J. Myanmar Acad. Arts Sci. 2021 **Vol. XIX. No.5A**

GEOCHEMICAL ANALYSIS OF SANDSTONE OF PAUNGGYI FORMATION IN THE AKYIBAN AREA, TILIN TOWNSHIP, MAGWAY REGION

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Abstract

The present study mainly focuses on the Geochemistry of Clastic sedimentary rock mainly on the sandstones of Paleocene. Paunggyi Formation exposed in the northernmost part of the Minbu Basin, Tilin, Magway region. The study attempts to constrain their source rocks, palaeo-weathering and tectonic setting of the provenance. The study area mainly consists of Tertiary Clastic Sedimentary rocks. Selected samples from the research area were analyzed using X-ray Fluoresence (XRF) for major oxides and some trace elements to know the chemical composition of sandstone and to classify the sandstone. Lithologically, the Paunggyi Formation is mainly composed of buff to grey, medium bedded sandstone, compact to friable thick bedded to massive gritty sandstone and conglomerate. By the XRF analysis, sandstones of the Paunggyi Formation fell within the litharenite zone. The analysis also points out that most of the sandstones are Fe-sand composition. By the discriminant diagram the Paunggyi sandstones samples indicating the mafic igneous and intermediate igneous provenances. Moreover, sandstones of the Paunggyi Formation were deposited in the active continental margin shifted to the downward of the oceanic island arc field. Additionally, the average CIA and CIW values of Paunggyi sandstones indicate very low degree of chemical weathering might have taken place in the source area.

Keywords: Litharenite, Mafic igneous provenance, Active continental margin

Introduction

The research area, northernmost part of the Minbu Basin, is located at 16 km east of Tilin, Magwe region. It lies between latitudes 21˚ 36′ N and 21˚ 44′ N and longitudes 94˚ 09′ E and 94˚ 17′ E in UTM-No 2194-02 and 2194-06. The location map of the study area is shown in figure (1). Tilin is easily accessible from Pakokku by car. The western part of the study area can be easily accessible by car from Pakokku to Tilin throughout the year but the eastern part of the study area is less accessible in rainy reason.

The research area is a mountainous and forested region and the ranges are running north-south direction. Because of the sandstone dominant and shale dominant formation, this area shows ridge and valley topography. The whole area is occupied by thick soil cover and cultivation is good. The study area is swampy during rainy season. It lies between Pondaung range and the eastern flank of the Chin hill. Three dimensional map of the study area is shown in figure (2).

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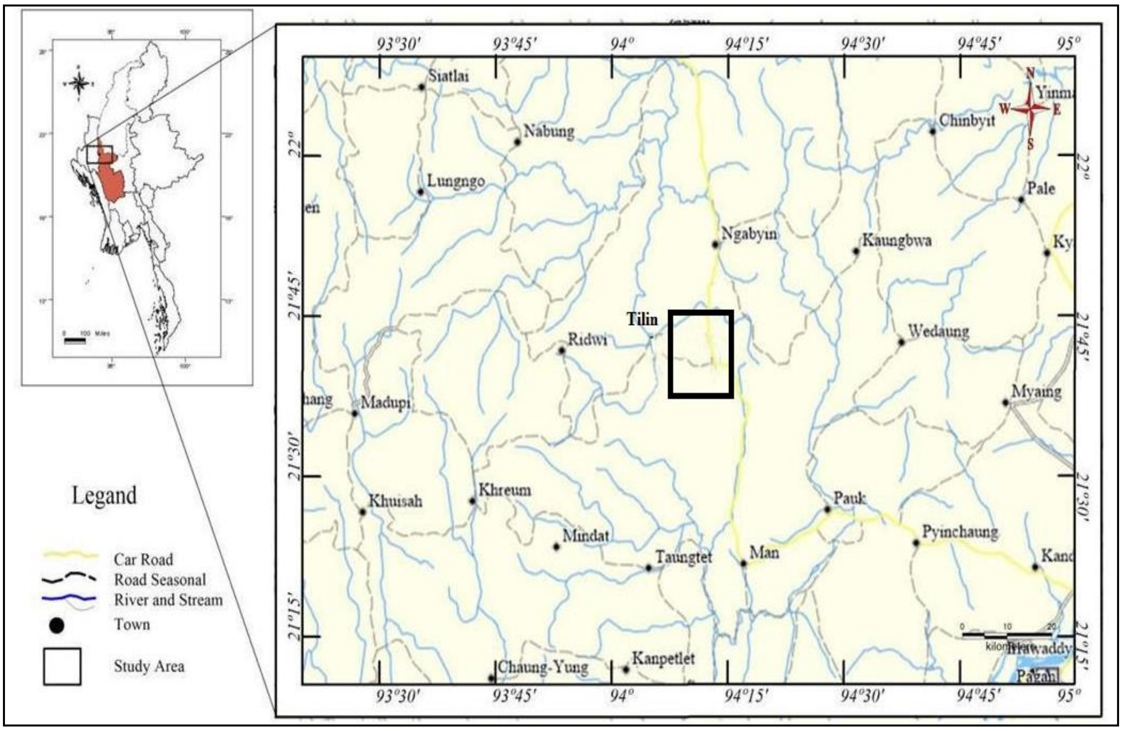

Figure 1 Location map of the study Area

Methodology

The X-ray Fluoresence (XRF) analysis conducted to know the chemical composition of sandstone and to classify the sandstone. The samples collected in the field were performed chemical analysis as X-ray Fluoresence. This method is most widely used analysis techniques in the application of quantitative major element analysis, minor and trace element analysis (Hutchison, 1974). Selected samples from the research area were analyzed using X-ray Fluoresence (XRF) for major oxides and some trace elements. In this research, X-ray Fluoresence (XRF) analyses were be done to interpret the chemical classification and weathering of the clastic sediments.

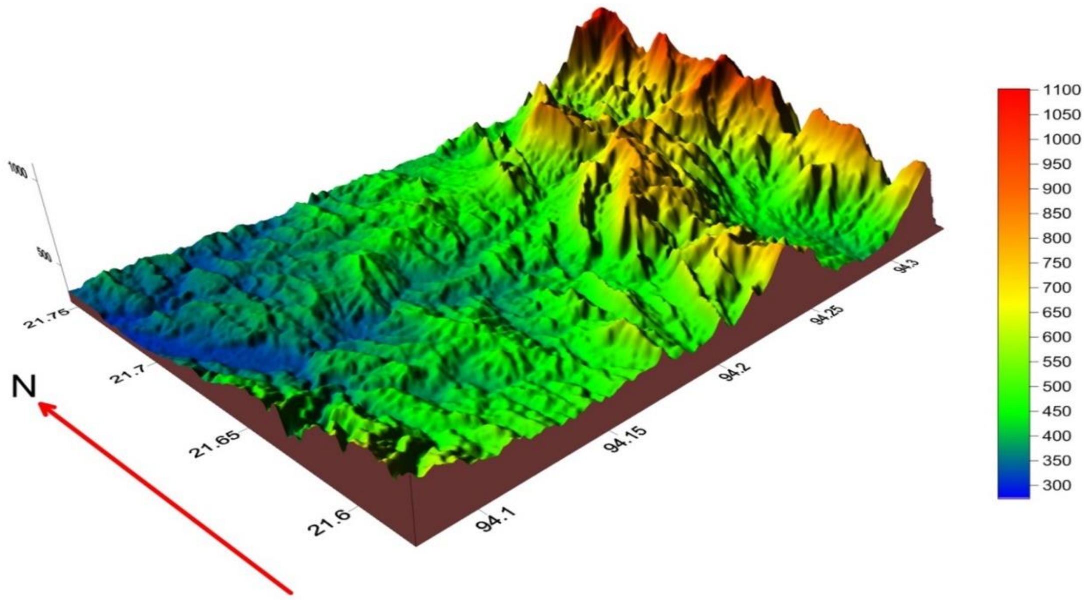

Figure 2 3D Map of the Ale ban Area, Tilin Township

Geochemical Analysis of Sandstone

Geochemical data are useful in the analysis of provenance studies, tectonic setting of basin, weathering, transport and erosion of sediments, depositional and diagnetic processes (Rollison, 1993). In geochemical analysis, the mineralogical and chemical composition of clastic sedimentary rocks are controlled by various factors, including (1) the composition of their source rocks, (2) environmental parameters influencing the weathering of source rocks (e.g., temperature, rainfall and topography), (3) duration of weathering, (4) transportation mechanism of clastic material from source region to depocenter, (5) depositional environment and (6) post-depositional processes (e.g., diagenesis and metamorphism).

The present study examines the geochemistry of sandstones including Paunggyi Formations attempts to constrain their source rocks, palaeoweathering and tectonic setting of the provenance. Owing to limitations of analytical facilities, the present work is based on chemical analyses data of major elements of the investigated sandstones of the study area. The geochemical composition (Wt %) of Paunggyi sandstones are shown in the Table (1).

Table 1 Chemical Composition of Paunggyi Sandstone

Element	Pg-1	Pg-70	Pg-91	Pg-140	Pg-152	Pg-170	Pg-183	Pg-195	Pg-234	Pg-227	Pg-70
SiO_2	36.83	55.63	51.46	52.33	54.28	53.3	44.97	35.76	41.43	38.51	55.63
Al_2O_3	10.63	14.78	12.57	12.41	14.64	15.56	12.11	10.03	9.024	11.82	14.78
Fe_2O_3	4.378	5.692	2.647	3.312	6.375	8.369	3.301	6.432	3.279	3.979	5.692
Na_2O	2.07	2.98	2.77	2.72	2.87	2.86	2.1	1.37	1.64	2.32	2.98
K_2O	1.01	0.815	1.54	1.26	1.02	0.859	1.31	1.01	1.03	0.831	0.815
SO_3	0.05	0.048	0.048	0.043	0.041	0.039	0.053	0.053	0.065	0.0647	0.048
TiO_2	0.547	0.723	0.412	0.606	0.701	0.922	0.797	0.633	0.489	0.987	0.723
CaO	18	0.833	10.28	8.139	3.482	1.11	14.67	18.27	14.84	17.23	0.833
MnO	0.632	0.0446	0.194	0.266	0.11	0.148	0.359	0.324	0.295	0.532	0.0446
Cr_2O_3	0.023	0.0341	0.0264	0.021	0.0391	0.0439	0.0547	0.026	0.023	0.031	0.0341
SrO	0.0466	0.0084	0.0335	0.0351	0.0263	0.0092	0.043	0.0486	0.0536	0.0403	0.0084
P_2O_5	0.0873	0.073	0.062	0.065	0.0106	0.056	0.0756	0.131	0.047	0.129	0.073
ZrO2	0.013	0.0143	0.0107	0.0133	0.016	0.0205	0.0125	0.015	0.009	0.0139	0.0143
CuO	0	0	0	0	0	0	0	0	0	0	0
Rb_2O	0	0	0.003	0	0	0	0	0	0	0	0
ZnO	0.0106	0.0085	0.007	0.0092	0.0129	0.0111	0.0095	0.0117	0.0089	0.0127	0.0085
NiO	0	0	0	0	0.008	0.007	0	0	0	0	0
FeO	0	0	0	0	0	0	0	0	0	0	0
MgO	0.817	1.23	0.543	0.527	1.04	1.38	0.026	0.745	0.597	0.705	1.23

Geochemical classification of sandstones

The composition of sandstone can be got from XRF analysis. To conduct XRF analysis, 10 sandstone samples were taken from the selected layer of sandstones from Paungyi Formation.

Sandstones are classified and named variously based on their chemical composition. In the present study, sandstones were classified according to the scheme proposed by Pettijohn *et al*. (1972) and Herron (1988). Although Pettijohn et al. (1972) classified the sandstones based on the bivarious log (Na_2O/K_2O) versus log (SiO_2/Al_2O_3) diagram. Herron (1988) proposed the bivariate log (Fe_2O_3/K_2O) versus log (SiO_2/Al_2O_3) diagram. Herron also examined the importance of the major oxide variables and classified the clastic rocks mainly as Fe-sands with little portions on the wacke zone. The results of log ratio are plotted on the diagrams of sandstone classification. The geochemical classification diagrams of Pettijohn et al., (1972) (figure-3) pointed that Paunggyi sandstones fell within the litharenite zone. However five samples of Paunggyi sandstone are greywacke. Herron (1988) also pointed out Paunggyi sandstones are Fe-sand except four samples of sandstone (figure 4).

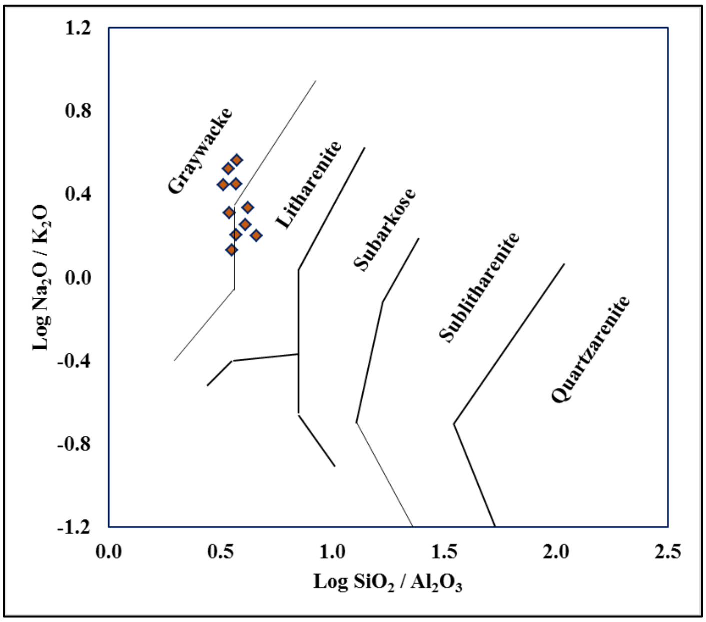

Figure 3 Chemical classification diagram of Pettijohn *et al*. (1972) of Paunggyi sandstones

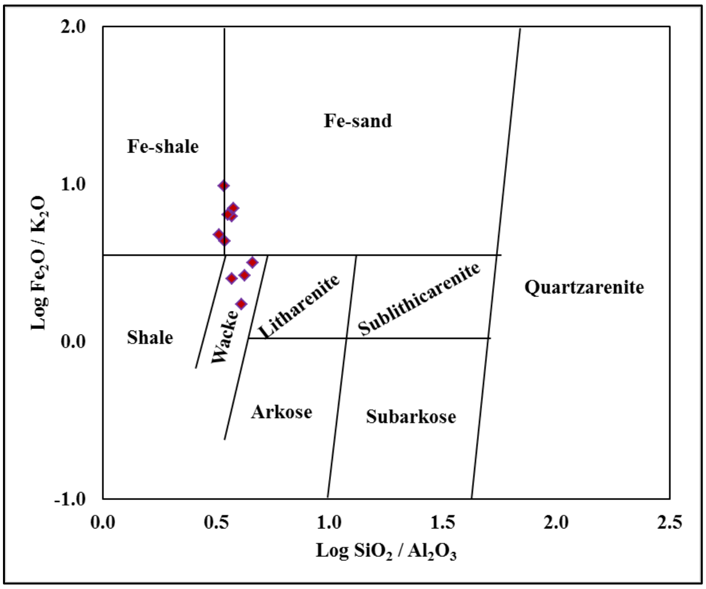

Figure 4 Chemical classification diagram of Herron (1988) of Paunggyi sandstones

Source rock lithology and tectonic provenance

In the published literature several major-, trace-, rare-earth element-based discrimination diagram are proposed to decipher the source rock of the siliciclastic sedimentary rocks (eg., Taylor and MclLennan, 1985; Roser and Korsch, 1988; McLennan *et al*., 1993; Condie, 1993; Gu *et al*., 2002; Cingolani *et al*., 2003). In order to use major element of provenance interpretations we considered the discriminant functions of Roser and Korsch (1988), which use Al_2O_3, TiO_2, Fe_2O_3, MgO, Cao, Na_2O and K_2O contents as variables. In the discriminant diagram (figure-5), the Paunggyi sandstones samples plot in the field of mafic igneous and intermediate igneous provenances. The Al_2O_3 and TiO_2 contents of the siliciclastic sedimentary rocks are considered as significant indicators of their provenance. During weathering of source rocks, Al and Ti remain essentially immobile, owing to solubility of their oxides and hydroxides in low temperature aqueous solutions (e.g., Stumm and Morgan, 1981; Yamamoto et al., 1986; Sugitani et al., 1996). It is well known that in normal igneous rocks Al resides mostly in feldspars and Ti in mafic minerals (e.g., olivine, pyroxene, hornblende, biotite, ilmenite).

According to the petrographically, the sandstone of this area comprises various lithic fragments such as quartz and volcanic rock fragments which are relatively abundant in Paunggyi sandstone (figure- 6 and 7).

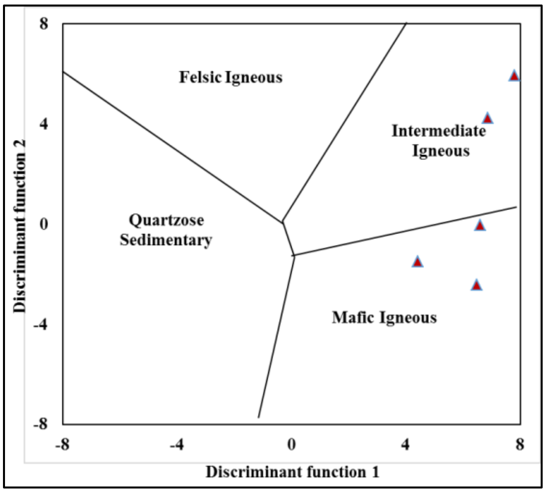

Figure 5 Discriminant function diagram for the provenance signation of the Paunggyi sandstones using major elements, Roser and Korsch (1988)

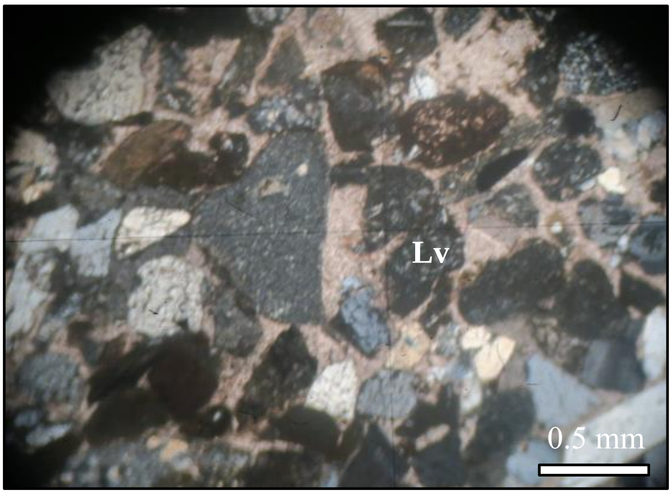

Figure 6 Volcanic rock fragment and frame work grain cemented with calcite cement and later fill iron cement in the Paunggyi Sandstone under X.N

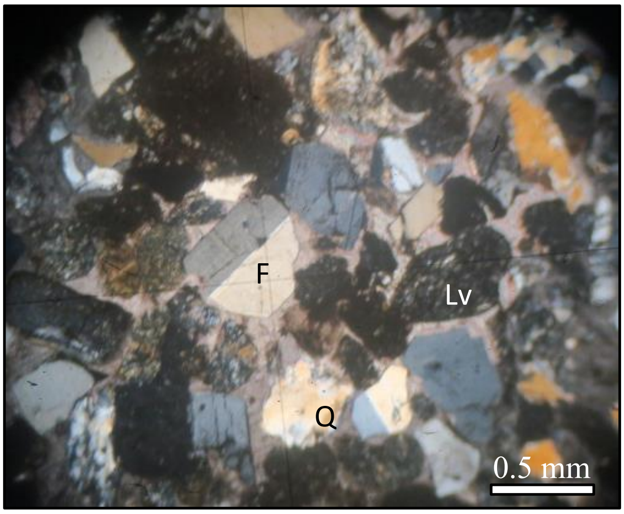

Figure 7 Photomicrograph showing monocrystalline quartz (Qm), feldspar (F), volcanic fragment in the Paunggyi sandstone under X.N

Several studies have shown that the chemical composition of siliciclastic sedimentary rocks are significantly controlled by plate tectonic settings of their provenances and depositional basins, and as a result, the siliciclastic rocks from different tectonic settings possess terrain-specific geochemical signatures (Bhatia, 1983; Bhatia and Crook, 1986; Roser and Korsch, 1986). Among the various tectonic setting discrimination diagrams, the major element-based discrimination diagrams of Bhatia (1983) and Roser and Korcsh (1986) are widely used. In the discrimination diagram of Bhatia (1983) and Roser and Korsch (1986) the bivariates, including discriminant functions, are based on immobile and variable mobile major elements, including Na_2O and K_2O.

In the present study, the discrimination diagrams proposed by Bhatia (1983) used to discuss the tectonic setting by the major element geochemistry of sandstone samples. The Paunggyi sandstones were deposited in the active continental margin (figure 8c). However, in the diagrams of Bhatia 1983 (figure 8a and b), some of the Paunggyi sandstones are shifted to the downward of the oceanic island arc field because of TiO_2 composition is low.

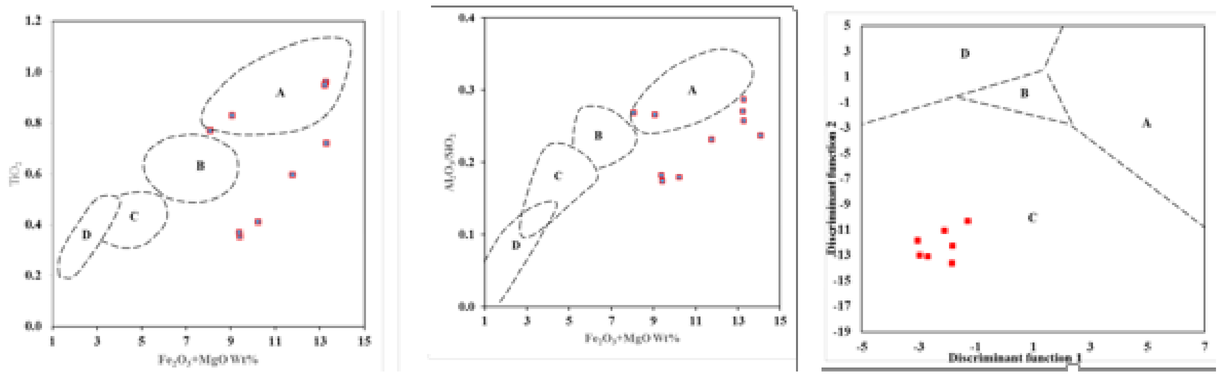

Figure 8 Plot of the major element composition of the Paunggyi sandstone on the tectonic setting discrimination diagrams of Bhatia (1983). a: Fe_2O_3+ MgO vs TiO_2; b: Fe_2O_3+MgO vs Al_2O_3/SiO_2; c: discrimination diagram. A: Oceanic island are, B: Continental island arc, C: Active continental margin, D: Passive margin.

Geochemical weathering of source area

Intensity of chemical weathering of source rocks is controlled mainly by source rock composition, duration of weathering, climatic and rates of tectonic uplift of source region. About 75% of the labile materials of the upper crust is composed of feldspars and volcanic glass and chemical weathering of these materials ultimately results in the formation of clay minerals (e.g., Nesbitt and Young, 1982, 1989; Taylor and McLennan, 1985). During chemical weathering Ca, Na and K are largely removed from source rocks.

The degree of source rock weathering is quantified variously. A few indices of weathering have been proposed based on molecular proportion of mobiles and immobiles element oxides (Na_2O, CaO, K_2O and Al_2O_3). Among the known indics of weathering/alteration the Chemical index of Alteration (CIA; Nesbitt and Young, 1982) is well established as a method of quantifying the degree of source weathering. Source weathering and elemental redistribution during diagenesis also can be assessed using Chemical Index of weathering (CIW; Harnois, 1988). The weathering effects can be evaluate in terms of the molecular percentage of the oxide components, using the formulae of chemical index of weathering (CIW= [Al_2O_3/ Al_2O_3+ CaO + Na_2O] x 100); (Harois, 1988) and chemical index of alteration (CIA= [Al_2O_3/ Al_2O_3+ CaO + Na_2O + K_2O] x 100); (Nesbitt and Young, 1982). The CIA and CIW are interpreted in similar way with values of 50 for unweathering upper continental crust and roughly 100 for highly weathered materials, with complete removal of alkali and alkaline-earth elements (McLennan, 1993). Low CIA values (i.e. 50 or less) also might reflect cool and/or arid conditions (Fedo *et al*, 1995).

According to CIA values, the Paunggyi sandstone of the degree of source weathering varies from 34 to 79% (average= 47%). CIW values suggest the degree of source weathering in the range from 23 to 82% (average= 52%). Average CIA and CIW values indicate very low degree of source weathering.

Mobility of elements during the progress of chemical weathering of source material and post-depositional chemical modifications of the sandstones can be evaluated by plotting the molar proportions of Al_2O_3, Na_2O+ CaO and K_2O in A-CN-K ternary disgram (Nesbitt and Young, 1982). Weathering trends might be predicated to be parallel to the A-CN join towards the composition of Al_2O_3 and Na and Ca are removed by chemical weathering of plagioclase feldspars. The average values of Paunggyi sandstones indicate extreme degree of chemical weathering (figure-9)

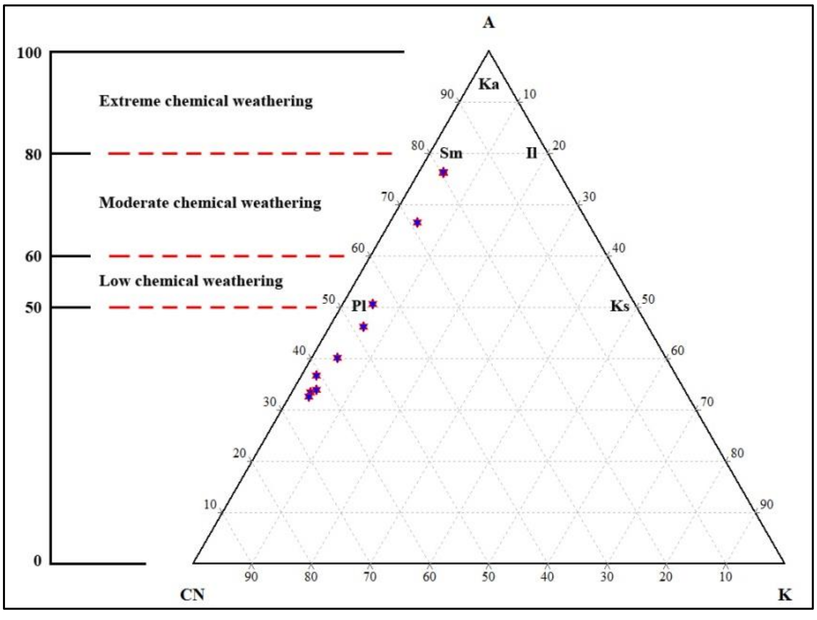

Figure 9 A-CN-K ternary Paunggyi sandstone of weathering diagram A= Al_2O_3; CN= ($CaO+Na_2O$); K=K_2O (Nesbitt and Young, 1982)

Conclusion

The research area, northernmost part of the Minbu Basin, is located at 16 km east of Tilin, Magwe region. It lies between latitudes 21˚ 36′ N and 21˚ 44′ N and longitudes 94˚ 09′ E and 94˚ 17′ E in UTM-No 2194-02 and 2194-06. The present study examines the geochemistry of sandstones including Paunggyi formations attempts to constrain their source rocks, palaeoweathering and tectonic setting of the provenance. Paunggyi sandstones fell within the litharenite zone. However five sample of Paunggyi sandstone is greywacke. The Paunggyi sandstone samples plot in the field of mafic igneous and intermediate igneous provenances. The Paunggyi sandstones were deposited in the active continental margin. The average CIA and CIW values of Paunggyi sandstones indicate very low degree of chemical weathering.

Acknowledgement

We would like to express our gratitude to Dr Kyi Kyi Swe, Professor and Head, Pyay University, for her permission and departmental facilitates and Dr Thida Oo, Professor, Department of Geology, Pyay University. we are greatly thankful to Dr Day Wa Aung, Professor and Head, University of Yangon, for his guidance and invaluable suggestions. Finally, we wish to thank to all teachers in Geology Department, Pyay University, for their help and encouragement throughout this research work.

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