The Impact of Coal Characteristics on CBM Prospectivity of Barakar Coals of Damodar Valley Coalfields*

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Search and Discovery Article #80205 (2012)
Posted January 30, 2012

*Adapted from oral presentation at AAPG International Convention and Exhibition, Milan, Italy, October 23-26, 2011

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Abstract

Barakar Formation Coal of Damodar valley Gondwana coalfields are of Permian age deposited in fluvio/deltaic condition having maturity from sub-bituminous to low volatile bituminous coal, are considered as storehouse of CBM. However, some authors have reported possible brackish/marine signature in the Barakar formation in western part of the valley. The coal resource is distributed vertically in a multi-seam environment rather than spatially as found in some of US basin. Author, due to association in CBM exploration activities for last one and half decade had the opportunity to study and interpret huge quantity of laboratory and other data generated in acreages of five prominent Eastern India Permian Gondwana coal fields. Systematic CBM specific data was generated from more than 67 coreholes (probe hole) and 31 test wells. Besides using primary data generated from more than one thousand coal samples, secondary data from published sources available from coal mining industry active in the area since beginning of last century was also used wherever required. The study made an effort to establish broad coal characteristics in terms of maceral composition (only the major constituent), maturity, coal quality in terms of mineral matter component of Barakar coals of the coal fields. Study also made an effort to establish CBM potential in terms of gas content vis-à-vis maturity and maceral composition. The impact of maceral composition & maturity on gas composition both molecular and isotopic was also tried to be deciphered. Gas saturation vis-à-vis maturity and coal composition was also studied. The study shows that Barakar formation coal of Jharia, Bokaro and Raniganj coalfields has maturity mostly in the range of 0.79 to 1.68VRo,0.67 to 1.69 VRo and 0.84 to 1.28VRo respectively and in the window of significant methane generation. VRo in South Karanpura ranges from 0.62 to 1.05 VRo and in North Karanpura from 0.5 to 0.9 VRo. Coals are mainly vitrinitic-inertinitic type, liptinic content increase as we move from east to west, showing maximum in North Karanpura coals. For Jharia and Raniganj molecular gas composition of desorbed gas from coal samples is dry to very dry with methane mostly constitutes more than 95% of the gas. However, in Bokaro the gas composition often shows significant amount of the Carbon Dioxide and further study is required to establish its genesis. Due to more liptinic component of coal desorbed gas composition from North Karanpura is less dry than other coalfield and have good amount of ethane & higher component in the gas

desorbed. Isotopic composition in all the cases follows maturity trend except in Raniganj coalfield which is erratic due to extensive localized intrusive heat effects. Adsorptive capacity of coal is mostly determined by maturity and Inertinitic coal seems to show good adsorptive capacity at maturity more than 1.3VRo. It can be assumed that from CBM potential perspective Jharia & Bokaro can be put in best category followed by North Karanpura & Raniganj coals.

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The Impact of Coal Characteristics on CBM Prospectivity of Barakar Coals of Damodar Valley Coal Fields

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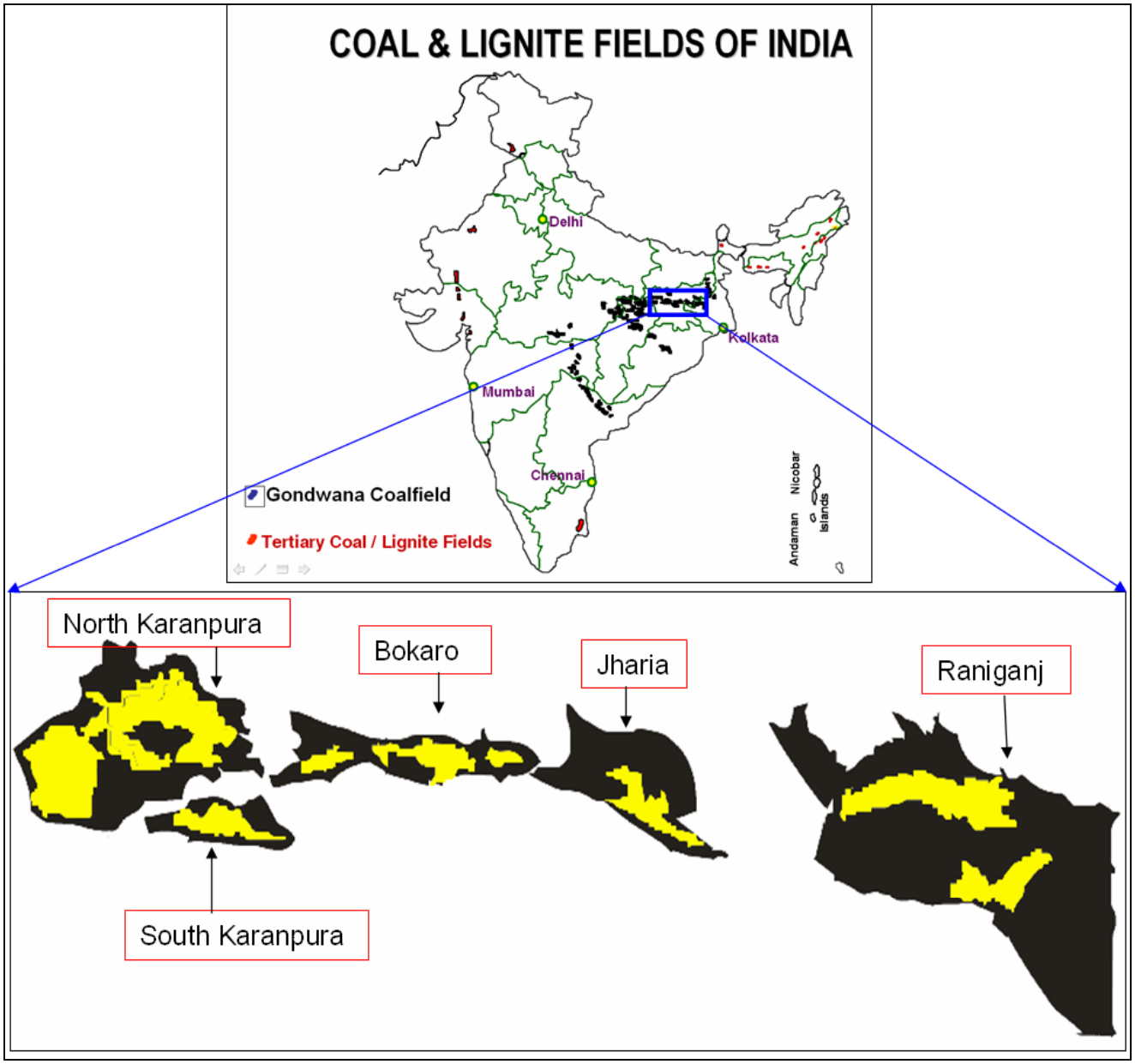
Presentation Outline

- Study Area
- Geological Setting
- Data Sources
- Cumulative Coal Thickness
- Maceral Composition
- Maturity of Coals
- Impact of Coal Characteristics on
  - ✓Gas Content
  - ✓Gas Composition-Molecular & Isotopic
  - ✓Adsorption Characteristics
- Sumup

Location of 5 Coalfields in Study area (ONGC Acreages shown in yellow color within the coalfields)



Data Sources:

- This study uses CBM specific data was generated more than 67 coreholes (probe hole) and 31 test wells from CBM acreages of ONGC.

- CBM specific primary data generated from more than one thousand coal samples,

- Secondary data - published sources available from coal mining industry active in the area since beginning of last century

Geological Setting

Fig.1. Distribution of Gondwana basin belts of India.

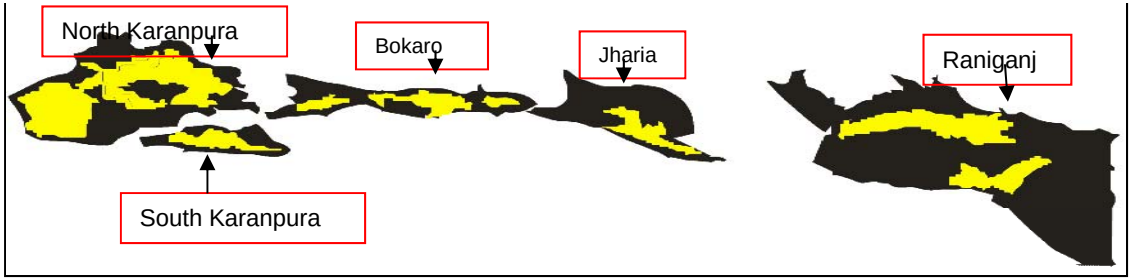
AGE	LITHOLOGY	FORMATION /GROUP		DEPOSTIONAL ENVIRONMENT	THICKNESS RANGE (M)
LOWER JURASSIC	CONGLOMERATES, SANDSTONES AND SILTSTONES. MINOR CLAY BANDS	MAHADEVA (OR SUPRA-PANCHET) FORMATION		BRAIDED RIVER SYSTEM	LESS THAN 800
TRIASSIC	ALTERNATING SHALE AND SANDSTONE	PANCHET FORMATION		MEANDERING RIVER SYSTEM	1000
UPPER PERMIAN	SANDSTONE, SHALE, SILTSTONE, COAL SEAMS	DAMUDA GROUP	RANIGANJ FORMATION	MEANDERING RIVER SYSTEM	900
LOWER PERMIAN	SANDSTONE, SHALE, SIDERITE BANDS, MINOR COAL STRINGERS	DAMUDA GROUP	BARREN MEASURES FORMATION	MEANDERING RIVER SYSTEM	100-500
LOWER PERMIAN	SANDSTONE, SHALE, SILTSTONE, COMMERCIALLY EXPLOITABLE COAL SEAMS	DAMUDA GROUP	BARAKAR FORMATION	MEANDERING RIVER SYSTEM	300-1200
LOWER PERMIAN	TILLITE, BOULDER BED, CONGLOMERATE, SANDSTONE, SHALE, VARVE DEPOSITS	TALCHIR FORMATION		GLACIAL, BRAIDED RIVER	100-300
UPPER PALAEOZOIC	SEDIMENTARY DEPOSITS	OCCASIONALLY PRESENT			
PRE-CAMB	GRANITES AND METASEDIMENTS (BASEMENT COMPLEX)				

-Damodar Valley Coal Basin is WNW-ESE trending belt of one of the four major linear belts of Gondwana Basins of India which occur within the suture zones of Precambrian cratonic blocks of Peninsular India.

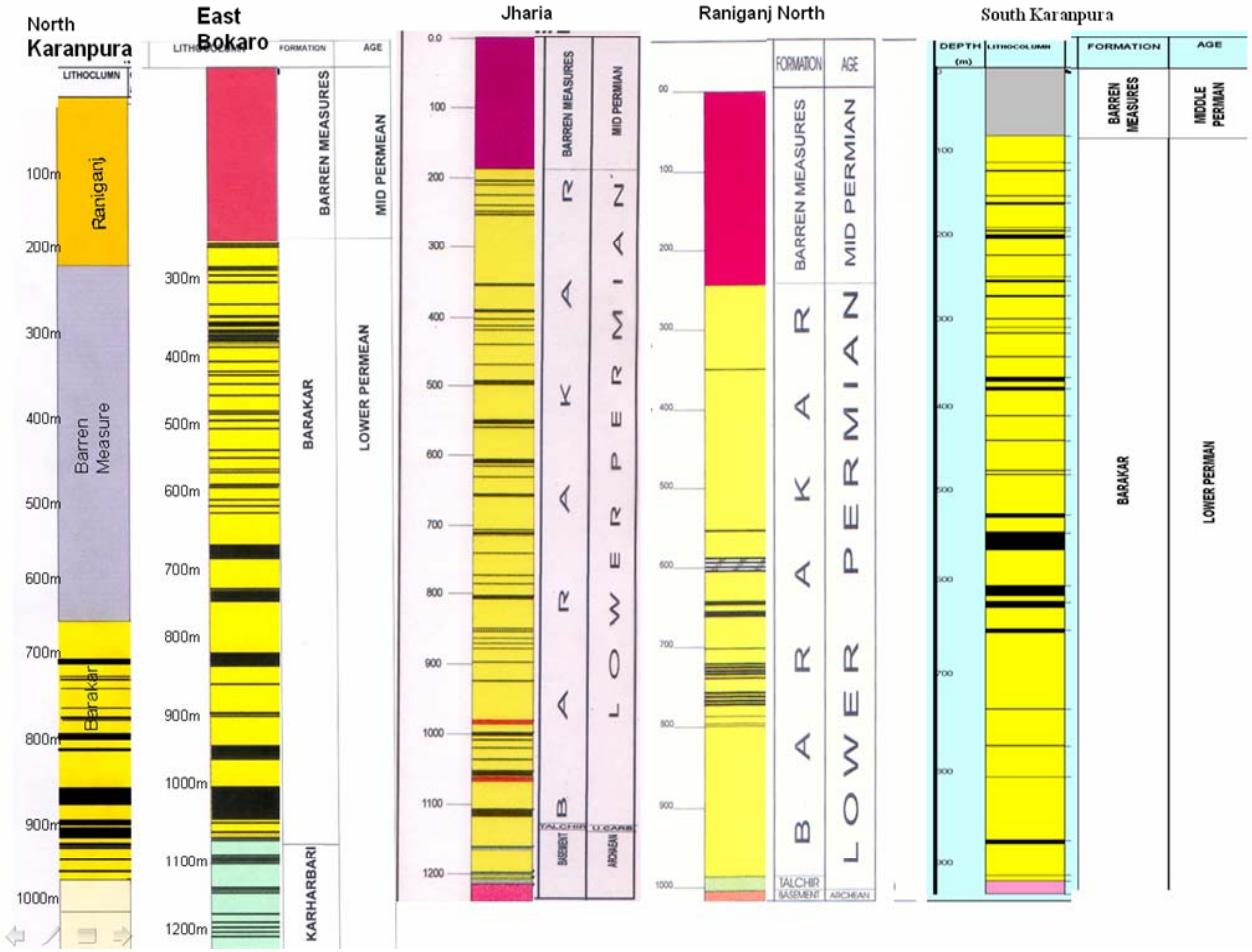
-The basin is demarcated by boundary faults having graben or half-graben geometry and unified by post-Permian strata and are named after the River Damodar.

-Gondwana Supergroup is subdivided into Permo-carboniferous Lower Gondwana Group and Mesozoic Upper Gondwana Group.

Cumulative Coal Seam Thickness:

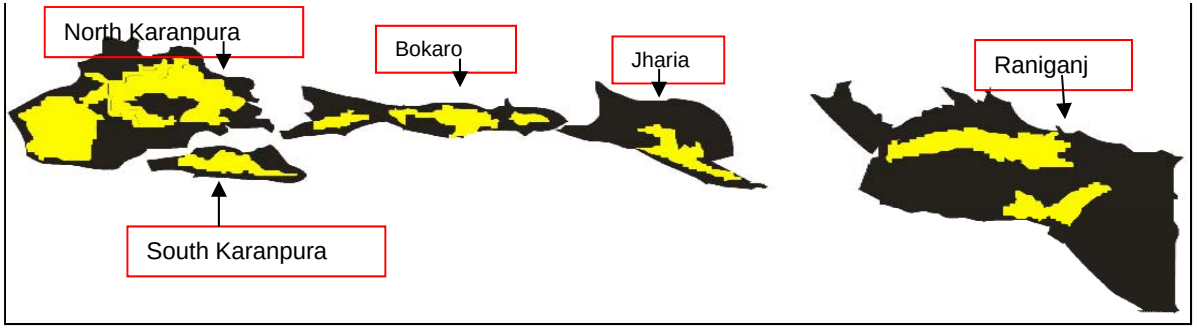


Typical Coal Seam Distribution



- The coal resource are distributed vertically in a multi-seam environment.
- Cumulative coal thickness in Barakar Formation may vary from 20 to 160 m having individual target coal seam thickness 3m to 30m as found in the identified fairway portion of the acreage area.
- The depth of coal seam occurrence varies from 300m to more than 1200m.

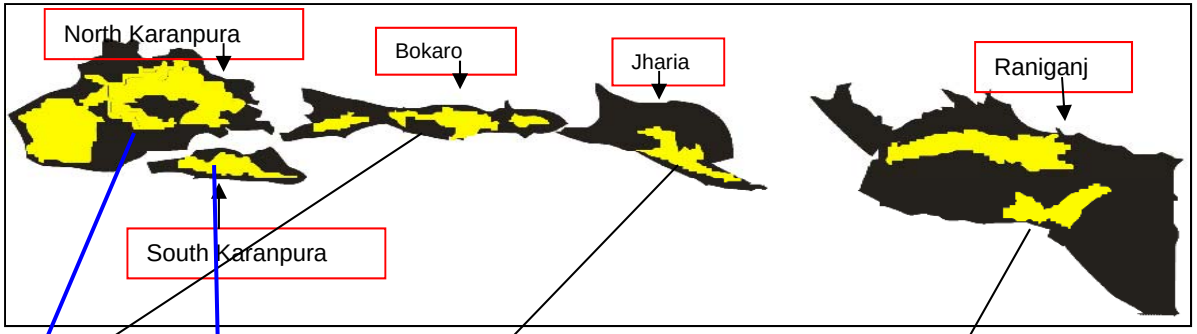
Maceral Composition

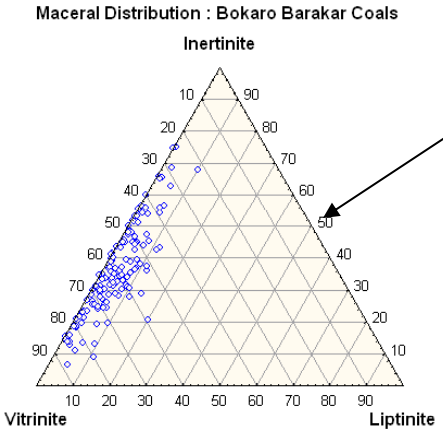


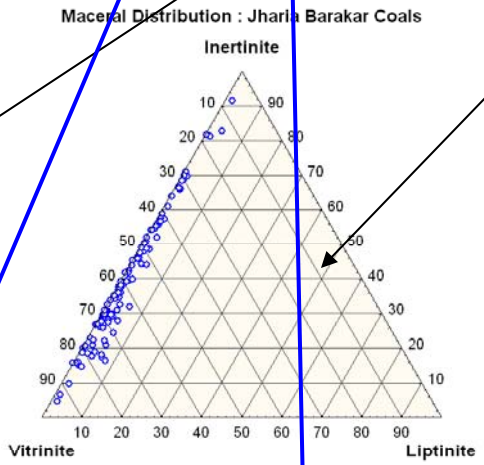
basis	Vitrinite % By Vol mmf	Inertinite % By Vol mmf	Liptinite % By Vol, mmf
Jharia	5 to 86%	18 to 87%	1 to 4%,
Raniganj	13 to 82%	5 to 50%	<1 to 12%
Bokaro	14 to 78 %	7 to 57 %.	1 to 19 %
North Karanpura	8 –87%,	3-62%.	2 –25%
South Karanpura	13-82%,	5-50%	2 - 19%

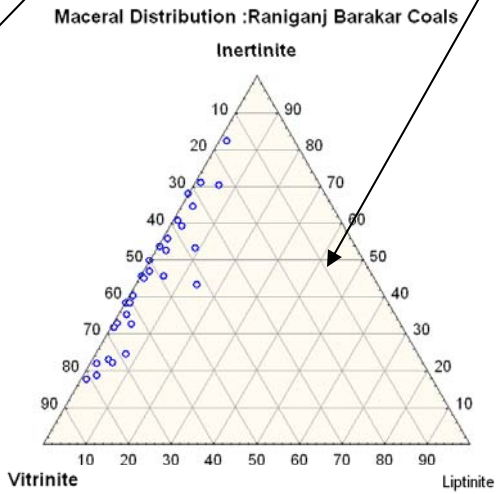
-The Vitrinite macerals are dominant in the shallower coals of Barakar Formation
-As the depth increases, in general it has been observed that ash content increases with consequent decrease in vitrinite content and increase in inertinite content for the Barakar coals of Jharia and Raniganj Coalfields. This trend is also visible in North Karanpura.
- Some authors (Misra H K,Chandra T K & Verma P,1990)reported the fact that Inertinite is relatively abundant (10–67%) in many Permian coals of India and consists mainly of semifusinite, inertodetrinite and fusinite.
- According to the authors, Coal-facies analysis based on petrographic parameters indicate that the Indian peats (coals) were deposited in ‘dry and wet’ forest swamps.

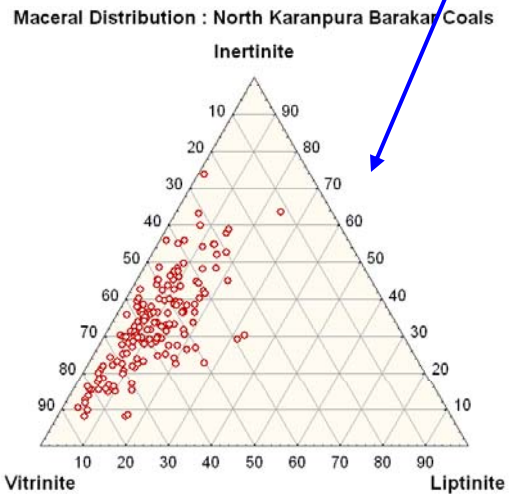
Maceral Composition

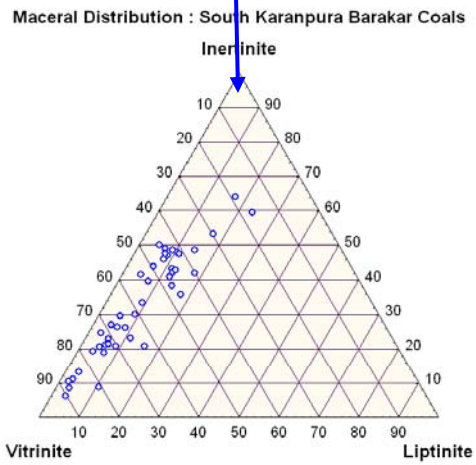




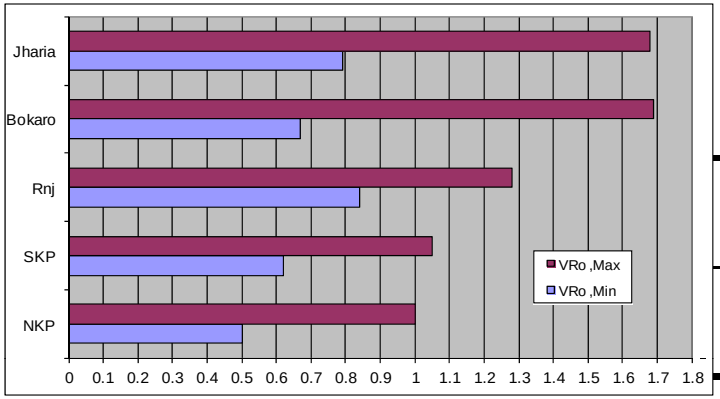


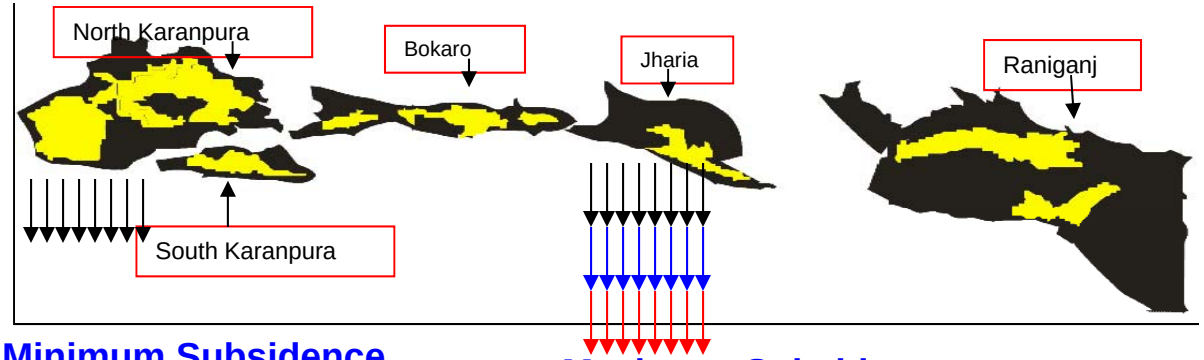






Maturity:

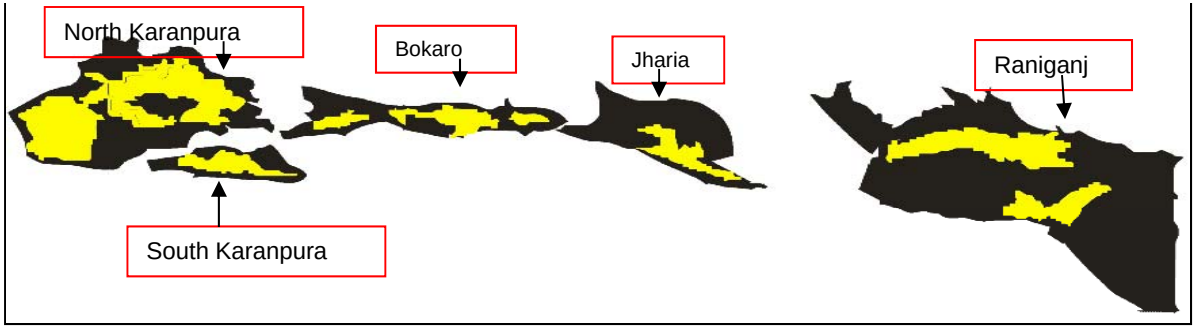


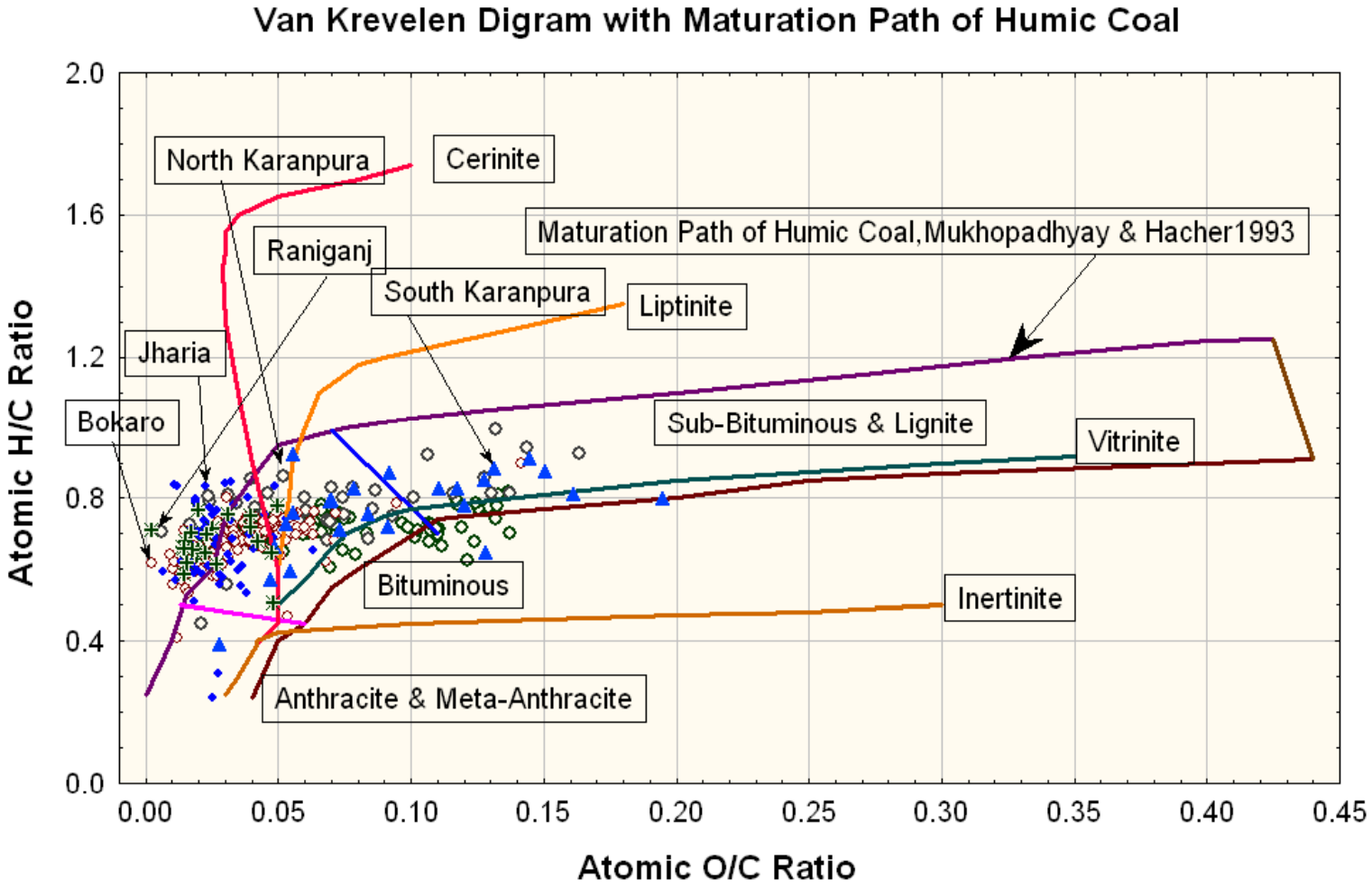


Coal Fields	NKP	SKP	Bokaro	Jharia	Raniganj
VRo Range:	0.5-1.0	0.62-1.05	0.67-1.69	0.79-1.68	0.84-1.28

- Earlier study (Review,EurekaMag.com) on maturation of organic matter has revealed that maximum paleodepth/ subsidence of the basin floor was reached in Jharia and minimum in South Karanpura during a span of 55 million years.
- Assuming 135 million years as soaking time/ stabilization period for the organic matter of Barakar Formation, the paleo-temperature attained is maximum in Jharia and minimum in South Karanpura.
- The higher geothermal province of which Jharia is the locus for the entire belt, is different from the lower geothermal region occurring further west.
- Earlier authors reported that calculated rate of accumulation of sediment and subsidence of the basin floor of these basins are in agreement with the paleo-depth, paleo-temperature and maturation condition of the organics.

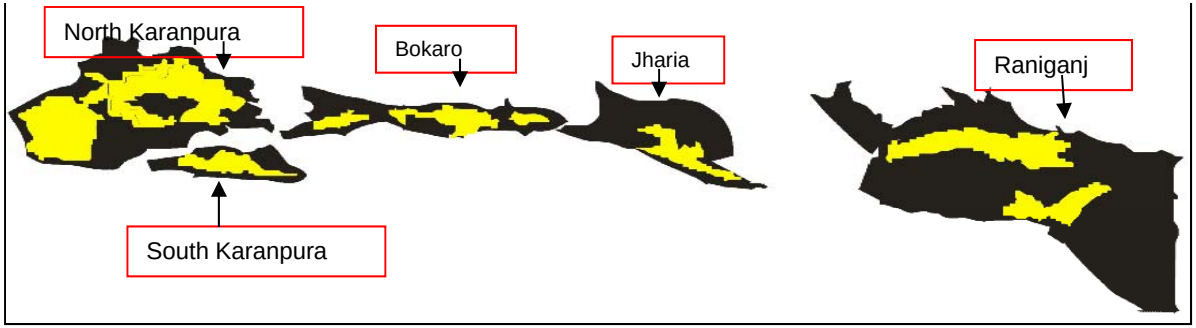
Maturation Path of Coal

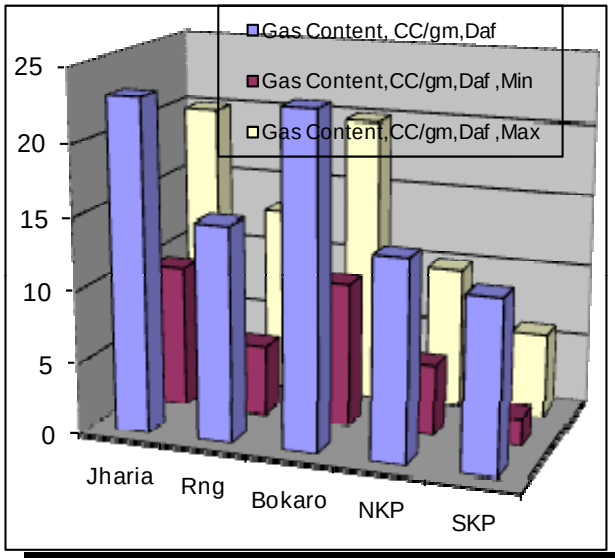




- The Barakar Coals are of Humic Origin

Gas Content:



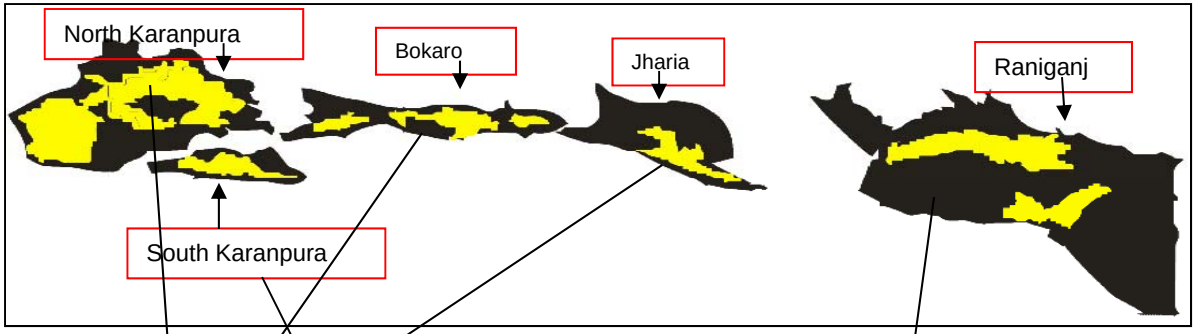


-Gas content of the Barakar coals of the Damodar Valley coalfields mostly follows their maturity trend specially in fairway portion of the acreages and increases with depth and maturity.

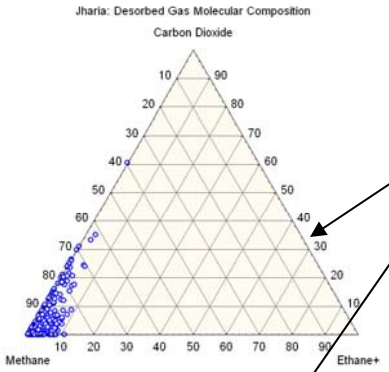
- In certain cases due to intrusive effect coal has been cooked thus gaining in maturity and consequent more gas generation and absorption. This is particularly true for Barakar coals of Raniganj in the northern sector of Raniganj acreages.

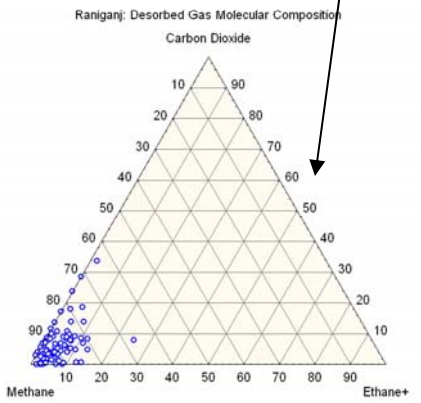
	Gas Cont,CC/gm,Daf Maximum Range	Gas Content,CC/gm,Daf Most Occuring Value	Ash % By Weight
Jharia	23	10 to 20	10 to 35
Raniganj	15	5 to 13	14 to 36
Bokaro	23	10 to 20	13 to 35
North Karanpura	14	5 to 10	18 to 35
South Karanpura	12	2 to 6	12 to 35

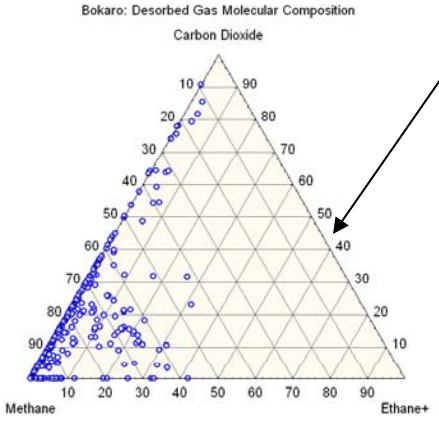
Gas Composition

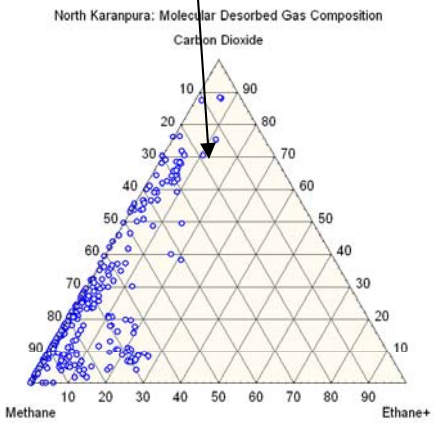


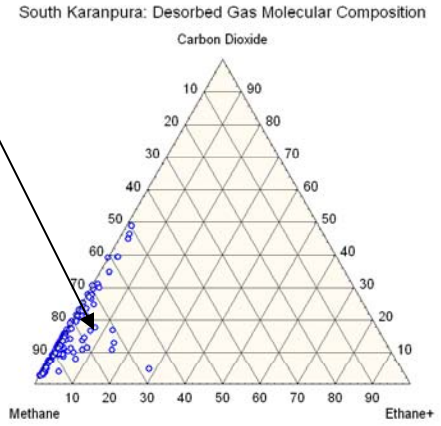
Dry to Very dry



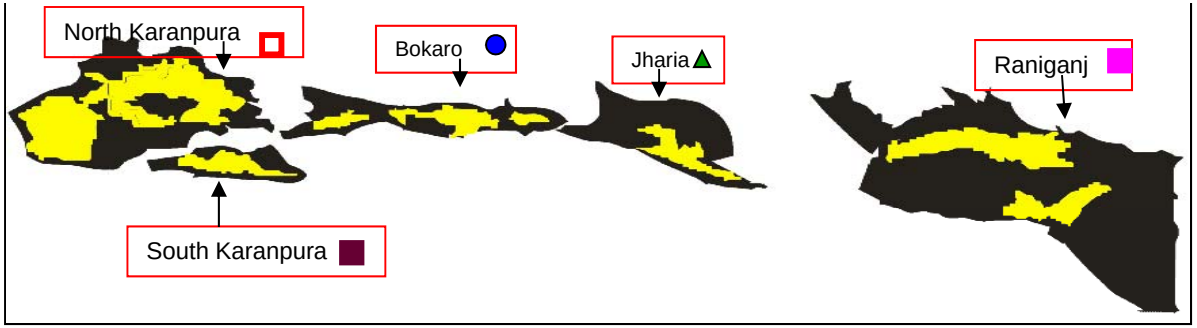


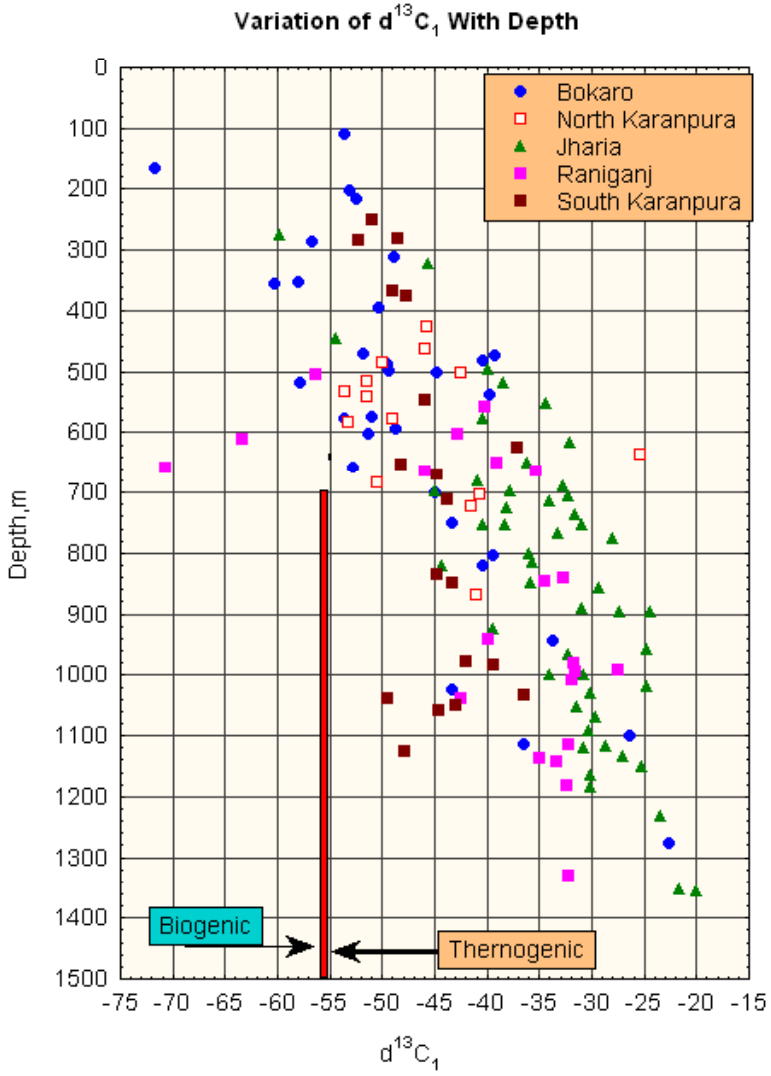


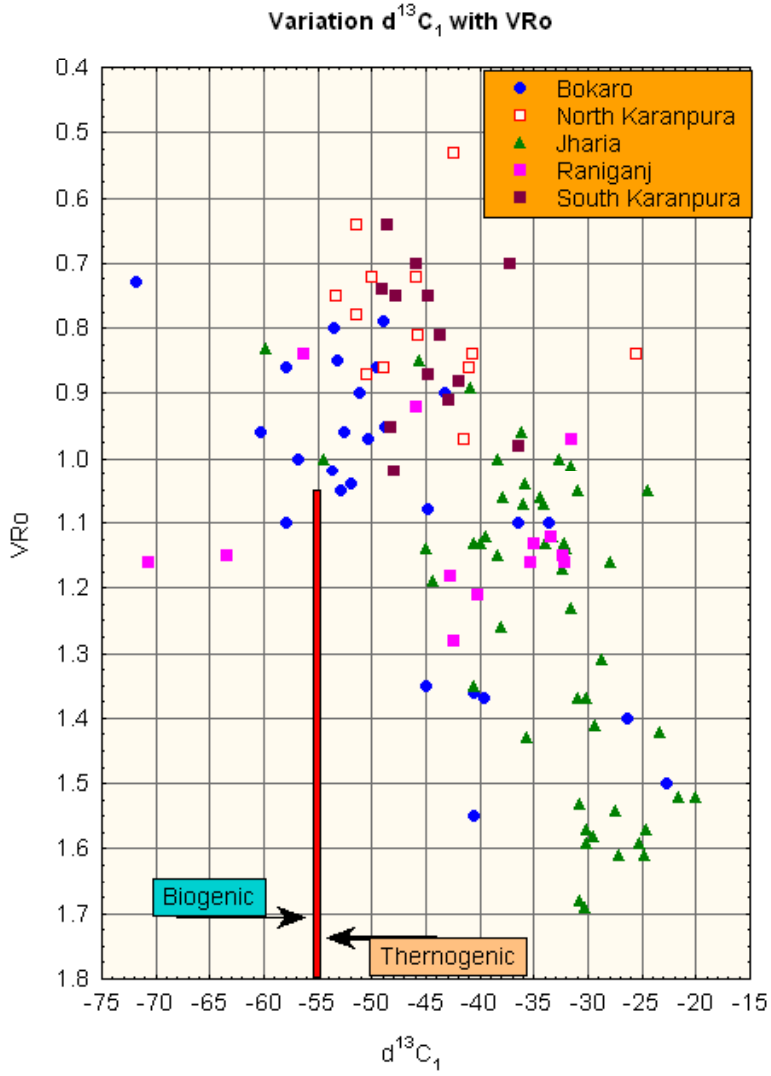




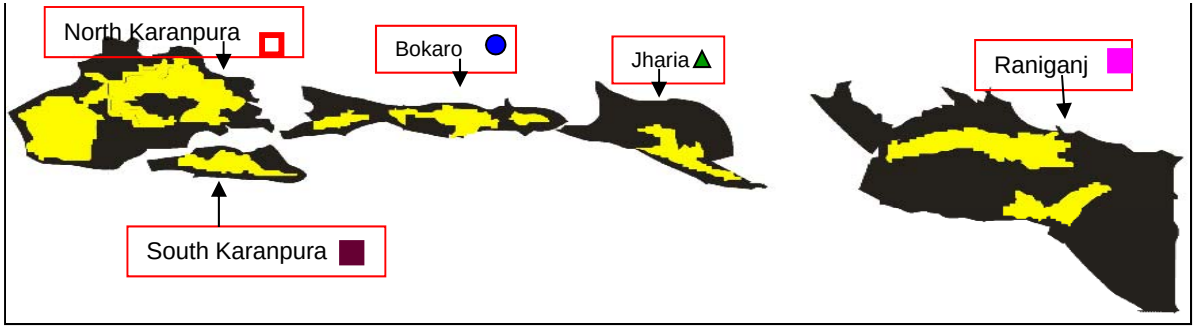
Isotopic Composition

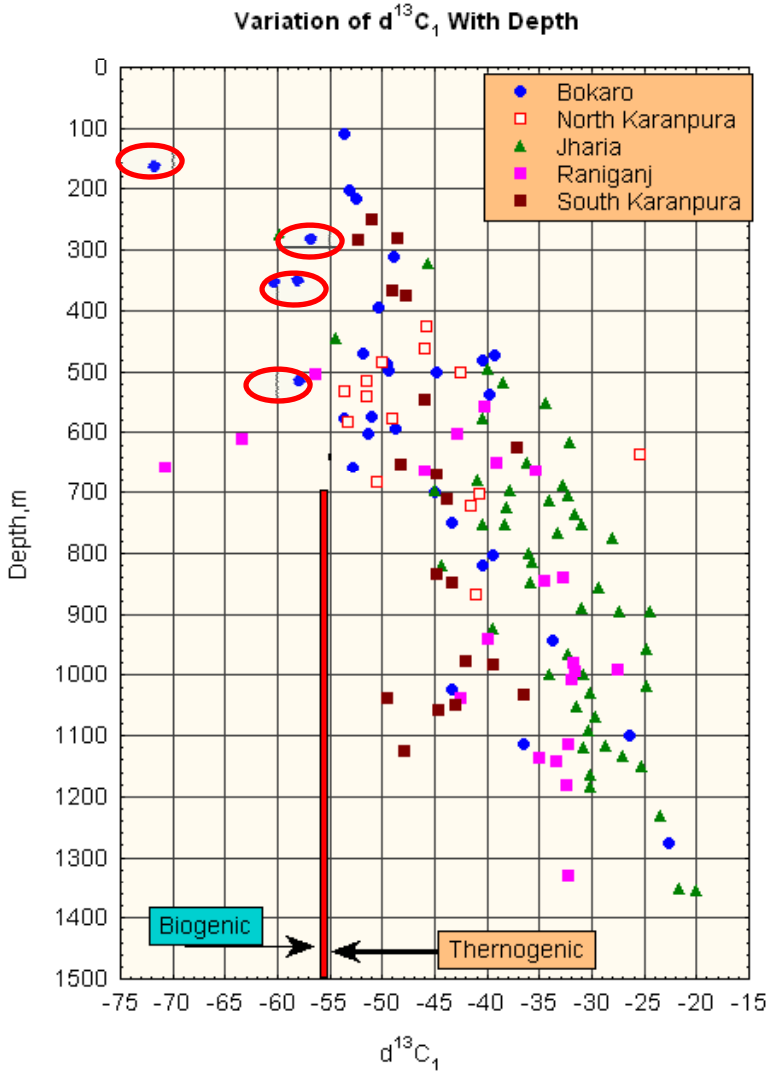


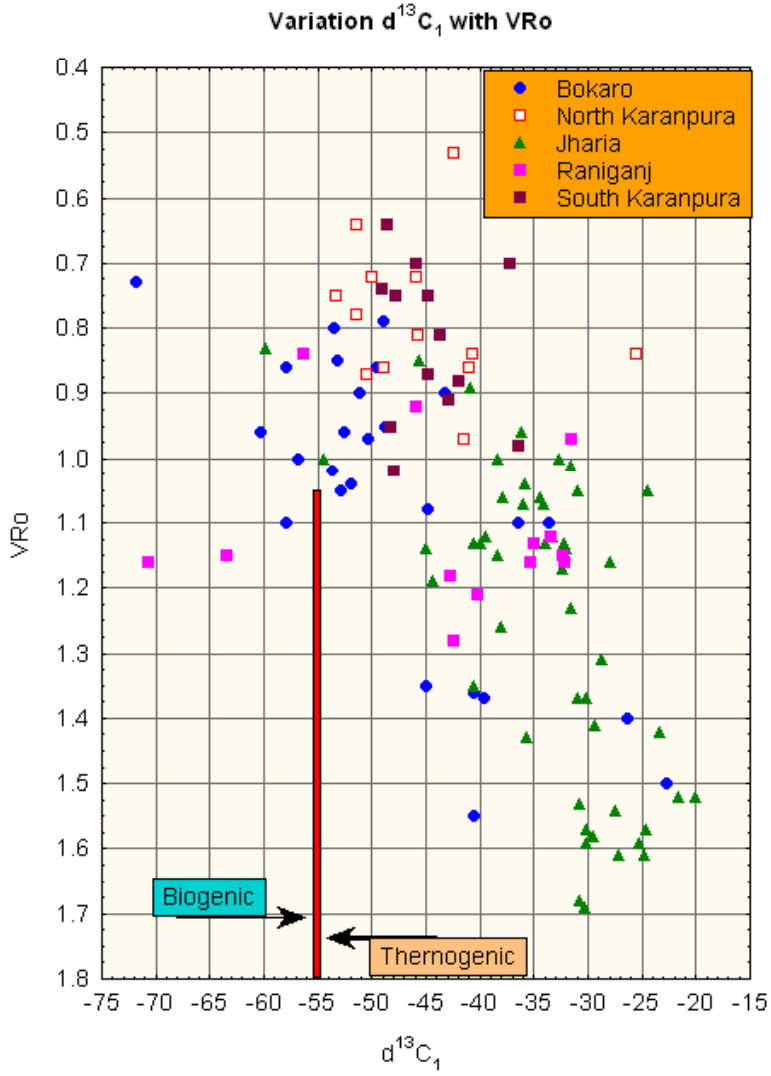




Isotopic Composition



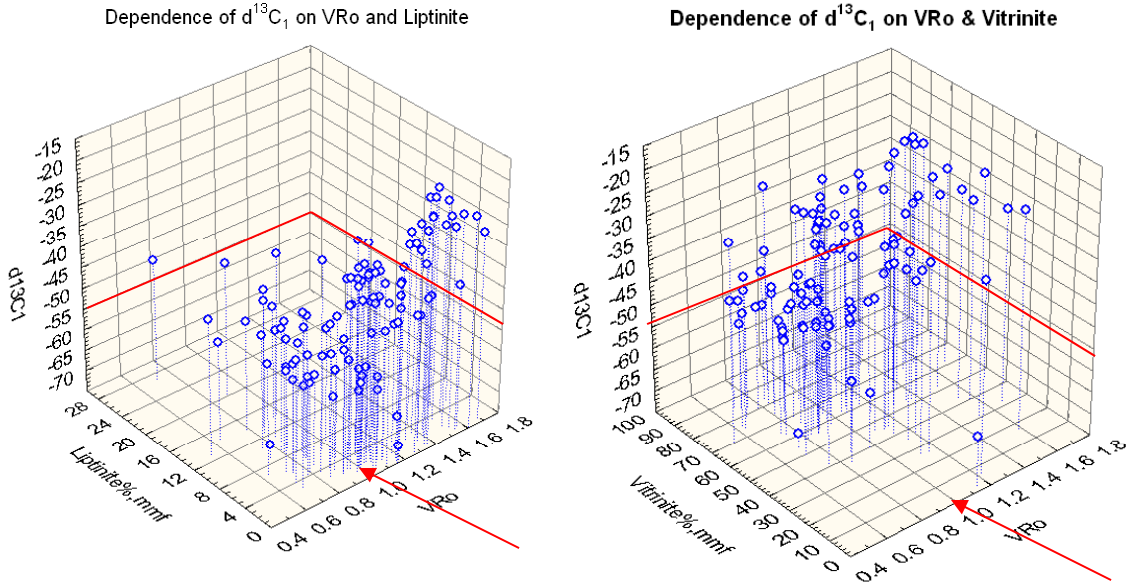




Isotopic Composition

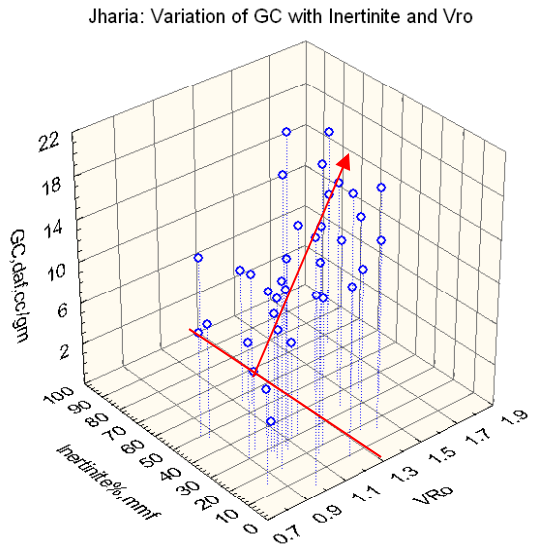
- Uniform increasing trend with maturity and depth is observed in general for gases from all the coal fields except Raniganj.
- In Raniganj there is some dispersal of data is there which can be ascribed to extensive intrusive intrusion in that area and thus changing the normal maturity trend.
- In Bokaro and also in Jharia in one area, in very shallow coal seam some gas has shown biogenic signature which can be explained to surface influx, also the same seams are being mined nearby area.
- But in Raniganj at about 650m or more distinct biogenic signature has been observed in gas desorbed from coal. Interestingly this coal are having very low gas content but very good coal maturity of the order of Vro 1.16.
- It can be inferred that the methane isotopic value in case of Jharia & Bokaro is mostly maturity controlled, which is also valid for North Karanpura and south Karanpura coals.
- In Raniganj coals the normal maturity trend is disturbed in methane isotopic composition.
- However, availability of biogenic signature at a depth of 650m in Raniganj in high rank coal may open window of developing non-CBM province for possible future biogenic methane farming.

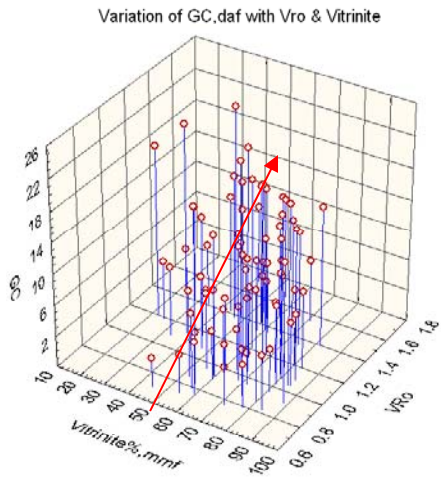
Organic matter quality & Isotopic Composition:



- Liptinitic contentent increase west ward from Bokaro. Earlier authors (Galimov, E M, 1988, Rice, D.D.,1993**)** have found that gases generated from coals with oxygen rich kerogen (mostly Vitrinite) are found to be heavier than gases produced from hydrogen rich kerogen-liptinite and and some hydrogen rich vitrinite.
- The data from five coalfield was plotted in 3D Plot with $d^{13}C1$,Vro & Vitrinite in three different axis & $d^{13}C1$,Vro & Liptinite in three different axis.
- It is clearly evident that the vitrinite rich coal is producing iso-topically heavier gases compared to liptinite rich coal which is producing iso-topically lighter gases.

Adsorptive Capacity & Saturation of Coal





- The gas content vis a vis saturation of the coals from the five coal fields were studied using adsorption isotherm constructed by laboratory study.
- It was found that in fairway portion (identified on basis of the parameters of cumulative coal thickness, gas contents and saturation) the gas saturation

  Jharia - mostly above 80%,

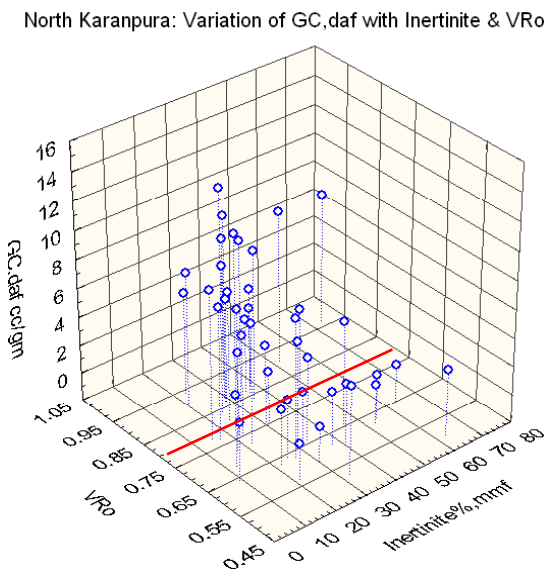
  Bokaro - more than 80%.

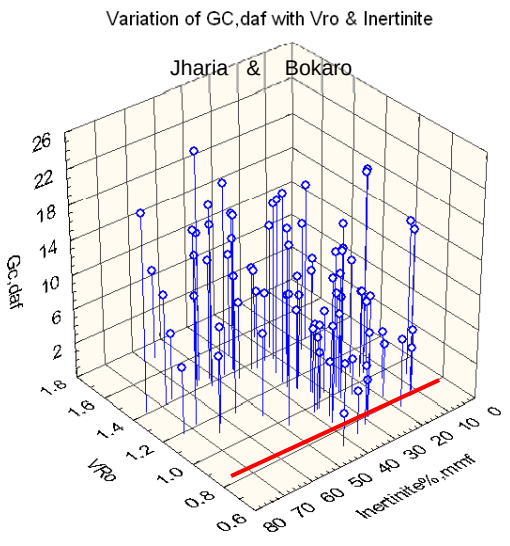
  North Karanpura - 60-80%.

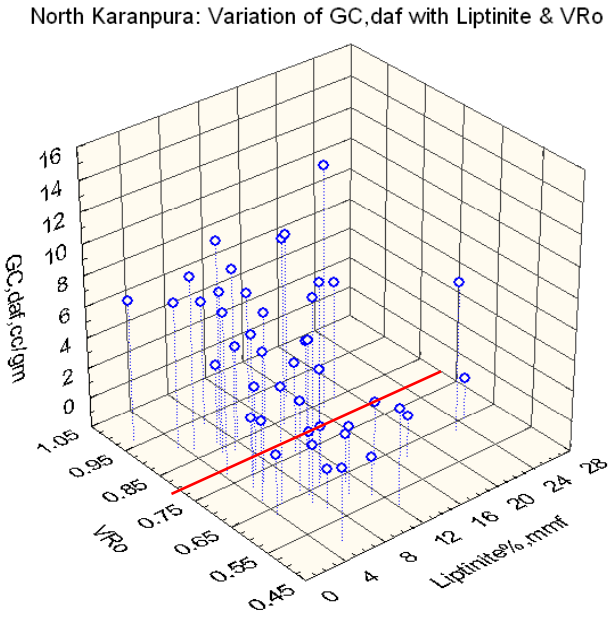
  North Raniganj – in a few pocket 60-80%.

  South Karanpura – less than 50%.
- It is known that vitrinite rich coal is good candidate for Coalbed methane. Since with increasing maturity its generative as well as adsorbtive capacity both increases significantly.

Adsorptive Capacity: Contribution of Liptinite to Gas Content

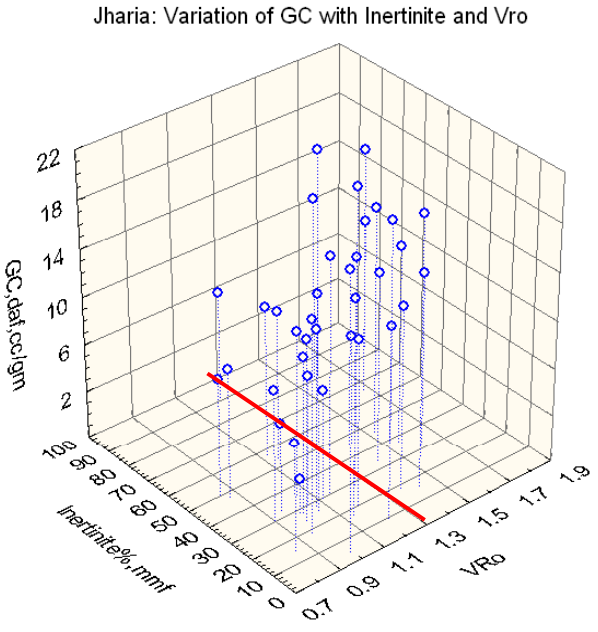


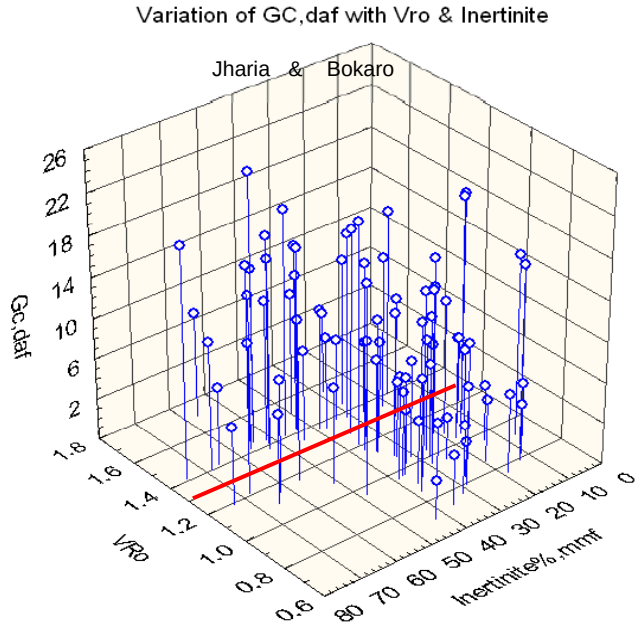




-North Karanpura coal has significant liptinite content
-It is showing good gas content in inertinite rich coal at maturity of 0.85 VRo and above.
-At this maturity only presence of good liptinite (12% mmf & above)content possibly has helped it to generate sufficient gas to have fairly moderate gas content.

Adsorptive Capacity: Inertinite rich Coal & Good Gas Content

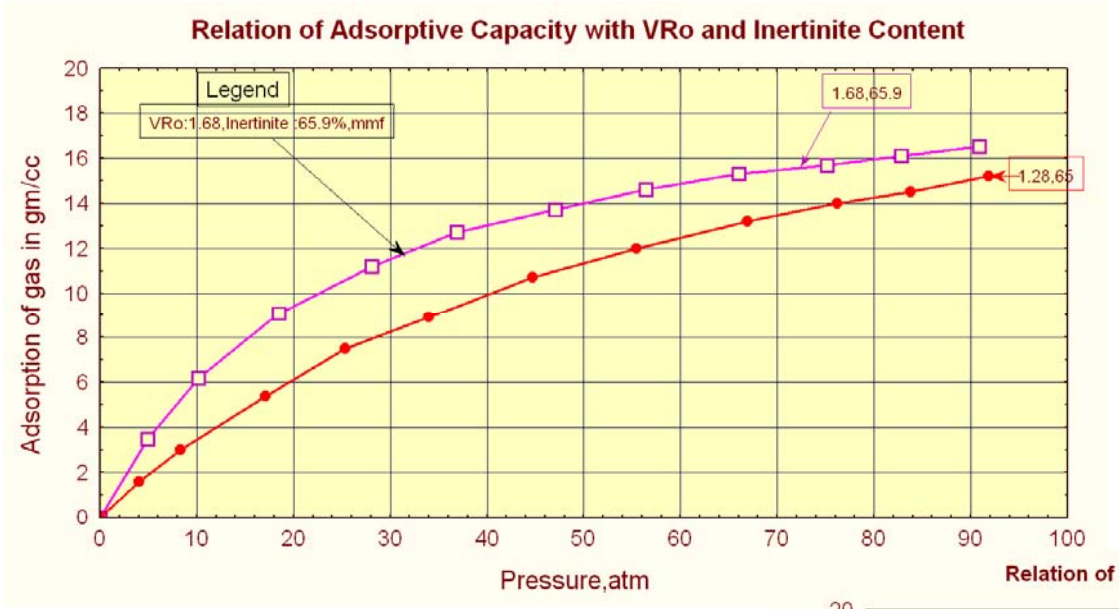


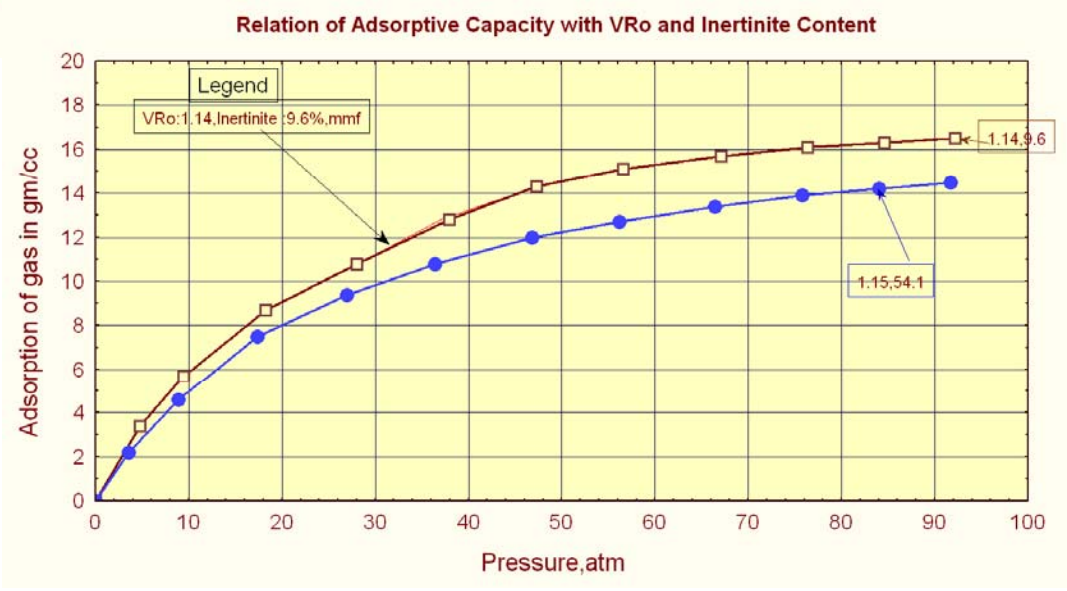


At higher maturity i.e. beyond 1.3 VRo inertinite rich coal having inertinite component of more than 40% ,mmf also shows good gas content.

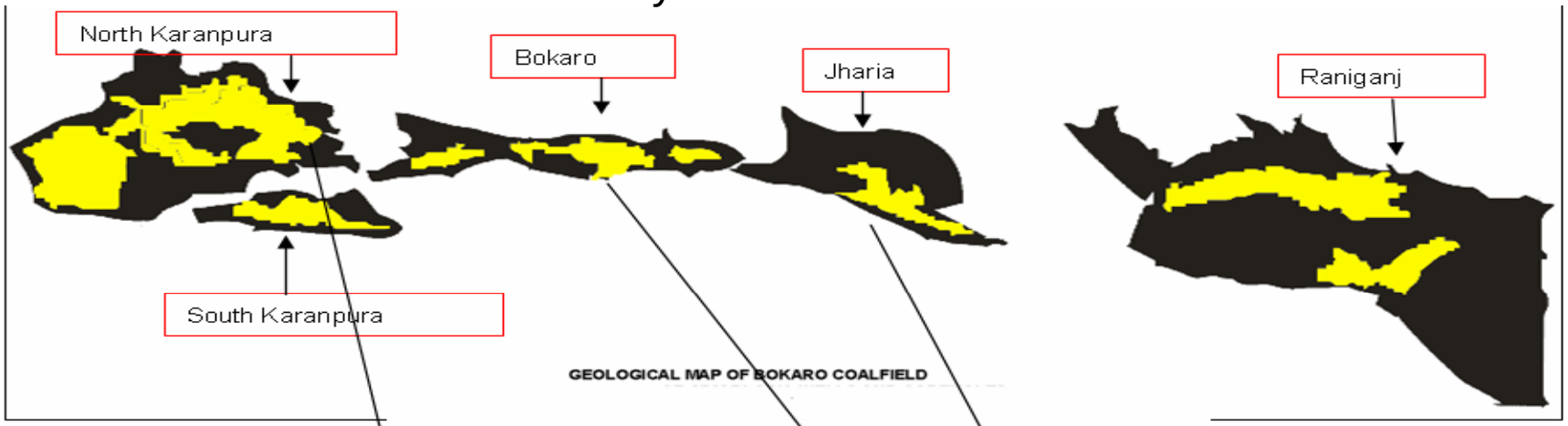
Adsorptive Capacity:

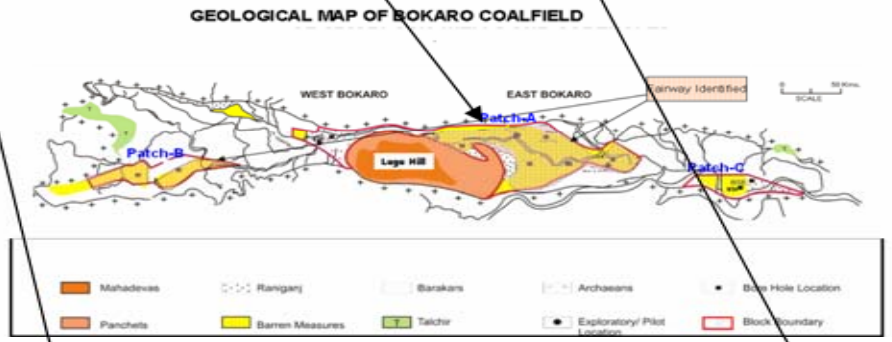
To study adsorption capacity of inertinite rich coal adsorption isotherm constructed on inertinite coal was examined

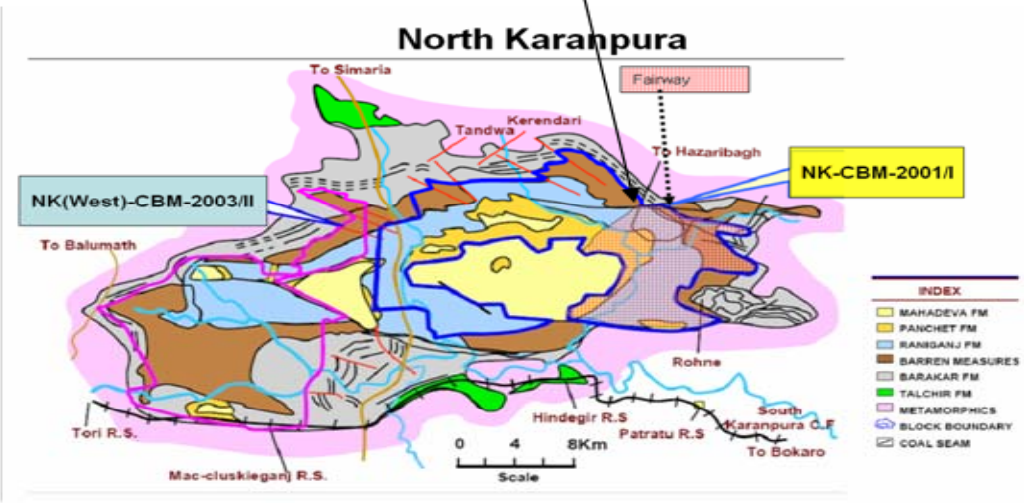


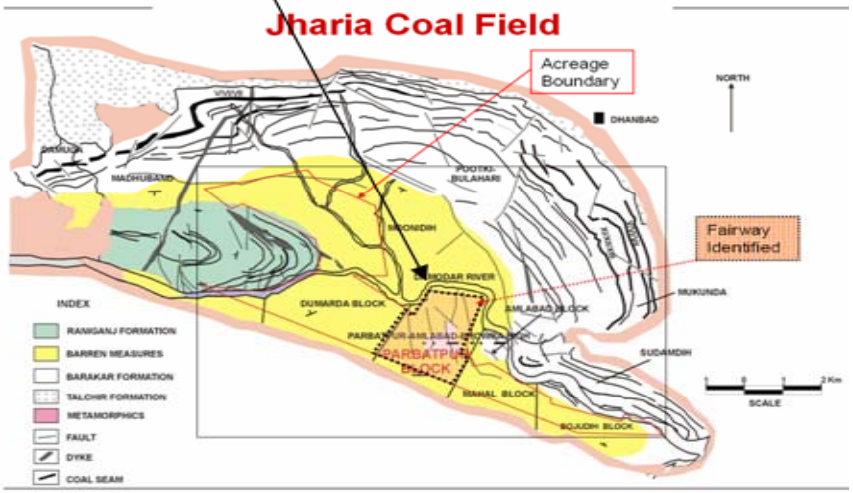


Fairway In 3 Coalfields

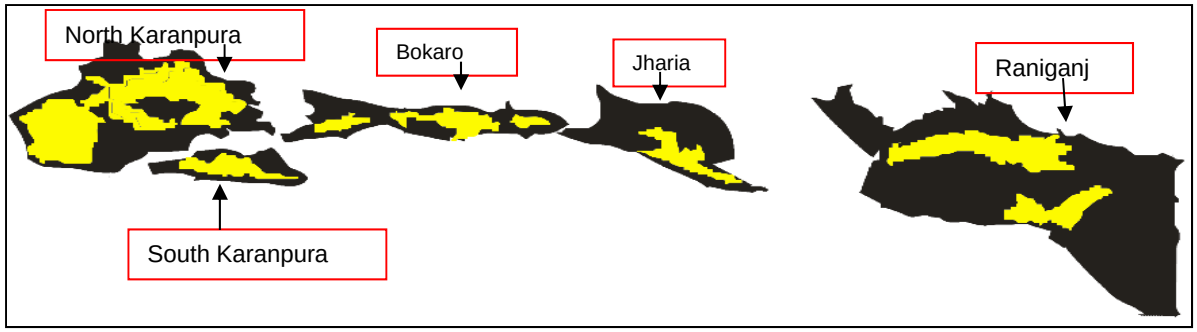






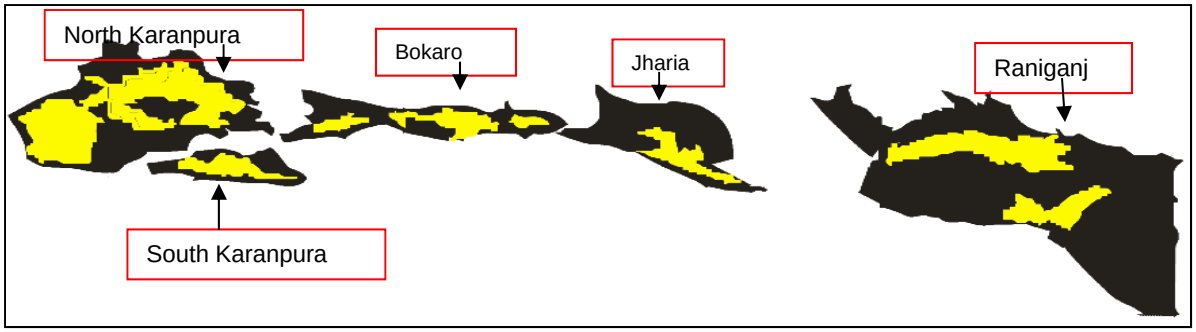


Sumup:



- ✓ Barakar Coals of Damodar valley are humic in origin.
- ✓ lower Barakar coals - high ash content due its deposition with drifted plant material. Predominance of Inertinite in lower Barakar coals points to its deposition in an dry and seasonal wet forest swamp.
- ✓ The maturity of coal in eastern part is more than western part of Damodar valley. This is due to the early & higher subsidence of eastern part of the valley compared to western part and consequent achieving greater depth and higher geothermal temperature in eastern part compared to western part leading to availability of high rank coal in eastern part of the Damodar valley coal fields .
- ✓ Higher liptinitic content in Maceral distribution has been recorded in western part compared to eastern part. This maturity and maceral distribution characteristic has decided coal bed methane prospectivity of the coalfields to a great extents.

Sumup(Continued**)**:



- ✓ Jharia and Bokaro barakar coals the gas contents are determined by maturity & amount of vitrinite content in the coal.
- ✓ In North Karanpura higher liptinitic content has helped to have moderate to good gas content (in fairway portion) in spite of less maturity compared to Jharia & Barkaro coals.
- ✓ The liptinitic rich coal of western coalfield has produced less dry gas compared to eastern coalfield of the basin and can have more heating value.
- ✓ From the study it was found that the inertinite rich coal at higher maturity beyond 1.3 VRo has shown good adsorptive capacity.
- ✓ Availability of biogenic signature at a depth of 650m in high rank coal may open window of developing non-CBM province for possible future biogenic methane farming.

Thank You