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APPLICATION X-RAY CT SCAN TOMOGRAPHY TO IDENTIFYING COAL CLEATS IN TANJUNG FORMATION, PASIR BASIN, SOUTHEAST KALIMANTAN, INDONESIA

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ABSTRACT

The network of natural fractures in the coal referred to as cleat; is one phenomenon that should be examined in the exploration of CBM. The CT scan is a non-destructive technique with wide applications in various geological disciplines as in coal exploration. From the Tanjung coal formation by CT scan techniques can be identified different types of the coal cleat which reflecting the geological processes during coal formation. By study CT scanning tomography from Tanjung Formation coal can be identified three types of natural fractures i.e. face cleats, butt cleats and fracture. The shape of cleats is dominated by a curved line, while the straight line shape was rare. The cleats origin in Tanjung Formation was mainly controlled by tectonic activity which indicated by the dominantly curved shape of cleats in coal samples.

KEYWORDS: X-Ray, CT Scan, Cleat, Tanjung Formation, Coal, Pasir Basin

INTRODUCTION

The development of CT (computed tomography) known starting in 1895 when Wilhelm Conrad Röntgen discovered X-rays (X-rays). Röntgen showed that X-rays are generated when light interacts with the cathode material. Because of its nature is not known, at the time, was given the name 'X-rays'. After this discovery, the science of radiology developed into a sub-specialty in the field of health in the first decade of 1900. The application of CT for the first commercial application in the late 1960s and early 1970s, when Cormack and Hounsfield, who received the Nobel Prize for Medicine in 1979. Furthermore, CT applications developed in science outside of the medical field. 1974 CT scanning for the first time applied to study paleontology [1].

Mechanical CT Scan Computed Tomography is a non-destructive method that can provide structural information on the coal such as cleats, micro fracture, porosity, mineral filler and coal matrix) in 3D. In the 1980s, several studies have been conducted [2, 3] reported the application of CT for evaluation in the field of petrology, coal cleat analysis and reservoir oil. More recently, CT technique has shown good prospects for application in coal petrography and petrophysical study. Several studies on samples of coal [4, 5 and 6] showed satisfactory results in research porosity, differentiating pores, fractures, cleats and minerals from coal matrices. The studies of CT scan in coal are still not enough, especially in natural network of coal cleat. The Tanjung coal formation exposed in Muara Samu and surrounding area, Pasir Basin, Indonesia is interesting to study the distribution pattern of natural fractures in relation to the use of micro bacteria in the enrichment of coal bed methane.

The aim of this study is to demonstrate capabilities of CT scan for nondestructive techniques in the identification of cleats in coal samples of Tanjung Formation from Mouser Coal Mines Areas in Paser Regency, East Kalimantan,

GEOLOGICAL SETTING

The Muser Coal Mines Areas are located in the vicinity of the Paser Regency, East Kalimantan Province (Fig. 1). There are two (2) coal seams in the Muser coal mine are present within the Tanjung Formation of Eocene age. Geologically, the Muser coal mine was situated in Pasir Basin. This basin is one of the Tertiary basin and well known as an area of major resources of oil, gas and coal in western Indonesia. The Pasir Basin is situated along the northwestern margin of the Paternoster Platform Shield in South Kalimantan.

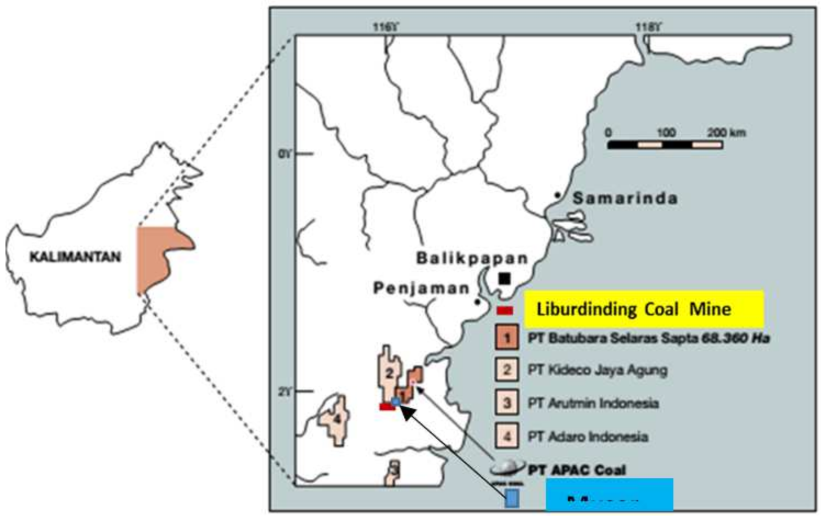

Figure 1: Muser Coal Mine Location, Paser Regency, Southeast Kalimantan

The basin is defined by the Meratus Ophiolitic Complex to the west and separated from the Kutei Basin to the north by a flexure related to the Adang Fault. The basin has a narrow opening to the south towards the Asem-Asem basin. The Barito Basin is an asymmetric basin, forming a fore deep in the eastern part and a platform approaching the Meratus Mountains towards the west (Figure. 2).

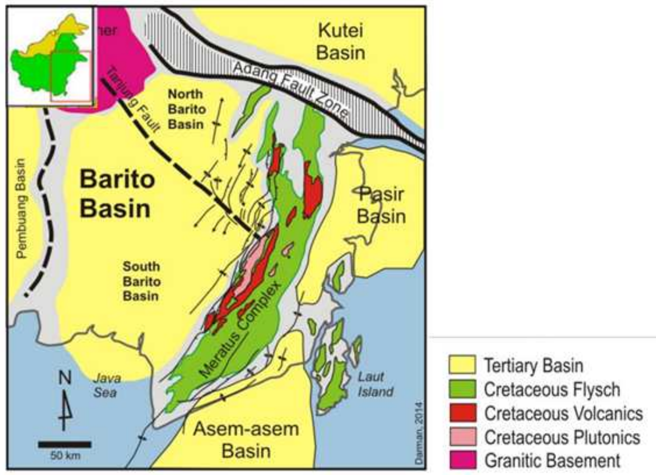

Figure 2: The Basin Map of Kalimantan Island (Darman H., 2014)

The Pasir Basin commenced its development in the Late Cretaceous, following a micro-continental collision between the Paternoster and SW Borneo micro continents. Early Tertiary extensional deformation occurred as a tectonic consequence of that oblique convergence. In Muser areas, the Late Cretaceous uplifted caused displacement of Haruyan Formation which contains of ultrabasic rocks which were then intruded by granite, granodiorite and diorite; a NE-SW horst-graben structural was developed and became accommodation space for lacustrine sediment of the Tanjung and Pamaluan Formations. The Pasir Basin is underlain by Jurassic Cretaceous ultrabasic rocks and the Jurassic Pitap

Formation. These are overlain by the Tanjung, Berai, Pamaluan, and covered by Quaternary alluvium. Research indicates that coal is formed mainly in the Tanjung, Pamaluan Formations within the basins. A generalized stratigraphic column is shown in Figure 3.

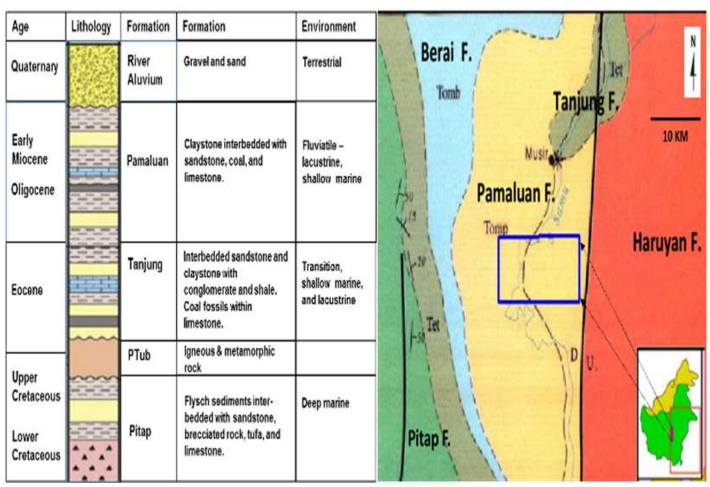

Figure 3: Geological Map and General Stratigraphic Column in Muser and Surrounding Area

CLEATS

Systematic fractures in the coal referred to as cleat, which is a pair of tensional fractures intersecting orthogonally and are often found in coal seams and has an important role to control the permeability and accumulation. Cleats broadly can be defined as a linear discontinuities structure that develops in coal with the form of orthogonal and intersect perpendicular to each other; as a result of physical and chemical changes during the process of coal formation. There are two types of cleats: face cleats is often found in coal seams and butt cleat (Figure 4). The face cleat representing more dominant and perpendicular to bedding rock. Instead butt cleat less developed, perpendicular to bedding rock, and oriented almost 90º to face cleat [7, 8].

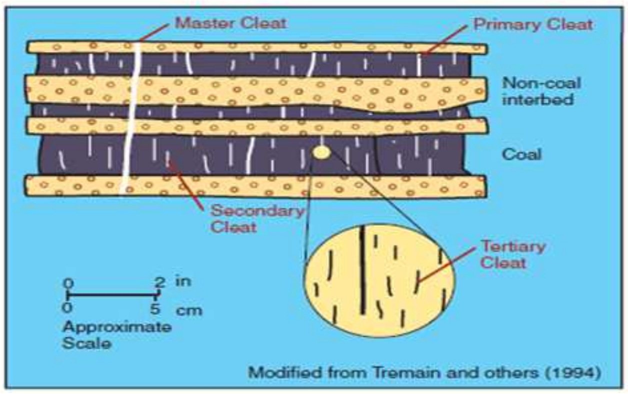

Figure 4: Cleats Network in Coal (L Laubach Et Al., 1998)

METHODOLOGY

Experimental

The X-ray attenuation coefficient data over the plane were stored in slice. The X-ray attenuation is mapped in Hounsfield units, and converted to CT numbers, in each voxel of a CT image of the object; where:

$$CT_{number} = \left(\frac{\mu c - \mu w}{\mu c}\right) \times 1000$$

μ_c is the calculated X-ray attenuation coefficient

μ_w is the attenuation of water.

In this study we used a water phantom for CT number calibration, the CT number is 0 for water (1 gr/cc) and -1000 for air [9, 10].

The CT scans were performed on Brightspeed Type equipment manufactured by GE Corporation of USA. The X-ray source is a 225 kV Fein Focus focal spot, which allows for resolution down to 10 µm for an object of 4.8 mm. The detector system is a Toshiba 3D image intensifier from which data are captured and digitized by a CCD digital camera with a spatial resolution of 4.4 lp/mm.

An X-ray source and detector array rotate about the axis of the object in a single plane. The cylindrical core sample was placed perpendicular to the sample couch (orientated in slice plane) and was aligned in the center of the scanner's field of view (Figure 5). A series of scanning is performed several times (slice). Each sample per meter sample was done scanning with a spacing of 3 mm; so that for each sample as long as 30 cm to scanning of 100 (one hundred) slice (Figure 2)

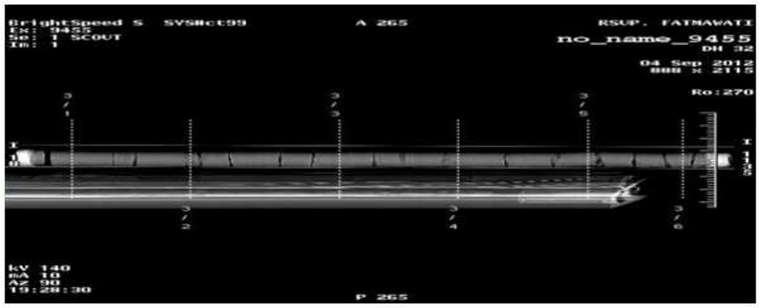

Figure 5: The Process of a Series of Scans to be Performed on a Coal Core Sample

Identification of Cleats

The CT scan technique provides quantitative images showing density and atomic number variation, and from that, cleat development in coal can be easily identified. CT scan produces a series of 2D images called "slices" that will be generated from scanning with the azimuth angle of 0^0 and 90^0, this is due to the image that will be in line with what would be seen if the object is sliced along the plane of the scan. Each slice will record all the X-ray attenuation coefficients along the plane of the scan. Data is converted to CT number attenuation range specified by the computer system. Generally, CT number listed as values of gray on gray image. A series of CT calibration were used to maximize the signal-to-noise ratio and minimize or eliminate imaging artifacts that might affect interpretation

In this study, the gray image is analyzed by Mimics™ software, Gray values are transformed into CTnumber with Hounsfield units (HU). Theoretically, for the X-ray energy is given to the object, CT number is a function of the density and effective atomic number of the object under investigation [6, 11]. Because there are differences in density between the components contained in the coal namely: the matrix (organic components), porous (form pores or fractures / cleats), mineral (inorganic filler material cracks or pores); thus the components in the coal can be identified with their respective numbers CT number [6, 11].

In general, the coal consists of three basic components, namely pores, the matrix of coal, and minerals. Due to the three components generally have a certain range of CT number, then these components can be measured with a threshold value method or segmentation.

RESULTS

CT Numbers of Coals

The present work have been calculated CT numbers for 400 scanned slices of four coal core samples (Table. 1)**.**

Table 1: CT Number of Coal Samples

No	CT Number (HU)		
	Minimum	Maximum	Average
TNJ-1	855	1126	989
TNJ-2	1189	1652	1306
TNJ-3	980	1392	1128
TNJ-4	1002	1561	1400

The coal of TNJ-1 has a low CT number comparing the other coal samples; it is indicated that in the TNJ-1 poor-developed cleats. However, the CT number not only depends on abundance of cleats or fracture, but was also influence by coal density, coal maceral composition, and amount of minerals within pore or cleats.

Cleat Type

From CT image, prominent cleats (face and butt) networks were identified on whole cores from well which can be seen in Figure 6. The CT slice show the small of face cleats (butt cleats is rare) developments in TNJ-1 and TNJ-4 with they show the intersection of simple face cleat and butt cleat' the shape of cleats are straight line and curve softly line. Other sample (TNJ-2 and TNJ-3) show that the cleats were well developed; and the shape is dominated by curved line. The shape of cleat is related with the geological processes during the formation of cleats. Increasing the intensity of tectonic deformation in the coal leads to brittle deformation, will change the cleats formed earlier intensively thus causing the cleats curved shape (curvature shape) or secondary cleat formed which is concentrated around the main cleat. Beside the cleats; the fracture with the irregular shape was identified in the core samples.

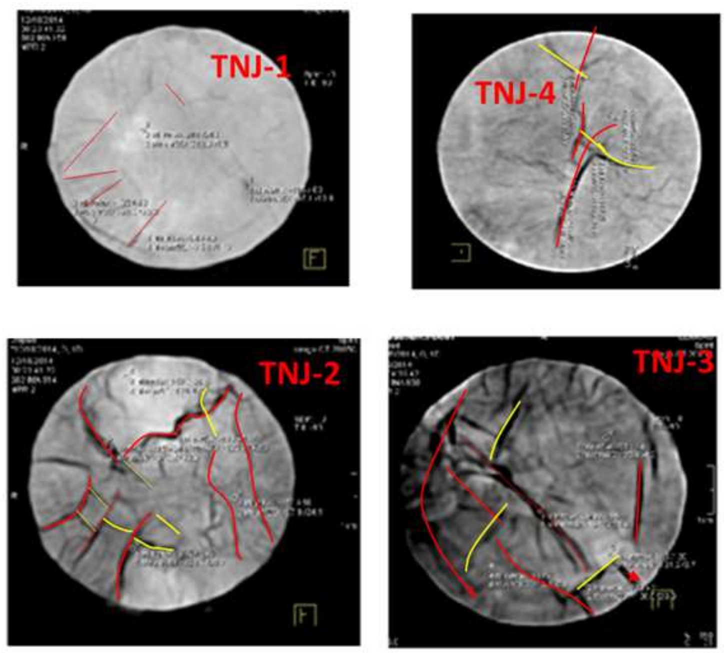

Figure 6: Representative CT Slice of Coal Samples (Red Line = Face Cleats, Yellow Line = Butt Cleat)

Cleats Origin

There three possibility to interpretation their genesis i.e. endogenic, exogenic and duogenic [10, 11]. The endogenic cleat type was formed by differential and vertical compaction during coalification processes with the relation of squeezing out of moisture organic matter due to diagenetic fluid mechanism with triggered by temperature and compaction of coal. The excogenic cleats type are related with the tectonic activity after the coal completely formed. They can be identified has similarity with the pattern of structural trends. The duogenic cleats type were formed by combining endogenic and exogenic which are related with saturation of fluid, overburden compaction and tectonic stress.

By the CT scan techniques of coal samples should be identified that there is a possibility of an endogenous process (matrix swelling) and exogenous (tectonic) are working together in the presence of distributing coal cleats. The structural deformation in the study area consists of cataclastic deformation; which is relatively weak tectonic has been found in coal from TNJ-1, TNJ-3.; while the type of stronger tectonic deformation type; such as brittle deformation and wrinkle deformation was occurred relatively near the core zone fault structure as seen in TNJ-1 and TNJ-4.

The endogenic cleats as a result of the swelling matrix, fracture dilatation and compacting that occurs in coal cause a reduction in the volume of water; it will form a cleat with a thin line shape that looks intersection between the face cleat and butt cleat were shown in Figure TNJ-1 and TNJ-4. With the increasing intensity of the tectonic deformation in the coal cleat formed will form early intensive will change its shape can cause the curved cleat (curvature shape) or secondary cleats formed concentrated around the main cleats as seen in TNJ-2 and TNJ-4 and is referred to as brittle deformation. The major N- S direction of normal fault in the vicinity of coal location were (Figure 3) were influence the development of coal cleats of Tanjung Formation in Muser Area.

CONCLUSIONS

By study of CT scan technique a straight line and curve line shape of cleat were identified in Tanjung coal formation Type types of natural fractures i.e. face cleats, butt cleat and fracture are found in the coal samples.

The domination cleat networks have been identified in coal seams at TNJ-2 and TNJ-3 comparing the coal sample of TNJ-1and TNJ-2, indicated their cleats were origin related the intensity of tectonic deformation.

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