International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064

The Identification of CBM Sweet Spot Area of Sajau Coal in Berau Basin based on Remote Sensing Imagery

Ahmad Helman Hamdani[1], Adjat Sudrajat[2], Emi Sukiyah[3]

[1]Faculty of Engineering Geology, University Padjadjaran, Jalan Raya Bandung, Sumedang Km. 21 Jatinangor, Indonesia

Abstract: ***The Berau Basin which is located in Northeast Kalimantan is one of the major coal basin in Indonesia are among the prolific gassiest in western Indonesia. The key work in the selection of CBM sweet spot is to look for the area which the tectonic activity can be generated fracture permeability in coal seams. The fracture permeability development in coal seam is related with density of the fracture and cleat within the coal. The CBM sweet spot tend to occur at relatively high permeability compartment. Based on the remote sensing techniques and field geological investigation indicated that coal cleat were shown similar trend in their earth stress. All the result of measurement from the imagery interpretation and field measurement were integrated statistically analysis to defined the trend of regional fracture direction to delineate of CBM sweet spot.***

Keywords: CBM Sweet spot, Berau Basin, Fracture Permeability, Remote Sensing

1. Introduction

Coalbed methane is an important source of clean fossil-fuel energy which is experiencing growing demand in the world. The exploration for unconventional energy (CBM) reserves has rapidly increased over the last five to ten years. Currently, there are a number of companies actively exploring for coalbed methane (CBM) in Indonesia. Coal Bed Methane (CBM) is a natural gas generated during the coalification process and stored in coal seams, in the adsorbed state, on the internal surfaces of coal matrix. The ability of coal to store methane gas is dependent on multi factors; one of them is the coal permeability.

The research location is the Berau Basin, which is the one of the biggest coalbed methane basin in Indonesia with has big potential of CBM around 17.5 Trillion Cubic Feet (TCF). This also supported by the study of Delmar Mining [1] indicate the coal thickness of Sajau Formation in Berau basin have the total coal reserve up to 225 million tons. Two coal bearing formation in Berau basin are Sajau Formation and Latih Formation (Fig. 1)

Regionally; the tectonic evolution in this basin was initiated by extension and subsidence during the middle to late Eocene formed wrench faults and resulted in the formation of major NW-SE oriented arches and had stopped by the end of early Miocene. The area was more tectonically stable from middle Miocene up to Pliocene with deltaic sedimentation from the west. The late stage tectonic in the Plio-Pleistocene reactivated the earlier structural trend and reverses the listrict faulting to form the reverse and thrust faulting. This deformation was reoriented the folding to be NE-SW. The Plio – Pleistocene tectonic periods resulting coarse clastic deltaic sedimentary rocks that have not resistant to erosion and denudation processes. Therefore; it is quite hard to identify geological structures directly on the surface.

The CBM "sweet spots" is defined as the location of good coal deliverability with reservoir condition exists or the coal characteristics are well-aligned with optimal gas content in certain areas. Gas contents are estimated by traditional geological data of CBM, drill hole, and laboratory test. The coal reservoir permeability is the one of the controlling the CBM gas storage. The CBM reservoir permeability can be identified by coal cleat or fissures and fractures in the coal [2].

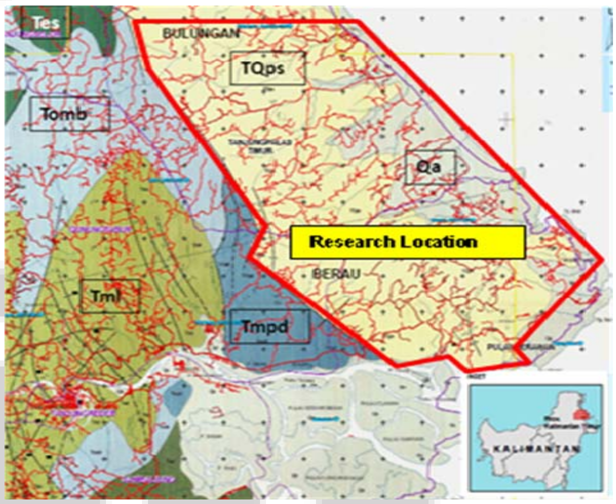

Figure 1: Research location of the Berau Basin in northeast Kalimantan, Indonesia

The shape surface appearance of the earth's or morphology is a reflection of the geological condition underneath. The process that takes place at the surface as a result both of interaction exogenous and endogenous processes [3]. Geological structures are the result of endogenous processes of regional tectonic activity and its presence can be detected at the surface due to the exogenous processes. Lineament is one of the geological structure indications of the activity. Lineament is line on a map that follows a linear trend [4] Lineament would be used as a reference basis for finding the CBM sweet spot in the Berau basin. The remote sensing techniques used to identify the geological structure at the surface of the earth as a benchmark in determining the CBM sweet spot in Berau basin. This resulted in the formation of geological structures in coal fracture permeability. Fracture permeability is related to the density of fractures and cleats in the coal. CBM sweet spot is an area that have a high value of fracture permeability.

Based on the systematically `site measurement of structural geology of coal seam and the remote sensing imagery interpretation of ground linear feature, and ground cracks, the relationship between coal seam fractures and ground cracks could be established, then the sweet spot areas, and these areas may have reflected the higher permeability and be prospective for development CBM.

The remote sensing techniques used to identify the geological structure at the surface of the earth as a bench-mark in determining the CBM sweet spot in Berau basin. This resulted in the formation of geological structures in coal fracture. The aim of the use of remote sensing interpretation to identify the characteristics of higher-producing coal, gas content and fracture permeability; and delineate CBM sweet spot in the Berau Basin.

2. Materials and Methods / Experimental

To uses a combination of remote sensing interpretation based satellite data of suitable resolution, secondary data (geological and other data collected from topographical maps), and field ground validation of structural, stratigraphic and geological information and laboratory analysis of gas content for preparation of various input to identification of CBM sweet spot. Based on all the hybrid joints, cleats and geological lineament data were then created a fracture density map that shows estimated the area of higher permeability areas. Fracture permeability delineation was created by investigation sum of all structure in grid cell area (i.e.,$\sum$ S1 + S2 + S3...). Each unit cell was assigned a nodal value at the cell centre in true geographic coordinates and then interpolated to be contour

By a combination of these techniques ensures that the delineation of prospecting area of CBM can completed within a very short time, as compared to traditional ground based approaches, while maintaining high accuracy levels. The various layers needed for mapping and delineation of CBM sweet spot sites require intelligent interpretation of satellite images, mapping and updating of geology and hydrogeological information (Fig. 2). The remote sensing data is used in the form of a digital elevation model (DEM) Shuttle Radar topographic mission (SRTM) and ASTER DEM. There are differences properties of both data. SRTM DEM has a smoother appearance but cannot see objects more detail because it just have 90 m of resolution while ASTER DEM have more texture and is sometimes still a lot of noise is recorded as high buildings, roads, and this is due to settlement ASTER DEM has a resolution more detail that is 30 m.

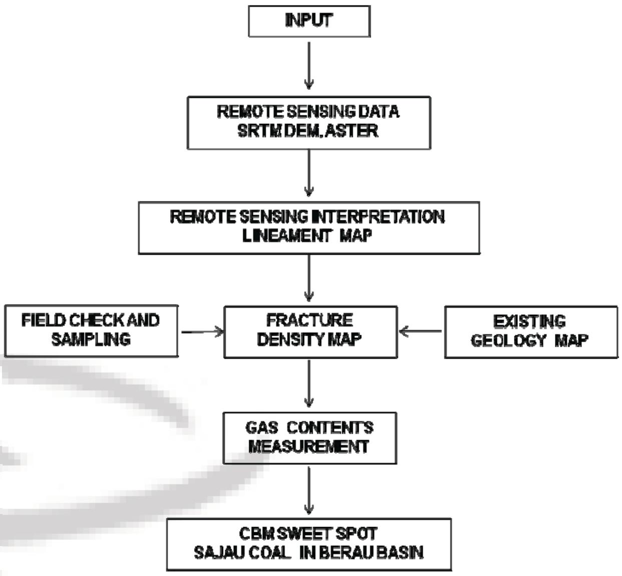

Figure 2: Procedure of remote sensing interpretation for identification CBM Sweet spot

Structural lineaments are defined as —regional linear features caused by the alignment of regional morphological features, such as streams, escarpments, and mountain ranges, and tonal features that in many areas are the surface expression of fractures or fault zones [5] known with anomalies or unusually morphological pattern form which can be shown by the DEM data. This anomaly consists of hills form, valley shape, rivers form, and ridge shape that have a different pattern to surroundings. While lithology can be identified by observing the color and texture of the morphology that appears on DEM data. For the area and geological structures delineation are still in doubt made changes DEM data properties such as changing the blending mode, shader option, altitude (slope irradiation), and azimuth (direction of radiation).

Finally, the result of DEM interpretation then checked by field observations and overlaid by DEM data for comparison. The laboratory analysis of micro fracture, measurement of permeability and gas content measurements were combined with the result of remote sensing interpretation were used to delineation of CBM sweet spot.

3. Results and Discussion

3.1. Structural Lineaments Analysis

The orientation patterns of geologic lineaments in Berau Basin derived from satellite imagery. The analysis of lineament orientations indicates two dominant and orthogonal directions; a mean average azimuth value of N 35º E and a conjugate direction at nearly N 130º E. Average values for preferential lineament directions are shown next to rose diagrams in Figure 3. The size of rose diagrams is proportional to the density of data analyzed on a grid of 20 km radius. Zones of sparse lineament coverage within the study area generally correspond to quaternary deposits, where lineaments are obscured Based on lineaments data the Berau Basin was dominated by NW-SE trending fold and faults with NE-SW trending is minor structures.

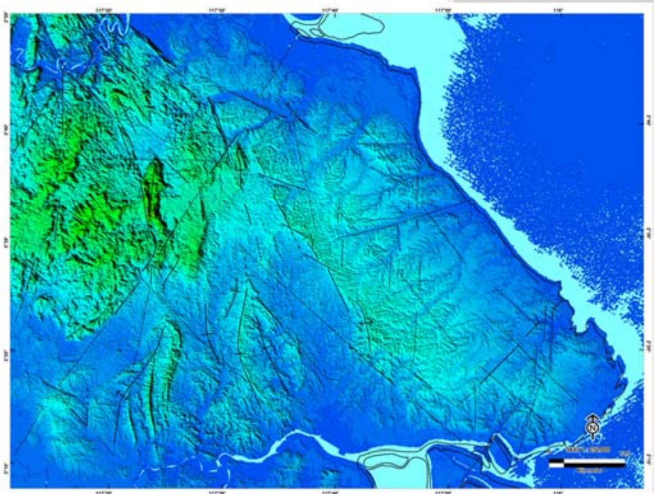

Figure 3: Structural lineament map interpreted from ASTER of Berau Basin

3.2. Fracture permeability delineation

The field work was carried out to verify the results of DEM data interpretation by descriptively fractures measure were founded in the field; the hybrid joint and cleat were measured simultaneously. The data in figure 4 indicate that lineaments tend to be aligned with the orientations of coal cleats and faults. However, there are some areas where the cleats and fractures are offset from the lineaments and these offsets may have resulted from changes in the tectonic regime and related stress vectors over time. Our studies reveal that lineament data from satellite in Berau basin do not agree with present-day maximum stress directions. There also was observable parallelism between face cleats, hybrid joints and the preferential orientation of geologic lineaments (45º - 50º). The associated butt cleats are poorly developed having a direction of N 320º - 350º E.

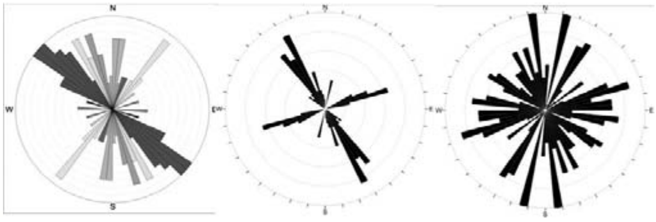

Figure 4: Rossete Diagram of Lineaments (left), Cleat Orientation (middle), and (c) Joint (right)

The fracture density map which constructed from the structural lineaments and field ground data indicated that there are two highly density fracture in the southeastern and central part of the basin (Fig. 5).

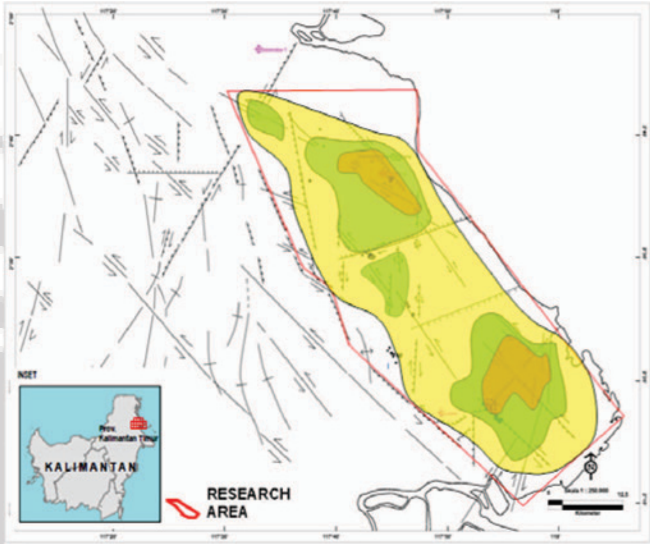

Figure 5: Density fracture map of Berau basin; showing the low density fracture (1 – 3; yellow color), medium density fracture (4-6; green color) and high density fracture (>7; red color)

3.3. CBM Sweet Spot Delineation

The statistical calculation and rose map drawing of geological lineament linear features from ASTER and DEM images in defined stable areas of coal basin together with results of ground fracture investigations on rock joints and cleat measurements, to reconstruct density fracture map. Then, to delineated the coal bearing areas based with concentrated in the areas within a buried depth of coal seam from 300 meter to 700 meter (depth of Sajau coal Formation) based on surface and subsurface geological research. The gas content measurement from gas well exploration complements previously data obtained to determine the CBM Sweet spot area. There are three group identified of CBM sweet spot in relation with the coal permeability (Fig. 6).

ISSN (Online): 2319-7064

4. Conclusion

Digital elevation model data can be used to analyze the geological structure of the area. Geological structure with NW - SE and NE - SW direction which developed in Berau basin are controller the coal permeability for the accumulation and mobilization of CBM. Some areas with a high density of geological structures have correlated with high permeability reservoir. CBM sweet spot were accumulated in areas with high permeability values with related to the fracture density. The research indicated that a remote sensing imagery is a good tool for CBM Sweet spot delineation which are reliable by gas well measurement and field investigation confirmation.

In the future remote sensing method is a method that can be used for CBM exploration because of low cost, does not require a long time and can provide initial accurate and important information for CBM drilling locations.

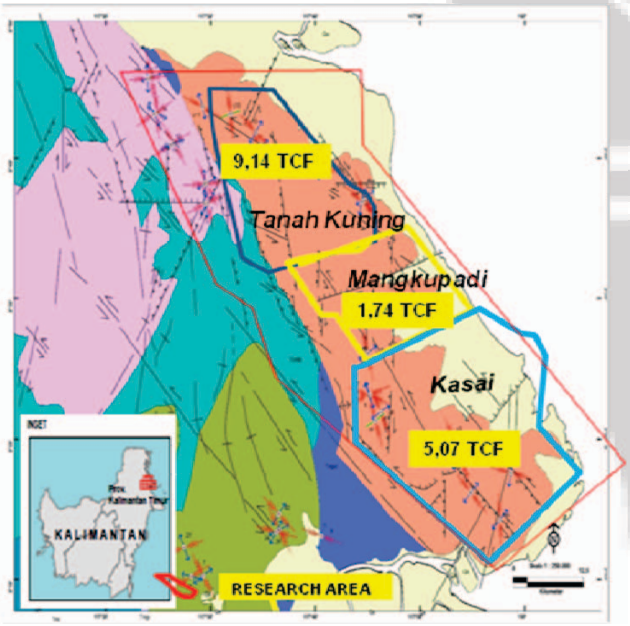

Figure 6: CBM Sweet spot of Sajau coal in Berau basin

References

[1] Delmar Mining , " Exploration of Sajau Coal in Berau Basin", Unpublished Report, 2005
[2] Laubach, S.E., Tremain, C.M., Ayers, W.B.J., 1991. Coal fracture studies: guides for coalbed methane exploration and development; Journal of Coal Quality 10, 81–88.
[3] Van Zuidam, R.A. 1985. Aerial Photo-Interpretation in Terrain analysis and Geomorphology Mapping. Smith Publisher The Hague Netherland. 442h.
[4] Fred J.Anderson, 2009. Lineament Mapping and Analysis in the Northeastern Williston Basin of North Dakota.
[5] Lillesand, T.M., Kiefer, R.W., 1994. Remote sensing and image interpretation, 3rd Ed. John Wiley & Sons, New York. 750 pp.

Author Profile

Ahmad Helman Hamdani, Lector on sedimentolo-gy in Faculty of Geology, University of Padjadjaran since 1980. He interested research in coalbed methane as a renewable energy.

Adjat Sudradjat, A Professor Emeritus in Faculty of Geology University Padjadjaran. He interested research in tectonics, earthquakes and volcanism.

Emi Sukiyah, Lector on geomorphology in Faculty of Geology, University of Padjadjaran since 1980. He interested research in geological hazards as a renewable energy.