Lithofacies and Facies Associations of Eocene Unit Exposed in the Yawzu Area, Kalewa Township, Sagaing Region

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Abstract

The study area is located in Kalewa Township, Sagaing Region. It comprises of 84 I/7 one inch topographic map and is bounded by Latitude 23°15' 45″N to 23°19' 30″ and Longitude 94°16'E to 94°20' 35″. The study area is situated at the south-western margin of the Chindwin Basin. It is mainly composed of the Paleogene-Neogene clastic sedimentary strata. The rock sequence of the study area is divided into, the Yaw Formation (Late Eocene) and the Letkat Formation (Early to Middle Miocene), the Natma Formation (Middle to Late Miocene) and the Shwethamin Formation (Late Miocene). The present research aims to find out lithofacies analysis and environments of the Yaw Formation. The Yaw Formation is composed mainly of shale, clay interbedded with sandstone and siltstone. Coal seams are formed at lower and upper portion of clay and shale units. From the facies analysis, there are at least ten lithofacies and three facies associations- prodelta/ shelf association, delta front association and delta plain association in the Eocene unit of the Yaw Formation. These associations indicate that indicate that the Yaw Formation may be deposited under deltaic environment.

Keywords: lithofacies, facies association, prodelta/shelf, delta front, delta plain, deltaic environment

Introduction

The study area is located in Kalewa Township, Sagaing Region (Fig. 1). It is situated between Latitude 23°15' 45″N to 23°19' 30″ and Longitude 94°16'E to 94°20' 35″. It is situated at the south-western margin of the Chindwin Basin. Chhibber (1934) describe briefly the geology of the Upper Chindwin Area. He reported that the flysch of the Western Ranges in rocks that range in age from Middle Triassic to Late Eocene. Brunnschweiller (1966) discussed the geology of the Indoburman Ranges, including Myittha Valley between Gangaw and Kalaymyo, describing that there was continuous marine sedimentation between Cretaceous and Tertiary in this area. Aung Khin and Kyaw Win (1968 and 1969) reported the geology and hydrocarbon prospects of the Burma Tertiary geosyncline including Chindwin Basin with a large number of oil prospect. Win Swe *et al*., (1972) presented the geology of the part of the Chindwin Basin including the Kyigon area and attempted the rock units of the Chindwin Basin with those of Minbu Basin.

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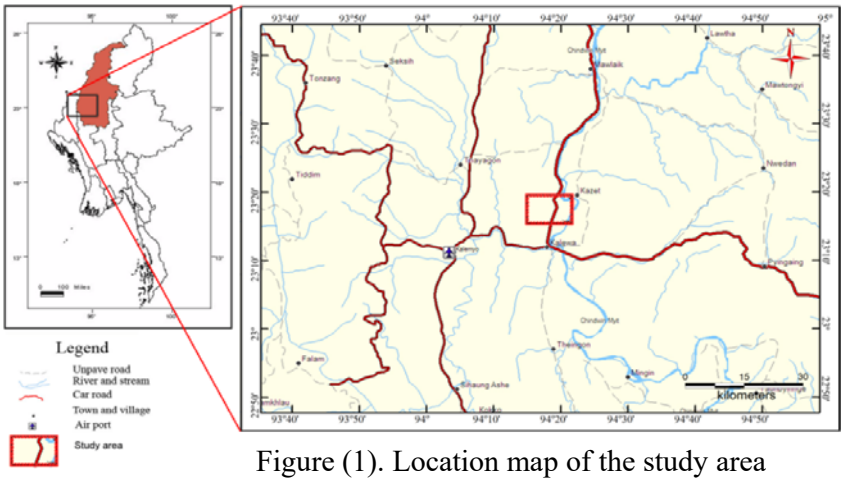

Figure (1). Location map of the study area

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Methods of Study

The locations of the lithologic contact were measured by applying GPS. An attempt was made in collecting selected rock samples which would represent each and every lithologic units of the whole area. The geological map of the area was made by using one-inch topographic map. The sedimentary succession of the area was investigated in the field by describing its lithologic variation and obtaining rough estimate of thickness along traverse.Detailed stratigraphic measurements were taken along the Kyauk O Chaung section and other stream sections for facies analysis to interpret the depositional environments.

Stratigraphy

General Statement

The study area is mainly composed of the Paleogene-Neogene clastic sedimentary units of the Yaw Formation, the Letkat Formation, the Natma Formation and the Shwethamin Formation. The Yaw Formation crops out in the western part of the study area. Geological map of the study area is shown in (Fig. 2).

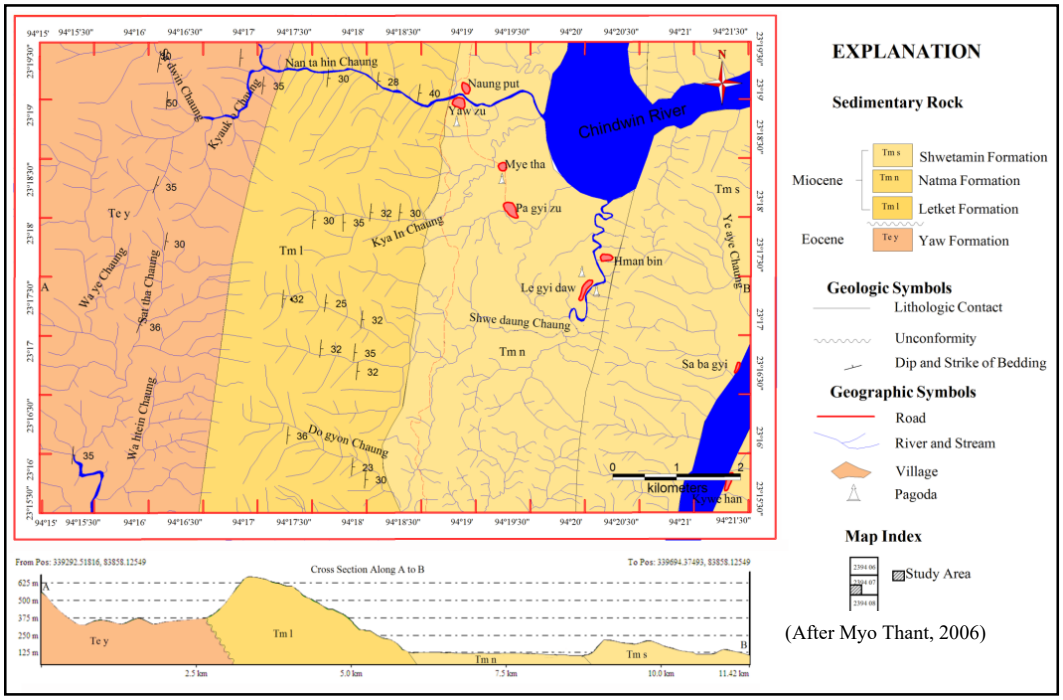

Figure (2). Geological map of the study area

Yaw Formation

The term Yaw Shales was first used by Cotter (1912). Aung Khin and Kyaw Win (1969) later renamed as Yaw Formation. The Yaw Formation is exposed in the western part of the study area. It is composed mainly of shale, clay interbedded with sandstone and siltstone (Fig. 3). Coal seams are formed at lower and upper portion of clay and shale units (Fig. 15). Coal seams are massive to flaky and 3cm to 300cm thick. It is overlain by the Letkat sandstones with basal conglomerate (Fig. 4). This boundary is unconformable. According to previous works and collect the gastropods: *Turritella* sp., *Coronia* sp., *Goniobasis* sp., *Drillia* sp., (Fig. 5) and pelecypods: *Clementia* sp., *Venus* sp., *Dosiniopsis* sp., (Fig. 6) it can be regarded Late Eocene age.

Figure (3). Interbedded of sandstone, siltstone and shale of the Yaw Formation (Sadwin Chaung, N 23˚19′30″, E 94˚16′15″)

Figure (4). Clast supported conglomerates (Nantahin Chaung, N 23˚19′ 15″, E 94˚17′28″)

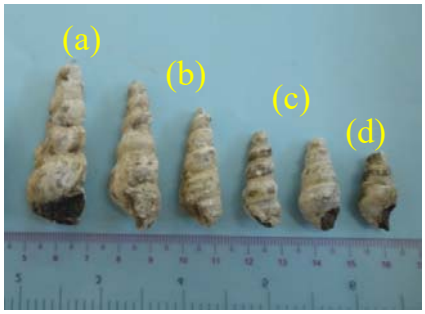

Figure (5). Gastropods: (a) *Turritella* sp,. (b) *Coronia* sp., (c) *Goniobasis* sp., (d) *Drillia* sp., in the Yaw Formation (Lat. 23˚18′42″N, Long. 94˚16′15″E)

Figure (6). Pelecypods: (a) *Clementia* sp., (b) *Venus* sp., (c) *Dosiniopsis* sp., in the Yaw Formation (Lat. 23˚18′58″N, Long.94˚16′17″E)

Sedimentary Facies Analysis and Environments

Lithofacies 1 (F1) Bluish grey nodular shale facies

Description

The lower part of the Yaw Formation is always started with thick bluish-grey shale facies (Fig. 7). This facies is characterized by thick sequence of shale (up to 20m thick). The shales are massive, bluish-grey color, less fissile, sub concoidal fracture and nodular characters.

Interpretation

The fine grained muddy sediments are the prodelta deposits, which are closely related to prograding deltaic system (Reineck and Singh, 1980).

Lithofacies 2 (F2) Bluish grey shale with intercalated thin bedded siltstone and fine-grained sandstone

Description

It is characterized by thin bedded of fine-grained sandstone and shale (Fig. 8). Sandstone is yellowish-brown and 2cm to 5cm thick. Shale is bluish-grey and 5cm to 12cm thick. Bluish grey shale facies is gradationally increased in silt and fine sand content upward. Leaf imprints and woodchips are common in this facies.

Interpretation

The silty, parallel and lenticular laminations occurred in this shale facies indicate depositional site near to the delta front (Reading, 1996). This facies could have deposited in prodelta/shelf environment where finer particles settle out from suspension and disperse over wide area by the basinal processes (Reading, 1996). Thin bedded, silty fine sandstone and shale, the presence of wood fragments indicate that this facies may be deposited in a sandy shoal formed near the seaward limit of the distributary channel.

Lithofacies 3 (F3) The fossil bands intercalated in bluish grey shale

Description

The fossil bands intercalated in bluish grey shale are observed in the particular stratigraphic intervals (Fig. 9). The fossils are gastropods; *Turritella* sp., *Coronia* sp., *Goniobasis* sp., *Drillia* sp., and pelecypods; *Clementia* sp., *Venus* sp., *Dosiniopsis* sp. Bioturbated horizon is sometimes occurred in bluish grey shale.

Interpretation

Bioturbation in which grey shale associated with a fossil band indicate a storm surged shell lag deposited on the prodelta/shelf environment (Kyaw Linn Oo, 2008).

Figure (7). Massive, bluish- grey shale facies in the Yaw Formation (N 23˚19′30″, E 94˚16′14″)

Figure (8).Bluish grey shale with intercalated thin bedded siltstone and fine-grained sandstone (N 23˚19′02″, E 94˚16′28″)

Figure (9).The fossil band intercalated in bluish grey shale (N 23˚18′42″, E 94˚16′15″)

Figure (10). Lenticular silt and silty fine sands laminated shale (N 23˚ 18′45″, E 94˚16′35″)

Figure (11).Wavy bedded or interlayered sand mud facies (N 23˚18′47″, E 94˚16′ 45″)

Figure (12). (a) Rippled or ripple cross-laminated sandstone (N 23˚19′30″, E 94˚17′16″)

Figure (12). (b) Rippled or ripple cross-laminated sandstone (N 23˚19′ 30″, E 94˚17′16″)

Figure (13). Thinly parallel laminated sandstone (N 23˚19′30″, E 94˚17′20″)

Lithofacies 4 (F4) Lenticular silt and silty fine sands laminated shale

Description

Thick bluish grey shale unit is gradually increased in sand content or sandier upward into the heterolithic facies (1-8m thick) comprises of lenticular, wavy to flaser bedded shale and fine sandstone interbedded unit (Fig. 10).

Interpretation

The lenticular silt facies with characteristic sandier up and thickening upward facies suggest influence of tidal action, shallowing upward, and prograding nature commonly found in a prodelta to delta front setting. The origin of flaser and lenticular bedding requires conditions of current or wave action depositing sand, alternating with slack water conditions when mud is deposited. Thus the main environments of its occurrence are subtidal zones and intertidal zones (Reineck and Singh, 1980).

Lithofacies 5 (F5) Wavy bedded or interlayered sand mud facies

Description

Wavy bedding or interlayered sand/mud facies shows thin wavy mudstone layers alternating with thin ripple bedded sandstone layers (Fig. 11). This facies contains fine sandstones with symmetrical wave ripples and mud flasers interbedded with thin, bluish grey lenticular laminated mudstones. The lower part of the facies is gradually decrease in thickness of rippled sandstone beds and increasing mud content resulting in thinly interlayered sand mud bedding to lenticular bedded shale unit.

Interpretation

Wave rippled sandstones alternate with thin mudstone also reflects deposition below normal wave base or intertidal region. Association of ventricular-wavy-flaser bedding are common in tidal flat and delta front sediments, where there are fluctuations in sediment supply wave activity (Tucker, 2001).

Lithofacies 6 (F6) Rippled or ripple cross-laminated sandstone

Description

This facies is mainly composed of thin to medium bedded, fine grained, current and wave ripple bedforms. The rippled sandstones show small scale current ripples such as flatten and undulatory ripples (Fig. 12 a) and straight-crested current ripples showing small tongue-like projections in the down current direction (Fig. 12 b). These small current rippled beds are thickening upwards into medium to thick bedded ripple cross laminated fine sandstones.

Interpretation

This facies represents alternate changes from low energy to higher energy wave and current conditions. The occurrence of alternate wave and current bedforms and suggested that the place where a condition favor for both current and wave processes alternately (Reineck and Singh, 1980). The asymmetrical wave formed ripple cross laminated sandstones are abundantly developed in the environments undergoing continuous reworking in agitating shallow water, especially found in sandy intertidal flats and fluvial sediments: upper point bars and levees (De Raaf *et al*, 1977; In Reineck and Singh, 1980).

Lithofacies 7 (F7) Thinly parallel laminated sandstone

Description

It is mainly composed of thinly parallel laminated fine sandstones with very thin carbonaceous laminations and minor ripple cross laminations. The laminated fine sandstones are commonly interbedded with dark bluish grey, less fissile and blocky, thin carbonaceous mudstones intercalated with thin oxidized fine sandstone layers (Fig. 13). This facies is underlain by the organic rich facies and thick bluish grey shale facies.

Interpretation

This facies represents the characteristic of a crevasse splay sandstone as well as carbonaceous silt and mud of interdistributary bay sediments deposited in delta plain environment (Coleman and Prior, 1980; In Reineck and Singh, 1980).

Figure (14). Large scale horizontal to stratified sandstone (N23˚19′30″, E94˚17′ 25″)

Figure (15). (a) Coal seam and shaly coal (N 23˚19′30″, E 94˚17′18″)

Figure (15). (b) Coal seam and shaly coal (N 23˚19′30″, E 94˚17′18″)

Figure (16). Carbonaceous shale or coaly shale with silt and sand alternation (N 23˚19′30″, E 94˚16′10″)

Lithofacies 8 (F8) Large scale horizontal to stratified sandstone

Description

This facies is observed as light greenish grey, thick bedded, calcareous, fine to medium grained sandstone with large scale stratifications (Fig. 14).

Interpretation

Large scale parallel stratified sandstone is a product of wave built features found in beach and shoreface deposits associated with active delta lobes (Allen, 1987; In Kyaw Linn Oo, 2008).

Lithofacies 9 (F9) Coal seam and shaly coal

Description

This facies is characterized by interbedded of yellowish brown, fine- grained sandstone (5cm-25cm) and bluish grey shale (20cm to 70cm) with coal seam and shaly coal. Coal seams are formed in clay and shale beds (Fig. 15 a, b). Coals are massive to flaky and 3cm to 300cm thick. These coal seams are sub-bituminous.

Interpretation

The carbonaceous shale and coal are thought to have been deposited in a marsh environment. The high preserved organic content and the association with coal, indicate an extremely low rate of sedimentation.

Lithofacies10 (F10) Carbonaceous shale or coaly shale with silt and sand alternation

Description

This facies is mainly composed of dark grey to black carbonaceous shale or coaly shale with thin silt and fine sand laminations. Thin sulphurous dull coal seams (10-12cm thick) are occasionally intercalated (Fig. 16).

Interpretation

The coals and rootlets beds record marsh development and plant growth (shallow water) giving rise to peat swamps that were subsequently inundated by transgressive events (Fielding, 1984; In Kyaw Linn Oo, 2008). The high preserved organic content and the association with dull coal, indicate an extremely low rate of sedimentation and an anoxic environment of deposition.

Facies Associations of the Yaw Formation

The observed ten lithofacies were grouped into three lithofacies associations; namely (1) prodelta/shelf facies association, (2) delta front facies association, and (3) delta plain facies association.

Prodelta/shelf facies association

The region seaward of the delta front environment is the prodelta environment. It is also known as delta front slope. The prodelta deposits are characteristically fine grained muddy sediments. Thinly laminated silts and clays are the most noticeable. Occasionally, ripple bedding, current ripples, and small scale graded bedding are common in more silty layers (Tucker, 2001). This facies association constitutes most of the lower part of the Yaw Formation. It is mainly composed of thick sequence of bluish grey nodular shale unit (F1), bluish grey shale with minor interbeds of thin silt, fine sandstones (F2) and the fossil bands (F3). Carbonaceous shale with thin parallel silt laminations (F10) and lenticular bedding (F4) are observed in the upper part of the facies association. The fossil bands are observed as reworked storm beds or due to marine incursion as transgressive lag deposits. Parallel and lenticular silt laminated shale with intercalated thin cross laminated sands suggested a combination of wave, sediment laden current incursion from the distributaries and continued deposition from suspension. This facies association is interpreted as upper shallow water portion of prodelta or lower delta front transition. The lenticular laminated bluish grey shale unit is also support the characteristic of prodelta deposits.

Delta front association

Distal mouth bar facies association

Seaward of the distributary mouth bar is a zone of predominantly laminated silts and clays with high rates of sedimentation. This is the seaward sloping margin of the delta front environment (Reading, 1996). This facies association is commonly overlying the thick prodelta facies association and upward transition to the distributary mouth bar facies association. Thick bluish grey nodular shale of the prodelta deposits gradually sandier upward into lenticular thin silt and fine sand laminated bluish grey shale (F4) and wavy or sand mud interlayered facies (F5). The facies association represents the heterolithic tidal facies commonly found in distal mouth bar of lower delta front. Association with bay mud or prodelta clay underlying the mouth bar facies association indicates the seaward progradation of the delta in which organic matter is rich (Reineck and Singh, 1980).

Distributary mouth-bar facies association

Lenticular silt and fine sand laminated bluish grey shale of lower delta front deposit is overlain by wavy bedded, fine to medium sandstone with abundant mud and coaly laminations (F5) and thin to medium bedded, ripple cross laminated fine sandstone and mudstone interbedded unit (F6) representing a tidally influenced distributary channel and associated distributary mouth deposits. This facies association show characteristic transition from lenticular through wavy bedding in fine sandstone shale alternations and thickening upward into rippled sandstones. Ripples are sinuous to straight crested ripples and wave formed patterns on the upper bedding planes of the sandstones, indicating low energy to higher energy, coastal tidal flats and small tidal channel developed in the distributary mouth bars of the upper delta front environment (Reineck and Singh, 1980). The distributary mouth bar is a sandy shoal formed near the seaward end of the distributary channel. Formation of the shoal is the direct result of the decrease in current velocity and carrying capacity of the stream as it leaves the channel. The sedimentary structures such as wave and current bedding are formed by the continuous action between the stream currents and sea waves (Allen *et al*., 1989; In Reading, 1996).

Delta Plain Association

Distributary channel facies association

This facies association is mainly observed in the upper part of the Yaw formation composed of sandstone with intraformational mud pebbles and coal seam (F9), large scale horizontal sandstone facies (F8), Rippled or ripple cross laminated sandstone facies (F6) and thinly parallel laminated sandstone facies (F7). This facies association shows the repeated cycle of small scale coarsening upward. In some places, the lithofacies sequence shows fining upward with the overlying thinly laminated carbonaceous fine sandstone and mudstone lithofacies representing a warning event. This lithofacies sequence indicates that sediments were deposited by unidirectional current in a channel. Mud pebbles, coal and plant debris also show the eroded delta plain materials. Fine upward through cross bedded sands into ripple laminated finer sands with silt and clay alternations also suggest the distributary channel characters (Tucker, 2001).

Interdistributary bay facies association

This facies association is mainly observed in the lower part of the Yaw Formation. It is composed of coal seam and shaly coal (F9), carbonaceous shale or coaly shale with thin fine sandstones and siltstone (F10), thinly parallel laminated sandstone (F7), ripple cross laminated sandstone (F6) and bluish grey shale (F1). This facies association is characterized

by the sulphurous, dull coal seams and peat layers. They are interbedded with bluish grey, carbonaceous, thinly parallel or lenticular laminated silty shale, fine sandstones and siltstones. Interdistributary areas of delta plains are composed of swamps, marshes and enclosed or partially enclosed water bodies which are quiet or even stagnant (Reading, 1996). The organic rich lithofacies assemblage suggests that the sediments were deposited under the quiet water condition and dense vegetation prevailed in interdistributary bay and marshes of the delta plain area under humid tropical climate (Coleman and Prior, 1980; In Reineck and Singh, 1980). Many ancient coals were accumulated in deltaic setting (Elliott, 1978; In Kyaw Linn Oo, 2008). Peat swamps are common in modern coastal plains, particularly along coastline where mangrove swamps may develop (Coleman, 1976; In Reineck and Singh, 1980).

Delta plains are occupied by distributary channels which are separated from each other by interdistributary lakes and bays (Elliott, 1978; In Kyaw Linn Oo, 2008). Bay fills or crevasses that break of main distributaries and interdistributary bays in the lower delta plain are characterized by small scale coarsening upward sandstone sequences with organic debris in the lower part, the middle part is alternating silts, sands and clays of distal bar, and the upper part is essentially prograding distributary mouth bars. The upper most capping unit of the bay fill sequence is an interdistributary bay or marsh deposit (Coleman and Prior, 1980; In Reineck and Singh, 1980).

Depositional Environment of Eocene Unit

The facies association of prodelta, delta front and delta plain indicate that the Yaw Formation may be deposited under deltaic environment. The deposition of facies F3 that marine transgression has been occurred during Late Eocene time and some fossil horizons (especially gastropods and pelecypods) including in this facies F3 indicates the marine transgression periods. Then the basin was gradually silted and became shallower at the end of the deposition of the Yaw Formation.

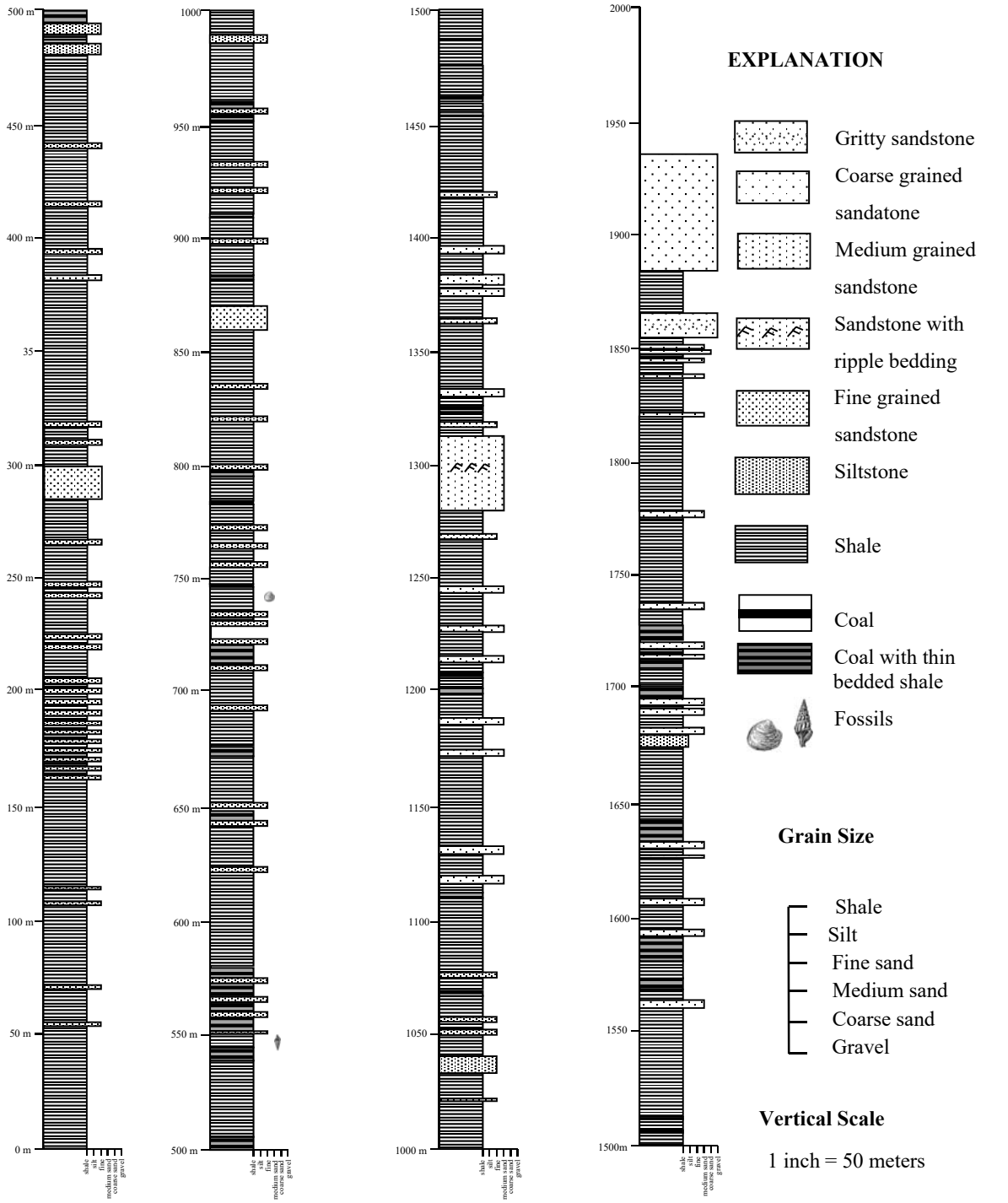

Figure (17). Columnar section of the Yaw Formation (Measured along Kyauk O Chaung Section)

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