Provenance, tectonic setting and geochemical maturity of the Early Miocene Pyawbwe Formation, Sakangyi –Thayet Area, Pyay Sub-Basin, Myanmar

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(*received:12/04/2017 ; accepted: 07/10/2017*)

Abstract

The best exposed Early Miocene (820m.thick.) shales and interbedded silty sandstones beds of the Pyawbwe Formation at Sakangyi-Thayat area are investigated geochemically by using Siemens SRS- X Ray 303 AS XRF Spectrometer. Major and some trace element concentrations have been determined to achieve their provenance, tectonic setting paleoweathering, paleoclimate and sedimentation characteristics. The geochemistry of sediments is particularly valuable in the study of fine-grained rocks that are difficult to characterize through petrographic studies. Geochemical data revealed that the felsic granitic plutonic provenance of moderate relief of arc massif exposed on tectonically calm continental margin which is probably the Shan- Thai continental block and northeastern Myanmar. Average values of both Chemical Index of weathering (CIW) and Chemical Index of Alteration (CIA) (77.4 and 67.3 respectively) suggest a moderately chemical weathering condition prevailed during transportation and deposition on passive shallow margin as progressive mature sediments.

Keywords*: Pyawbwe Formation, Early Miocene,Central Myanmar Basin,Passive Margin.*

Introduction

A little studies have been carried out done on the sedimentation and sediment provenance in Central M yanmar Basin. Still the sedimentary supply to the Central Myanmar Basin is a matter of debate (Naing *et al*., 20 13, Licht *et al*., 2013, Robinson *et al.,* 2014). The economic importance of the Miocene formations as reservoir r ocks for the gas and oil in the Central Myanmar (Burman) Basin attracte d the attentions of the several rece nt geologists (Wandrey, 2006, Harun *et al*., 2014 and others), then the Pyawbw e Formation is chosen to this study. This study focuses on the provenance of the Pyawbwe Formation sediments of the Pyay embayment, Sakangyi – Thayet area within the central Myan mar Belt. The area under study is comm only located in the Thayet Suddle and n orthern margin of the Pyay Sub - Basin (Figs. 1 & 2). It is structurally complex trending NNW – SSE with many folds and fault systems (Fig. 3b).

It is majorly fallen in the Sakangyi anticline to north of the Thayet, bounded by Tokkaing syncline in the west and Thayet thrust fault to the east. This structure is cored by the Pyawbwe Formation and surr ounded by middle Miocene to Pliocene sediments (Fig. 1). The aim of the present study is to understand and document the evolution of the sedimentarys upply and also to construct a pictorial sedimentation scenario of the Pyawbw e Formation for the first time. The p resent authors combine the litho- geochemical results to evaluate its source and tectonic depositional setting. The characterization of the p rovenance and tectonic setting of t hese units is important for unde rstanding the geodynamic of a part of the Central Myanmar Basin of the western margin of the Shan Plateau (Fig. 2) during the Early Miocene.

Stratigraphically, the Pyawbwe Formation lies between the Okhmintaung Formation (Upper Oligocene) at lower and the Kyaukkok Formation (Middle Miocene) at upper level (Fig. 3C). In general, all the rocks belonging to the Oligocene – Miocene ages are mainly built up conglomerate, sandstone, mud, siltstone, shale and claystones. Lithologically, the Pyawbwe Formation consists of blue grey shales and clay members intercalated with few fine-grained sandst ones and carbonaceous siltstones sediments (Fig. 4)

Regional Geological Setting

Located at the southern Range of the eastern edge of Himalayan Chain, the Central Myanmar Basin (CMB) is located between Shan Plateau to the east and the Indo-Burman Ranges to west which are composed of sedimentary, metasediments, inten sive and volcanic rocks.

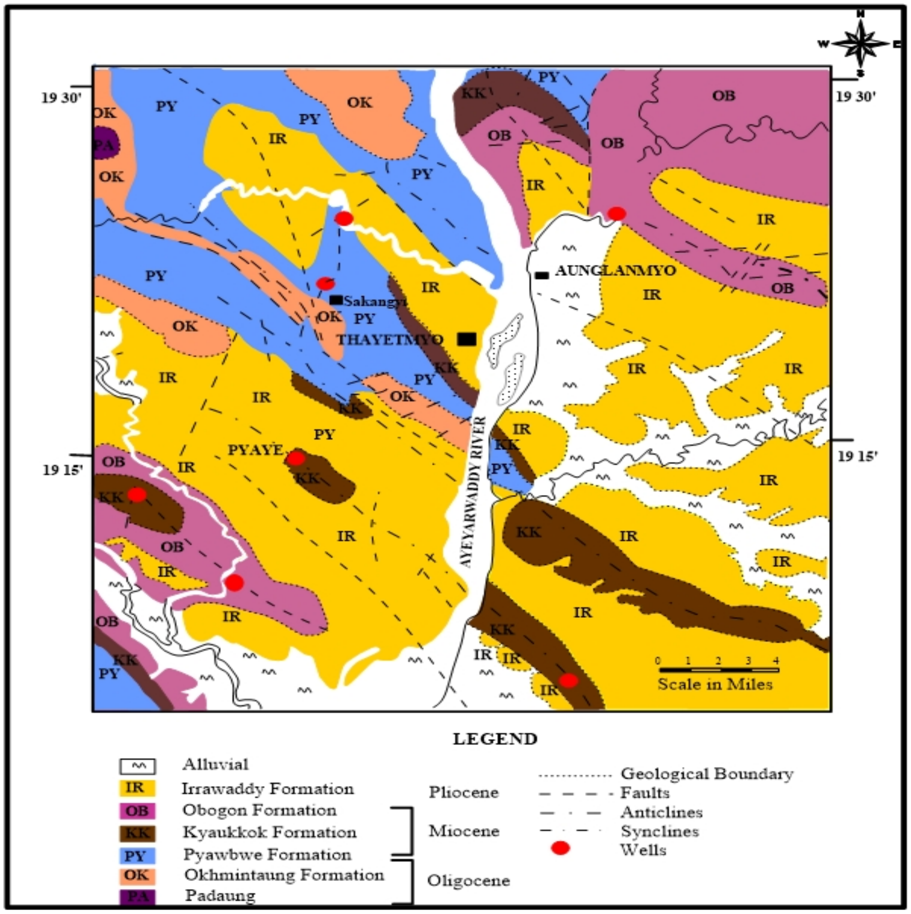

Figure 1. General geological map showing distribution of the Pyawbwe Formation around the Central Myanmar Basin, Pyay, Thayet, Sakangayi areas: (after Moc, 1985)

The Central Cenozoic Belt or Central Myanmar Basin is divided into several Tertiary Sub-Basins (Fig.2) along its nearly 1100 km. length. The sub-basins have been almost filled since the Indo-Asian collision **(**Bender, 1983, Bertrand & Rangin, 2003, Searl *et al*., 2007, Allen *et al*., 2008, Licht *et al*., 2014). These sub-basins may ha ve formed as a series of en echelon p ull-apart basins (Fig. 2) trending approximately NW-SE with about 50 km. wide in the Early Eocene (Fig. 3D) as the Burma Plate moved northward relati ve to the Asia Plate (Pivink et *al*., 1998 , Rangin *et al*., 1999). A 15 km. thick succession of Cenozoic deposits was f ound in Central Myanmar Belt (Pivink *et al*., 1998).

Materials and Methods

A total of 70 shale sam ples (Plate, 1) were collected mostly with an equal interval of space of 20 m. all along these sections (820 Thick.). Only 16 representative samples of visibly fresh shales and interbeds sandstones representative samples of visibly fresh shales and interbeded s andstones were analyzed for their major and some trace element concentrations. They were examined with Shimatz u u Model ED-720 energy dispersive X RF system with Standard Curves based on International Rock Standards at the Institute of Electron Optics, University Research Center (URC), Yangon .The obtained results as well as the calculated indices are tabulated in Table (1).

Results and Discucssions

The obtained results of the major and some trace elements for both shales and the intercalated silty-sandstone beds of the Early Miocene Pyawbwe Formation are reflected by narrow range of variations.

Geochemistry

Major Elements

The range and avera ges of the major chemical concentrations and ratios are tabulated in Table (1).

Table 1. Major and some trace elemant concentrations (wt %) of the Pyawbwe Formation, Myanmar.

Elements	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Average
SiO_2	25.16	37.41	37.39	19.73	38.52	27.83	37.48	36.03	37.3	35.46	36.91	42.05	52.72	22.25	39.08	37.67	35.2
Al_2O_3	8.71	33.16	33.59	10.35	33.62	15.43	33.89	32.32	33.97	13.43	34.06	30.45	15.73	10.33	31.24	22.48	46
$Ti\ O_2$	0.47	0.58	0.54	0.53	0.5	0.25	0.52	0.53	0.51	0.75	0.56	0.48	0.18	0.62	0.52	0.42	0.5
Fe_2O_3	34.87	9.66	8.83	20.47	8.15	9.76	8.29	8.96	8.42	14.99	8.27	8.27	5.64	17.43	10.02	14.76	11.4
Mn O	1	0.09	0.08	0.69	0.08	0.96	0.07	0.14	0.09	0.32	0.07	0.07	0.15	0.81	0.1	0.18	0.34
Ca O	18.4	0.9	0.82	33.41	0.8	33.47	0.71	3.32	0.42	19.17	0.92	2.8	15.99	35.54	1.92	9.32	11.1
Mg O	0.77	6.47	6.56	1.17	5.77	4.3	6.17	6.11	6.58	0.9	6.52	5.33	2.61	0.3	6.01	5.1	3.5
Na_2O	4.14	1.2	1.37	4.97	1.66	2.89	1.57	1.54	2.13	4.22	1.86	1.34	1.68	3.47	1.33	1.77	2.3
K_2O	6.11	10.44	10.75	3.33	10.34	5.08	11.21	10.59	10.47	10.45	10.75	9.14	4.01	9.1	9.53	7.34	9
P_2O_5	0	0	0	0	0	0	0	0.22	0.03	0	0	0	1.15	0	0.14	0.82	0
$Cr_2\ O_3$	0.13	0.03	0.02	0.12	0.03	0.05	0.03	0.04	0.03	0.09	0.03	0	0.03	0	0.03	0.08	0.05
SO_3	0.1	0.01	0.01	0.09	0.01	0.02	0.02	0.17	0.02	0.12	0.01	0.02	0.06	0.06	0.03	0.02	0.05
$Zr\ O_2$	0.06	0.02	0.02	0.05	0.01	0.02	0.02	0.02	0.01	0.05	0.02	0.02	0.02	0.03	0.02	0.02	0.03
Zn O	0.03	0.01	0.01	0.01	0.01	0	0.01	0.01	0.01	0.02	0.01	0.01	0	0	0.01	0.01	0.01
Ni O	0	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cu O	0	0	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Rb_2O	0	0	0	0	0	0.01	0	0	0	0.01	0	0	0	0.02	0	0	0
$Y_2\ O_3$	0	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sr O	0.05	0.01	0.01	0.08	0.01	0.06	0.01	0.02	0.01	0.04	0.01	0.02	0.03	0.05	0.02	0.02	0.03
Al_2O_3/SiO_2	0.35	0.89	0.9	0.52	0.87	0.55	0.9	0.09	0.91	0.38	0.92	0.72	0.3	0.29	0.8	0.6	0.62
SiO_2/Al_2O_3	4.33	1.18	0.66	5.09	1.25	2.39	1.05	1.15	1.06	2.79	0.82	1.27	1.26	3.62	1.2	1.12	1.6
K_2O/Na_2O	1.48	8.73	7.85	1.68	6.55	1.76	7.14	6.88	4.91	2.48	5.77	6.8	2.39	2.62	7.18	4.15	5
ICV	8	8.7	0.85	6.7	0.81	3.7	0.83	0.95	0.83	3.7	0.83	0.89	1.9	6.5	1.2	1.7	3
Fe_2O_3+MgO	35.64	16.13	15.39	21.64	13.92	14.05	14.46	15.07	14.99	15.88	14.79	13.61	8.25	17.73	16.03	19.86	14.5
Al_2O_3/TiO_2	18.37	47.47	62.66	19.53	67.11	62.96	65.68	61.09	66.09	17.81	60.38	63.56	88.85	16.67	59.85	54.18	47
K_2O/Al_2O_3	0.7	0.32	0.32	0.81	0.32	0.33	0.33	0.33	0.31	0.78	0.32	0.3	0.26	0.88	0.31	0.33	0.43

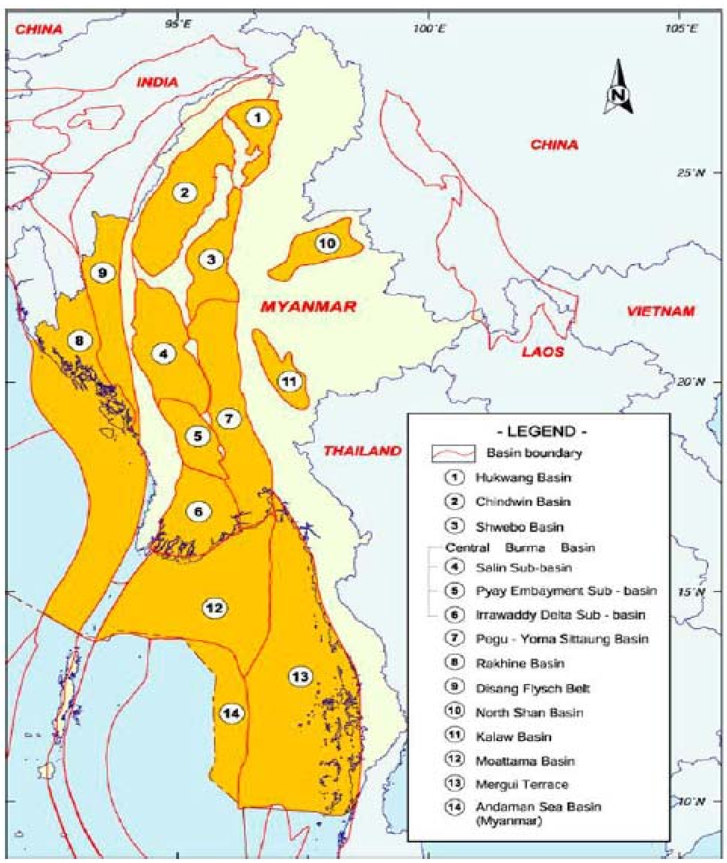

Figure 2. Basins of Myanmar,Pyay Embayment Sub-Basin no. 5, (afterUtitsan*et.al*., 2014).

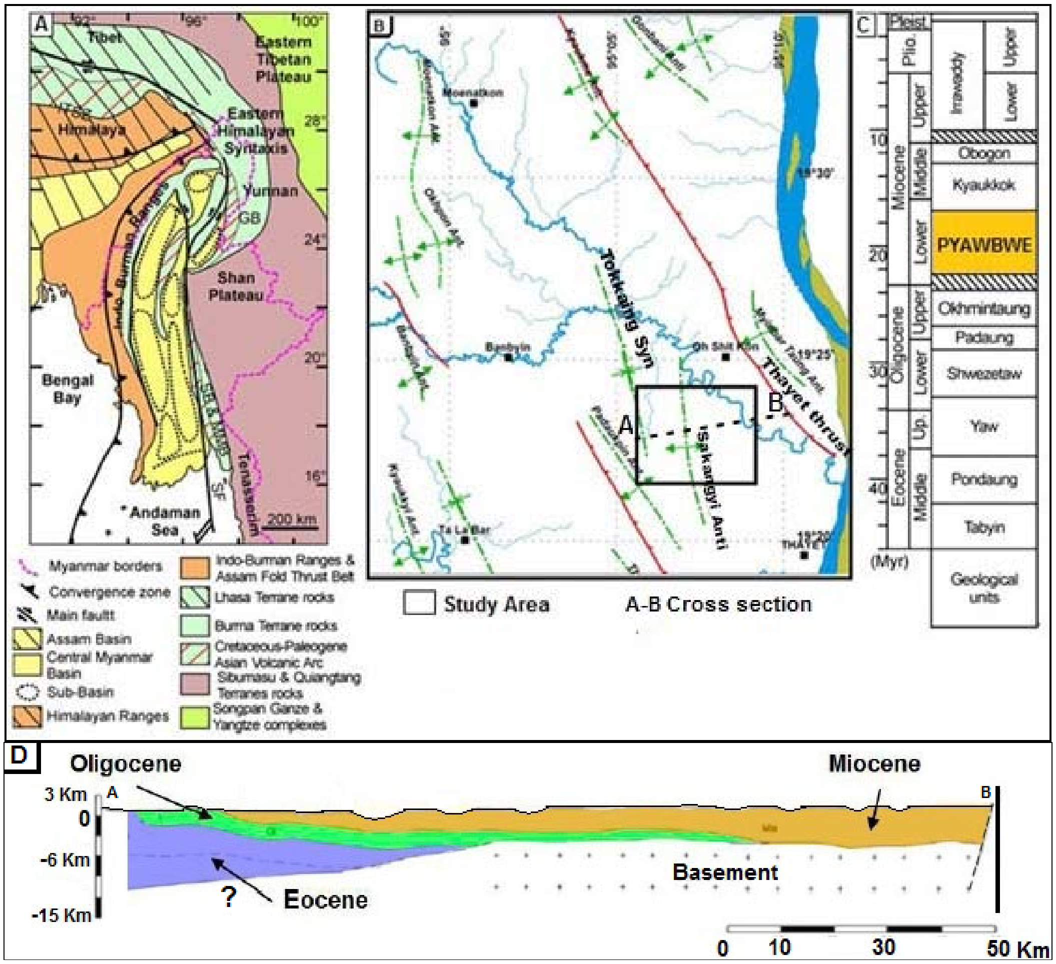

Figure 3. (A) Simplified geological map of central Myanmar Basin (after Mitchell *et al*., 2012; Metcalfe, 2013). (B) Detailed structural map of the study area in Central Myanmar (partially Pyay sub-basin .(C) Schematic stratigraphic log of the Central Myanmar Basin (Licht *et al*., 2013) showing the stratigraphic position of the Pyawbwe Formation.(D) Schematic cross section across the study area (Generally modified from Bertrand & Rangin, 2003).

K_2O and Na_2O contents and their rat ios show a narrow range of differences (from 3.33 to 10.75 and from 1.2 to 4.97 respectively). This may attributed to redistribution of alkali elements during post-depostional alterations (Bandopa dhyay & Ghosh, 2015). The bivariate plotting K_2O wt. % versus Na_2O wt. % on the graph of Crook (1974) reveal ed that all the analyzed samples are plotted in the field of quartz – rich shales (Fig. 5). The composition of non-quartz component of the present samples can be evaluated from the values of Index of Compositional Variation (ICV) of Cox *et al*. (1995) where:

$ICV = (Fe_2O_3 + K_2O + Na_2O + CaO + MgO + MnO + TiO_2) / TiO_2$. ICV values of the present samples vary from 0.8 to 8.7 (average = 3). The values of ICV more than 1 in dicates presence of less clay minerals and more rock forming minerals such as plagioclase ,K- feldspar, amphip oles , pyroxens and and lithics (Cox *et.al*.,1 995). It is known that the values of ($K2O/Al_2O_3$) of clays are less than 0.3 and the values of the same ratio of feldspars range from 0.3 to 0.9 (Cox *et al*.1995).

The values of K_2O / Al_2O_3 ratio of the sandstones vary narrowly from 0.17 to 1.19 (average = 0.18, Pettijohn, 1957). The K_2O / Al_2O_3 values of the present samples averaged 0.4 indicate a significant quantity of alkali feldspar relative to other minerals in the original rocks. Also, average value of K_2O/Na_2O is 4.9, slightly high indicating presence of K-bearing minerals (McLennan *et.al*., 1983, Nath *et al*., 2000, Osae *et al*., 2006).

On other hand, the pre sent values of SiO_2 show negative correlations with major elements. All ajor elements except SiO_2 exhibit positive correlations between themselves. Th ese correlations confirm that the bulk of SiO_2 is present as quartz grains as indica ted on Fig. (5), (Rahman &Suzuki, 200). Also, Al_2O_3 shows strong positive correlation with K2O (r= 0.74) indicates that the bulk Al and K are primarily contributed by clay minerals as illite or smectite (McLennan *et.al.*, 1983). The negative correlation between SiO_2 and MgO (r= -0.5) and SiO_2 and (Mg O+ Fe_2O_3) (r= -0.64) rule out presence of biotite (Hayashi *et.al.*, 1997). The strong negative correlation betw een Al_2O_3 and (MgO + Fe2O3) (r= -0.46) rule out presence of biotite, chlorite and ferromagnesian minerals (biotite andhornblend) and confir m the presence of smectite (Fig. 6), (Hayashi *et al.*, 1997). The CaO content of the shale beds averaged 2.9 indicating the the calcium resides in silicate phases while in sandstone interbeds averaged 25 reflecting presence of carbonate cement. Also, MgO concentrations are higher than the global shale (Pettijohn, 1957) supporting carbonate association. The strong negative correlation coefficient between Al_2O_3 and CaO (r = 0.91, R^2 = 0.83) in dicates that the carbonates are secondary rather than primary origin (Akaris h & El-Gohary, 2011).

Trace Elements

The studied samples (Table, 1) have low concentrations and / or strongly depleted of the analyzed metals asNi,Co,V,Rb,Yand o thers may indicate the negligible role of the mafic rocks in the source area.

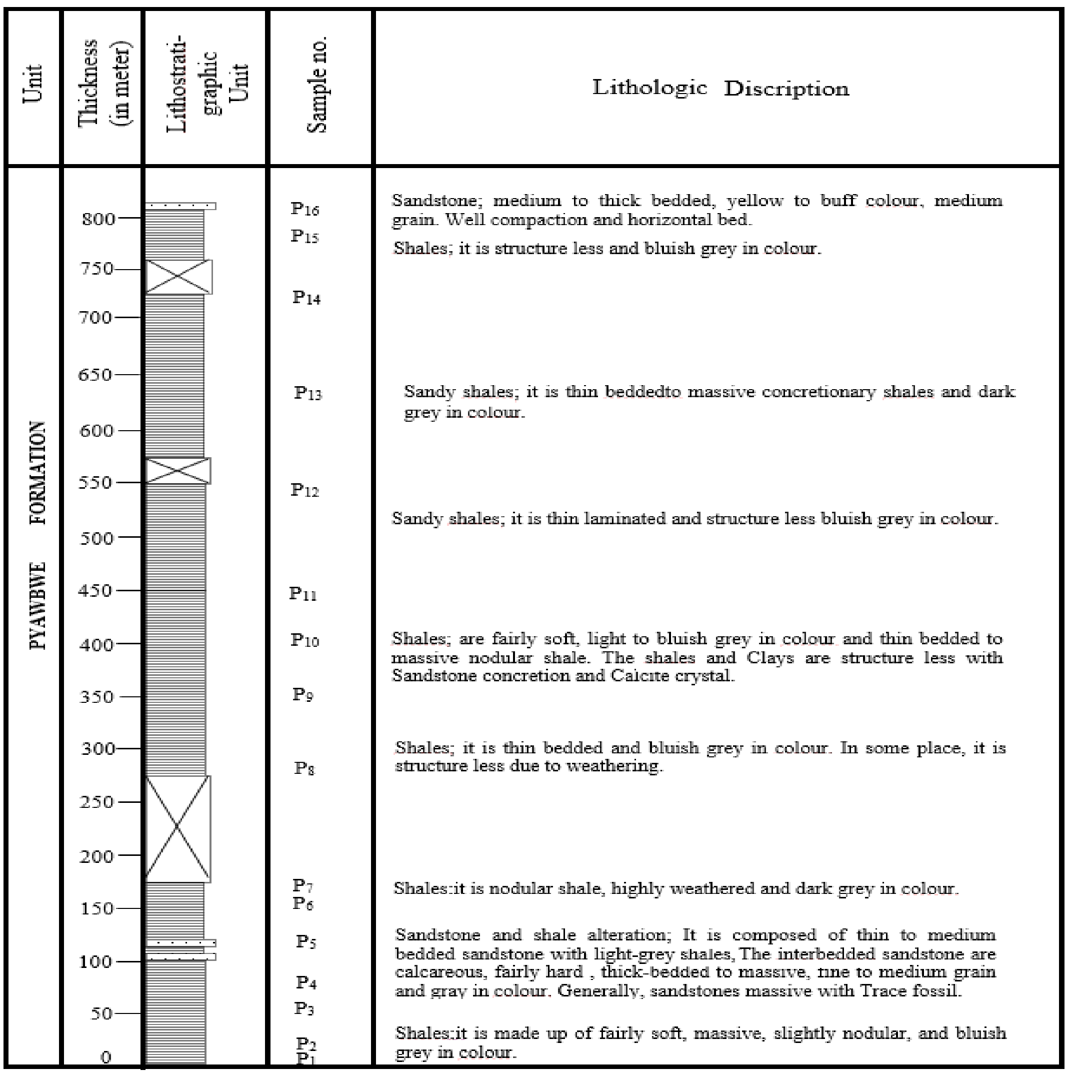

Figure 4. Stratigraphgic section showing the different lithologic beds of the Pyawbwe Formation, Central Myanmar Basin.

Plate 1. (1): Photograph showing light-gray, thin-bedded to massive concretionary shales in the middle part of the Pyawbwe Formation. (2): Photograph showing bluish -gray, thin-bedded to massive concretionary shales exposed in the Upper part of the Pyawbwe Formation. (3): Field photograph showing massive, light gray, slightly mottled clay exposed in the Lower part of the Pyawbwe Formation.(4):Photograph showing massive, light gray, slightly mottled clay exposed in the Lower part of the Pyawbwe Formation. (5): Photograph showing massive, light gray, slightly mottled clay exposed in the Lower part of the Pyawbwe Formation. (6): Photograph showing massive, light gray, slightly mottled clay exposed in the Lower part of the Pyawbwe Formation.

Zn shows weak negative correlation with SiO_2 (r = - 0.19) Al_2O_3 (r = -0. 09) and very weak positive correlation w ith TiO_2 (r = 0.44) and K_2O (r = 0.16). Sr shows negative correlation with SiO_2 (r = -0.71), Al_2O_3 (r= -0.89), TiO_2 (r = -0.13) and with K_2O (r = - 0.77). Also, Cr shows negative correlations with SiO_2 (r = - 0.48), Al_2O_3 (r = -0.6), K2O (r = - 0.52) and positive correlation with TiO_2 (r= 0.04), Mn (r= 0.52), CaO (r= 0.41), Na_2O (r = 0.73) and Fe_2O_3 (r = 0.76).The negative correlations indicate presence of the trace elements in the clay fraction, while the positive correlations confirm their occurrence in the mafic minerals of the shales. According to Hall berg berg (1976), low values (= 1 in prese nt samples) of Cu/ Zn ratio suggest oxidizing conditions of deposition indicatin g very shallow marine conditions. Zn shows very weak negative correl ation with MgO (r= -0.18) ,with SiO_2 (r = -0.19) and with Al_2O_3 (r=-0.09) indicating that Zn is endemic to the mafic minerals of the shales.The present shales have low content of Cr ranges from 20 to 130 ppm (average = 50 ppm) and depleted both Ni, Rb, Y and Cu. Cr and Ni values suggest that ultramafic and even mafic rocks were hardly present or even not widespread at the source region (Garver*et.al*.,1996). Low Sr content of our samples is generally related to low content of CaO probably due to the lack of calsicplagioclase (Akarish &

ElGohary, 2011) Long *et.al*.(2008) showed that the relatively high Rb concentration (>40 ppm) and low Rb/Sr (0.04 – 3.24) ratio indicative of acidic intermediate igneous source rocks that had undergone weak chemical weathering. The present Rb/Sr ratio (average = 0.7) is very low indicating felsic igneous source rocks and reflecting weak to moderate chemical weathering. The present Rb/Sr ratio (average = 0.7) is very low indicating felsic igneous source rocks and reflecting weak to moderate chemical weathering(Rashid, 2002) . This interpretation is consistent with that inferred from the major element interpretation and the framework compositions.

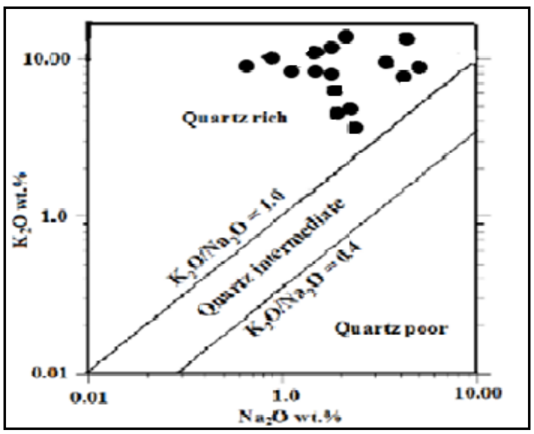

Figure 5. Geochemical classification, bivariant diagram of Pyawbwe Fm., Data reveal quartz rich sediments.

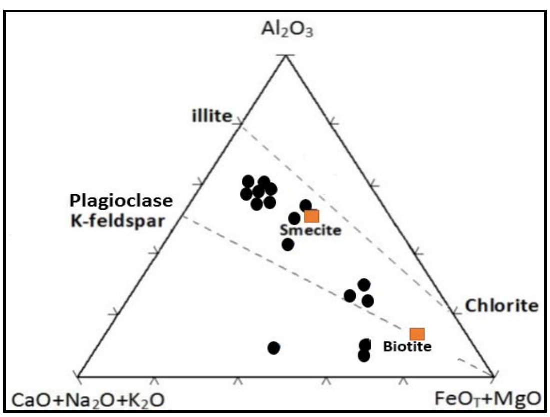

Figure 6. Provenance indicating ternary diagram. The lines are after Hayashi *et al*. (1997).

Source Rocks of the Pyawbwe Formation Sediments

With respect to Al_2O_3/ TiO_2 ratios range of 3 to 8 for mafic igneous rocks, from 8 to 12 for intermediate rocks and from 21 to 70 for felsic igneous rocks (Hayashi *et.al*.,1997) . The average Al_2O_3/ TiO_2 ratio of our analyzed samples of the Pyawbwe Formation is 47 suggested felsic igneous rocks as being probably source rocks (Fyffe & Pickerill, 1999). Also, low content of average TiO_2 (= 0.5) indicates presence of phyllosilicates in minor amounts (Dabard, 1990, Condie*et.al*., 1992, Ferdous& Farazi, 2016).

As indicated (Fig.7),owing to low solubility of their oxides and hydroxides in low temperature aqueous solutions (Stumm& Morgan, 1981, Yamamoto *et.al*.,1986, Sugitani ,1996), the values of Al / Ti ratios of residual soils can be considered to very close to those of the parent igneous rocks. Then, the residual soils contain kaolinite, illite or smectite. The presentation of our data (Fig.7) confirm the most of clays represented by the smectite type. Several studies on clay mineralogy have shownthat during fluvial transportation of Al and Ti involve insignificant fractionation (Yamamoto *et.al*., 1986).

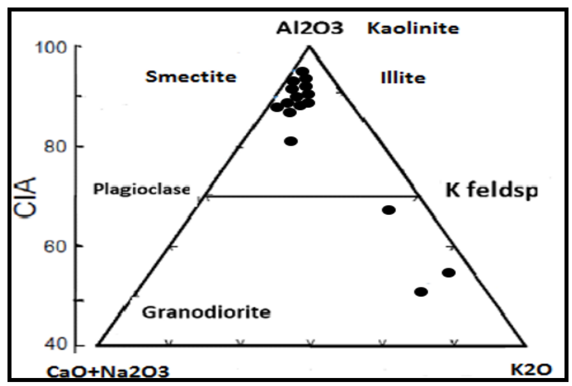

Figure 7. CIA ternary diagram (Al_2O_3, K_2O, $CaO+Na_2O_3$) of Pyawbwe Fm., (diagram after Nesbitt & Young, 1984).

Plotting the data (Fig. 8) on the tectonic discriminating diagram of Maynard *et.al*. (1982) indicates the sediments of the Pyawbwe Formation is derived from the evolved arc setting, felsic plutonic detritus. Also, their plotting (Fig. 9) on diagram of Roser & Korsch (1986) modified by Murphy (2000) and on McLennan *et al*. (1980), (Fig. 10) confirm the same interpretation.

Paleoweathering and Paleoclimate

The upper crustal rocks are composed of feldspars and volcanic glass. By chemical weathering of these materials ultimately results in the formation of clay minerals (Nesbitt& Young, 1984, 1989; Taylor & McLennan, 1985, Fedo*et.al*., 1995). Ca,Na,and K are largely removed from the source rocks. These elements are surviving in soil profiles (Fig.11).

Owing to the presence of K_2O+ Na_2O (average= 9.9 ≈ 10) and the K_2O/ Na_2O ratios (average=4.9 ≈5) and contents of Na_2O and K_2O of the present samples do not suggest intense weathering of the source area. By applying the data of Lindsey (1999) and Harnois (1988) on the present data, it can be concluded that the provenance of thePyawbwe sediments were subjected to low to moderate intense chemical weathering in spite of presence of chemical weathering on source rocks (K-feldspars, granitic felsic composition), another chemical weathering of detritus during fluvial transportation and chemical weathering in depocenters and diagenitic processes.

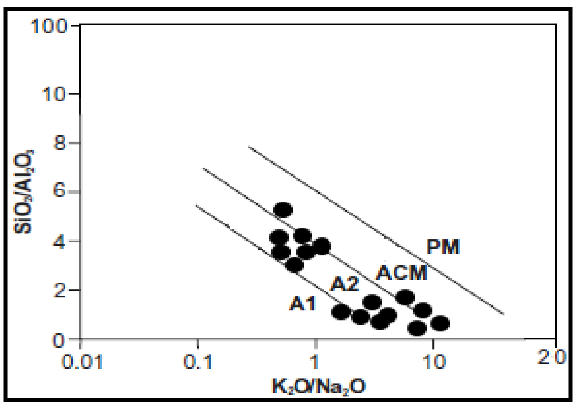

Figure 8. Tectonic setting bivariate discrimination diagram of Pyawbwe Fm. (after Maynard *et al*., 1982). A1= arc setting, basaltic and andesitic detritus. A2=evolved arc setting, felsic plutonic detritus. ACM=active continental margin. PM= passive margin

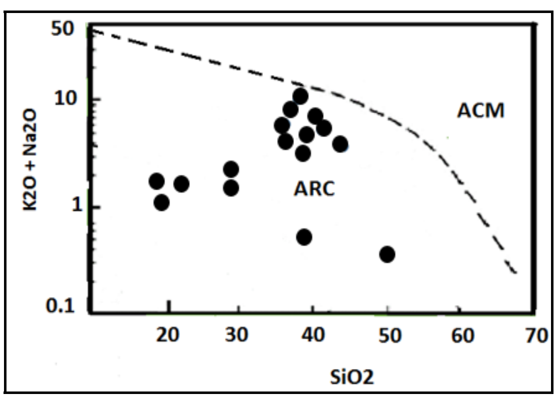

Figure 9. Tectonic setting discrimination diagram of Pyawbwe Fm. The lines are modified after Roser and Korsch (1986) and Murphy (2000). ACM=active continental margin. ARC=oceanic island arc margin.

This may probably due to prepondenanceof arid to semi-arid paleoclimate (Sutter and Dutta, 1986), (Fig. 11). By applying the calculated average of CIW (C hemical Index of Weathering) and CI A (Chemical Index of Alteration) (Fig.12), according to Nesbitt & Young (1 982) and Fedo*et.al* (1995), where: CIA = Al2O3 / (Al2O3+CaO+Na2O+ K2O) x 100, CIW= Al_2O_3 / (Al_2O_3+CaO+Na_2O) x 100.

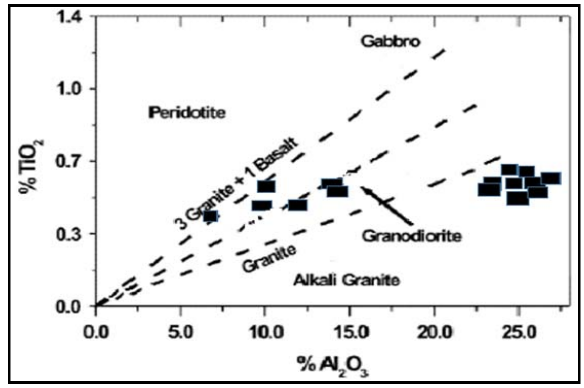

Figure 10. Provenance discrimination diagram of Pyawbwe Fm. TiO_2% versusAl_2O_3 % bivariate plot, (diagram after McLennan *et al*., 1980). The granite line and ^3granite + 1 basalt line are after Schieber (1992).

It can be concluded that the source rocks were expose d to intermediate silicate weathering either in the original source terrane or during transportation by fluvial streams before deposition on passive margin of shallow marine environment (Fig. 13).

Moreover, high averages of CIA values suggest derivation from a stablecratonic source (Hossain *et al*., 2010, Akarish & El- Gohary, 2011). The present studied sediments commonly form a trend of almost parallel to K-feldspare to smectite clay type.

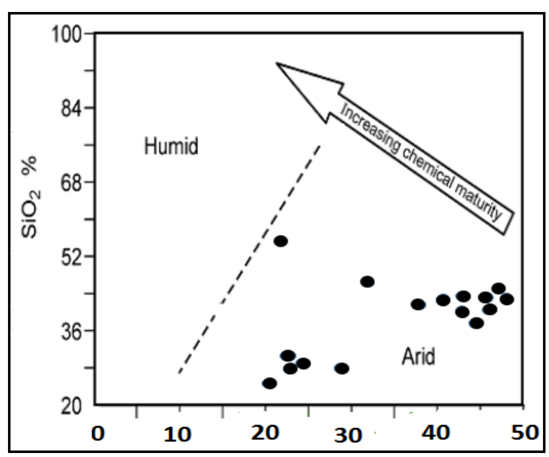

Figure 11. Bivariate paleoclimate discrimination diagram, boundary lines after Suttner & Dutta, 1986, showing the chemical maturity of the Pywbwe Fm. sediments.

The smectite samples are more than that of K-feldspars with increase of Al_2O_3 cocentrations. The presence of smecite mineral improves the conclusion of passive marine margin as site of deposition with fluctuations (El-Gammal, 1985).

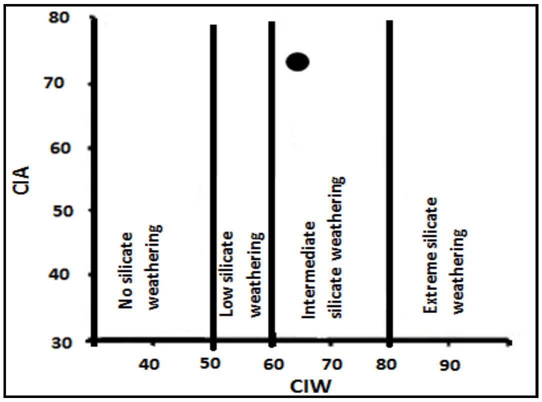

Figure 12. Plot of averages of chemical index of alteration (CIA) vs. chemical index of weathering (CIW), showing intermediate silicate weathering of Pyawbwe Formation.

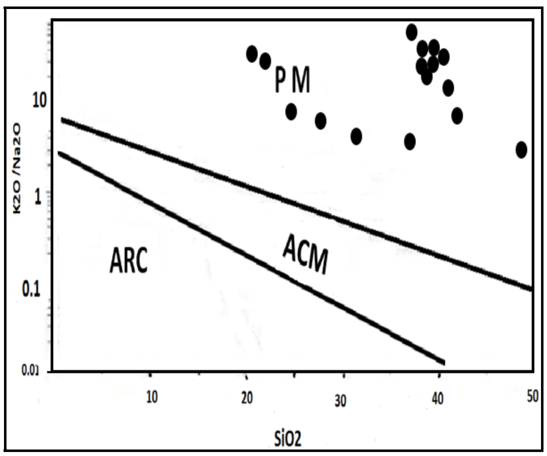

Figure 13. Tectonic Discrimination diagram. Boundaries after Roser and Korsch (1986). PM=Passive Margin. ACM=active continental margin. ARC=ARC=oceanic island arc margin.

Maturity and Tecto nics

Suttner & Dutta (1986) proposed a bivariate diagram to constrain the climatic conditions during the sedimentation of the siliciclastic rocks Plotting our data on that diagram (Fig. 11) indicates th at our shales were deposited under arid to semi-arid climate and may oxic co nditions (Jones & Manning, 1994). Average SiO_2/Al_2O_3 ratios in unaltered igneo us rocks range from ≈ 3.0 (basic rocks) to ≈5.0 (acidic rocks). Our data reached to 1.6 (i.e. < 5) indicating of progressive maturity (Roser *et al.*,1996) as siliciclastics of predominant shales and silts confirmed mature nature (Bahatia,1 983),where the samples are enriched in SiO2 but depleted in Na_2O,TiO_2, MnO, and CaO (except the sandsto ne samples) indicating fluctuating in f luvial luvial sediment input on passive margin . Increase of degree of chemical weathering may reflect the decrease in tectonic activity and / or change of climat e towards warm and humid cond itions (Jacobson *et al*., 2003). Figure (14) confirms that our data imply maturity low than thoseshales of UC (Upper Crust, after Taylor & McLennan, 1985) and NASC (average North American Shales, after Gromet *et al*., 1984).

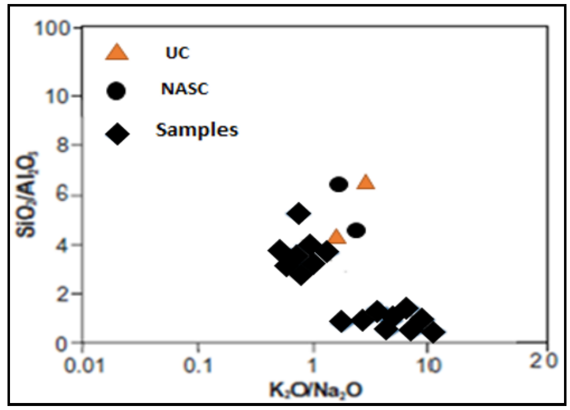

Figure 14. Bivariate diagram of the Pyawbweshales maturity degree compared with UC and NASC shales.

Provenance

On the major eleme nts and some trace elements – based discrimination function discussed before, indicated the sediments were derived weathered felsic –granitic –gneissic terrane (Laird, 1972). The type of source terrane as indicated have been located to the eastern and northeastern Myanmar where the Pre-Cambrian to the Paleozoic, intermediate to felsic igneous rocks of the Shan-Thai Block (Mitchell, 1993). A moderate range of weathering inferred in this study indicate the sourc e region was a moderate relief and tectonically calm terrane exposed to arid to semi-arid paleoclimate during weathering.

The weathered debris was transported by fluvial streams to alluvial fans tore deposited on passiv e marine margin with relatively s hallow fluctuated marine conditions (Fig. 15). On an unconformable Late Oligocene surface marking the top of the Okhmintaung Formation, the Pyaw bwe Formation was deposited in shallo w marine Central Burman Basin which was opened to present Gulf of Marta ban (Fig. 15) since Early Eocene times (Wandrey, 2006). The eastern portio n of the Central Burman Basin which is part of the Asian Plate was emergent during the Early Eocene (Wandrey, 2006, Searly *et al*., 2007, Lich *et al.*, 2014).This final interpretation is consistent with the another micropaleontological and paleoecological research on the same collected samples by the same present authors and also, in consistent with the regional geology of the study area and the basin config uration of the Central Myanmar Basin.

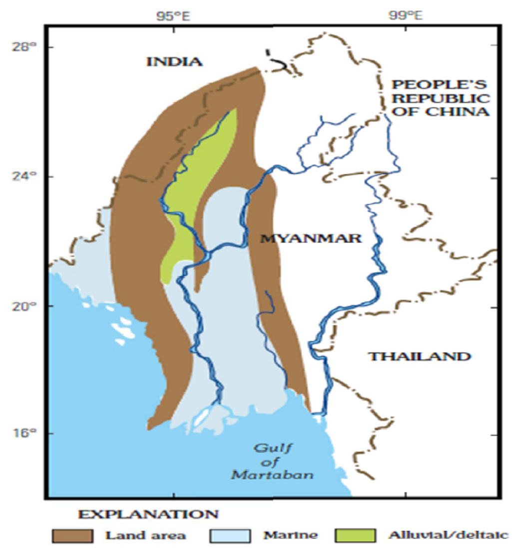

Figure 15. Generalized Early Miocene paleogeography (modified from Khin and Win, 1968)

Conclusion:

The exposed Early Miocene Pyawbwe Formation of Thayet S uddle, northern margin of Pyay sub-basin is an argillaceous unit, which is mainly composed of of thick clays and shales with sandstone interbeds. The clays and shales are fairly soft, bluish gray in colour and thin bedded, massive in the base of the formation. The interbedded sandstones are calcareo us, fairly hard, and thick bedded to massive, fine to medium grained, and gray in colour. Geochemically, the shales are smectite clay type rich in quartz grains and interbedded with silty arkosic sandstones. Major an d some trace elements, ratios andd digrams suggest that the source rocks are moderate relief of arc massif of fellsic igneous rocks exposed to moderately intensive chemical weatheringg. The weathered debris were transp orted by fluvial streams to alluvial fans as progressive maturity sediments and redeposited on passive shallow marine margin with fluctuating silty silty sandstone alluvial loads in arid to semi-arid paleoclimate.Such lithologies and indices suggest that the Shan-Thai block of the eastern and northeastern Myannmar continental region as the dominnant source trrane.

Acknowledgement

This paper has benefited from the detailed and constructive criticism offered by the reviewwers who preferred to remain anonymous. The present authors are indebted to Dr. Cho Cho Aye (Professor and Head of Geology Department, East Yangon University) for her kind permission to carry out this research. We most cardinal thanks are due to Dr. Chit Saing, Part-time Professor in Geology Department, University of Yangon, for his advices and guidance throughout the research. We would like to express our great thanks to Prof. Adel Akarish, Geology Depart., and Egyptian National Research Center for his reviewing the manuscript and valuable discussioons.

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