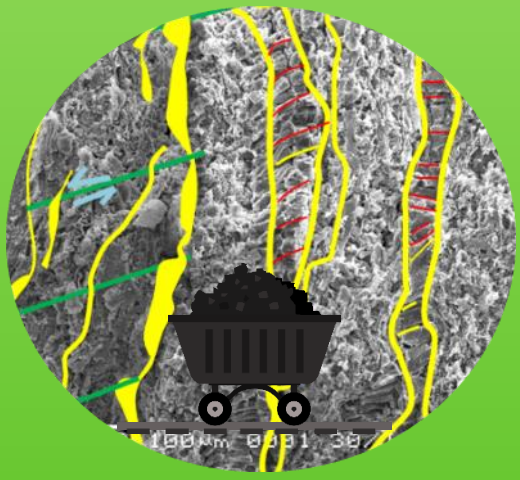
Dr. Drs. H. Ahmad Helman Hamdani.

SAJAU
LOW RANK COAL
Its Geology and Genesis



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NORTHEAST KALIMANTAN
INDONESIA

PT. Geokonsultan Solusindo

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PREFACE

The work of geological study of the Sajau low rank coal lignite to sub-bituminous is presented and discussed in this book started in 2005. It was initiated by author during coal exploration geology in IUP PT. Patriot Wira-perkasa in Berau Basin, Northeast Kalimantan. The ex-ploration activities consist of field observations, geo-logical mapping and coal outcrop observations, tracking continuity of coal outcrops, well construction, trenching, drilling shallow up to 60 meters, sampling, coal quality analysis and calculation of the existing coal reserves. The exploration results indicate the coal bearing for-mation in the area of investigation is the Pliocene to Pleistocene Sajau Formation with extensive distribution both laterally or vertically. In 2009-2010, the author began a geoelectric survey; with the aim is the mapping of coal distribution beneath the surface in the Kasai region, Mangkupadi and Tanah Kuning. The geoelectric results conducted to determine the location of the drilling to be done. Since 2011 the authors began an intensive study of the coal formation Sajau related with doctoral

programs being undertaken at the University of Padjadjaran. I thank to our student Mr. Lucky, Mr. Fikri whose assistance during structural geology mapping in this area.We appreciate the great help of Mr. Alit (Laboratory of coalbed methane, Lemigas), who did this work with great patience and accuracy for 3D CT scan tomography of coal samples; to identify the cleats characteristics and cleat mineralization. In 2012, at that time, started to study the organic geochemistry of the Sajau coal in Corelab and BSI Lab; thanks to Mr. Djatmiko; who helps this research; also thanks to Elmo Sagita, Khalda Az Zahra, all my student who assistance our research in organic geochemistry analysis in BSI and LIPI. Thereafter, interval samples were taken considering the lithotype variability and semi-quantitative palynological and micro-petrographical studies of the coal. One of the main results was the discovery that coal can be clearly separated into several geochemically, palynologically and petrographically, each of them being a result of specific peat-forming environments and subsequent diagenetic processes.

The author thank also Prof. Dr. Ir. Hendarmawan, MSc, Dean of the Faculty of Geology, University Padjadjaran, for all the encouragement and enthusiasm that this book can be completed. Also thanks to Prof. Dr. Ir. Adjat Sudradjat MSc, Dr. Ir. Edi Sunardi, MSc; Dr. Ir. Agus Guntoro, MSc and Dr. Ir. Yoga Adriana MSc; for their great personal and professional help during this research until completion of this research. Thanks to Mr. Rasus B, FIB UNPAD for english gramatical editing. Finally, I am especially thankful to our families, dear wives and children for their support and encou-regment during the preparation this book.

Finally, The book describes how the importance of integrated studies in studying the geology and genesis of low rank coal in Berau Basin; which include geological mapping petrography, Geochemistry, coal sequence stratigraphy and CT Scan Tomography. Thus will give good results and accurately where each method can serve as a check and recheck during this research.

Jatinangor, 2014

Ahmad Helman Hamdani

ABSTRACT

The Berau basin which is located in East Kalimantan is one of the major coal basin in Indonesia are among of the sedimentary basin rich-coalbed methane with complicated geological structure conditions. The low rank Sajau coal formation is predominantly composed by lignite to sub bituminous C coal with a mean huminite reflectance of 0,32% indicated in the immature stage and have a thickness from 0,90 – 38 m.

The main topics of this book are the tectonics, coal sequence stratigraphy, coal petrographic and organic, inorganic geochemical characterization of the low rank coal of Sajau Formation. To obtain optimal results in studies have been carried out various measurements both in the field and in the laboratory with various scales of molecular research (GC and GC-MS), micro (reflected-light microscopy and scanning electron microscopy/ SEM), meso (CT Scan Tomography) to macro levels.

The stratigraphy succession in Berau Basin from the old to the young, such as ; Sembakung Formation, Tabalar Formation, Birang Formation, Latih Formation, Labanan Formation , Domaring Formation , and Sajau Formation. The Sajau formation consist of recurring intervals of sand, silt-, and mudstones with coals The Sajau low rank coal seam was rested on the top of regional unconformity in Early Pliocene sediments and formed in the graben and/or pull-apart basin. This basin type is characterized by very high subsidence rates, which control basin architecture and peat forming

environments. The first stages of sedimentation of Sajau formation in Berau basin by filled with fluvial sediments. Because subsidence exceeded sediment input, the fluvial environment was replaced by a deltaic environment. The Sajau coal seam formed during the transition from the fluvial to the deltaic environment. The formations show four facies: braided river, meandering, and lower delta plain and upper delta plain. These facies are grouped to form three facies associations braided river, fluvial and delta based on vertical and lateral facies relationships. These facies and their associated environments to reflected the shifted landward and basinward as a response to base level changes resulting in a complex, but well-defined cyclic architecture within the Sajau Formation. The recurring architecture reveals a distinct deepening trend represented by successively more preferences marine sedimentation towards the top (fining upward). The high ash content in lower part of the Sajau coal seam (Seam A, B, and C) indicated there were a strong influenced by fluvial processes, while in the low-ash coal seam (coal seam K, L, M) in the upper part has been mainly influenced by deltaic processes. The strong influenced of fluvial processes in lower part was also confirmed by the abundance of xylitic coal (XC) with a conifer trees in the lower part comparing in the upper part which dominated by detro-xylitic coal (DXC) rich in bush and reed vegetation.

The macro organic petrography was studied from geological mapping of Sajau coals in the outcrops and borehole cores. The “10 % rule” is the quantitative rules was used by most scientist and also recommended by the ICCP (1993) in determining the low rank coal lithotypes;

xylitic coal (forest swamp) facies characteristic for the lower part of the coal seam, to fine detrital (detro-xylitic coal) in upper part which has open-water surfaces with dwarf plant vegetation or fen facies predominating in the inner and the upper part of the seam. The xylitic coal is forming in a dry forest mire, whereas the detrital coal is forming in wetter swamp with herbaceous vegetation in the central and northern part of the basin.

Based on the maceral assemblage, especially the huminite and mineral matter content, the Sajau Coal succession should be grouped into three coal facies i.e. (I) high humocolinite (more than 40%), categorized as limno-telmatic type, formed in the lower delta plain in wet conditions, with the herbaceous plant was a source of peat. (II) moderately humocolinite (20% - 40%) formed in the upper delta plain in the wet to dry condition is the most probable environment of this coal facies and wood was a major contributor of the peat; and (III) low humocolinite (less than 20%) was formed in fluviatile dominated influence environment with the conifer is a major source of peat**.**

The organic geochemistry study of the low rank Sajau coals by the absence of saturated sesquiterpenoid and diterpenoid (pimarane, abietane, and phyllocladane - type diterpenoids of the C_{19} to C_{20} range); it is may likely result from the low maturity of organic matter and the dominance of an anoxic environment, where dehydro-genated and aromatic terpenoids (can be easily transfor-med and preserved through microbial activities.

The predominance of hopanoid and non hopanoid terpenoid biomarkers, such as oleanane, lupane and ursane-type triterpenoids, indicate the predominance of

angiosperm plants in the Sajau palaeomire, particularly Dipterocarpaceae. The low presence of aromatic sesquiterpenoid of cadelene-type (cadina triene, cadina tetraene) and A-ring opened isohexyl alkylaromatic; were confirmation that the gymnosperm/conifer trees should be possible contributor the organic material to the Sajau coals. The presence of such combustion-derived PAHs may reflect the burning of vegetation prior to deposition. The inorganic geochemical analysis of Sajau coal was performed throughout the DH-102 well profile. It was found that inorganic matter of the coal is characterized by the following composition: SiO_2 (33.84–42.13%), Al_2O_3 (13.60–22.68%), Fe_2O_3 (18.10–38.82%), MgO (3.10-8.82%) and CaO (1.02–7.02%). The SiO_2+ Al_2O_3 is increasing upward and following by the decreasing Fe_2O_3 and CaO. The kaolinite is a predominance clay mineral type in Sajau coals which indicated from strong correlation between SiO2 and Al2O3 (r = 0.92).

The Pliocene lignite-sub-bituminous seams are characterized by the presence of natural discontinuities, so-called cleats. Most often they are opening-mode fractures, consisting of two orthogonal sets (face and butt), both almost perpendicular to the bedding. This paper determines distributions of cleat orientation, spacing, and aperture from the Sajau lignite seams. All observations and measurements were conducted at macroscopic, mesoscopic and microscopic scale. The butt cleats mean orientations are NE–SW, NW-SE; whereas mean orientation of face cleats NNE-SSW and NE–SE, dipping at a high angle N75°. The angle between strikes of cleat sets is nearly 90°. The spacing of macro face cleats is from 9.52 to 14.46 cm (averaging 11.61 cm) and

the spacing of butt cleats is from 2.3 to 11.3 cm (averaging 5.35 cm), and the aperture has a mean 0, 54 cm On the other hand, the mean spacing of microcleats 1.58 mm and aperture measurements of these cleats range from 0.021 to 0.029 mm (averaging 0.026 mm), respecttively. The obtained results from outcrop and micro CT Scan Tomography clearly indicate that face cleat orientations NNE–SSW are strictly parallel to the elongation of the main tectonic structures in the study area. Their origin may be explained in at least there was relationship with local tectonic (the maximum principal stress, σ1, was horizontal). The Partial Least Square analysis, of cleat and faults data in this area indicate that a power-law distribution exists between cleats characteristics (spacing, density and aperture) with the distance of faults (R2 = 0.56). The cleat formation in Sajau Formation was mainly controlled by mechanical in response to tectonic. Based on SEM photography; the origin of cleats in Sajau Formation area endogenic process and tectonic activity which indicated by change the shape of the cleats; from the straight line cleats to curved shape and branching.

Keyword: Berau basin, Sajau Coal, Low rank coal, geologi, genesis.

CONTENTS

INTRODUCTION

1.1. Research Background

Energy is a fundamental driver of economic development and contributor to people's quality of life and poverty alleviation. Although the choice of energy resources has diversified to sources of clean energy and renewable; such as solar power, waves energy, and geothermal; fossil fuels are still the world's main source of energy supply, as well as in Indonesia. Coal is one of the sources of energy that have played an important role for decades, not only can be used as an energy such as electricity generation, fuel processing steel industry, cement or materials, but also can be gasified to ethanol, methanol.

The type of coal, should be reflection in increasing order of alteration, are lignite (brown coal immature), sub-bituminous, bituminous, and anthracite

About the Author

Dr. Drs. H. Ahmad Helman Hamdani MSi born in Bandung, August 28, 1955. He earned an undergraduate degree from the Dept. of Geology, Faculty of Mathematics and Natural. Science (MIPA) Universitas Padjadjaran.

Earned a Master of Science in Chemistry at the Department of Chemistry, Faculty of Mathematics and Natural Science, University of Indonesia. A doctorate degree in Technique of Geology has obtained from Universitas Padjadjaran .

Has written extensively on the coal of various aspects of sedimentology, organic geochemistry, organic petrography; published in various scientific journals in Indonesia or overseas.

Participated in various seminars and a speaker at various scientific meetings, mainly to discuss the study of low rank coal. Either theoretically or in industrial utilizations.

Since 1980 until now teaching at the Faculty of Engineering Geology, Universitas Padjadjaran, Bandung; course taught are sedimentology, coal geology, petroleum geochemistry.

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