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TECTONIC SETTING AND PROVENANCES OF PANE CHAUNG FORMATION EXPOSED AT THE EASTERN PART OF INDO-MYANMAR RANGE, WEST MYANMAR

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Abstract

The Pane Chaung Formation exposes at the eastern part of the Indo-Myanmar Range. It overlies on the Kanpetlet Schist and underlies by ophiolites. The present study intends to petrography and whole rock geochemistry for tectonic and provenances of this formation. Thirty samples of sandstone were collected from Kalay-Tiddim Road, Webula Section and Gangaw Section along the eastern Indo-Myanmar Range that were made thin sections for petrographic study. Sixteen sandstones samples were collected for whole-rock major and minor oxide analyses. This formation consists predominantly of turbidite sandstones, graywacke, mudstone and shale. Graywacke, sandstone and shale interbedded units are dominant. The *Halobia* sp. is found at the Kalay-Tiddim Road that indicated the Triassic depositional age and deep water condition of salted Tethys Sea. The sandstones are composed of a detrital framework of angular to subangular, poorly sorted sand-sized grains associated with high matrix. The petrographic characters show the lithic wacke or greywacke. In the chemical composition, the SiO_2/Al_2O_3 ratio ranges from 1.97 – 7.943 and Al_2O_3/SiO_2 also ranges from 0.163-0.559. The Na_2O/K_2O ratio range from 1.01- 23.09 and K_2O/Na_2O range 0.228-2.619. The geochemical characters indicate that the sandstones are wacke to greywackes. These chemical data show the tectonic environment of active continental margin to oceanic island arc. Their source rocks indicated by chemical data are acid to basic igneous rocks. So, these turbidite sandstones may be deposited at trench near the collision-subduction boundary of southern Asian margin during the closing events of Meso-Tethys at Triassic Period.

Keywords: Pane Chaung Formation, Turbidite, *Halobia* sp., active continental margin, provenances

Introduction

The Pane Chaung Formation exposes at the eastern part of the Indo-Myanmar Range that separate the western trough and Indo-Myanmar Range (Fig.1). These Pane Chaung Formation and Kanpetlet Schist were assumed as continental fragments (Mitchell, 1993; Yao *et al*, 2017).

The Pane Chaung Formation was deposited over the southern margin of Southeast Asia during the Late Triassic that confirmed by Asian-affinity Cr-spinel and Permo-Triassic detrital zircon ages (Sevastjanova *et al*., 2015). On the other hand, Permian-Triassic zircons in its sandstones were derived from West Papua along the northern Australian shelf (Metcalfe, 1996; Cai *et al*., 2016). This formation deposited in Carnian-Norian derived from the multi-sources at the submarine fan along northern margin of Australia (Yao *et al*, 2017). Upper Triassic turbidites in Central Tethyan Himalaya, western Myanmar (Pane Chaung Formation) and Australia were sourced from India continent and Australia, respectively (Liu *et al*, 2020). In this study, petrographical and whole rock geochemical data from sandstones of Pane Chaung Formation were interpreted for tectonic setting, source rocks and provenance.

Regional Geologic Setting

Myanmar consists of the Eastern Highland, Central Basin, and Indo-Burman Ranges from east to west. The Eastern Highland or Shan Plateau is part of Sibumasu terrane (Metcalfe, 2011). This terrane consists of Precambrian to Late Mesozoic carbonate and clastic sedimentary rocks

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(Oo *et al*., 2002) At the Shan Scarp Zone, the Mogok metamorphic belt separates the Eastern Highland and Central low land Basin. Magmatic rocks were intruded in metamorphic rocks and sedimentary rocks that called Eastern Granitoid Belt. Sagaing Fault divides the Sebumasu from West Myanmar Block (Win Swe, 1980). The West Myanmar Block (West Burma) composes of Central Low Land and Indo-Myanmar Ranges (Fig. 1).

The Central Low Land was subdivided into three parts: (1) the central magmatic arc, (2) the western forearc basin, and (3) eastern backarc basin. Forearc strata exposed in the western basin consist of Late Cretaceous to Pliocene sediments (Khin and Myitta, 1990). Eastern backarc strata are Early Eocene to Pliocene. The central magmatic arc consists of Late Cretaceous tholeiitic to calc-alkaline rocks and Cenozoic potassic rocks (Bender, 1983), generated during subduction of oceanic lithosphere and upwelling of asthenospheric material, respectively.

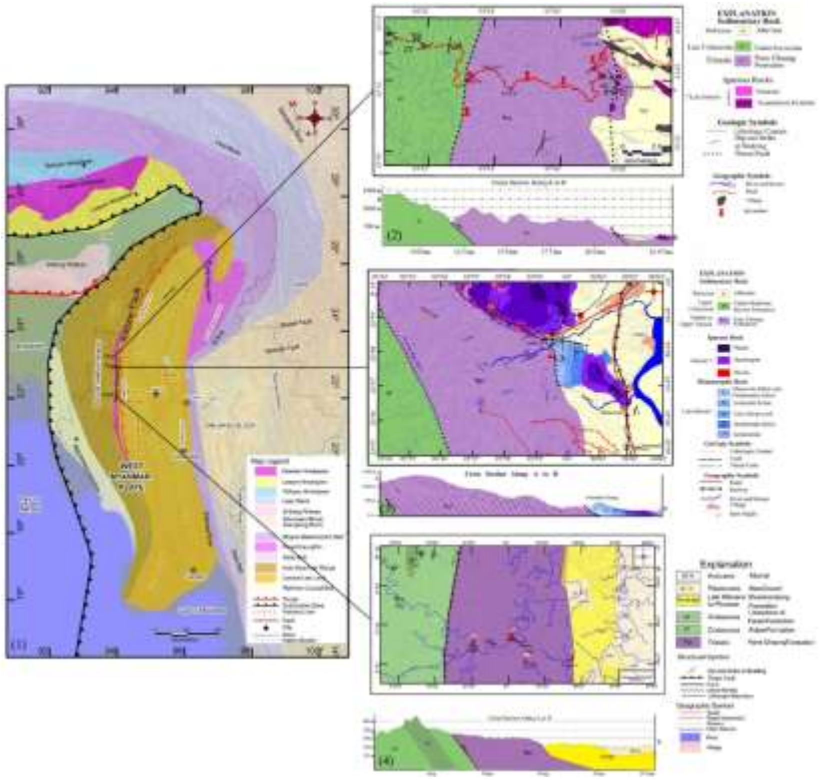


Figure 1 Regional geological map showing major terranes, terrane boundaries and geological units in Myanmar and eastern Himalayan regions (After Robinson *et al*. 2014)

Figure 2 Geological Map of Kalay-Tiddim Road Section

Figure 3 Geological Map of the Webula Area (After Tint Swe Myint, 2015)

Figure 4 Geological map of the Gangaw Area.

From east to west, the Indo-Burman Ranges include: (1) Cretaceous ophiolitic rocks, (2) the Triassic Pane Chaung Formation and Kanpetlet Schist, (3) Cretaceous Falam Formation, and (4) Cenozoic flysch and molasse (Bannert *et al*., 2011; Liu *et al*., 2016). The Pane Chaung Formation and Kanpetlet Schists flank at the eastern part of Indo-Myanmar Range (Fig. 1) and comprised turbidite sandstone and shale (Tint Swe Myint, 2015). Sandstone and shale contain Halobia fossils, indicating deposition in Late Triassic (Myint Lwin Thein, 1970, Bannert *et al*., 2011). Falam Formation consists of mudstone, turbiditic sandstones and limestone containing Late Cretaceous foraminifera (Bannert *et al*., 2011). Overlying Paleocene Chunsung Formation consist of mudstone, limestone with nammulites and minor sandstone with trace fossils (Tint Swe Myint, 2019). Atop this is the Kennedy Formation which contains phytodetritus fossils (Bannert *et al*., 2011).

Analytical Methods

Thirty samples of sandstone were collected and made thin sections for petrographic study. The petrographic texture, grain size, grain morphology were studied under microscope. Six samples from Kalay-Tiddim Road, five samples from Webula Section and another five from Gangaw Section were choose for whole-rock major and minor oxide analyses. Major and minor element oxides were measured by X-ray fluorescence spectrometry (XRF) at the laboratory of Defense Service and Technology Academy (DSTA) of Pyinoolwin, Mandalay University Research Center and Monywa University Research Centre. The major and minor oxides were used to classify the sandstone and to define the tectonic setting and provenance.

Results

Stratigraphy and Lithology

The Pane Chaung Formation exposes along the Panmon chaung and Zi chaung in Webula Section (Fig. 2), Kalay- Tiddim Road (Fig. 3) and Gangaw Area (Fig. 4). This formation consists predominantly of monotonous succession of turbidite sandstone and graywacke, mudstone and shale. The graywackes are fine- to medium-grained, hard and compact, light gray color when fresh and buff color when weathered.

Sandstones are commonly massive or weakly graded beds up to 2 m thick. They are mostly medium to thick bedded, many crossed quartz veins (Fig. 5a), highly jointed and intercalated with mudstones and shale. Minor fold and contorted fold are well dominant. Graywacke, sandstone and shale interbedded units (Fig. 5.b) are exposed 1.5 km west of Panmon village in Webula Section. The shales are dark grey to black, compact, well laminated and highly deformed feature (Fig. 5c). Medium- bedded sandstone outcrop is found along the road section (Fig. 5d). Buff colour sandstone and shale interbedded unit dominant (Fig. 5e). The beds are steeply dipping. This formation overlies the Kanpetlet metamorphics and underlies the Ophiolitic rocks and Falam Formation. According to the load cast on the bedding planes (Fig. 5f), the beds may be overturned beds. The trace fossils found in sandstone near Yazagyo (Fig. 5g). The Halobia fossils are found at the Kalay-Tiddim Road (Fig. 5h) that proved the Triassic depositional age.

Petrography

The sandstones of the Pane Chaung Formation are composed of a detrital framework of angular to subangular sand-sized grains associated with chemical cement and matrix (Fig. 6). The framework made up of grains supported 55 to 65 % of the rock, made up of quartz, feldspar, micas, rock fragments and other heavy minerals. The average grain size varies from 0.03 mm to 0.2 mm in diameter. They have poor sorting. Quartz grains are found as sub-angular to sub-rounded, grain size range from 0.05 to 0.25 mm and poor sorting. It is the most common mineral and composed of 30 – 50 percent of the total detrital grains (Figs. 6a, b & c). They are coated by iron oxide in some grains. Feldspar comprises 10 to 24 percent of the detrital sediment. They are plagioclase feldspar and a few orthoclase. Their sizes are less than 0.04 mm, sub-angular to sub-rounded and poor sorting. Plagioclase feldspar shows polysynthetic twin, albite twin and the other are untwined feldspar (Figs. 6a, b, c & d). Muscovite comprises about 2 to 4 percent of the total detrital grains. It can be found as green colour as euhedral flake.

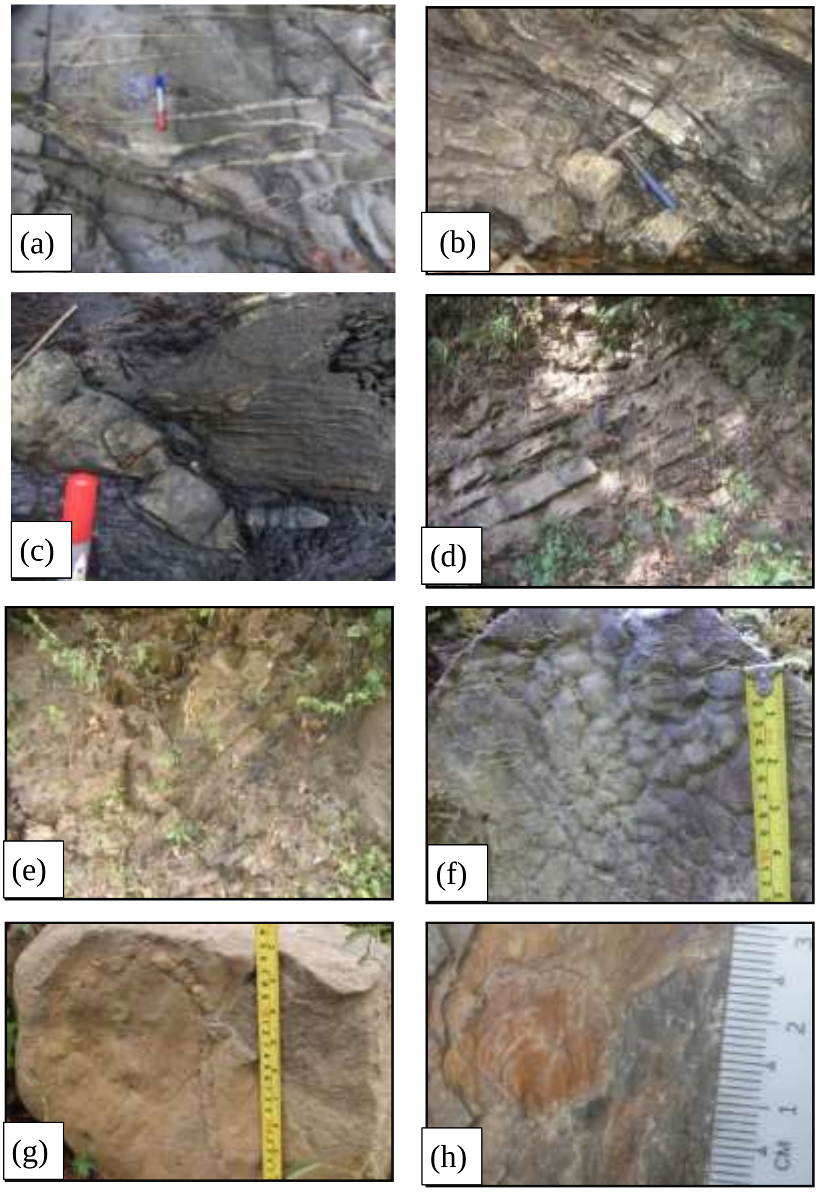


Figure 5 Field photographs of the Pane Chaung Formation. (a) Quartz vein cross-cutting in sandstone, (b) sandstone and shale interbedded deformed beds, (c) ollistromal black shale, (d) medium-bedded sandstone, (e) buff colour sandstone and shale interbedded unit, (f) load cast, (g) trace fossil in sandstone and (h) Halobia fossil in black shale

Approximately 1 to 2 percent of the detrital fraction is made up of heavy minerals, mostly zircon, apatite and other opaque minerals. Quartzite, chert, phyllite, schist, slate and volcanic fragments constitute 25 to 46 percent of the detrital framework. Quartzite, chert and volcanic fragments are more abundant. The matrix constitutes approximately 30%. These petrographic characters show the sandstone of lithic wacke or greywacke (Fig. 3).

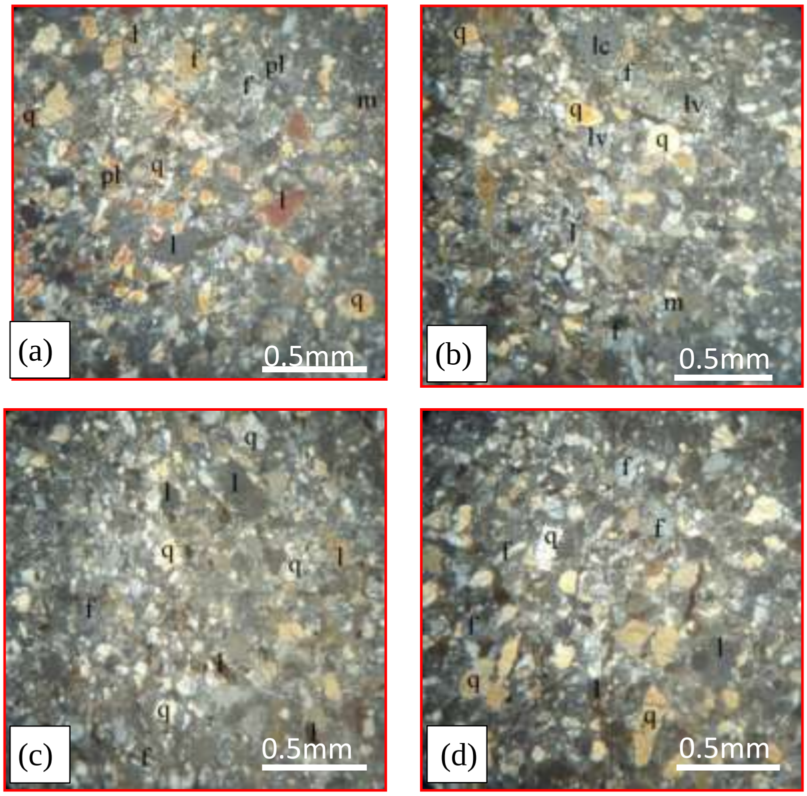


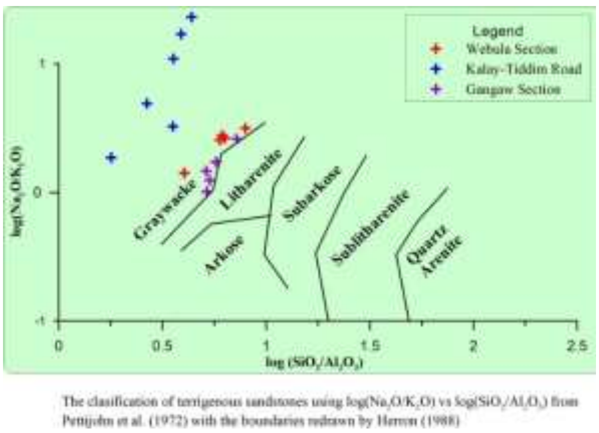
Figure 6 Petrography of sandstones (a) irregular crack in angular fragment of quartz, feldspar, (b) mica, volcanic & chart fragments, (c) poorly sorted and (d) angular fragment of quartz

Whole-rock geochemistry

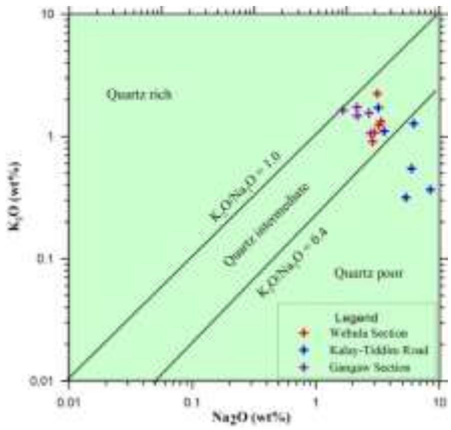
Sixteen sandstone samples were collected from three different localities and analyzed by XRF for whole rock geochemical data. The chemical compositions of these sandstones are shown in Table (1). The SiO_2/Al_2O_3 (1.97 – 7.943), Al_2O_3/SiO_2 (0.163-0.559), Na_2O/K_2O (1.01- 23.09) and K_2O/Na_2O (0.228-2.619) values keys for classification and tectonic setting, respectively. The log (SiO_2/Al_2O_3) vs. log (Na_2O/K_2O) (Roser & Korsch 1986) diagram show geywackes (Fig. 7a). In the Na_2O vs K_2O variation diagram, their compositions are fairly high, the study samples fall in the quartz intermediate to quartz poor region (Fig. 7b). The SiO_2/Al_2O_3 vs. Na_2O/K_2O diagram expresses quartz-rich greywacke to greywacke type (Fig. 8). In this diagram, Na_2O/K_2O values are fairly low and range in wacke-greywacke field. Therefore, sandstones of the Pane Chaung Formation are graywacke or wackestone.

Table 1 Whole rock geochemical data of the sandstone samples

Area	Webula Section					Kalay-Tiddim Road						Gangaw Section				
Sp.No.	**1**	**10**	**14**	**107**	**128**	**1**	**2**	**14**	**51**	**52**	**98**	**5**	**6**	**10**	**13**	**15**
Na_2O	3.37	3.25	3.15	2.98	2.88	3.58	5.96	5.37	6.23	8.45	3.2	2.69	2.17	2.16	1.66	2.78
MgO	1.60	2.32	1.15	0.80	0.69	1.58	3.8	4.36	1.58	0.97	3.18	0.80	1.28	0.78	1.41	0.86
Al_2O_3	12.2	11.5	17.5	12.0	10.1	18.4	18.9	17.2	24.1	16.4	31.5	13.0	13.3	13.6	13.6	10.7
SiO_2	72.9	72.6	70.6	73.7	80.2	65.3	67.6	66.9	64.2	71.8	56.4	74.6	69.5	72.9	70.7	76.8
P_2O_5	0.12	0.25	0.10	0.13	0.09	0.11	0.09	0.13	0.13	0.15	0.17	0.17	0.21	0.16	0.15	0.18
K_2O	1.32	1.23	2.23	1.07	0.91	1.1	0.54	0.32	0.27	0.37	0.72	1.56	1.48	1.73	1.64	1.06
CaO	2.53	1.25	0.20	0.14	1.39	6.95	0.58	2.88	0.17	0.11	0.17	2.06	3.04	3.24	1.49	2.88
TiO_2	0.47	0.45	0.53	0.61	0.40	0.28	0.14	0.23	0.33	0.22	0.50	0.58	0.44	0.54	0.47	0.42
MnO	0.14	0.12	0.00	0.02	0.04	0.13	0.05	0.06	0.0	0.02	0.04	0.08	0.19	0.05	0.21	0.13
Cr_2O_3	0.03	0.00	0.02	0.00	0.04	0.02	0.02	0.05	0.0	0.0	0.03	0.01	0.02	0.02	0.01	0.01
Fe_2O_3	1.13	1.03	1.16	1.17	1.04	0.77	0.76	0.7	0.61	0.48	0.99	0.98	2.23	1.12	2.38	1.01
FeO	2.37	2.17	2.43	2.46	2.18	1.61	1.6	1.47	1.3	1.0	2.07	2.05	4.69	2.36	7.15	3.04
CoO	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NiO	0.00	0.02	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SO_3	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SrO	0.01	0.01	0.01	0.01	0.01	0.05	0.00	0.01	0.01	0.00	0.01	0.01	0.02	0.01	0.02	0.02
ZrO_2	0.04	0.04	0.03	0.08	0.05	0.02	0.01	0.02	0.03	0.02	0.01	0.05	0.03	0.05	0.03	0.04
Rb_2O	0.01	0.01	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.02
Total	**98.2**	**96.2**	**99.1**	**95.0**	**99.9**	**99.9**	**100**	**99.7**	**98.9**	**99.9**	**98.9**	**98.7**	**98.6**	**98.7**	**100.9**	**99.9**



(a)



(b)

Figure 7 Classification diagram of terrigenous sandstones using log (Na_2O/K_2O) vs. log (SiO_2/Al_2O_3) form Pettijohn *et al* (1975) with the boundaries that show the greywacke type of Pane Chaung Formation sandstone. (b) Na_2O vs. K_2O diagram for determination of quartz dominant sandstone that show quartz intermediate sandstone of Pane Chaung Formation

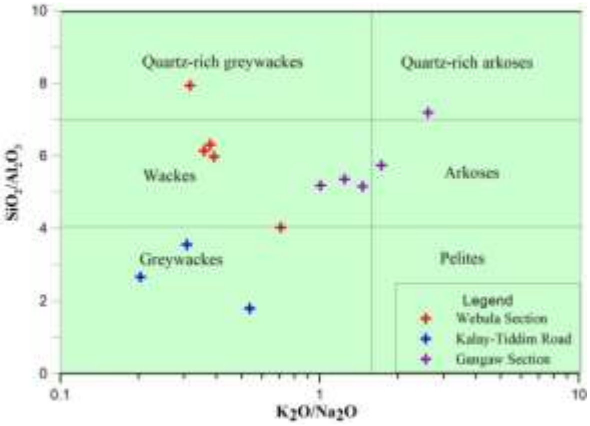


Figure 8 K_2O/Na_2O vs SiO_2/Al_2O_3 scatter diagram of sandstone (after Pettijohn, 1975). Most of the studied samples fall in the wacke-greywacke fields.

Discussion

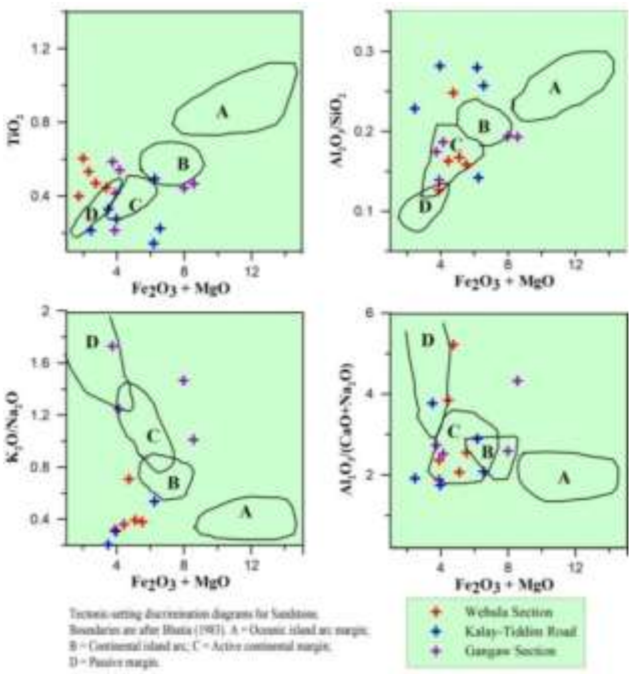
Tectonic Setting

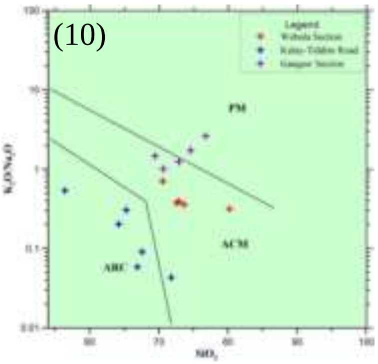
Sandstone samples were plotted on the Fe_2O_3+MgO vs TiO_2, Al_2O_3/SiO_2, K_2O/Na_2O and $Al_2O_3/(CaO+Na_2O)$ diagrams (Fig. 9). The studied samples fall around the passive margin and active continental margin fields. In the SiO_2 vs K_2O/Na_2O diagram, most of the sandstone samples of the study area fall in the active continental margin and island arc (Fig. 10). In Na_2O/K_2O vs SiO_2/Al_2O_3 diagram, all Webula sandstones fall in active continental margin and two samples of Gangaw Section and one of Kalay-Tiddim Road are fall (Fig. 11). Sp. No. 5 & 15 of Gangaw sandstones are high SiO_2 and fall in the passive margin. The rest samples fall in active continental margin and island arc.

Provenances

The Pane Chaung Formation sandstones have uniform K/Rb ratios that lie close to a typical differentiated magmatic suite or main trend with a ratio of 230 (Fig. 12) (Shaw, 1968). So, Pane Chaung Formation sandstones are more similar to values of sediments derived from felsic-intermediate source rocks to basic igneous rocks.

Major oxides data of sandstones fall in the field of felsic igneous provenance, intermediate igneous provenance to basic igneous provenance. Only one sample form Webula Section fall in quartzose sedimentary provenance. In the second diagram, the study sandstone samples fall in the intermediate to basic igneous provenances. The halobia-daonella fossils evidence in black shale indicates the salt water condition of Tethys Sea. Moreover, the maximum age was assigned as Late Triassic from these fossil evidences. Therefore, the sandstones of Pane Chaung Formation deposited under the marine condition when tectonic setting was active continental margin. Base on abundant of Permian-Triassic zircons, the Pane Chaung are most probably derived from the SE Asia tin belt granitoids (Sevastjanova *et al*., 2015). The Triassic turbidite possibly Pane Chaung Formation was deposited on the southern margin of Asia, which was identified with the Shan-Thai foreland (Mitchell, 1993).





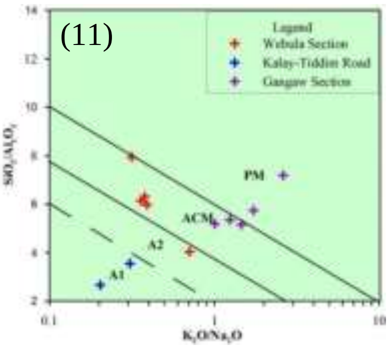
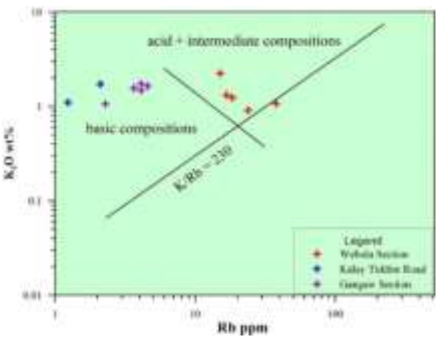


Figure 9 Sandstones of the studied samples plotted in tectonic discrimination diagram for sandstones base upon Fe_2O_3+MgO vs TiO_2, Al_2O_3/SiO_2, K_2O/Na_2O and Al_2O_3/(CaO+Na_2O) diagrams, boundaries after Bhatia (1983)

Figure 10 Tectonic setting of the sandstone of the Pane Chaung Formation

Figure11 K_2O/Na_2O vs SiO_2/Al_2O_3 diagram of Roser and Korsch (1986)

PM, passive continental margin; ACM, active continental margin, ARC, island arc



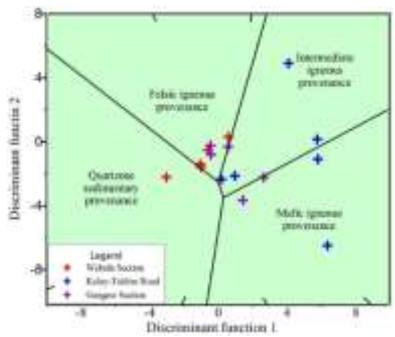


Figure 12 K_2O and Rb content in the Pane Chaung Formation sandstones indicate acid + inermeciate composition (main trend of Shaw, 1968).

Figure 13 Studied sandstones were plotted on the discriminant function diagram (Roser and Korsch, 1988) sandstone-mudstone suites for provenance using discriminant function 1 and 2

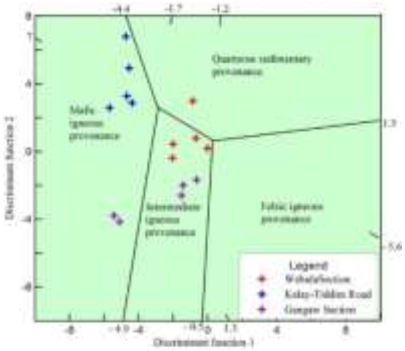


Figure 14 Provenance determination plot of discriminant functions F1 and F2 for the sandstones from the Pane Chaung Formation. Fields are after Roser and Korsch (1988)

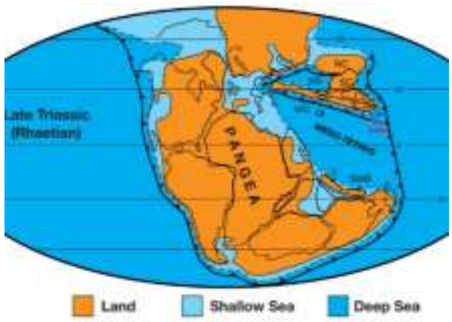


Figure 15 Paleogeographic reconstructions of the Tethyan region for the Late Triassic West Burma showing relative position of the East and SE Asian terranes, land and sea. (After Metcalfe, 2011)

SE Asia was built largely from continental fragments that separated from Gondwana and have amalgamated from the Paleozoic onwards (Fig. 15). The West Sumatra, East Malaya, Indochina and West Burma blocks rifted and separated from Gondwana opening the Paleo-Tethys in the Devonian and formed a composite terrane 'Cathaysialand' (Metcalfe, 2011). It was supported with the occurrence of Permian fusulinids Cathaysian type from Karmine in the northern part of the West Burma Block (Thura Oo, 2002).

Conclusions

South East Asia is composed of continental fragments derived from the Gondwana super-continent by rifting during Paleozoic and Mesozoic. The present studies of lithology, petrography and whole-rock geochemical data indicate the following points:

1. Petrographically, sandstones contain poorly sorted, angular to subangular, low sphericity more poly quartz, lass amount of feldspar and abundant of lithic fragment. The matrix contents are range in wacke composition.
2. The geochemical data indicates active continental margin, continental arc to island arc. The provenances study indicates the source of acid to basic igneous provenances.
3. The halobia-daonella species in black shales deposited at deep water condition of salt Tethyan Sea. The turbidity currents cannot carry the low sphericity and high matrix sediment for long distances. So, these turbidite sandstones may be deposited at trench near the collision-subduction boundary of southern Asian margin during the closing events of Meso-Tethys at Triassic Period.

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