# KARAKTERISTIK MINERAL LEMPUNG PADA SEDIMEN RESEN PERMUKAAN DASAR LAUT DI PERAIRAN KOTA SEMARANG

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## SARI

Mineral lempung merupakan salah satu mineral kompleks yang menyusun lebih kurang 16% endapan sedimen di permukaan bumi. Mineral lempung dapat terbentuk di darat maupun di laut. Mineral lempung yang terendapkan pada kawasan pantai dan lepas pantai memiliki suatu mekanisme sedimentasi yang unik, sehingga menimbulkan berbagai jenis mineral lempung. Perbedaan ini disebabkan oleh faktor kedalaman, temperatur, cahaya, topografi, dan organisme.

Studi komposisi mineral lempung di kawasan pantai dan lepas pantai sangat memungkinkan untuk menganalisis proses sedimentasi, yang keberadaannya dipengaruhi oleh asal sedimennya. Sedimen permukaan dasar laut di lepas pantai Kota Semarang pada umumnya terdiri atas lempung dan lanau pasiran.

Berdasarkan analisis SEM, mineral lempung di lepas pantai Kota Semarang terdiri atas : kaolinit, illit, antara campuran lempung montmorilonit dan ilit.

Kata kunci: sedimen permukaan dasar laut, mineral lempung, proses sedimentasi



## *ABSTRACT*

*Clay mineral is a group of mineral which suplay more than 16% of sediments distribution in the earth surface. The clay mineral can be occurred both on the land and sea bottom. The clay mineral which is deposited in the coastal and sea bottom have a unique mechanism, and consequently creates many kind of clay mineral where this conditions is influenced by the deph, temperature, light, topography and organism.*

*The study of clay mineral distribution in the coastal and marine sediments enables to analysis the sedimentation processes, where the occurrence of this mineral is influenced by the origin of the sediments. Generally, the surficial sediments of Semarang offshore is consists of clay and silt.*

*Based on the SEM analysis the clay mineral in Semarang offshore is dominated by caolinite, illite and mixed layer of montmorilonite and illite.*

*Keywords: offshore surficial sediments, clay mineral, sedimentation process*

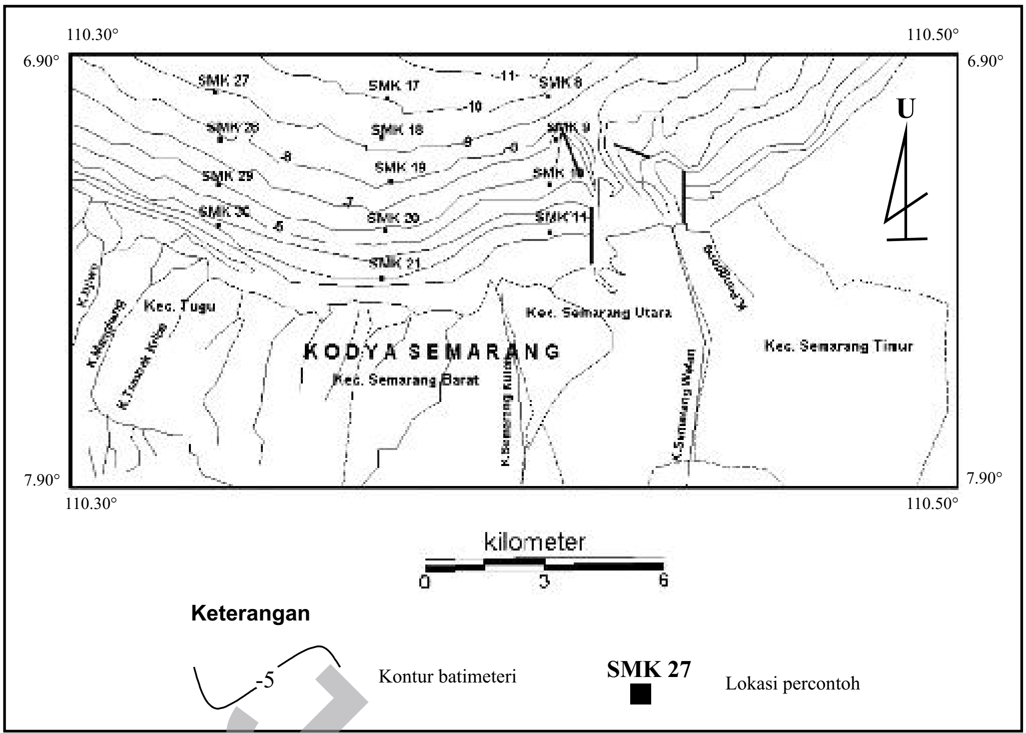
## PENDAHULUAN

Daerah penelitian terletak di lepas pantai Kota Semarang, Provinsi Jawa Tengah yang secara geografis terletak pada koordinat 110,30° - 110,50° BT dan 6,9° - 7,0° LS .

Penelitian karakteristik mineral lempung merupakan salah satu unsur pengembangan dari penelitian Geologi dan Geofisika Lepas Pantai Kota Semarang yang telah dilakukan oleh Puslitbang Geologi Kelautan pada bulan April 1995.

Latar belakang penelitian ini adalah mengingat bahwa lepas pantai Kota Semarang merupakan salah satu wilayah pantai yang sedimen permukaan dasar lautnya pada umumnya didominasi oleh sedimen lempung. Keberadaan sedimen lempung tersebut kemungkinan sangat berkaitan erat dengan kondisi geologi di kawasan daratnya.

Tujuan utama penelitian ini adalah untuk mengetahui penyebaran mineral lempung dan kemungkinan sumber asalnya yang telah terendapkan di lepas pantai Kota Semarang tersebut. Dengan diketahuinya




Gambar 1. Lokasi daerah penelitian.



jenis mineral lempung dan sumber asalnya, diharapkan di kemudian hari hamparan luas sedimen di dasar laut tersebut dapat diketahui kegunaannya. Untuk kepentingan analisis mineral lempung, telah dilakukan pengambilan percontoh pada tiga belas lokasi (Gambar 1) yang dianggap dapat memberikan gambaran jenis dan distribusi mineral lempung pada sedimen permukaan dasar laut lepas pantai Kota Semarang.

Ke tiga belas percontoh tersebut selanjutnya dipilih untuk dianalisis SEM (*Scaning Electro Microscope*) dan XRD (*X-ray diffraction*).

Tanah atau sedimen secara definisi merupakan kumpulan butiran mineral alami yang dapat dipisahkan secara mekanis apabila teraduk di dalam air ( Velde, 1985)

Partikel-partikel lempung yang berukuran mikroskopis mengelompok membentuk kawasan domain-domain dan akhirnya membentuk gugus.

Lebih lanjut Pettijohn, (1975) mendefiniskan bahwa lempung merupakan tanah plastis dan alami berkomposisi aluminium hidrosilika dan merupakan butiran detrital yang memiliki partikel dengan diameter lebih dari 1/16 mm.

## METODE PENELITIAN

Metode penelitian yang telah dilaksanakan terdiri atas pengambilan percontoh sedimen dengan mempergunakan penginti jatuh bebas (*gravity core*) dan analisis laboratorium yang terdiri atas analisis SEM (*Scanning Electron Micrograph*) dan analisis XRD (*X-ray diffraction*).

Pengambilan percontoh untuk kepentingan analisis mineral lempung telah dilakukan di tiga belas lokasi yang dianggap dapat mewakili distribusi mineral lempung pada sedimen permukaan dasar laut di daerah penelitian.

SEM (*Scanning Electron Micrograph*) merupakan suatu metode untuk menentukan jenis mineral-mineral yang terdapat pada batuan, tanah, atau sedimen melalui gambaran tiga dimensi mineral-mineral tersebut.

SEM terdiri atas lensa elektron dan perangkat elektronik. Percontoh batuan yang telah dilapisi oleh dan emas diletakkan pada tempat percontoh dan divakum dengan tekanan tinggi. Gambar yang dihasilkan dibentuk oleh sinar elektron yang dihasilkan dari pemanasan *hairpin tungsten filament* pada piston elektron yang selanjutnya disalurkan pada tabung dengan voltase 5 - 30 KV.

Gambar topografi tiga dimensi (*SEM micrograph*) dibentuk dengan mengumpulkan *secondary electron* yang merupakan elektron berenergi rendah yang dihasilkan oleh *primary beam*.

Gambar tiga dimensi yang dihasilkan dapat ditampilkan pada layar monitor atau difoto dengan kamera.

Sebagai percontoh, smektit pada gambar yang dihasilkan oleh metode SEM akan terlihat seperti kerutan, ilit terlihat bermorfologi serat-serat *pseudohexagonal*, sedangkan kaolin dan *dickite* berkembang seperti buku-buku tertumpuk membentuk serpihan berukuran *pseudohexagonal*.

Metode X-RD yang digunakan untuk menganalisis mineral lempung adalah metode serbuk. Peralatan X-RD terdiri atas pesawat sinar X yang berfungsi mempercepat elektron dan merupakan sumber radiasi.

Pancaran elektron yang mengenai spesimen setelah berinteraksi dengan atom-atom akan menembus, dipantulkan, didifraksikan, diserap, dan terurai.

Analisis X-RD memberikan data dalam bentuk grafik. Grafik-grafik ini muncul berdasarkan data elektron yang ada pada masing-masing percontoh yang dianalisis.

Nilai masing-masing mineral memiliki parameter sebagai berikut (Panggabean, 1998) :

| | |
|---|---|
| Smektit/montmorilonit puncaknya | : 4 - 6 |
| Mika/ilit puncaknya | : 9 |
| Kaolinit puncaknya | : 25 - 28 |

## GEOLOGI DAERAH PENELITIAN

Jenis, komposisi, dan distribusi mineral lempung sangat bergantung kondisi geologi yang terdapat di sekitar wilayah lepas pantai Kota Semarang yang sangat berpengaruh terhadap keberadaan sedimen permukaan dasar lautnya.

Secara umum, tataan geologi di sekitar lepas pantai Kota Semarang adalah sebagai berikut:

- Sedimen endapan laut, terdiri atas batulempung bersifat gampingan dan napal. Pada beberapa tempat terdapat selang-seling antara pasir kuarsa, batulanau, dan batupasir mengandung pelapukan konkresi dolomit.
- Formasi Damar, terdiri atas batupasir tufaan, breksi gunungapi, dan tufa.
- Breksi gunungapi, pada umumnya bercampur dengan batuan lava, batupasir tufaan, dan batu lempung mengandung moluska.
- Lahar, terdapat di bagian selatan Semarang dan tersebar cukup luas.
- Lava andesit, berasal dari Gunung Ungaran dan Gunung Sumbing, dan tersebar di bagian selatan Semarang.
- Endapan aluvium, terdapat di sepanjang pantai utara Semarang yang memanjang dari barat ke timur yang terdiri atas lempung dan pasir (Gambar 2).
- Sedimen permukaan dasar laut terdiri atas lanau pasiran dan lempung (Budiono drr., 1996) .

## HASIL PENELITIAN

Berdasarkaan hasil analisis SEM (*Scanning electron micrograph*) dan XRD (*X ray Difraktion*), komposisi sedimen lempung permukaan dasar laut lepas pantai Kota Semarang adalah sebagai berikut:

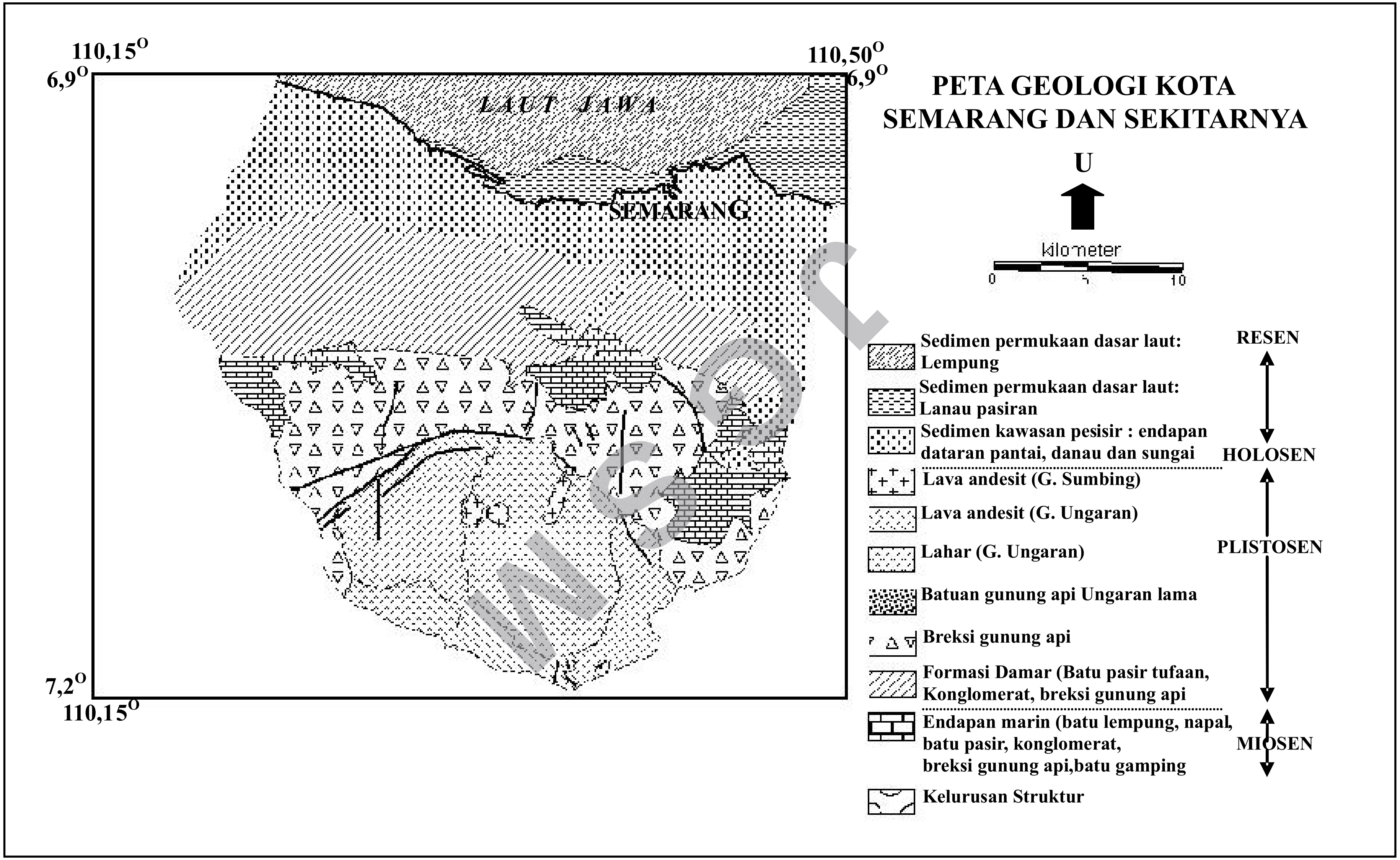
Kaolinit dijumpai pada contoh-contoh sedimen SMK 11, SMK 20, dan SMK 30. Analisis SEM memperlihatkan bahwa mineral lempung kaolinit keberadaannya bercampur dengan mineral-mineral kalsit, kuarsa, karbonat, dan fragmen batuan. Jenis mineral lempung kaolinit bersifat *immature*, belum mengalami kompaksi, porositas primer, dan belum mengalami diagenesis ( Tabel 1).

Berdasarkan analisis X-RD mineral lempung kaolinit pada percontoh SMK 11, SMK 20, dan SMK 30 bercampur bersama 70% mineral haloysit, 11% - 30% mineral halit dan lebih kecil dari 10% terdiri atas mineral anortit, kuarsa, kalsit, dan albit

Ilit dijumpai pada contoh-contoh sedimen SMK 9, SMK 18, dan SMK 28. Berdasarkan analisis SEM (Tabel 1), mineral lempung jenis ilit terlihat bercampur dengan mineral kuarsa, felspar dan fragmen batuan, bersifat *immature*, belum mengalami kompaksi, porositas primer, dan belum mengalami diagenesis.

Berdasarkan analisis X-RD ketiga percontoh tersebut jenis mineral lempungnya adalah kaolinit dengan mineral halosit sekitar 70 %, halit 11 - 30 %, kuarsa lebih kecil dari 10 % sampai 30%, anortit lebih kecil dari 10%, albit lebih kecil dari 10%, dan kalsit lebih kecil dari 10%.

*Mixed layer* montmorilonit dan ilit terdapat pada contoh-contoh sedimen SMK 8, SMK 10, SMK 17, SMK 19, SMK 27, dan SMK 29.




Gambar 2. Peta geologi daerah Kota Semarang dan sekitarnya (Thanden, 1975 dan Budiono drr., 1996).

Tabel 1. Hasil Analisis Mineral Lempung Dengan Metode SEM

| No.Percontoh | Sedimen | *Constituent* | *Framework* | Kompaksi | Porositas | *Porespace* | Jenis Mineral |
|---|---|---|---|---|---|---|---|
| SMK-8 | lempung | Foraminifera | *Immature* | Tidak | Primer | *Open.Undisc* | Mont-illit |
| SMK-9 | Lempung | Kuarsa,feldspar | *Immature* | Tidak | Primer | *Open.Undisc* | Illit |
| SMK-10 | Lempung | Mika karbonat | *Immature* | Tidak | Primer | *Open.Undisc* | Mont- Illit |
| SMK-11 | Lempung | Kuarsa , Kalsit | *Immature* | Tidak | Primer | *Open.Undisc* | Kaolinit |
| SMK-17 | Lempung | | *Immature* | Tidak | Primer | *Open.Undisc* | Mont-Illit |
| SMK-18 | Lempung | Fragmen batuan | *Immature* | Tidak | Primer | *Open.Undisc* | Illit |
| SMK-19 | Lempung | | *Immature* | Tidak | Primer | *Open.Undisc* | Mont- Illit |
| SMK-20 | Lempung | | *Immature* | Tidak | Primer | *Open.Undisc* | Kaolinit |
| SMK-21 | Lempung | Kalsit | *Immature* | Tidak | Primer | *Open.Undisc* | Kaolinit |
| SMK-27 | Lempung | Foram,kalsit | *Immature* | Tidak | Primer | *Open.Undisc* | Mont- Illit |
| SMK-28 | Lempung | Fragmen batuan | *Immature* | Tidak | Primer | *Open.Undisc* | Illit |
| SMK-29 | Lempung | Kalsit | *Immature* | Tidak | Primer | *Open.Undisc* | Mont-illit |
| SMK-30 | Lempung | Mineral bijih, karbonat, Fragmen batuan | *Immature* | Tidak | Primer | *Open.Undisc* | Kaolinit |

Gambar 3 Foto SMK 8 memperlihatkan adanya campuran mineral lempung ilit dan montmorilonit. Perbedaan yang sangat mencolok antara ilit dan montmorilonit adalah minertal lempung ilit memberikan gambaran tiga dimensi seperti rambut dan tidak menerus, sedangkan montmorilonit cenderung terlihat menggumpal berwarna terang dan berkelok-kelok.

Mineral lempung ilit yang dijumpai di daerah penelitian merupakan masa dasar dan di antaranya dijumpai fragmen batuan seperti kuarsa dan felspar yang dijumpai pada SMK-10. Mineral felspar memperlihatkan bentuk memanjang dengan warna agak terang, sedangkan kuarsa memperlihatkan bentuk hexagonal dengan warna yang terang.

Mineral lempung jenis kaolinit terlihat berbentuk *pseudohexagonal* dan berwarna cerah, mengandung juga mineral bijih, fragmen batuan, kuarsa, dan felspar.

Untuk jelasnya hasil pemerian mineral lempung dan mineral lainnya dapat dilihat pada Tabel 1.

Analisis X-RD memberikan data dalam bentuk grafik. Grafik-grafik ini muncul berdasarkan data elektron yang ada pada masing-masing sedimen yang dites.

Hasil analisis X-RD dengan menggunakan tembaga (CU) menunjukkan semua mineral lempung yang terdapat di lepas pantai Kota Semarang adalah jenis kaolinit dengan mineral penyerta terdiri atas kuarsa, anortit, kalsit, albit, halit, dan halosit.

Hasil analisis X-RD dari seluruh percontoh yang dianalisis dapat dilihat pada Tabel 2.



**PEMBAHASAN DAN DISKUSI**

Mineral lempung merupakan mineral yang sangat mudah berubah menjadi mineral lempung lainnya.

Menurut Ehler dan Blatt (1982) serta MC. Clane (1995), faktor-faktor yang mempengaruhi berubahnya mineral lempung ini antara lain adalah: batuan asal, pelapukan secara fisik maupun kimiawi, iklim, temperatur, tekanan, air laut dan biota.

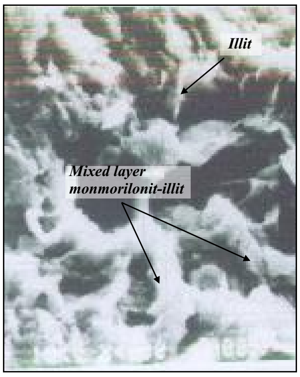
Semua faktor yang mempengaruhi perubahan mineral lempung tersebut saling berkaitan satu sam lain. Di daerah penelitian, kemungkinan besar faktor tekanan dan temperatur tidak akan banyak berpengaruh terhadap perubahan jenis mineral lempung sehubungan dengan kedalaman lautnya yang hanya 11 m (Gambar 5).

Batuan asal merupakan faktor yang penting dalam pembentukan jenis mineral lempung pada sedimen dasar laut.

Sebagai contoh, mineral lempung dapat terbentuk akibat adanya pelapukan batuan gunung api. Di daearah penelitian, dijumpai adanya batuan gunung api intermedier, namun pada saat hasil pelapukan batuan tersebut diendapkan pada lingkungan laut dengan kadar NaCl dan $H_2O$ yang relatif tinggi ditambah dengan kondisi kedalaman laut maksimal 11 m, maka sedimen lempung tersebut akan didinubasu oleh mineral-mineral kuarsa dan felspar yang batuan asalnya adalah letusan gunungapi bersifat asam hingga intermedier.

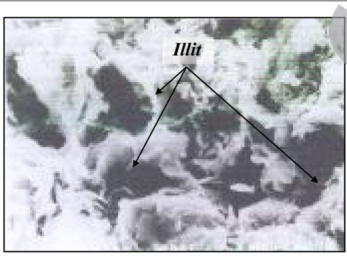
Hasil analisis SEM memperlihatkan bahwa jenis mineral lempung yang terdapat pada sedimen permukaan dasar laut di lepas pantai Kota Semarang terdiri atas kaolinit, ilit dan *mixed layer* antara ilit dan montmorilonit.

Jenis mineral lempung kaolinit dijumpai di sekitar kawasan pantai sampai dengan kedalaman laut 5 m. Mineral kaolinit ini kermungkinan merupakan fase pertama terbentuknya mineral lempung. Pembentukannya sangat didukung oleh proses pelapukan batuan gunung api dan kondisi air laut pada proses pengendapannya. Di samping itu jenis kaolinit dapat juga dihasilkan dari pelapukan mineral lempung lainnya, dan secara umum merupakan mineral *detrital* dalam sedimen.



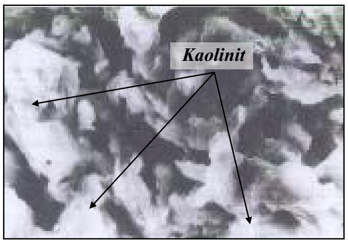

SMK-8 (4000X)

Lempung dengan kondisi belum terkompaksi yang diperkirakan belum mengalami proses diagenesis.
Jarak antar butir relatif sangat besar, yaitu antara 0,5 - 3 Cm, sehingga membuat pori-porinya terbuka.
Dijumpai foraminifera planktonik.
Jenis mineral lempungnya adalah *mixed layer* montmorilonit-illit.




SMK-18 (4000X)

Lempung dengan kondisi belum terkompaksi dan belum mengalami diagenesis, pori-pori relatif terbuka dengan jarak antarbutir 0,3 - 5 Cm.
Dijumpai fragmen batuan sebagai mineral penyerta.
Jenis mineral lempungnya : ilit




SMK-20 (4000X)

Jenis lempung kaolinit, pori-pori terbuka dengan jarak antarbutir 0,2 - 2 Cm, belum terkompaksi dan belum mengalami diagenesis.

Gambar 3. Foto mineral lempung berdasarkan hasil analisis SEM.

Tabel 2. Hasil Analisis X-RD

| No.percontoh | Sedimen | K | Ha | H | Q | An | Al | C |
|---|---|---|---|---|---|---|---|---|
| SMK-8 | Lempung | m | | sp | r | | | r |
| SMK-9 | Lempung | m | | sp | r | | | r |
| SMK-10 | Lempung | m | | sp | r | | | r |
| SMK-11 | Lempung | m | | sp | r | r | | r |
| SMK-18 | Lempung | | m | | sp | | r | r |
| SMK-20 | Lempung | | m | | sp | | r | r |
| SMK-21 | Lempung | | m | | sp | | r | r |
| SMK-27 | Lempung | m | | sp | r | r | | r |
| SMK-28 | Lempung | m | | sp | r | r | | r |
| SMK-29 | Lempung | m | | sp | r | r | | r |
| SMK-30 | Lempung | m | | sp | r | r | | r |

Keterangan : K : Kaolinit ; Ha : Hakit : An : Anortit : C : Kalsit
H : Halloysit ;Q : Kuarsa;Al : Albit
m : major (70%) ; sp : sparse (11 - 30%) ; r : rare (lebih kecil dari 10%)

Jenis mineral lempung ilit merupakan mineral lempung yang paling luas penyebarannya pada sedimen permukaan dasar laut di lepas pantai Kota Semarang. Mineral ini dapat merupakan hasil pelapukan dalam tanah atau dari hasil transformasi mineral sebelumnya, seperti misalnya dari mineral jenis kaolinit.

Lebih lanjut MC. Clane, (1995) mengatakan bahwa sebagian besar mineral ilit terbentuk karena alterasi, dan mencerminkan indikasi pelapukan secara kimiawi. Secara umum, ilit banyak terdapat pada endapan *argillaceous* dalam bentuk *mixed layer*.

Reaksi kimia yang terjadi pada pelapukan kaolinit menjadi ilit adalah proses yang sangat rumit sekali. Proses ionisasi, oksidasi, dan hidrolisasi pada kaolinit sangat mempengaruhi menjadi ilit.

Secara umum, terbentuknya mineral-mineral lempung di daerah penelitian adalah sebagai berikut:

Distribusi sedimen yang berasal dari batuan gunung api di daratan mengalami pelapukan dan ditranspor ke laut yang membentuk dan mengendapan sedimen lempung jenis kaolinit. Pembentukan mineral kaolinit sangat dipengaruhi oleh kondisi sifat keasaman batuan pada waktu sebelum dan selama proses pelapukannya.

Setelah terbentuk menjadi mineral kaolinit, pada kedalaman tertentu mengalami perubahan menjadi mineral ilit. Terbentuknya mineral ilit salah satunya karena adanya presipitasi kalsit ($CaCo_3$), dan pelapukan batuan yang banyak mengandung felspar sehingga terjadi subsitusi Mg dan Al pada kaolinit.

Seperti telah dibahas sebelumnya, mineral lempung adalah mineral yang tidak stabil dan sangat mudah untuk berubah menjadi mineral lempung lainnya. Seperti halnya ilit yang sudah terbentuk, mudah sekali berubah menjadi *mixedlayer clay* montmorilonit-ilit. *Mixedlayer* yang terjadi tersebut merupakan bagian dari ilit yang mempunyai perbedaan pada nilai OH nya. Pengaruh hujan pada daerah tropis mengurangi tingkat keasaman serta membantu terlarutnya kalsit.

Berbeda dengan analisis SEM, hasil analisis XRD memperlihatkan bahwa seluruh jenis mineral lempung di daerah penelitian merupakan kaolinit dengan mineral penyerta terdiri atas kuarsa, anortit, kalsit, albit, halit, dan halosit.

Dominasi mineral lempung jenis kaolinit mencerminkan bahwa daerah penelitian mempunyai tingkat pelapukan kimiawi yang intensif dengan curah hujan yang tinggi.

Perbandingan hasil analisis SEM dan X-RD dalam penentuan mineral lempung masing-masing mencerminkan tingkat ketelitian yang berbeda-beda.

Metode SEM akan mempermudah untuk mengamati gambaran mineral lempung dalam bentuk tiga dimensi, sehingga kesalahannya relatif kecil sekali.

Salah satu kelemahan metode X-RD dalam menganalisis mineral lempung dengan anode Cu adalah pada waktu pembacaan contoh dimulai pada nilai 5-10. Anode Cu mencapai tingkat stabilitas pembacaannya mulai dari 7 - 11.

## KESIMPULAN

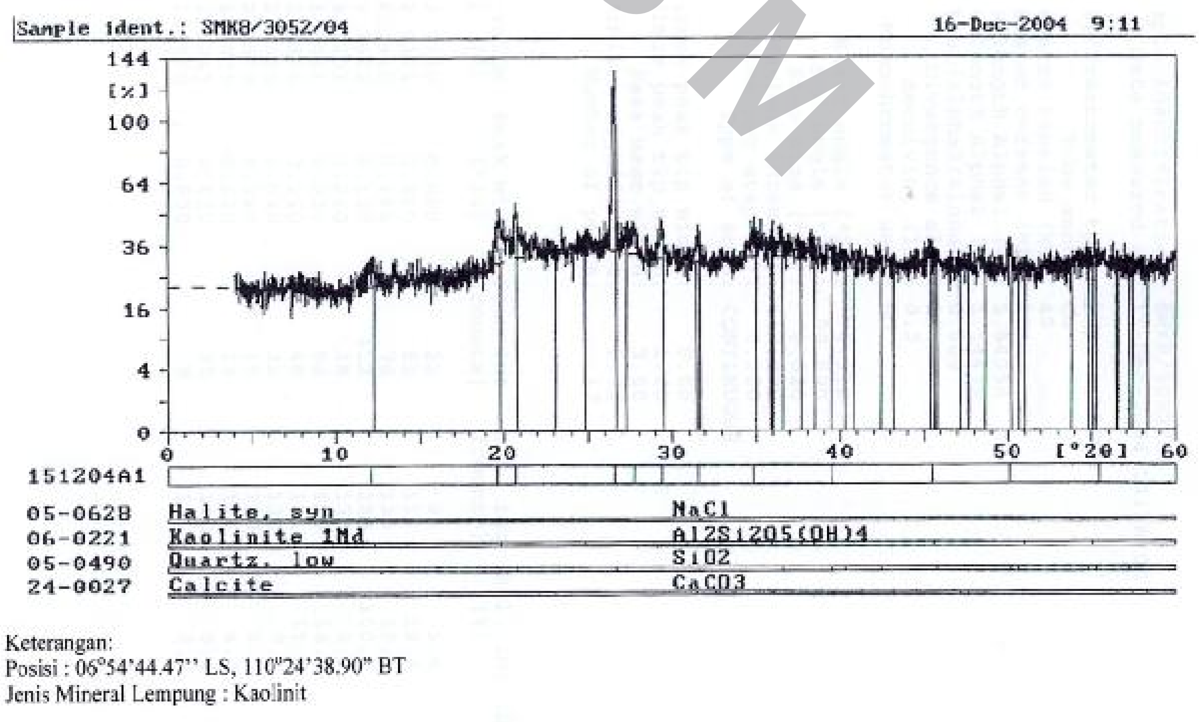
Sedimen permukaan dasar laut terdiri atas lempung dan lanau pasiran yang menempati kedalaman laut 0 - 11 m. Hasil analisis SEM memperlihatkan bahwa mineral lempung di daerah penelitian terdiri atas kaolinit, ilit dan *mixed layer* antara montmorilonit dan ilit, sedangkan analisis X-RD memperlihatkan hanya satu mineral lempung, yaitu kaolinit.

Keberadaan dan terbentuknya mineral lempung tentunya tidak terlepas dari kondisi gologi di sekitar lepas pantai Kota Semarang.

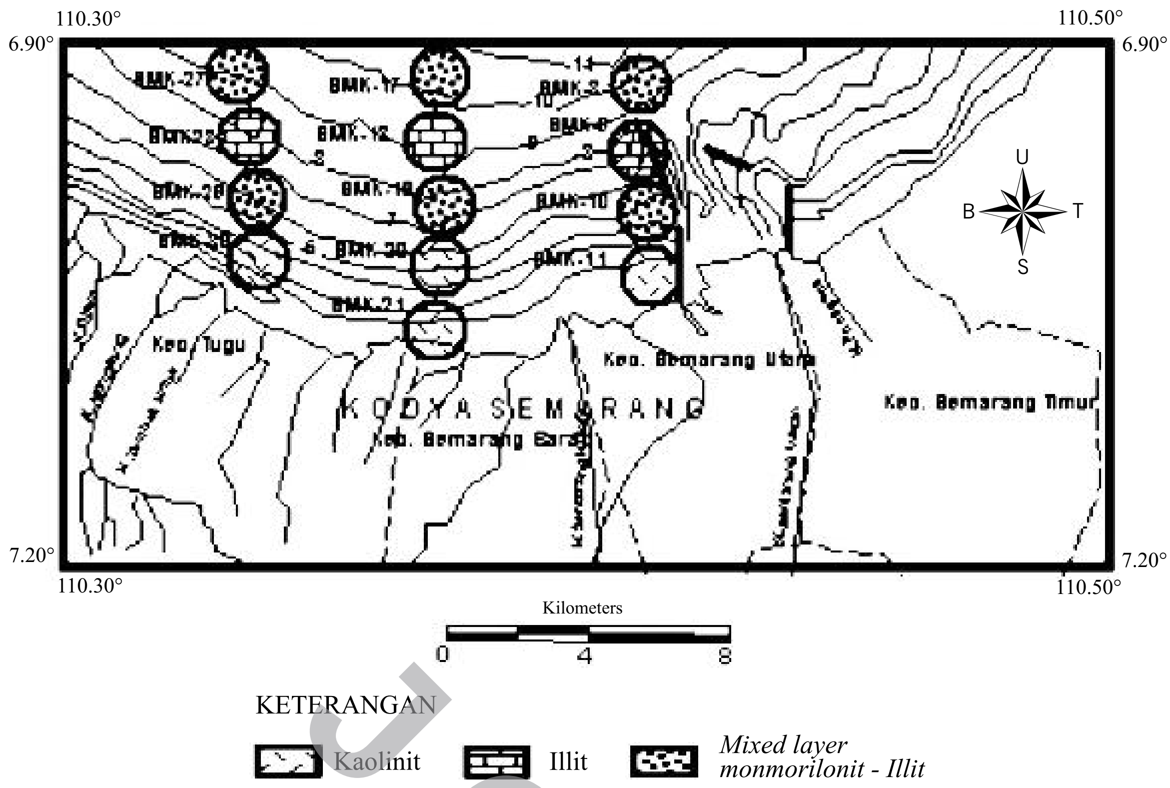
Berdasarkan hasil yang didapat, analisis untuk menentukan jenis mineral lempung sebaiknya memakai metode SEM.

## UCAPAN TERIMA KASIH

Penulis mengucapkan terimakasih kepada teman-teman yag telah membantu mengambil percontoh tanah di lapangan. Tak lupa terimaksih pula atas saran dan kritiknya hingga selesainya tulisan ini.




Gambar 4. Salah satu hasil analisis X-RD.




Gambar 6. Peta distribusi mineral lempung pada sedimen permukaan dasar laut perairan Kota Semarang.



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# COALBED METHANE POTENTIAL AND COAL CHARACTERISTICS IN KUANTAN SINGINGI, CENTRAL SUMATERA BASIN, RIAU

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**ABSTRACT**

The Keruh Eocene Formation is a coal-bearing formation in Kuantan Singingi (Kuansing) area, Riau. The Keruh Formation consists of conglomerate, sandstone with intercalation of parallel laminated mudstone in the lower part, coal seams with some interbedded carbonaceous shales and mudstone in the middle part and interbedded laminated shale and mudstone occupy the upper part of the formation. Megascopically, the coal lithotype varies from banded to bright banded, showing brownish to black streak, dark grey to black colour, with some of subchoncoidal fractures. Some pyrites are recognised. The interburden comprises light grey fine-grained sandstone, siltstone, claystone/mudstone, and shale.

Based on geochemical analysis, indicates that its ash content ranges from 1,61% to 32,93%, total sulphur content is 0,18 - 4,84%, total moisture is 4,47 - 22,83 % and volatile matter is 28,18 - 43,31%. Furthermore, petrographic analysis shows that the coal is dominated by vitrinite (46,4 - 88,6%),with minor amounts of exinite (2 - 22.6 %), inertinite (0,4 - 16%) and mineral matter (2,4 - 37,4%). Vitrinite reflectance having a value of 0,39 - 0,63% tends to indicate a sub-bituminous to high volatile bituminous-A coal rank. An in-situ coal gas calculation tends to indicate a low to high methane content level, with a value of 16.85 scf/t - 139.85 scf/t.However, the Q1,Q2 and Q3 calculation exhibits the gas content ranging from 24,03 scf/t - 57,02 scf/t; Moreover, total calculation methane gas in-place in Kuansing area is 542,743,212.5657 scf or 542,74 mmcf.

Keywords : coalbed methane (CBM), Keruh Formation, Eocene, Kuansing



***SARI***

*Formasi Keruh merupakan formasi pembawa batubara di daerah Kuantan Singingi (Kuansing), Riau. Formasi Keruh yang berumur Eosen terdiri atas konglomerat, batupasir dengan sisipan batulumpur laminasi sejajar di bagian bawah; lapisan batubara dengan perselingan serpih karbonan dan batulumpur di bagian tengah dan perselingan serpih laminasi dan batulumpur di bagian atas. Secara megaskopis, batubara di daerah ini termasuk ke dalam tipe bright banded yaitu berwarna abu-abu gelap sampai hitam, cerat kecoklatan sampai hitam, pecahan konkoidal, mengandung pirit, kandungan sulfur cukup tinggi. Batubara ini terletak diantara lapisan batupasir sangat halus, batulanau, batulempung dan serpih.*

*Berdasarkan hasil analisis geokimia batubara, di daerah Kuansing berkandungan abu berkisar 1,61 - 32,93%, belerang total 0,18 - 4,84%, air total 4,47 - 22,83 % dan zat terbang 28,18 - 43,31%. Batubara di blok ini mempunyai kalori berkisar dari 4000 sampai 7000 kal/g. Selanjutnya dari hasil analisis petrografi organik batubara di daerah ini didominasi oleh maseral vitrinit (46,4 - 88,6%), eksinit (2 - 22,6%), inertinite (0,4 - 16%) dan bahan mineral (2,4 - 37,4%). Reflektan vitrinint rata-rata berkisar dari 0,39 - 0,63% yang termasuk ke dalam tingkat sub-bituminous sampai high volatile bituminous-A. Kandungan gas batubara secara perhitungan "insitu" menunjukkan tingkat rendah sampai tinggi, dengan nilai 16.85 scf/t - 139.85 scf/t. Sementara itu, dari penjumlahan Q1,Q2,dan Q3, kandungan gas berkisar antara 24,03 scf/t - 57,02 scf/t; sedangkan kandungan total methane gas in-place di Kuansing adalah 542,743,212.5657 scf atau 542,74 mmcf.*

*Kata Kunci : "coalbed methane" (CBM), Formasi Keruh, Eosen, Kuansing*

## INTRODUCTION

A research focused on coalbed methane was performed, in order to gain a better understanding on the potential and resources of the Coal Bed Methane (CBM) in Central Sumatera regions, located in Kuantan Singingi (Figure 1). This activity was carried out in 2006 under the Coal Bed Methane Development Project (*Proyek Pengembangan Coal Bed Methane*), a program of the Research and Development Centre For Oil and Gas Technology (*Pusat Penelitian dan Pengembangan Teknologi Minyak dan Gas Bumi* ) "LEMIGAS".

Recently, in several areas of the world, an emerging energy resource of considerable significance is represented by coalbed methane. Distributed among more than 11 basins in Indonesia, the resource of CBM is estimated at 337 tcf up to 500 tcf (Stevens *et al*., 2001).

The aims of the research is to collect information obtained from coal and its coal measures, both field and laboratory analyses. Results of analyses are important for having a better understanding on the coal characteristics relating to CBM potential, predominantly, within the Tertiary coal-measures far away from effect of intrusives.

Main objective of the paper is to evaluate the CBM potential of low rank Tertiary coals in the several coalfields mentioned, in order to define future exploration objectives in regions that contain rich CBM resources. Specific objectives are to : (a). determine quantity and quality of CBM generated, and exploration implications of CBM as a source for new alternative energy, (b). determine and analyse the coal deposits and their coalification process, (c). evaluate source rock characteristics of the coals and identify the major CBM source area.

Afterwards, collection of field data and samples for organic petrology, SEM, and geochemical analysis purposes were carried out. The essential laboratory techniques deal with micro-cleat determination, organic petrology including rank, and volatile matter analysis.

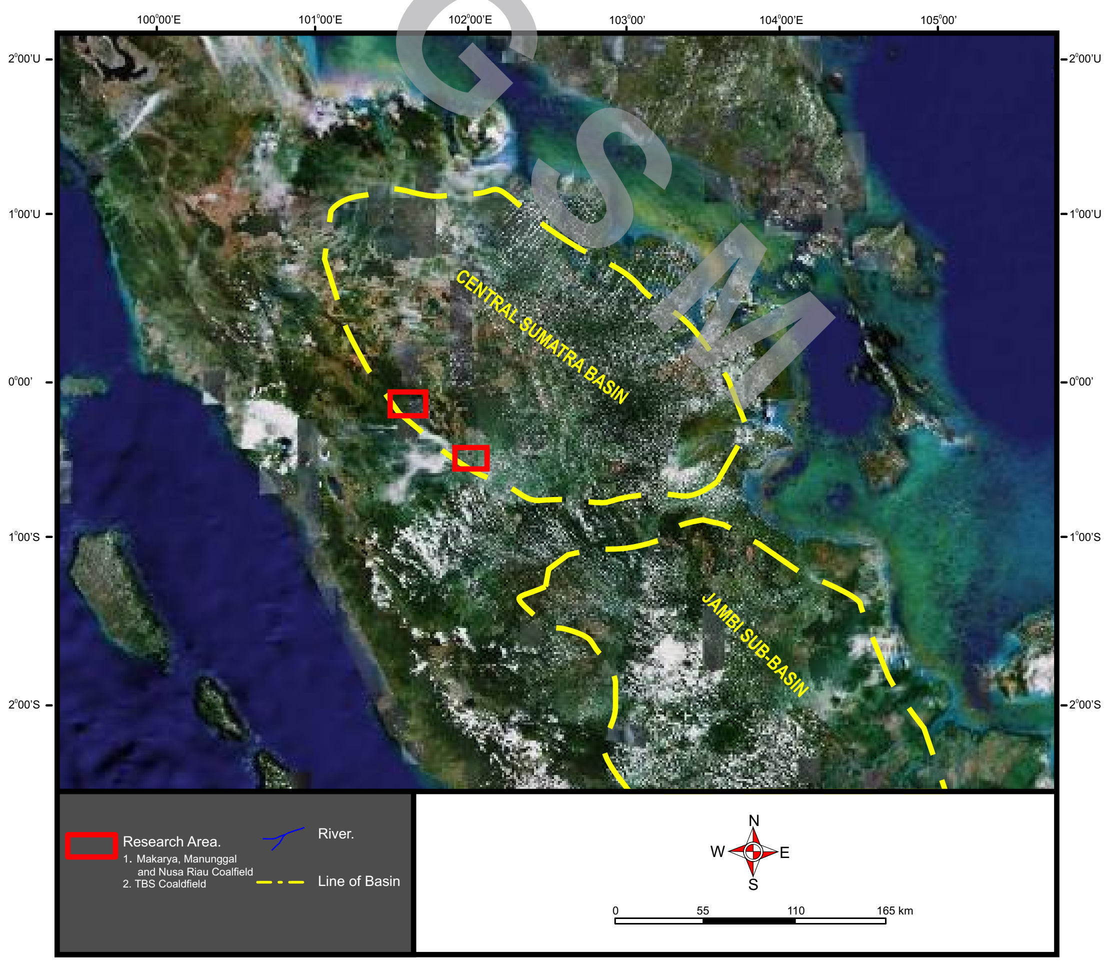



Figure 1. Detailed locality map of the Coalbed Methane study in Kuansing Area

## GEOLOGICAL SETTING

### Physiography

The study area is suggested to be a small intra-montane basin or presumably the southwestern tip of the Central Sumatera Basin. Morphologically, the area under discussion can be divided into: Rolling Hills and Mountainous Units. In general terms, the study area comprises gentle low lying hilly areas, rolling country, and rugged mountainous areas.

### Stratigraphy

Based on the 1: 250.000 scale geological map of the Solok Quadrangle (modified from Silitonga & Kastowo, 1995), the oldest Tertiary sedimentary rocks exposed around the Nusa Riau and Manunggal Coalfields at Muara Lembu, Singingi Sub-Regency, is the Keruh Formation (Figure 2). The formation is widely distributed along the eastern margin of the basin, and stratigraphically unconformable above the pre-Tertiary Kuantan Formation. The Eocene - Oligocene Keruh Formation comprises conglomerate, upwards followed by well bedded sandstone with intercalation of parallel laminated mudstone in the lower part. Then this sequence is overlain by alternating of coal seams, carbonaceous shale and mudstone, with some inteebedded of sandstones in the middle part. Interbedded laminated shale and mudstone occupy the upper part of formation. The Keruh Formation is overlain by conformably with the Oligo-Miocene Lakat Formation (Toml) composed of lower part : polymict conglomerate, quartz sandstone and intercalation claystone, siltstone and tuff, with coal lenses. upper part : alternating beds of quartz sandstone and silty, carbonaceous claystone with siderite nodules. The Oligo-Miocene Lakat Formation comformably overlying the Late Miocene Tualang Formation (Tmt) that comprises lower part : claystone with quartz sandstone intercalation, in places calcareous and silty, with fine grained calcareous sandstone nodule, containing galuconite and muscovite, Upper part : Quartz sandstone with intercalations of claystone, pyritiferous mudstone and glauconite sandstone. Generally light brownish grey to light greenish grey with thickness 200 - 300 m. The Late Miocene Tualang Formation is overlain unconformably by the Middle Miocene Binio Formation (Tmb) composed of sandy and marly claystone, numerous sandstones with glauconite, sometimes calcareous. The Middle Miocene Binio Formation is overlain unconformably by the Mio - Pliocene Korinci Formation (Tmpk) composed of interstratified sandstone and brownish claystone with principal coal seams, greennish blue claystone with numerous ligniteous coal seams were deposited in a brackish environment. The Kasai Formation (QTk) consisting of gravel, tuffaceous sands and clays, volcanic concretion, pumice, and tuff. The formation comformably overlies the Mio - Pliocene Korinci Formation in Plio - Pleistocene time.

### Keruh Formation

In accordance with the recently agreed Indonesian stratigraphic nomenclature and referring to Kusumahbrata and Suwarna (2003), which used the propose tentative name, that is the Keruh Formation (previously as the Lower Telisa Formation of Silitonga & Kastowo, 1995), for the well-exposed sedimentary succession along the Keruh River and Nusa Riau Manunggal Coalfields at the Muara Lembu Sub-Regency, and also in the Tri Bakti Sarimas Coalfield, Lubukjambi Sub-Regency, both included into the Kuantan-Singingi Regency. The area is part of the southeastern margin of Tertiary Central Sumatera Basin, one of the Indonesian oil producing back-arc basins. The basin is underlain by the pre-Tertiary basement rocks, and it has been filled by the Eocene to Plio-Pleistocene siliciclastic-dominated sediments.

According to Heryanto, *et al*. (2004), the Eocene - Oligocene Keruh Formation comprises conglomerate, upward followed by well bedded sandstone with intercalation of parallel laminated mudstone in the lower part. Then this sequence is overlain by alternating of coal seams, carbonaceous shale and mudstone, with some inteebedded of sandstone in the middle part. Interbedded laminated shale and mudstone occupy the upper part of formation.

The upper and middle parts of the Keruh Formation appear as on oil source rock sequence. The sequence mainly consists of laminated shale and mudstone, underlain by coal seams with some interbedded carbonaceous shale and mudstone. Shale and mudstone, light to blackish grey, flaky to thickly laminated, showing a parallel lamination in places, abundant organic material and contain iron oxide veinlets. Physically, these rocks are hard when its fresh and soft when its altered. These rocks are also interbedded by a light grey mudstone with a poor organic material content.

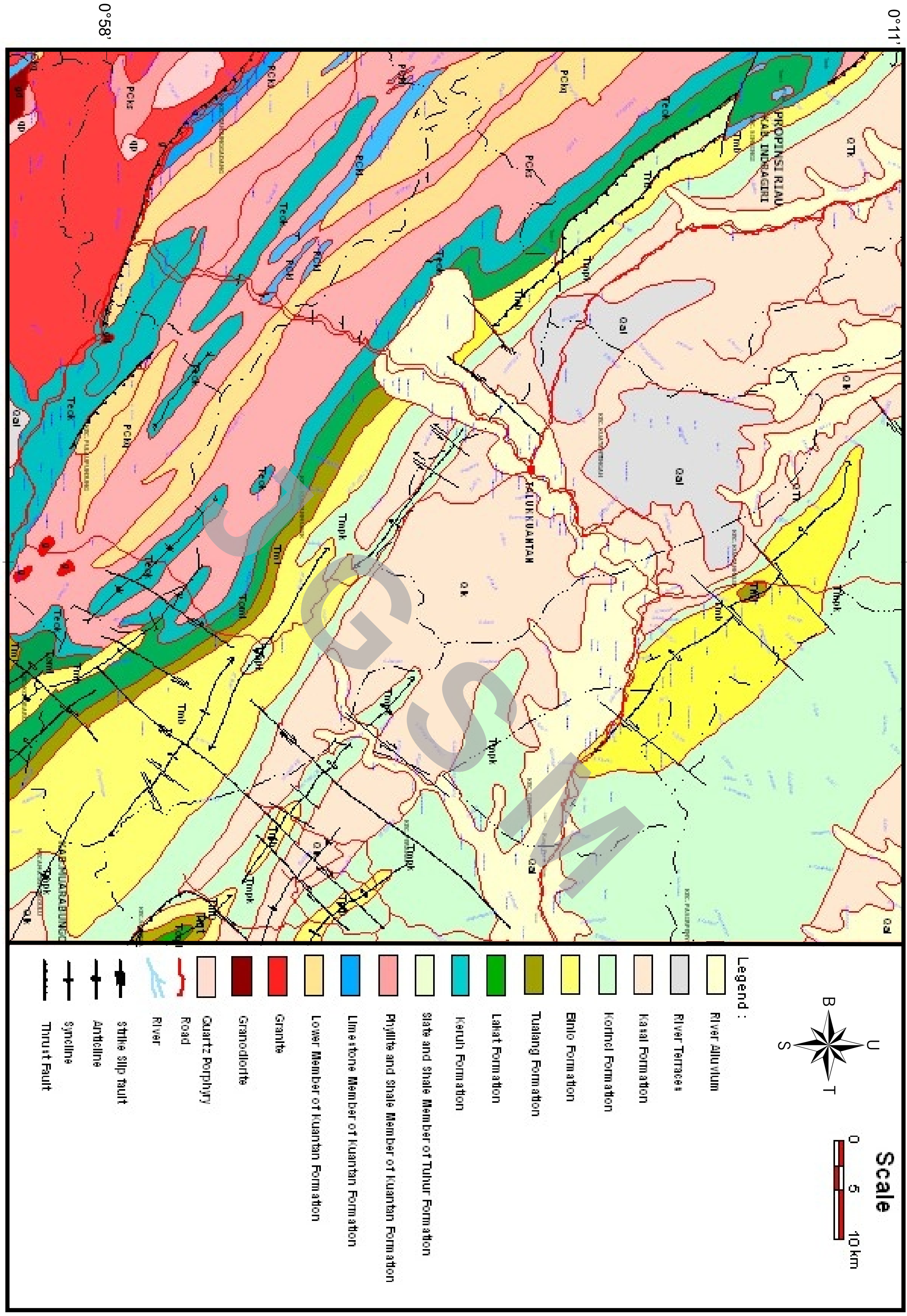



Figure 2. Geological map of the Solok Quadrangle (modified from Silitonga & Kastowo, 1995).

Based on the presence of *Palmaepollenites kutchensis, Florschuetzia trilobata, Cicatricosisporites dorogensis, Verucatosporites usmensis and Retistephanocolpites williamsii*, the formation is postulated to be a Late Eocene in age (Heryanto *et.al*, 2004). On the basis of lithological characteristics, the Lower part of Keruh Formation was deposited in a fluvial system, whilst the middle part was accumulated in a swampy area, interconnected with floodplain or upper part deltaic system.

The presence of Palmaepollenites kutchensis, *Florschuetzia trilobata*, *Durio*, *Discoidites borneensis*, fungal spore and small diatomea tend to show a littoral or fresh water conditions. The appearance of telalginite-Botryococcus, and also the presence of framboidal pyrite indicate that a marine condition occurred. Thereby, the suitable depositional environment for the hydrocarbon source rocks sequence of the Keruh Formation is a lacustrine with some influences of marine conditions (Heryanto *et.al*, 2004).

## RESULT OF INVESTIGATION

### Petai Area

The region is located approximately 30 km to the northwest of Taluk Kuantan (Figure 1). There are three private coal companies, those are the P.T Nusa Riau Manunggal - Makarya, which are running to exploit coal deposits.

Based on the field observation, a potential coal deposit was recognised in the Petai area. Its calorific value varies from 5000 - 7000 cal/g. The coal seams in the area occupy the low geologic condition, due to fault disturbances taking place within the area are hardly observed. Based on the core samples present, thickness of each sub-seam is more than 75 cm. In this region, coal seam with coally shale and claystone intercalation show on the upper part of the Keruh Formation. Coal stratigraphic columns observed in the region are presented in Figures 3a and 3b.

Megascopically, the coal lithotype varies from banded to bright banded, showing brownish to black streak, dark grey to black colour, with some of subchoncoidal fracture. Some pyrites are recognised. The interburden comprises light grey fine-grained sandstone, siltstone, claystone/mudstone, and shale (Photo 1).

The coal quality gained from geochemical analysis, indicates that its ash content ranges from 1.61 to 31.66 %, total sulphur content is 0.18 - 4.84 %, and volatile matter of 38.52 % (Table 1). On the basis of ash and total sulphur contents, it can be concluded that the mineral matter contained in the coal is low to high level.

Furthermore, petrographic analysis shows that the coal is dominated by vitrinite (70 - 88.6 %), with minor amount of exinite (2 - 22.6 %), inertinite (1 - 4 %) and mineral matter (2.4 - 28.8 %) (Table 2). Vitrinite reflectance having a value of 0.4 - 0.63 %, tends to indicate a sub-bituminous A to high volatile bituminous-B coal rank.

Field observations on cleat from coal exposures in the Petai area demonstrate that, the dip direction of coal face cleat varies from N170°E/76° to N230°E/80°; space ranges between 1.5 cm to 7 cm, averaged 2.88 cm; aperture of 0.1 to 02 cm, frequency is 0.351 cm, and density of 0.235/cm (Photo 2).



Table 1. Anaysis Result of Coal Geochemistry in Kuansing, Riau

| No. | Sample Marks | Total Moisture % ar | Ash % ar | Volatile matter % ar | Fixed Carbon % ar | Calorific Value cal/gr, ar | Total Sulphur % ar | Location |
|---|---|---|---|---|---|---|---|---|
| 1 | 06 WG 90A | 13.92 | 32.93 | 34.74 | 18.41 | 3920 | 1.03 | TBS Coalfields |
| 2 | 06 WG 91A | 18.02 | 21.27 | 35.19 | 25.52 | 4500 | 1.30 | TBS Coalfields |
| 3 | 06 WG 91B | 21.22 | 5.02 | 43.31 | 30.45 | 5626 | 2.14 | TBS Coalfields |
| 4 | 06 WG 92A | 22.83 | 31.26 | 36.53 | 9.38 | 5033 | 0.85 | TBS Coalfields |
| 5 | 06 MH 41A | 22.39 | 1.61 | 40.65 | 35.35 | 5264 | 0.18 | Petai Areas |
| 6 | 06 MH 41B | 11.50 | 6.15 | 37.55 | 44.80 | 6273 | 3.62 | Petai Areas |
| 7 | 06 MH 42A | 6.59 | 1.79 | 40.51 | 51.11 | 7329 | 1.43 | Petai Areas |
| 8 | 06 MH 42B | 8.71 | 26.24 | 28.18 | 36.87 | 4623 | 1.04 | Petai Areas |
| 9 | 06 MH 43A | 6.39 | 31.66 | 28.87 | 33.08 | 4645 | 2.05 | Petai Areas |
| 10 | 06 MH 44A | 8.31 | 9.08 | 36.42 | 46.19 | 6525 | 1.62 | Petai Areas |
| 11 | 06 MH 45A | 4.47 | 4.92 | 41.17 | 49.44 | 7126 | 2.94 | Petai Areas |
| 12 | 06 MH 47A | 6.02 | 6.14 | 36.53 | 51.31 | 7009 | 4.84 | Petai Areas |
| 13 | 06 MH 48A | 8.14 | 4.37 | 35.97 | 51.52 | 7085 | 2.45 | Petai Areas |

Table 2. The Results of Petrographic Analysis in Kuantan Sengingi

| No. | Tanda Contoh | Maseral | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | TX | TC | TL | At | Dns | Dsm | DT | Crp | GL | **V** | Sp | Cu | Re | Sb | Exu | Alg | Lipt | **EKS** | F | Sf | Sc | Intr | Ma | **IN** | Cly | Crb | PyF | PY | **MM** | Rv min | Rv max | Rv rata |
| 1 | 06 WG 90A | 0.0 | 1.2 | 1.2 | 29.4 | 14.6 | 1.2 | 45.2 | 0.0 | 0.0 | **46.4** | 1.6 | 0.0 | 3.6 | 0.0 | 0.0 | 1.6 | 0.8 | **6.8** | 0.0 | 1.2 | 1.6 | 0.0 | 0.0 | **2.8** | 26..6 | 9.0 | 0.6 | 1.2 | **37.4** | 0.35 | 0.44 | 0.39 |
| 2 | 06 WG 91A | 0.8 | 14.2 | 15.0 | 6.8 | 34.2 | 5.2 | 46.2 | 2.2 | 2.2 | **63.4** | 1.0 | 0.0 | 7.0 | 0.0 | 0.0 | 0.0 | 0.0 | **8.0** | 0.0 | 5.0 | 8.6 | 2.4 | 0.0 | **16.0** | 12.0 | 7.4 | 0.4 | 1.2 | **21.0** | 0.38 | 0.54 | 0.46 |
| 3 | 06 WG 91B | 1.4 | 27.2 | 28.6 | 10.2 | 20.2 | 8.6 | 39 | 1.2 | 1.2 | **68.8** | 0.6 | 2.8 | 8.2 | 0.0 | 1.0 | 1.0 | 0.4 | **14.0** | 0.0 | 2.6 | 5.4 | 1.6 | 0.0 | **9.6** | 1.0 | 4.6 | 0.8 | 1.2 | **7.6** | 0.48 | 0.60 | 0.54 |
| 4 | 06 WG 92A | 1.2 | 32.8 | 34.0 | 2.6 | 29.6 | 4.6 | 36.8 | 4.0 | 4.0 | **74.8** | 1.0 | 1.0 | 4.2 | 0.0 | 0.0 | 1.6 | 0.0 | **7.8** | 0.0 | 2.0 | 8.0 | 1.4 | 0.0 | **11.4** | 5.0 | 0.0 | 0.0 | 1.0 | **6.0** | 0.44 | 0.58 | 0.51 |
| 5 | 06 MH 41A | 17.4 | 18.0 | 35.4 | 6.6 | 22.0 | 4.6 | 33.2 | 1.4 | 1.4 | **70.0** | 3.0 | 0.6 | 12.0 | 0.4 | 1.2 | 0.0 | 5.4 | **22.6** | 0.0 | 3.0 | 0.0 | 1.0 | 0.0 | **4.0** | 0.6 | 0.6 | 0.0 | 1.2 | **2.4** | 0.38 | 0.66 | 0.52 |
| 6 | 06 MH 41B | 0.0 | 40.0 | 40.0 | 0.6 | 31.6 | 4.0 | 36.2 | 3.6 | 3.6 | **79.8** | 1.0 | 6.4 | 1.4 | 1.0 | 0.0 | 0.4 | 1.0 | **11.2** | 0.0 | 0.0 | 1.4 | 0.0 | 0.0 | **1.4** | 2.6 | 1.8 | 3.2 | 1.0 | **8.6** | 0.46 | 0.70 | 0.58 |
| 7 | 06 MH 42A | 0.0 | 53.4 | 53.4 | 3.6 | 24.4 | 6.2 | 34.2 | 0.6 | 0.6 | **88.2** | 0.0 | 3.4 | 0.4 | 0.0 | 0.0 | 0.0 | 0.0 | **3.8** | 0.0 | 0.4 | 2.0 | 0.0 | 0.0 | **2.4** | 0.8 | 2.0 | 1.2 | 0.5 | **4.5** | 0.48 | 0.72 | 0.60 |
| 8 | 06 MH 42B | 2.0 | 35.2 | 37.2 | 4.0 | 33.4 | 9.6 | 47 | 2.6 | 2.6 | **86.8** | 0.0 | 0.0 | 2.4 | 0.0 | 0.0 | 0.6 | 0.4 | **3.4** | 0.0 | 0.4 | 1.0 | 0.0 | 0.0 | **1.4** | 14.0 | 2.4 | 0.2 | 2.0 | **18.6** | 0.40 | 0.46 | 0.40 |
| 9 | 06 MH 43A | 2.0 | 22.0 | 24.0 | 10.6 | 28.4 | 13.6 | 52.6 | 2.2 | 2.2 | **78.2** | 0.2 | 0.4 | 1.0 | 0.0 | 0.0 | 0.0 | 0.4 | **2.0** | 0.0 | 0.0 | 1.0 | 0.0 | 0.0 | **1.0** | 18.6 | 7.0 | 2.4 | 0.8 | **28.8** | 0.40 | 0.52 | 0.46 |
| 10 | 06 MH 44A | 0.4 | 42.0 | 42.4 | 1.8 | 30.2 | 7.6 | 39.6 | 1.6 | 1.6 | **83.6** | 0.0 | 1.2 | 1.2 | 0.0 | 0.0 | 0.0 | 0.0 | **2.4** | 0.0 | 0.4 | 1.4 | 0.6 | 0.0 | **2.4** | 6.4 | 3.1 | 1.6 | 0.5 | **11.6** | 0.48 | 0.72 | 0.60 |
| 11 | 06 MH 45A | 0.0 | 48.0 | 48.0 | 0.6 | 25.4 | 5.2 | 31.2 | 1.2 | 1.2 | **80.4** | 0.8 | 1.2 | 1.2 | 0.0 | 0.0 | 0.0 | 2.4 | **5.6** | 0.0 | 0.0 | 0.4 | 0.0 | 0.0 | **0.4** | 5.6 | 1.2 | 2.4 | 0.8 | **10.0** | 0.44 | 0.72 | 0.58 |
| 12 | 06 MH 47A | 55.2 | 4.4 | 59.6 | 1.2 | 25.4 | 0.0 | 26.6 | 0.0 | 0.0 | **86.2** | 0.0 | 1.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.4 | **2.4** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | **0.0** | 5.4 | 1.0 | 4.6 | 0.4 | **11.4** | 0.52 | 0.72 | 0.62 |
| 13 | 06 MH 48A | 0.6 | 52.4 | 53.0 | 1.0 | 33.0 | 1.4 | 35.4 | 0.2 | 0.2 | **88.6** | 0.4 | 0.6 | 1.0 | 0.0 | 0.0 | 0.6 | 0.2 | **2.8** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | **0.0** | 1.2 | 3.8 | 0.0 | 2.6 | **7.6** | 0.52 | 0.74 | 0.63 |

Keterangan:

TX : Tekstinite
TC : Telokolinite
TL : Telovitrinite
At : Atrinite
Dns : Densinite
Dsm : Desmokolinite
DT : Detrovitrinite
Crp : Korpogelinite
GL : Gelovitrinite
V : Vitrinite

F : Fusinite
Sf : Semi fusinite
Ma : Makrinite
Sc : Sclerotinite
Intr : Inertoderinite
IN : Inertinite

Re : Resinite
Sp : Sporinite
Sb : Suberinite
Cu : Cutinite
Lipt : Liptodetrinite
Alg : Alginite
Exu : Eksudatinite
EKS : Eksinite

PY : Pyrite
PyF : Pyrite Flambodial
Crb : Carbonat
Cly : Lempung
MM : Mineral Mater
Rv min : Reflectance vitrinite minimum
Rv max : Reflectance vitrinite maksimum
Rv rata : Reflectance vitrinite rata

Photo 1. Coal seam showing brownish to black streak, dark grey to black colour, with some of subchoncoidal fractures.

Photo 2. Well developed face cleats in Manunggal Inti Artamas Coalfield.

The coal seams having a volatile matter content of 28.18 - 40.65%, show that predicted calculated methane content of the coal seam is 0.48 $m^3$/t - 3.90 $m^3$/t. It is obtained by plotting the volatile matter contents on a diagram created by Barbara/Winter shown in Figure 5. This character indicates an in-situ coal has a low to moderate methane content. However, it is not a pessimistic methane value excepted from the coal, because the coals analysed were collected from surficial outcrops.

**Tri  Bakti Sarimas (TBS) Coalfield**

The fourth coalfield studied, is the Tri Bakti Sarimas, falling under the Lubukjambi Sub-Regency. It is situated approximately 40 km to the southeast of Taluk Kuantan Town (Figure 1).

The coal sub-seam is mainly composed of bright banded lithotype, showing black to black streak, and dark grey to black colour, slightly to highly cleated. Subchoncoidal to conchoidal fracture, and also thick banding condition are recognised. Some pyrite, and abundant resin contents are observed. Thickness of each coal sub-seam is more than 1.5m. In this region, coal seam with coally shale and claystone intercalation shows on the upper part of the Keruh Formation.

Table 1 displays the geochemical analysis result of the selected coal samples. The result indicates that in the TBS area, the ash content varies from 5.02 % to 32.93 %, sulphur of 0.85 % to 2.14 %, and volatile matter of 34.74 % to 43.31 %. On the basis of ash and total sulphur contents, it can be concluded that the mineral matter contained in the coal is dominated by low to intermediate level.

Moreover, petrographic analysis displays that the coal is dominated by vitrinite (46.4 - 74.8 %) comprising mainly telocollinite (Photo 3) and detrovitrinite; with moderate amount of exinite (6.8 - 14 %) consisting of cutinite, resinite, sporinite, and suberinite; and low inertinite content (2.8 - 16 %) composed of semifusinite, sclerotinite, and macrinite.  Moderate mineral matter content (6 - 37.4%) such as clay mineral and framboidal pyrite (Photo 2.9) are also determined. Additionally, vitrinite reflectance has a value of 0.39 - 0.54 %, tending to categorized a sub-bituminous C to B coal rank of the ASTM classification.

The dip direction of coal face cleat is N60°E/750° and N120°E/85°, spacing ranging from 2 cm to 10 cm with dominant values range from 1.5 0 - 10.0 cm, averaged 5.85 cm, aperture of 0.1 to 02 cm, frequency  is.0.1713 $cm^{-1}$, and density of 0.1335 $cm^{-1}$.

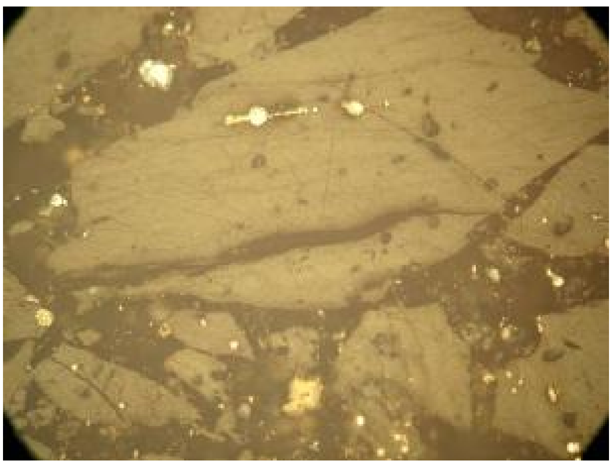


Photo 3. Microphotograph of telocollinite within the coal seam in the Kuansing region (Reflected light): magnification x 200 Sample: 06 MH 47A.

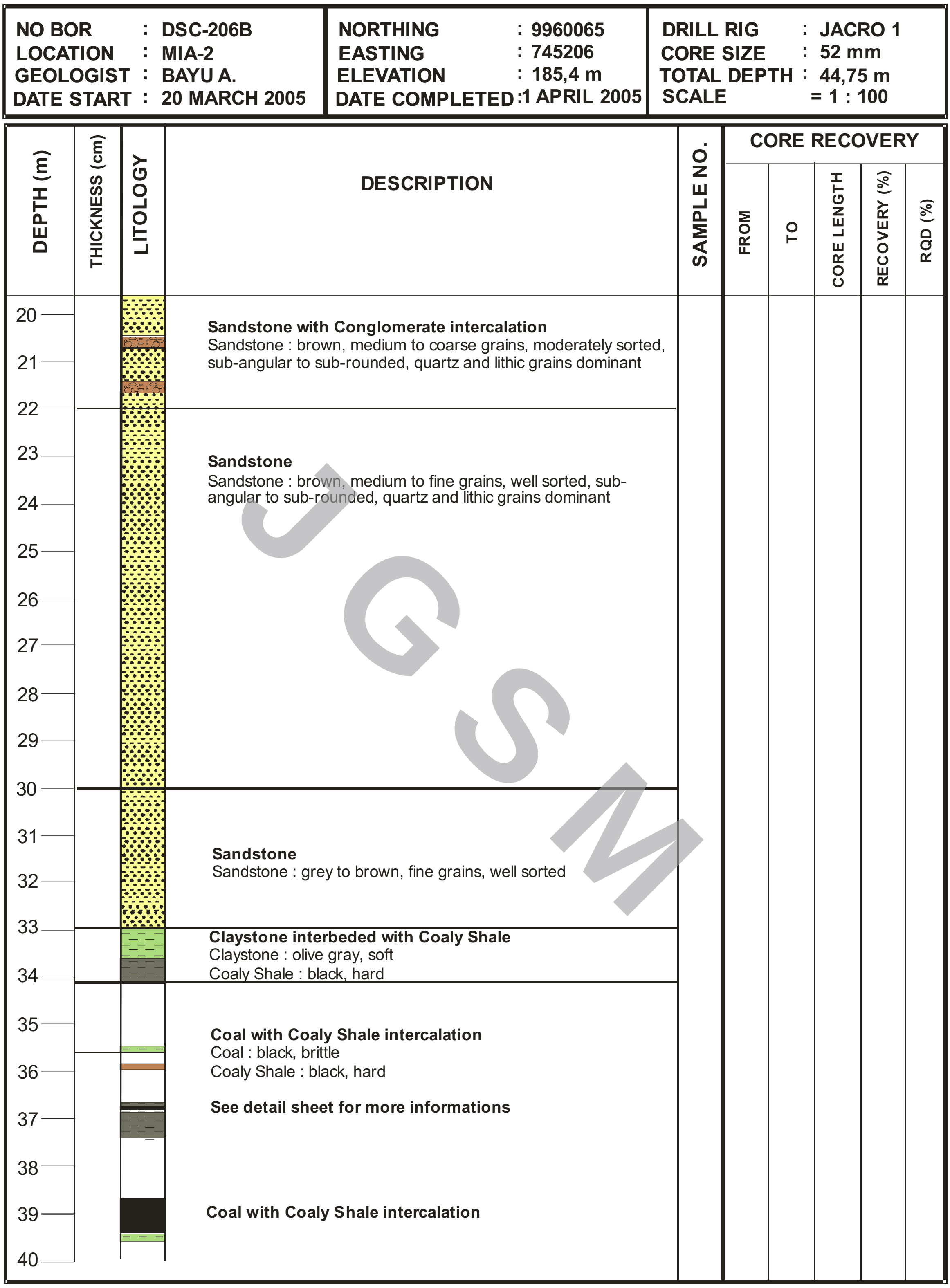



Figure 3a. Statigraphic section of coal seam in the Manunggal Inti Artamas Coalfield (MIA-2) area (PT Manunggal Inti Artamas, 2005).

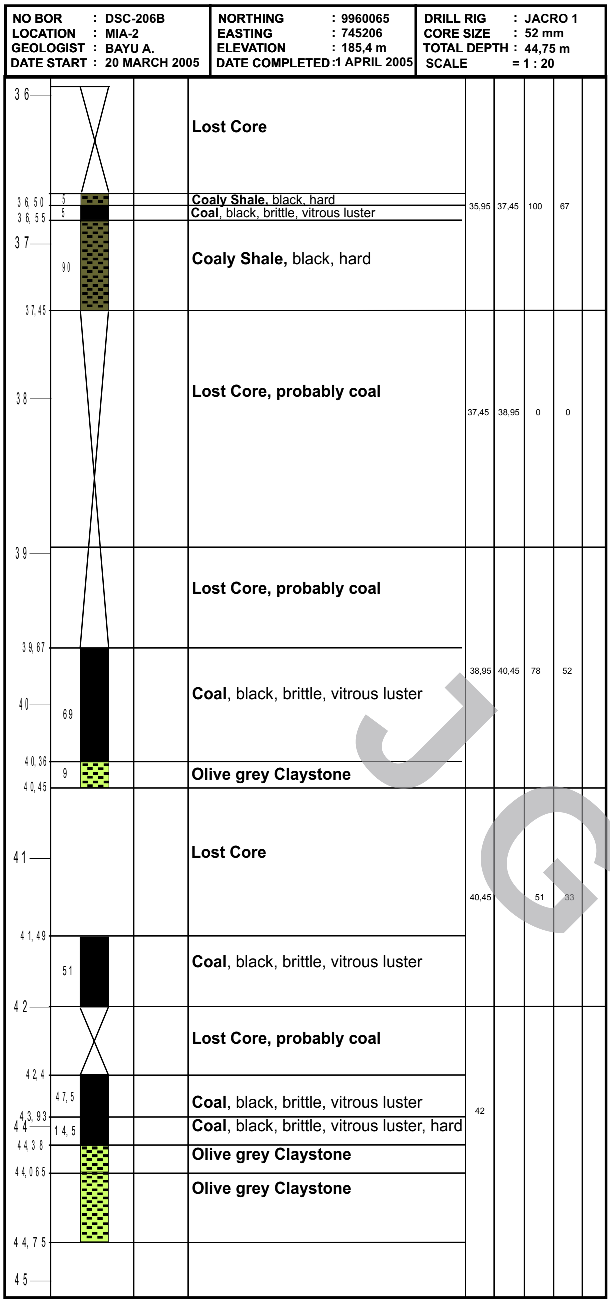



Figure 3b. Statigraphic section of coal seam in the Manunggal Inti Artamas Coalfield (MIA-2) area (PT Manunggal Inti Artamas, 2005).

The TBS coals have a volatile matter content varies from 34.74 - 43.31 %. It shows that predicted methane content of the coal seam, on the basis on the Barbara and Winter Diagram, is 1.70 to 2.20m$^3$/t (Figure 6). This methane content variation indicates an in-situ coal has a low to moderate methane or coalbed gas content.

In general, the cleat intensity is related to the maturity of coal rank, the higher the coal rank the more developed cleat intensity. In the study area, the rank of the coal commonly

moderate (Rv >0.5 %) shows an implication to the cleat intensity.

The coal permeability is expected to be moderate, although the coals themselves are fairly well cleated, and they have a very low porosity. This condition tends to indicate a moderate methane desorption capacity. Another substantial factor is desorption rate influenced by both rank and type of coal. With increasing rank, the effective diffusivity coefficient decreases. In higher rank coal, gas-release rates are slower than in lower rank coal.

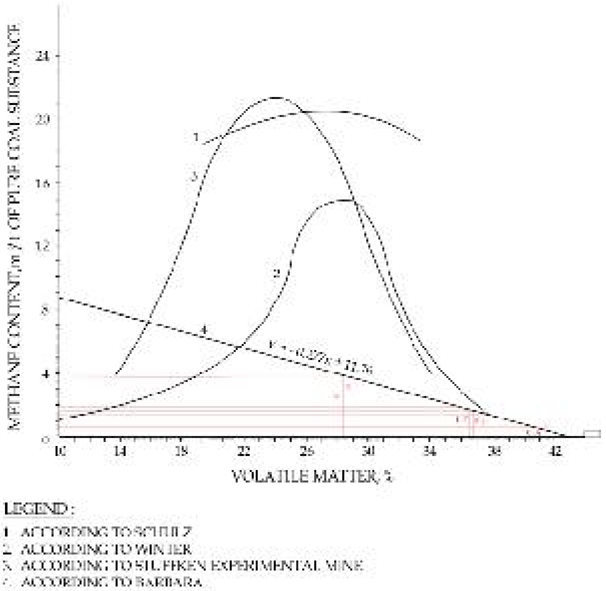
Additionally, the mineral matter acting as a simple diluent to decrease the methane adsorption capacity indicates that the mineral matter content had the strongest influence on the adsorption capacity. The mineral matter content of the coal studied is low to moderate level. Therefore, it is presumed that the adsorption capacity of the coal is relatively moderate. The lower moisture content ranges from 1.2 - 9.6 %, indicates that methane adsorption of the coals will be slightly high. On the other hand, methane sorption will be low to moderate.

Based on those parameters influencing the coal adsorption capacity, coalbed methane content derived from the TBS area coals is expected to be at least a moderate level. This level category is evidenced by the presence of bright to bright banded lithotype, maceral composition dominated by vitrinite; low moisture content, moderate to slightly high volatile matter, moderate to high vitrinite reflectance, but low to medium ash content.

## SEM Analysis Results

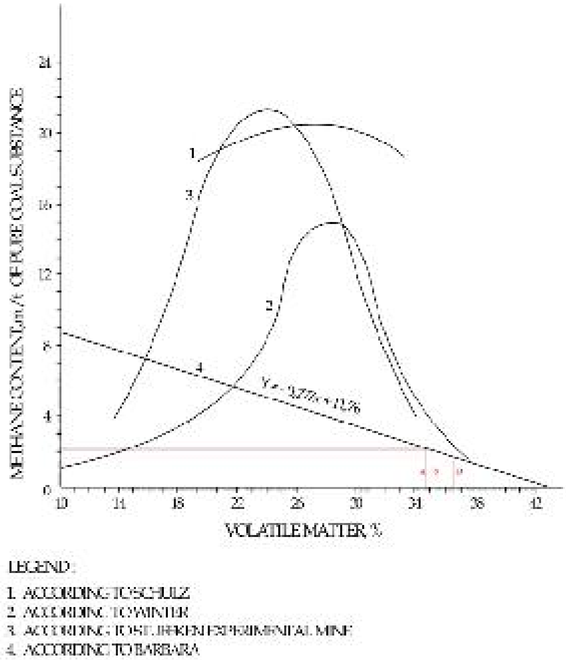
Six samples analyzed by SEM method have recorded in digital microphotograh, including the EDX result of all objects that observed clearly and brightly.

Six samples from Petai area are present as coals which are represented by samples 06 MH 41A, 06 MH 42A, 06 MH 44A, 06 MH 45A and 06 MH 47, whilst one sample (06 MH 43A) is coaly shale. Coal is generally predominated by vitrinite maceral group, varying from 70 % - 99 %; and it consists of telocollinite, rare textinite, and desmocollinite. Exinite maceral group, ranging from 1 % to 3 %, is present as sporinite and cutinite; while inertinite is very rare in all samples. The predominant mineral




| No. | Coal Seam | Volatile Matter | Methane Content | |
|---|---|---|---|---|
| | | | (4) | (2) |
| A | 06 MH 41A | 40.85 | 0.60 | 0.18 |
| B | 06 MH 42B | 37.75 | 1.47 | 0.06 |
| C | 06 MH 43A | 40.51 | 0.65 | 0.18 |
| D | 06 MH 43B | 28.28 | 1.95 | 0.18 |
| E | 06 MH 43 A | 28.87 | 1.75 | 0.06 |
| F | 06 MH 44 A | 36.42 | 1.75 | 0.06 |
| G | 06 MH 45 A | 41.17 | 0.45 | 0.16 |
| H | 06 MH 47 A | 36.33 | 1.70 | 0.16 |
| I | 06 MH 49 A | 36.87 | 1.55 | 0.16 |

Figure 4. Coalfields consist of theoretical gas content based on Barbara and Winter Diagram, and Lost Gas during drilling (Q1) in Petai Area.




| No. | Coal Seam | Volatile Matter | Methane Content | |
|---|---|---|---|---|
| | | | (4) | (2) |
| A | 06 WG 90A | 34.75 | 2.20 | 0.00 |
| B | 06 WG 91A | 35.10 | 2.09 | 0.00 |
| C | 06 WG 91B | 41.51 | 0.00 | 0.00 |
| D | 06 WG 92A | 36.36 | 1.70 | 0.00 |

Figure 5. Coalfields consist of theoretical gas content based on Barbara and Winter Diagram, and Lost Gas during drilling (Q1) in TBS area.



matter is kaolinite, followed by pyrite, ankerite, iron oxide, rutile, molybdenite, and pyrite, having amount of 1 % to %.

Generally, all coal samples observed by SEM method are bright. Clay mineral is composed of kaolinite that has a book texture, and vermiculite rather irregular; as well as pyrite having framboidal (Photo 4) texture. Vitrinite maceral generally has been cut by micro cleat; some are filled with kaolinite mineral, ankerite, pyrite, and iron oxide.

**CBM Potential and Content**

This section attempts to evaluate CBM potential in the Kuansing area based on the field works and laboratory data. Physical properties (type, porosity/ permeability, and rank) and thickness of coal, structural geology, and cleats have been assessed in the previous section and only the important result will be extracted for the purpose of Kuansing CBM resource assessment.

The Kuansing area, located in the Sumatra back- arc region, possesses many favorable and risks for CBM development. Favorable attributes include slightly thick coals in the Miocene Keruh Formation, low ash and sulfur content, low to moderate inherent moisture and volatile matter content, low rank coal (sub-bituminous B to A grade), and well-developed cleats. Negative attributes include poor data control, poor sorption isotherm data, structural complexity, probably extremely high $CO^2$ gas content, and relatively narrow prospective area for CBM play.

– **Gas In-Place Resources**

Considering the availability of Kuantan Singingi field and laboratory data set required for calculating CBM resources, the calculation of gas in-place potential in the area was conducted. Parameters used to calculate the gas in-place potential of the Kuansing Coalfields consist of theoretical gas content based on Barbara and Winter Diagram, and Lost Gas during drilling (Q1) plus gas desorption during transportation (Q2) and residu gas (Q3). Thereby, the parameter used is the theoretical gas content calculation on the basis of the Barbara and Winter Diagram.

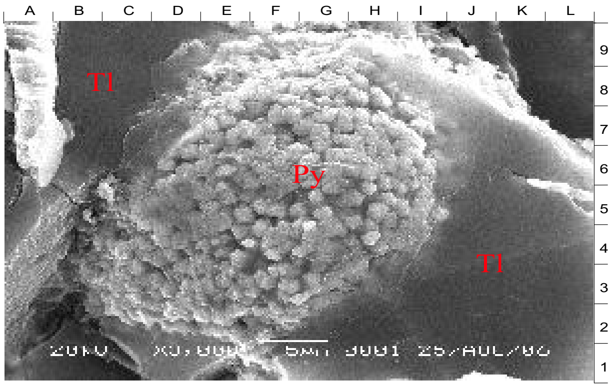



Photo 4. Seam microphotograph of coal comprising tellocolinite (Tl) and framboidal pyrite ( Py): magnification x 3000. Sample number 06 MH 45 A

In order to calculate the theoretical gas in-place potential of the Kuansing area, the required important parameter is the volatile matter content of the coal. The gas in-place potential/content of each selected coal seams are shown as follows:

- Petai Area on the the Barbara and Winter Diagram shows that methane gas content is from 0.47 $m^3$/t - 3.90 $m^3$/t = 16.85 scf/t - 139.85 scf/t.
- Tri Bhakti Sarimas (TBS) on the Barbara and Winter Diagram shows that methane gas content is from 1.7 $m^3$/t - 2,25 $m^3$/t = 60.96 scf/t - 80.69 scf/t.

The graphics of Volatile Mater versus Methane content according to Barbara and Winter diagram are shown in Figures 5 and 6. The methane content within the coal seam in the Kuansing and its surrounding areas is as follows: According to Barbara-Winter Diagram, the content of methane gas ranges from 16.85 scf/t to 139.85 scf/t. Gas in-place which is supported by the Q1, Q2 and Q3 values,as well as laboratory result has been calculated. The calculation follows the formula proposed by Aminian (2007) with some modifications as written below:

**$G = 1359,7\ Ah\,\rho_c\,G_c$**

Where,

G = Gas in place, scf (*standard cubic feet*)

A = Reservoir area, acres

h = thickness, feet

$\rho_c$ = Average In situ Coal density, g/$cm^3$

$G_c$ = Average In situ Gas content, scf/ton

Thus, the investigated area has a gas reserve in place for:

Coal seam in TBS area : **72,013,367.4682 scf**

Coal seam in Petai area : **546,918,404.8961 scf**

The total reserve of gas in reservoir in the investigated area :

**618,931,772.3643 scf**.

**– Methane Gas in-Place Resources**

Methane gas (CH4) in-place resources which supported by the Q1, Q2 and Q3 calculations, as well as laboratory result values, have been calculated using formula proposed by Aminian (2007) with some modifications as written below:

**$G = 1359,7\ Ah\,\rho_c\,G_c$**

Where,

G = Methane Gas in place, scf

A = Reservoir area, acres

h = thickness, feet

$\rho_c$ = Average In situ Coal density, g/$cm^3$

$G_c$ = Average In situ Methane Gas content, scf/to

Thus, the investigated area has methane gas reserve in-place for:

Coal seam in the TBS area : **98,934,518.8431 scf**

Coal seam in the Petai area : **443,808,693.7226 scf**

The total reserve of methane gas reserve in the investigated area is suggested to be :

**542,743,212.5657 scf.**

Moreover, in Kuansing region, the content of methane (CH4) within coalbed gases varies from 13.43 - 100%.

## DISCUSSION

Gas content measurement is dependant of several factors, such as sampling procedures, sample type, coal properties, and analytical methods and quality. The gas storage capacity of coal beds was generally assumed to correlate with coal rank. There is a relationship between gas content with depth for each rank coal category. Furthermore, sorption capacity increases with progressive coalification.

The investigated coal seams for CBM purposes located in Kuansing area, based on the vitrinite reflectance, coal seams in Petai area are categorized as a sub-bituminous A to high volatile bituminous-B coal rank. But coal seams in TBS area are identified as a sub-bituminous C to B coal rank. Furthermore, the coal seams in the Petai and TBS area are commonly characterized by low ash and moderate sulfur contents. Due to the level of vitrinite reflectance values of coal tending to thermally late immature to early mature (Rv: 0.39 - 0.63%), the expected gas present is suggested to be of biogenic origin, coinciding with the low to medium thermal maturity. The coalbed gas level category is suggested to be evidenced by the presence of banded to bright banded lithotype; maceral composition dominated by vitrinite with minor content of exinite and inertinite; moderate moisture content; moderate to slightly high volatile matter; low to medium vitrinite reflectance, and low ash content.

SEM analysis displays that the coal is dominated by vitrinite macerals, with minor exinite and inertinite. The microcleat occurs in a rare to medium density, and shows an opened texture.

In Petai area, the content of methane (CH4) within coalbed gases ranges from 16.85 scf/t - 139.85 scf/t. Whilst in TBS area it varies between 60.96 scf/t - 80.69 scf/t. Thus, the average coalbed gas in TBS areas is higher potential level compared with parts of areas in Petai. Based on geological map this condition caused by geological structure of the Petai area more than intensive with TBS area.

## CONCLUSIONS

- The Keruh Coal Measures, included into the category of high geologic condition group, are characterised by moderate to high tectonic deformation influence, with moderate faults and folds, moderate level of dip and thickness variation of coal seams, and development of seam splitting. Lithostratigraphically, the coal measures comprise claystone/shale, calcareous siltstone, sandstone, conglomerate, with intercalations of coal.
- Coal is characterised by the banded to bright banded lithotype, with brownish to black streak, dark grey to black colour, some showing subchoncoidal to choncoidal fracture, slightly to highly cleated. and also thick banding condition are recognised. Some pyrites and abundant resin are recognised. Thickness of each coal sub-seam is more than 1.5 m. The interburden comprises light grey fine-grained sandstone, siltstone, claystone, and shale. The coal quality indicates that ash content varies from 1.61 - 32.93 %, total sulphur content is 0.18 - 4.84 %, and volatile matter of 34.74% to 43.31%. The dominant maceral is vitrinite (46.4 - 88.6 %), comprising mainly telocollinite and detrovitrinit; with minor amount of exinite (2 - 22.6 %) consisting of cutinite, resinite, sporinite, and suberinite; low to moderate inertinite content (1 - 16%) composed of semifusinite, sclerotinite, and macrinite; and low to high mineral matter (2.4 - 37.4 %). Vitrinite reflectance has a value of 0.39 - 0.63 %, tending to indicate a sub-bituminous to high volatile bituminous-A. rank. Methane content of the coal seam is 0.47 $m^3$/t - 3.90 $m^3$/t.
- Coal Cleats of each coalfield is as followed:
  - In the Petai Area, dip direction of coal face cleat is N170°E/76o up to N230°E/80°, spacing ranging from 1.5 cm to 7 cm, averaged 2.88 cm, aperture of 0.1 to 02 cm, frequency is 0.351 cm, and density of 0.235/cm.
  - In TBS area, dip direction of coal face cleat is N60°E/750° and N120°E/85°, spacing ranging from 2 cm to 10 cm with dominant values range from 1.5 - 10.0 cm, averaged 5.85 cm, aperture of 0.1 to 02 cm, frequency is.0.1713 $cm^{-1}$, and dens.
- Coalbed methane content of the coal seam, based on the Barbara and Winter Diagram, ranges from 0.47 $m^3$/t - 3.90 $m^3$/t. This character indicates an in-situ coal have a low to moderate methane content. Gas in-place reserve supported by the Q1,Q2 and Q3 calculations show a calculated varieted value between **542,743,212.5657scf** and **618, 931,772.3643 scf.**

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