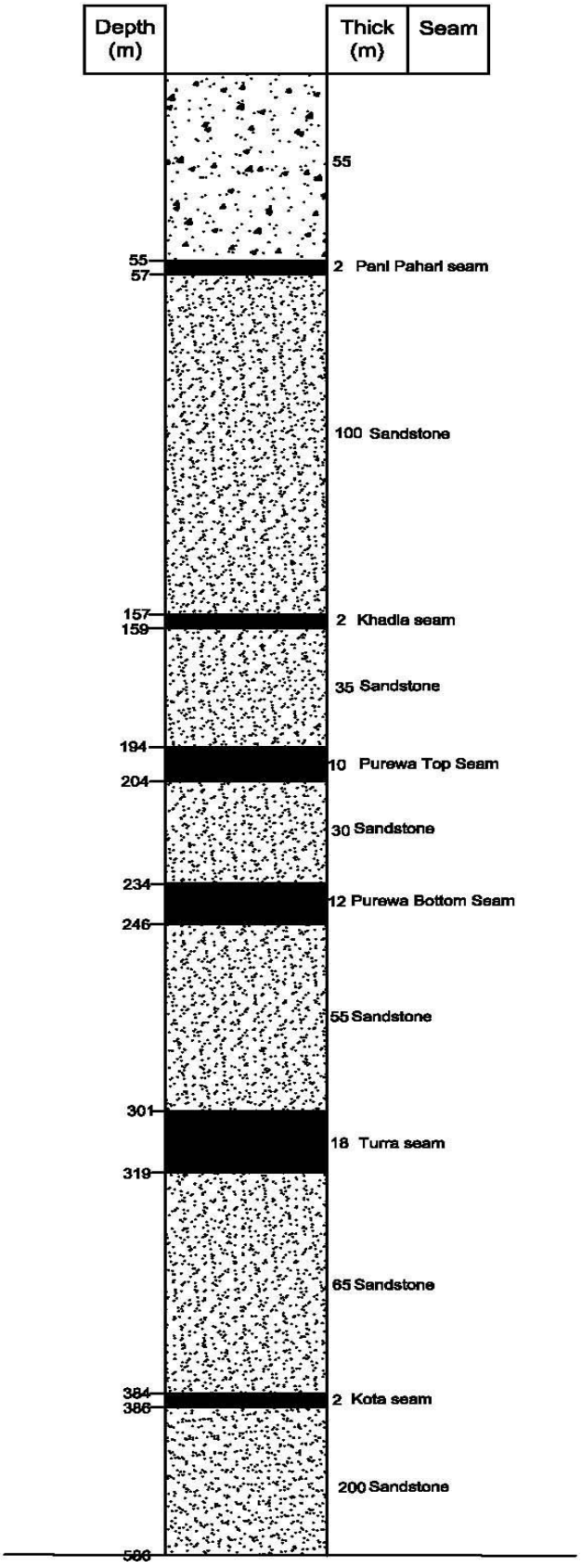

Figure 3.6. Generalized sequences of coal bearing Barakar Formation (Mahapatra, 2016).

3.7 Mode of Occurrence of Coal Seams

3.7.1 Introduction: The productive coalfields investigated in this study are part of Bina and Kakri, Krishnshila, Dudhichua, and Jayant mines (Figure 3.4). These coalfields are parts of the Moher sub-basin, and the Moher sub-basin is located in the Singrauli main basin. The Barakar formations are the coal-bearing hosts of these coals. The coal seams in these coal fields are confined to the Barakar formations. The Singrauli Basin is a significant repository of Permian Gondwana coal in India and is estimated to have 10060 Mt of coal reserves. The coal exploration carried out by the GSI in the Singrauli Main sub-basin noted the development of seven regionally persistent coal seams, viz., Seam-I to VII, in ascending order within the Barakar Formation (Khan et al., 2020).The Singrauli Coalfield, managed and controlled by the Northern Coalfields Limited (NCL), contributes about 13% of India's total coal production through semi-mechanized opencast mining operations. The coalfields are made up of ten mining blocks (Kakri, Bina, Nigahi, Amlohri, Khadia, Dudhichua, Jayant, Moher, Gorbi, and Jhingurdah).

The coal is banded in appearance, with vitrain and clarain being the predominant lithotypes. Durain has also been seen only in a few coal samples, and fusain has also been observed. Some coal samples also have pyrite framboids and small nodules. The seams are also characterized by pinching and swelling structures. The total coal-bearing area covered the whole basin. Coal is intercalated with black shale and sandstone in the formation and occurs as seams that indicate the fluvial environment's coal deposits (Singh et al., 2016). The seams occur as continuous parallel bodies and split into other beds. The coal-bearing Singrauli Basin is overlain by a sequence of alternating medium to coarse-grained sandstone and clay belonging to the Gondwana sedimentation with a gradational contact. The entire region is covered by recent

sediment (soil), and the sub-surface geology has been worked out based on mine faces and borehole data. Subsurface data of wells drilled for coal exploration in and around the block by various agencies like CMPDI, GSI, and MECL. This data provides a detailed insight into the thickness depth, stratigraphy, and coal measure.

3.7.2 Coal Seams of Barakar Formation

The Barakar Formation, which hosts the coal seams, covers a large area in the region's eastern part. It is comprised of rugged and compact, coarse to fine-grained, gray, pink, and white-colored sandstones, along with grey and carbonaceous shale beds. The Barakar Formation contains seven coal seams, locally known as Kota, Turra, Purewa Bottom, Purewa Top, Purewa Merged, Khadia, and Pani Pahari seams, from bottom to top, separated by inter-seam partings of shale and sandstone (Figure 3.6). The coal exploration carried out by the GSI in the Singrauli sub-basin established the development of seven regionally persistent coal seams, viz., Seam-I to VII, in ascending order within the Barakar coal-bearing Formation (Khan et al., 2020).

i. **Kota seam:** The thickness of the seam lies between 0.35 and 3.16 m. It is the lowest coal seam in the Moher basin and is inconsistent and erratic in both lateral and horizon extremes. It usually occurs in the form of splits. The composition of the seam ranges from interbedded coals to carbonaceous shale.

ii. **Turra seam:** This is the most prominent coal seam in the Moher basin, found in all blocks from Kakri in the east to Block B in the west. Here its thickness ranges from 12 m to 26 m. The upper part of the seam is inter-bedded, while the lower part is free from dirt bands varying from block to block.

iii. **Purewa bottom seam:** On this horizon, the entire thickness of the seams ranges from 9 to 14 meters, which is present in the eastern and southern portions of the

Moher basin. The seams of this horizon are highly interbedded and are more or less parallel to the Turra seam.

iv. **Purewa top seam:** In contrast to the above seam, this seam is highly interbedded with a thickness of about 9 to 50 m. In the western part of the coalfield, both the sections consolidated into the Purewa merger seam.

v. **The Purewa merger seam:** The thickness of this seam is about 25 m. The seam is located in the west part of the Moher basin and is highly interbedded in characteristics.

vi. **Khadia seam:** The seam occurs above the Purewa top. Khadia seam is not considered for exploitation because of thinness. It is inter-banded and impersistent, and locally developed in Khadia, ranging between 1 to 2 m in thickness.

vii. **Pani Pahari seams:** Like the latter seam, this 1- to 2-m seam, occurring at 150 m above the Purewa top, is local in extent and a workable section is not available.

3.8 Mining and Allied Industries in the Area: The discovery of coal led to the development of much industrial activity and large-scale coal mining in the last few decades. CIL has delegated coal excavation in this region to NCL, a subsidiary of CIL. Rapid industrialization has caused a high-grade metamorphosis of the environment. The combined impact of large-scale industrial activity will likely threaten the natural ecosystem and environment. The neighboring industries affect the quality of land, air, and water, as well as the population of flora and fauna of the region. The availability of coal reserves and the nearby extensive water reservoir known as Govind Ballabh Pant Sagar provide an excellent position for thermal power

plants (TPPs), aluminum, cement, and chemical industries. Water availability in the Govind Ballabh Pant Sagar area is suited to the capital of power generation in India through the pithead power stations. There are many thermal power stations producing energy. Besides these power plants and other industries in the area, Hindustan Ammonium, Hindalco industries, Dalla Cement Factory, Jaypee Power Limited, Essar Power Limited, Lanco Power Limited, Mahan Power and Alumina Limited, and NTPC are present.