Outline Of Tertiary Coal Basins Of Indonesia

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Abstract

Based on crustal composition and plate tectonics the Indonesian Archipelago can subdivided into three distinct tectonic regions, namely: Western Indonesia, Central Indonesia, and Eastern Indonesia. Western Indonesia consists of the Sunda shelf belonging to the Asian continent and its associated active margin continental island arcs and passive margins as well as intra-continental tectonic features, such as sutures. Central Indonesia consists of an assortment of sliding and colliding continental fragments or micro-continents, mainly detached from the Australian continent' amids oceanic platelets of various ages and associated volcanic island arcs. Eastern Indonesia consists of the Arafura Shelf belonging to the Australian continent and its associated continental margin features.

Previously Tertiary coal deposits in Western Indonesia were classified as Paleogene and Neogene coals. Recent knowledge indicates that Tertiary coal was deposited during three distinct tectonic episodes: 1) Syn-rift depositional phase (Eocene-Oligocene), 2) Post-rift transgression phase (Late Eocene to Early Miocene), and 3) Syn-orogenic regressive phase (Mid-Miocene to Plio-Pleistocene). These episodes do not occur at the same time throughout western Indonesia, but varies from basin to basin.

Syn-rift coal was deposited in active rift basin and associated valley-fill sediments in fluviatile to lacustrine environment. Coal deposited in this environment tends to be lencticular and limited areal extent, with high calorific values (~7000 Kcal/kg), low moisture content and low sulphur content. This type of coal is represented by Sawahlunto Formation in Ombilin basin, Central Sumatra.

Post-rift transgressive coal was deposited on a stable shell environment, during a tectonic quiesence in Late Eocene to Early Miocene time. Examples of this coal is given from Central Sumatra basin (Early Miocene), and especially represented by Senakin coal in the Eocene Lower Tanjung Formation in the Barito basin and in the Pasir-Asem-asem basin. Coal seams deposited in this environment tends to be thin but laterally continuous and persistent, with high calorific values, variable to high sulphur content.

Syn-orogenic regressive coal deposition took place in mid-Miocene to Plio-pleistocene time in response to uplifts adjacent to various types of basins in which the coal was deposited. In Java and Sumatra these are the back-arc and fore-arc basins, as the result of the Indian oceanic plate subduction beneath the Asian continent forming an island arc environment. Coal was deposited in a prograding deltaic sequence both in the fore-arc (Bengkulu basin) and back-arc basin South Sumatra or Palembang basin in response to the uplift of the magmatic arc. In Southeast Kalimantan syn-orogenic coal was deposited in the regressive sequence of the Miocene Warukin Formation (Warukin Coal) in response to uplift of the Meratus Range suture on the related adjacent Barito and Asem-asem/ Pasir basins. In East Kalimantan syn-orogenic coal was deposited in prograding deltas developed at the passive margin associated with the opening of Makassar Strait (Lower Kutei and Tarakan basins), and regression took place in response to the uplift of the Kuching zone toward the west. An example of this syn-orogenic coal is the Pinang coal in the Balikpapan Formation. Coal in the syn-orogenic regressive phase tends to develop thick but variable seams, rather low calorific values (~5000 kcal/kg), high moisture content, and low sulphur content.

In Central Indonesia region, only SW Sulawesi, a continetal fragment belonging to the Sunda shelf, shows significant coal deposits. Syn-rift, post-rift transgressive and syn-orogenic coal can be distinguished, such as the syn-rift coal at Tondongkura.

Eastern Indonesia is dominated by the island of Irian Jaya/ Papua, which shows the same tectono-stratigraphic development as on the Australian mainland. The Tertiary sequence is mainly developed as carbonates. Clastics were deposited in only in Plio-pleistocen time in response to uplifts related to collision of the Australian continent with island arcs systems, and to lateral displacement of continental fragments. Lignites are known in the resulting syn-orogenic basins, such as the foreland basins of the Central Irian Jaya Mts range (Akimeugah and Iwur basins), the Meervlakte or Mamberamo basin in North Irian Jaya, the Bintuni basin associated with the Lengguru foldbelt, and the Salawati basin related to wrenching of the Sorong Fault. However, significant coal occurrences are known in Bintuni basin, which at present is still an enigma.

Introduction

The purpose of this paper is to outline the occurrence of coal deposits in Indonesia within the tectono-stratigraphic framework of Tertiary sedimentary basins. The study is a compilation of data on stratigraphy, tectonics and occurrences of coal deposits using mainly available literature sources.

Coal deposits are found in a sedimentary basin but not all sedimentary basins contains coal deposits, only basins where sediments are exposed to exposure above sea-level are capable of forming coal. Previously coal deposits of Indonesia are classified as Paleogene and Neogene (Koesoemadinata & Hardjono, 1976), following van Bemmelen (1949). A classification involving tectonics of basin evolution would greatly enhance the understanding of coal occurrences in the sedimentary basins of the Indonesian Archipelago from quantity as well as quality point of view.

It is well known that the main coal deposits of Indonesia are of Tertiary age, although Paleozoic coal occurrences are known in Irian Jaya and Sumatra

Geotectonic Framework Of Tertiary Basins

It is well recognized that the Indonesian Archipelago is the results of the convergence of the three major tectonic plates of the world; the Euro-Asian Continental Plate in the Northwest, the Pacific Oceanic Plate in the Northeast and the Indian-Australian Tectonic Plate in the south. As the result of this convergence, the Indonesian archipelago can be subdivided as follows (Figure 1):

1) Western Indonesia: Asian Continent represented by the Sunda Shelf (Sunda Shield)

2) Central Indonesia: Micro-continent from Australia and Asia (an assortment of continental fragment)

3) Eastern Indonesia: Australian Continent represented by the Arafura Shelf

It is within these crustal setting that Tertiary sedimentary basins developed, related to continental plate margins or continental sutures. Coal deposits are generally found in basins on continental crust. These continental margins are as follows:

1) Active Margins - which is related to the subduction of the oceanic crust beneath the

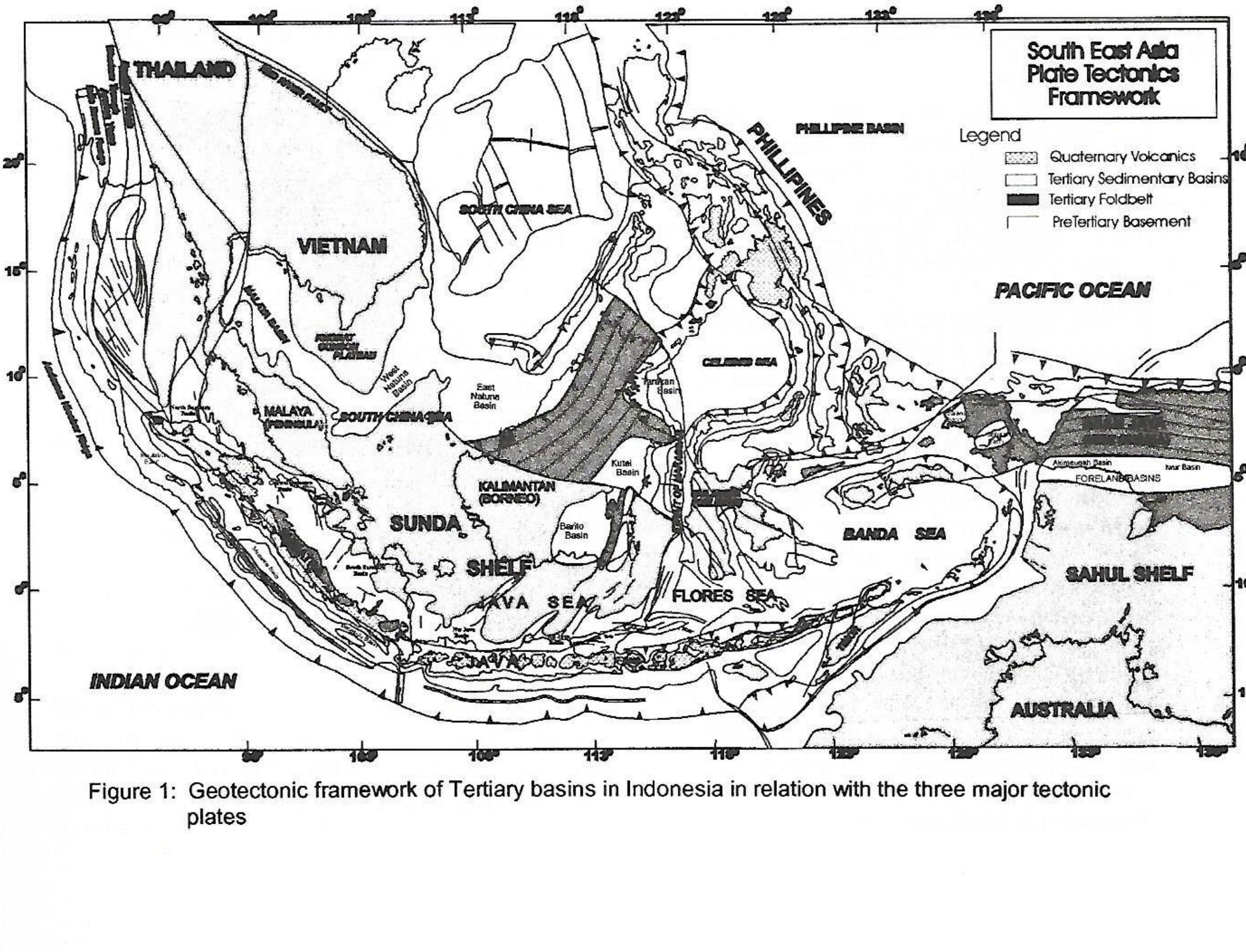

Figure 1: Geotectonic framework of Tertiary basins in Indonesia in relation with the three major tectonic plates

continental crust, such as the Indian Oceanic crust beneath the Asian continental crust, represented by the Sunda trench and western Indonesia continental island arc, which developed into an oceanic island arc (Nusatenggara Barat) , and a subducted continental crust beneath an oceanic crust (Banda Arc). Considered as active margins are also the major wrench faults separating continental crusts from oceanic crusts such as the Sorong Fault zone north of Irian Jaya.

2) Passive Margins - which are related to rifting and opening of an oceanic crust, such as the Makassar Strait between the island of Borneo (Kalimantan) and Sulawesi (Celebes) and the Natuna basins in the South China Sea

In addition, there are also intra-continental features: 1) Collision Sutures, such as the Barito Basin and the Asem-asem Pasir basinal areas at either side of the Meratus Range in Southern Kalimantan, and 2) Continental Rift-valleys which is exclusively known in the Paleogene development of the Western Indonesia Landmass.

Western Indonesia

Tectonic Development of Tertiary Sedimentary Basins

The Pre-Tertiary basement of the Sunda shelf is a highly tectonized terrain. Its origin has been interpreted as the result of collage tectonics; the collision of at least three micro-continents (Stauffer, 1974, Hutchinson, 1984, 1986, Pulunggono & Cameron, 1989, Bransden & Matthews, 1992)

1) The Malaya-Borneo Sunda nucleus; a protuberance of the Asian continent as the result of an extrusion tectonics due to the collision of the Indian subcontinent and the main Asian continent (Taponiere et al, 1982)

2) The Mergui Micro-continent; probably a break-away from the Gondwana continent, which collided with the Malaya-Borneo nucleus in Triassic-Jurassic time Pulunggono & Cameron, 1989)

3) The East Sunda-Paternoster Micro-continent, probably also a breakaway from the Australian continent, which collided with the Malaya-Borneo nucleus (main Sundaland) at the end of the Mesozoic (Bransden & Matthews, 1992).

The Sundaland became a cohesive landmass at the end of Mesozoic time, and before 50 my ago. The sutures of these collisions are influential to the Tertiary tectonic development of the Tertiary basins at the continental crust perimeter.

Based on stratigraphy and tectonic framework of the Tertiary sediments and coal deposits in Western Indonesia can be grouped into: Paleogene (Paleocene, Eocene and Oligocene) and Neogene (Miocene and Pliocene). It was thought that the Tertiary consists of a megacycle of sedimentation consisting of a transgressive phase (Paleogene Coal) and a regressive phase (Neogene Coal)

Recent knowledge from petroleum exploration activities indicates that the following events took place on the continental Sundaland during the Tertiary (Sudarmono, et al, 1997):

1) Regional rifting took place in Paleogene time resulting into syn-rift deposition and associated rift-valley fill in graben and half-grabens usually followed by an inversion. Paleogene subduction took place only in certain parts of the continental margin (SW Java and NW Borneo). This regional rifting is probably associated with the wrench-faulting along the continental margin (pull-apart and tensional rifting) or continental rotation of the Sundaland, and was terminated by an inversion and subsequent erosion

2) Regional subsidence followed by uplift during the Neogene time. Regional subsidence (often referred to as "sag") followed by a marine transgression resulted into broad shelf seas culminating in carbonate deposition. The uplift was related to a general subduction of the Indian Oceanic crust beneath the Sundaland (Sumatra-Java) or related to a previous micro-continental collision (SE Kalimantan), and resulted in the formation of back-arc and fore-arc basins, or foreland basin. At the same time rifting and opening up of the Makassar Straits continued resulting into a passive margin basinal setting (East Kalimantan)

Rift-valley basins with syn-rift deposition were observed for the first time in a seismic section in Central Sumatra basin (Mertosono and Nayoan, 1974), later also identified in other basins in western Indonesia, including Kalimantan and the Natuna area .

Inversions have been well documented in Central Sumatra (Eubank and Makki, 1981 Eastern Java Sea (Letouzy et al, 1990) and Natuna basinal area (Ginger, et al,. 1993). Presently inversions are generally recognized in all Tertiary Basins of western Indonesia.

Tectonic Classification of Tertiary Coal Basins

It has been pointed that during the Tertiary two phases of tectonic development took place resulting into an earlier basin system (conveniently called Paleogene basins), which is superimposed by a later basin system(conveniently will be called Neogene basins). As it has been pointed out by Sudarmono et al (1997), the early Tertiary system took place from the Eocene to Oligocene (which is Paleogene), but the later developed basin system started as early as Late Oligocene in the eastern part of western Indonesia, so that the term Neogene basin is not entirely correct

1) Paleogene Basins: Two types of Paleogene basins have been recognised in Western Indonesia: Rift-valley basins with syn-rift fill and Fore-arc/inter-arc basin

2) Neogene Basins: The following Neogene basins can be recognised: a) Active Margin Fore-arc and Back-arc basins of Sumatra, Back-arc basins of Jawa , b). Passive Margin: Delta basins and Carbonate Platform of East Kalimantan, and c) Suture Related basins (Meratus Range), Barito and Asem-asem/Pasir basin.

Classification and the names of these basin are illustrated in Figure 2.

Tectono-Stratigraphy Of Tertiary Coal Deposits

In a previous publication (Koesoemadinata, et al, 1978), the author classified coal deposits in the transgressive phase of the early stage of the Neogene basin development which is Oligocene-Miocene also as Paleogene Coal. However, in view of recent knowledge it is more appropriate utilize tectono-stratigraphic setting.

From tectono-stratigraphic point of view the following depositional episodes can be recognized: 1) Syn-rift and Associated Rift-valley Fill Deposition (Eocene-Oligocene), 2) 'Post-rift' Transgressive Phase Deposition (Oligocene-Early Miocene), and 3) Syn-orogenic Regressive Phase Deposition (see Figure 3)

The term syn-rift deposition is limited to deposition of the rift-valley basin during active rifting (initial and climactic phase of Posser, 1993, syn-rift of Lambiase, 1990, Lambiase & Morley, 1999) while subsequent filling of the rift-valley basin is referred to as post-rift deposition. Lambiase (1990) shows in his diagram that fluviatile deposition took place at the end of syn-rift fill as well as in the subsequent post-rift fill of the rift-valley. This is presumably what is referred to as Early Post-rift and Late Post-rift deposition

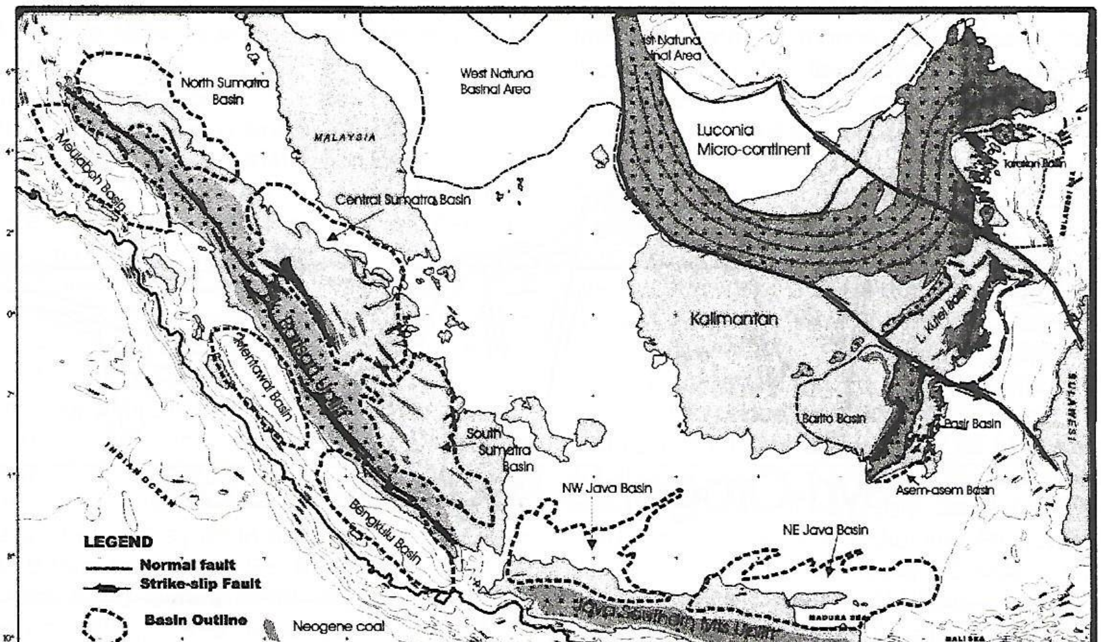

Figure 2: Neogene sedimentary basins in Western Indonesia. Note as well the distribution of both Paleogene and Neogene coals.

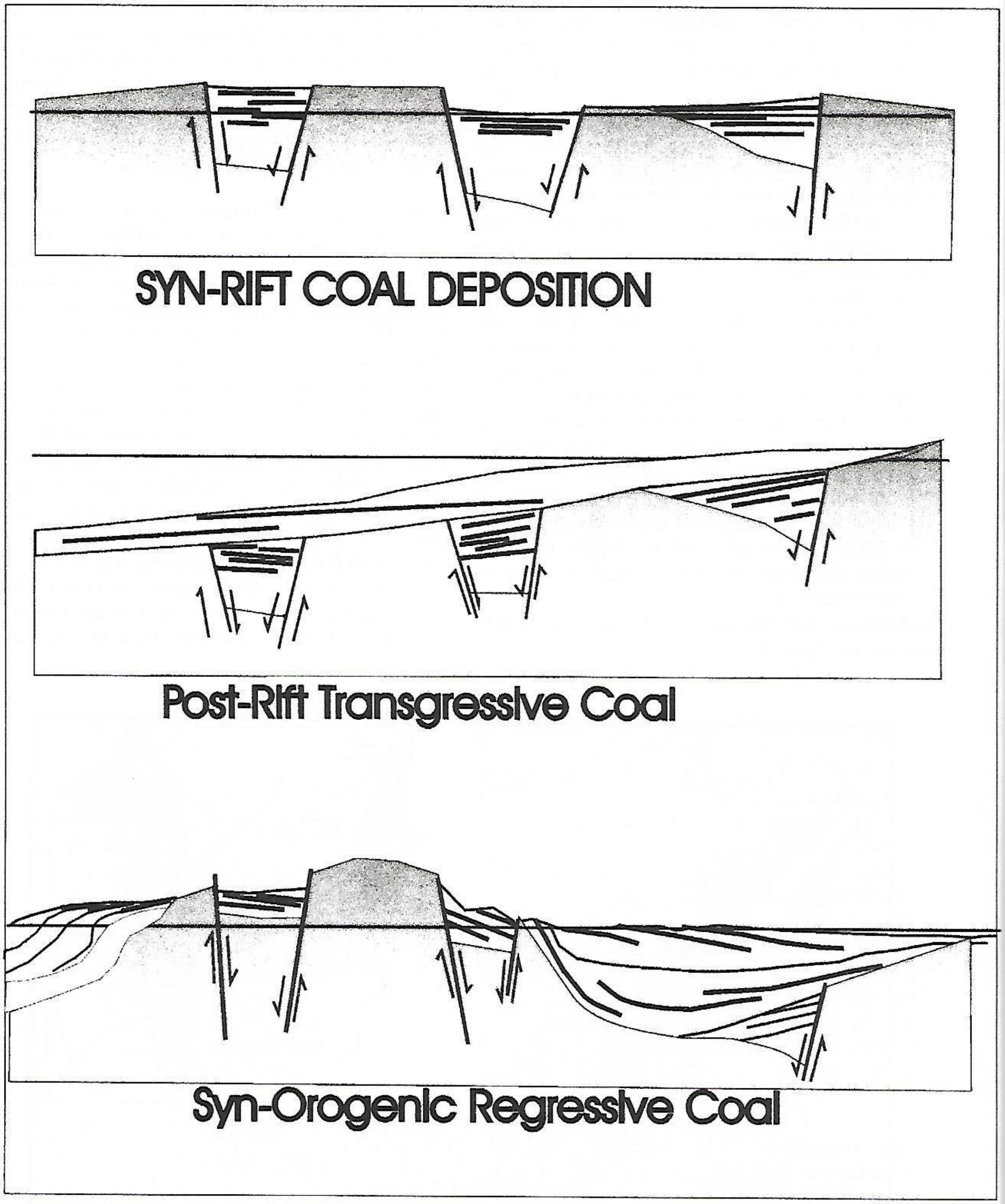

Figure 3: Cartoon of various possible coal deposition from tectono-stratigraphic point of view. These three settings tend to be common in Indonesia.

of Prosser). Coal is deposited in the deltaic environment in the flexural side of the half-graben and the fluviatile environment toward the end of active rifting as well as in the post-rift fluviatile environment. In this paper the term syn-rift and associated rift-valley deposition will be referred to as 'syn-rift deposition', while the term post-rift will be used in the subsequent tectonic environment of wide-spread general subsidence, often called "sag' in the Indonesian geology literature.

Paleogene Syn-orogenic Coal Deposit in Fore-Arc Basin Setting

These coal deposits are associated with fluvilatile to deltaic deposition prograding from a magmatic arc uplift, related to Paleogene subduction. Example of this type of coal occurrences is in the Upper Kutei Basin (Wain & Berod, 1989) and probably also the coal deposits in the Melawi-Ketungau basin in West Kalimantan. It is also possible that coal deposits in the Bayah Basin, SW Java belong to this environment.

Paleogene Syn-rift Coal Deposits

These coal deposits are associated with fluviatile-lacustrine deposits, characterized by high calorific values (~7000 kcal/gr.), low sulphur content (<1%), but variable ash content, generally lenticular or limited lateral extent,. In Central Sumatra syn-rift coal is represented by the coal deposit in the Sawahlunto Formation, an established coal field in the Ombilin Basin, and Karbindo Mine, near Gunung Medan (Camell & Butterworth, 1997), while a very significant subsurface coal deposit is known in the Kiri Trough (Hardjono and Atkinson, 1990).. In South Sumatra, the Eocene Lahat Formation and the lower part of the Talang Akar Formation (Oligocene) are recognised as syn-rift deposits where numerous coal seams have been identified in the subsurface (Taupitz, 1987). In North Sumatra early marine ingression took place resulting into combustible shale of the Bampo Formation.

Syn-rift deposits have been identified in the Barito Basins (Kusuma & Darin, 1985, Satyana & Silitonga, 1994, Satyana, 1995), but its presence on the surface has not been identified so far. Some of the coal layers in the Tanjung formation in the Barito basin and SE Kalimantan may be classified as a syn-rift coal deposit, although Friederich et al, 1995 have not identified its presence in Pasir and Asem-asem basins, SE Kalimantan.. Well-known subsurface occurrences of syn-rift coal are within the Oligocene Lower Talang Akar Formation in the Arjuna Subbasin (Gordon, 1985) and Sunda Basin (Molina, 1985) in NW Java basinal area and in the Ngimbang Formation in Northeast Java basinal area (Bransden and Matthews, 1992), and especially in the West Natuna basinal area.

Paleogene Post-Rift Transgression Related Coal Deposits in a Shelf Setting.

Coal is developed in the transgressive phase was associated with nearshore marshes and tidal flats and deltaic environment.The coal beds are relatively thin laterally continuous and characterized by high calorific values (above 6000 cal/gr.), a lower ash content, relatively higher sulphur content (>1%). Coal deposited in this setting is known in Central Sumatra as surface outcrops as well as in the subsurface, such as in the Sihapas Formation in the so-called Duri Delta and Padang Island (Hardjono & Atkinson, 1990). In South Sumatra coal seams in the upper part of the Talangakar Formation which are generally thin can be included as post-rift transgression related coal deposit. In Southeast Kalimantan Pasir/Asem-asem Pulu Laut basin and Barito basin coal seams were developed in the transgressive phase of post-rift deposition (Senakin Coal seam in the lower Tanjung Formation). This Eocene high volatile bituminous coals (CV: 6400, TS: 0.70%, Ash: 15%, FC; 42.0%, VM: 39.5%, IM: 3.5%, TM:9.0%, Frederich et al, 1995) are less than 10 m thick (4-6 m), but laterally continuous and persistent, and is interpreted to be formed as low lying topogenous mires with substantial levels of standing waters. The coal bed overlies fluvial sandstones and siltstones and is overlain by brackish water to marine fine-grained siltstones, mudstones and tidal-channel sandstones, and consequently it is low in sulphur at the base increasing toward the top. (Frederich, et al, 1995)

Neogene Syn-orogenic Regression Related Coal Deposits

Back-arc Basin Setting: In North Sumatra basin few occurrences of coal are known in the regressive phase related to deltaic deposition in the Miocene to Pliocene (Keutapang and Julurayeu formations). In Central Sumatra Basin, regression-related coal deposits are known in the deltaic Petani Formation, such as at Cerenti.. In South Sumatra, syn-orogenic regression-related coal seams are extensively developed in the deltaic deposition of the Miocene-Pliocene Muara Enim Formation, where over 10 coal seams are present, with maximum thickness exceeding 20 m (Suban Coal Seam) (Taupitz, 1988). Over 20 coal occurrences have been discovered around the Tanjung Enim field where the coal is being mined. Average calorific value is 5504 to 5347 kcal/kg (as received) and total moisture content: 23.6% (as received), sulphur content of 0.5% Ash 4% , VM 32.1%, and FC: 40.3%

At Tanjung Enim some of the coal has been ameliorated by andesitic intrusion into anthracite with CV of 8000 kcal/kg. In NW Java basin area few coal seams are developed in the regressive phase, i.e in Middle Miocene Bojongmanik Formation in Banten area, while in NE Java basinal area coal is found in the Middle Miocene Ngrayong Formation in the Rembang area.

Fore-arc Basin Setting: Coal deposits related to syn-orogenic regressive phase is represented in the Bengkulu Basin in SW Sumatra and the Meulaboh Basin in NW Sumatra. In the Bengkulu Basin, coal seams are well developed in the Middle to Late Miocene represented by the westward prograding Lemau Formation in deltaic environment (Kuncoro, 1999). Three main coal zones have been recognised, where in the Main Seam, where up to 14 lignite to sub-bituminous coal layers are found with a maximum thickness of 2.9 m with quality ranges as follows: CV:5.474-6.721 kcal/kg, TS: 0.23-0.60%, Ash: 7.24-14.24%. Total resources are up to 60 million tons (1994) In the Meulaboh Basin in northern Sumatra lignite is found in the Plio-Pleistocene Tutut Formation, developed in deltaic environment (CV: c.a.6000, TS: c.a. 1.0%,)

Suture Related Basin Setting

In Barito Basin, South Kalimantan, thick coal seams are well developed in regressive phase the Warukin Formation in deltaic environment. No published data are available.

Whereas in Pasir/Asem-asem Basin, coal seams were also formed in the regressive phase (Warukin Coal) of the sedimentation cycle. The Miocene \lignitic coal seams ((CV: 4967 kcal/kg; TS: 0.19; FC: 31.4%; VM: 37.6%; Ash; 3.3%; IM: 27.7% and TM: 34.5%), show sudden lateral changes, and are locally very thick to over 35 m (Sarongga) and over 60 m at Asam-asam, but highly discontinuous and outside the area it can thin-out quite easily to less than 1 m thick (Friederich et al, 1995).

Passive Margin Setting

Within East Kalimantan basinal areas, coal deposits are related to the deltaic floodplain environment of the prograding deltas during the Miocene time. The coal seams tend to be thick, less lateral continuity, and low calorific values (>6000 cal/gr.), sulphur content tends to be low, but occasionally above 1%. Moisture content are inherently higher than the Paleogene coal.

In the Kutei Basin coal seams are well developed in the deltaic environment of the Miocene Balikpapan and Pulubalang Formations. In the Late Miocene Balikpapan Formation 19 coal seams have been identified in an about 500 meters thick stratigraphic interval (Van Leeuwen, 1988). Well known is the Pinang coal deposit The thicknesses varies from 1.5 m to 9 meters (Pinang Seam) with calorific values for the coal varies from 7642 at the base to 6567 kcal/kg at the top layer), but can also be as low as 5100 (North Pinang). Other coal qualities are: Total Sulphur 0.15-0.70%, but can be as high as 2.5% in the north, VM: 38-40%, Ash: 1.0-4.0% and Air Dried Moisture: 4.0-10.%. The total reserves of the multi-seam deposit at the Pinang is 360 million in situ and 106 tonnes open-cut.

In the Tarakan Basin, coal seams are developed in deltaic deposits throughout the Miocene and also in the Pliocene, e.i. in the Early Miocene Latih Formation and Late Miocene Langap Formation. The coal seams are generally thin with maximum thickness of 5 m.

Tertiary Basins On Micro-Continents In Central Indonesia

Very little is known on coal from these islands, except from South Sulawesi. Central Indonesia consists of assortments of micro-continents drifting mainly from the Australian continent amidst oceanic crusts, mainly along strike-slip faults. In the south the Sunda island arc system developed into a pure oceanic island arc system of Bali-Lombok-Sumbawa-Flores, with no continental crust to the north, occupied by the Flores Sea oceanic crusts, which extend to the Banda Sea basin. One major island in Central Indonesia is Sulawesi. To the east is the Banggai Sula Archipelago (Banggai-Sula-Obi islands), Australian micro-continents, which have been put in place by the great Sorong Fault zone. Toward the Northeast are oceanic island arc system of Halmahera and associated island. Farther toward the east are the Ceram-Buru islands, which is tectonically closely associated with the Arafura continental landmass of the Australian continent. No significant coal deposits are known from these islands.

Sulawesi consists of three distinct mega-tectonic provinces, 1) A northern arm which is a pure oceanic island-arc, 2) The South Arm, which is a margin of the of the Sundaland, and 3) East and Southeast Arm comprising the hinterland of an orogene) composed of Mesozoic autochthone and younger allochthonous metamorphic and ophiolitic rocks which were obducted over an eastern province of Australian derived microplates during the late Oligocene(Banggai-Sula micro-continent)

South Sulawesi is stratigraphically related to the Sunda shelf, but is being separated by the opening-up of Strait Makassar. Coal seams are only well-known from South Sulawesi.

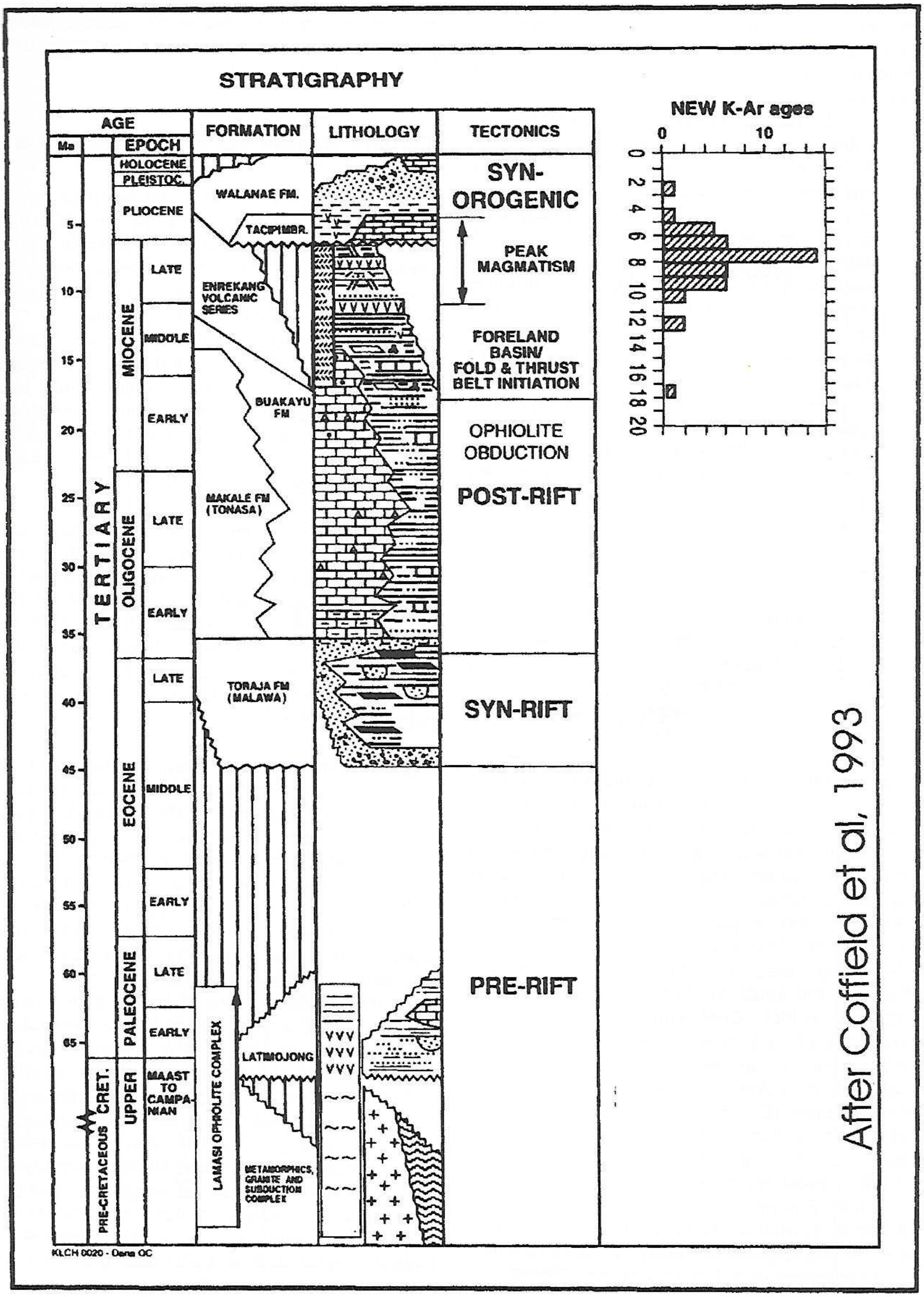

Figure 4: Tectono stratigraphy of South Sulawesi (after Coffield et al, 1993) with respect to the coal occurrences.

Tectono-stratigraphy of South Sulawesi.

South Sulawesi is the onshore portion of Spermonde Basin. Its tectono-stratigraphic development is similar to west Indonesia. The following tectono-stratigraphic units can be recognised (Coffield et al, 1993) (see Figure 4):

1) Pre-rift: A basement of metamorphic subduction complex (Bantimala)

2) Syn-rift: Syn-rift deposition took place in the Paleogene (Middle to Late Eocene) as rifting took place in the forming a presumably in a northwest-southeasterly trending rif-valley basins depositing fluviatile- lacustrine sedimentation of the Malawa Formation (Toraja Formation). In the final stage of syn-rift deposition the fluviatile-lacustrine sedimentation gave way to deltaic deposition,

3) Post-rift: Post-rift marine transgression took place depositing the predominantly carbonate Oligocene to Early Miocene Tonassa Fn (Makale Formation). This marine carbonate conditions prevailed until Mid-Miocene

4) Syn-orogenic: Syn-orogenic deposition when volcanism erupted depositing the Enrekang volcanics in foreland basin accompanying fold-thrust belt initiation subsequent to ophiolite obduction . Magmatism peaked in Late Miocene - Early Pliocene followed by syn-orogenic deposition of the Walanae Formation clastics

Coal Deposits

The syn-rift coal deposits are found in at least in 17 localities in South Sulawesi, indicated as Paleogene coal by Van Bemmelen, (1949, vol. II). These coal seams were deposited in the final stage of syn-rift deposition as the fluviatile-lacustrine sedimentation gave way to deltaic deposition before post-rift marine transgression took place. These localities are spread from Pangkjene area (Tondongkura and Malawa fields) in the south to Mamuju area in the north (Karama fields). Coal seams with a uniform thickness of 2.5 m are found at Tondongkura with calorific values ranging 5925 to 7115 , but rather high sulphur content (4.7) as marine transgression (CV: 6385, TS: 4.7, TM: 4.2, FC: 39, VM: 40.3, Ash: 16.4)

Syn-orogenic coal deposits: Van Bemmelen (1949) mentioned 5 Neogene coal occurrences in South Sulawesi, which occurs mainly in the Walanae Formation. None of these occurrences are of any significant, even an occurrence in Enrekang (Kautu) a 2 m coal seam is found with 0.6% sulphur content.

Elsewhere in Sulawesi, Buton Isl., Banggai Sula Archipelago and the Molucca's Van Bemmelen (1949, vol II) mentioned scattered occurrence of thin lignite veins, which are of no significance. These occurrences are generally in the syn-orogenic regressive Pliocene deposits related to wrench faulting and collision of micro-continental fragments, such as the Buton /Selayar and the Bangai-Sula micro-continents.

Tertiary Basins In Eastern Indonesia

Eastern Indonesia is mainly represented by the Arafura Shelf, which includes the island of Irian (Papua-New Guinea), which is underlain by a continental crust. The Australian continent is presently pushed to the NW under the Banda Sea oceanic plate crust resulting in the imbricated structures of the Banda Arc islands, while to the north it collided with the Pacific oceanic plate forming the Central Irian Jaya Mountain Range. It is further complicated by the presence of E- W striking wrench faults, i.e the Sorong Fault, displacing several micro-continental fragments to the west.

In Eastern Indonesia, no significant coal occurrence have been reported, except one locality in the Bintuni basin. This is due to the fact that tectono-stratigraphic development of Irian Jaya and with the associated island of the Arafuru shelf is completely different from that of Western Indonesia, where marine deposition prevailed, particularly carbonate sedimentation during the Tertiary

The stratigraphy of eastern Indonesia is remarkably very similar to that of Australia (Pigram & Panggabean, 1981; 1984) related to the development of the Australian continent and break-up of Gondwanaland. A rift-drift model for this development has been given by the Falvey & Mutter (1981), which is applied to Eastern Indonesia by Peck & Soulhol, 1986, and Lunt & Jaafar (1991) (see Figure 5). This model traces the development of the northern part of the Australian continent from its pre-rift deposition of coal-bearing Permian Aifam/Aiduna Formation, followed by infra-rift in the Triassic Tipuma Formation and initial break up or the onset of syn-rift deposition of the Lower Kembelangan Formation with final break-up in Late Jurassic, where rift changed to drift, with post-break-up submarine erosion, with considerable subsidence changing into deep bathyal conditions, passing into a passive margin clastics deposition of the Middle Kembelangan in Early Cretaceous, passing again into a carbonate platform/shelf deposition of the Upper Kembelangan carbonate shelf in Late Cretaceous to Miocene and finally colliding into a island-arc system in the Pacific plate in the north-east, and the western Irian Jaya micro-continent (Bird's head) in the west, resulting into of Neogene syn-orogenic clastics deposition in the foreland basin south of the thrust belt (Akimeugah and Iwoer basin) and in the strike-slip related basin in the north (Meervlakte basin) as well as in the Vogelkop area (Bintuni and Salawati basins.. These coal occurrences can be classified as syn-orogenic coal.

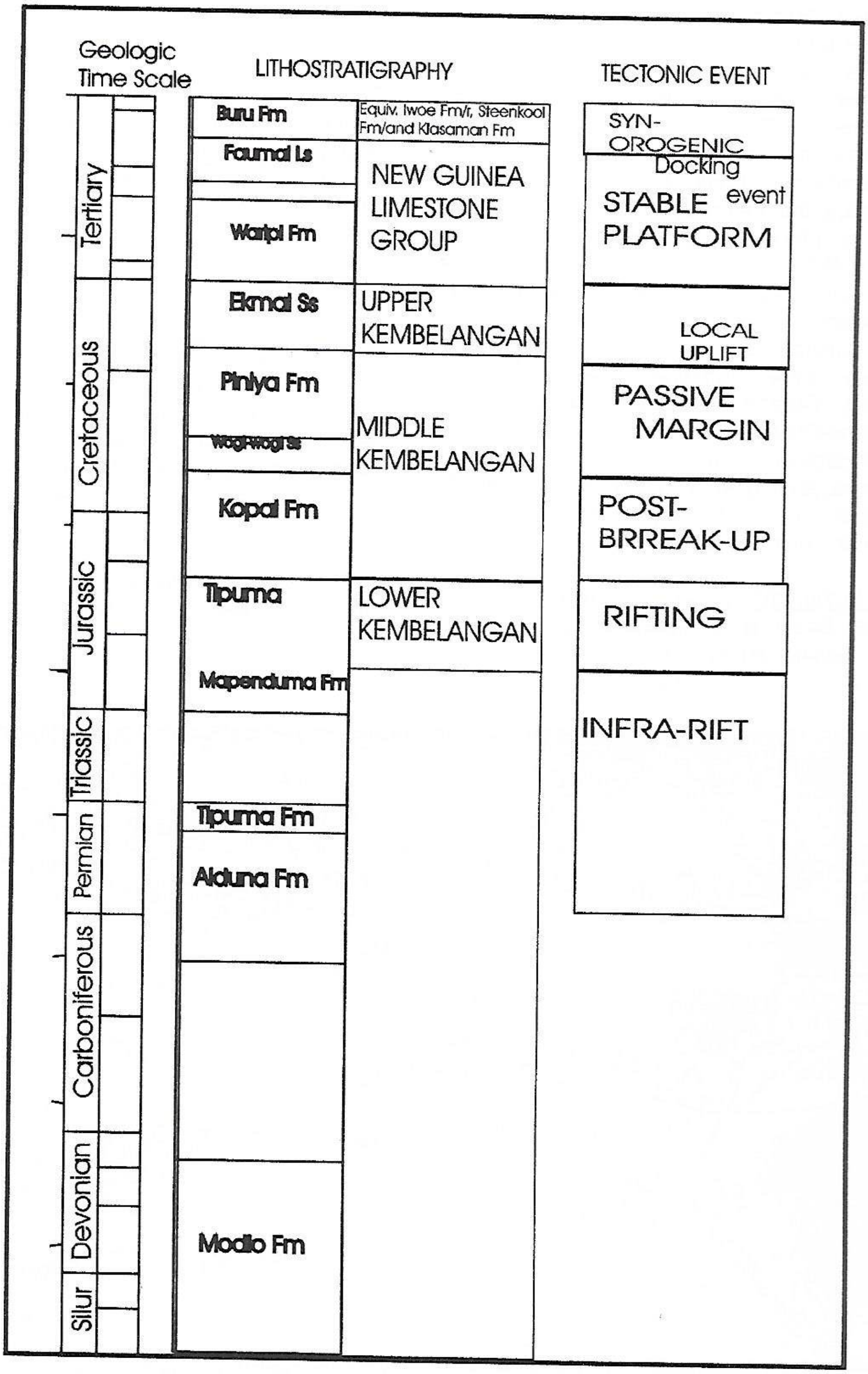

Figure 5: Tectono stratigraphy of Papua (adapted from Lunt & Jaafar, 1991) which is remarkably similar to the Australian continent

Collision Related Basins in South Irian Jaya
At least two Neogene collision-related (Foreland) basins are developed in front of the Central Irian Jaya thrustbelt Wijaya mountain range (Figure 6): the Akimeugah and Iwoer basins, with syn-orogenic clastics deposition of the Akimeugah and lower formations (Middle Miocene to late Miocene) and Boeroe Formation (Late Miocene-Plio-Pleistocene). (Hermes & Visser, 1962). No significant coal deposits have sofar been discovered, but thin lignites beds have described within these clastics

The Mamberamo Basin in Northern Irian Jaya - also called the Meervlakte Basin - is a narrow Neogene strike-slip related basin wedged between the Cyclops Mt. Thrust-belt and the , where over 7000 m of Late Miocene-Pliocene Mamberamo Formation overlying the deep marine clastics turbidites of the Middle Miocene to early Late Miocene Makat Formation. Overlying Durante limestones which overlain Paleocene-Oligocene Auwewa Formation of mixed limestones and overlying the ophiolites. A regressive ending in a deltaic E member Plio-Pleistocene cycle, known as the Brown Coal horizon or Lignite zone

Basins in the Bird's Head, Irian Jaya
Salawati Basin is a Sorong Fault strike-slip related basin, where the carbonate sequence dominance was terminated by the Late Miocene uplift changing into clastics of the Pliocene-Pleistocene Klasaman Formation, where few lignites are found.
Bintuni Basin is bordered by the Lengguru fold belt to the east, where over 5000 m thick Tertiary sediments have accumulated. The cabonate sequence dominance was terminated by Late Miocene Uplift into Pliocene clastics of the Steenkool Formation. Several coal seams with rather high calorific values have been found near Horna, in the NE rim of the basin. This coal occurrence is rather of an enigma as a high calorific value of more than 7000 cal/gram has been assigned (Van Bemmelen, 1949, vol II, p.89)

Summary

Tertiary coal is mainly found in Tertiary basins of western Indonesia, related to the Asian continental crust of the Sunda shield, except of few Pre-Tertiary occurrences in Irian Jaya (Papua)

From tectono-stratigraphic point of view coal deposits in western Indonesia occur in 1) Syn-rift deposits, 2) Post-rift Transgressive Sequence, and 3) 'Syn-orogenic' Regressive Sequence.

Figure 6: Neogene basin distribution in Iran Jaya (Papua)

Paleogene coal occurs both as syn-rift as well as post-rift transgressive deposit

The tectono-stratigraphic framework of coal deposits tends to give a broad generalization concerning the quality and the seam characteristics of the coal.. However, local geological conditions ultimately control seam characteristics and quality.

In Central Indonesia, coal of any significance occurs only in South Sulawesi (Celebes) a separated micro-continent from the Sundaland, where the coal seams occur mainly as syn-rift deposits and possibly also as post-rift transgressive deposits, while syn-orogenic coal occurrence are also known.

In East Indonesia, mainly Irian Jaya/ Papua (New Guinea) lignites occurrences are known in the final phase of syn-orogenic deposition (Iwoer basin, Akimeugah basin, Meervlakte basin (Lignite Horizon), Salawati basin and Bintuni basin, where in the latter basin a significant coal deposit with an anomalous high calorific value is found at Horna.

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