GEOCHEMISTRY OF SUBDUCTION RELATED LAMPROPHYRES FROM MOKPALIN-KANNI AREA, MON STATE, MYANMAR

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Abstract

The study area is located within southern part of the Mogok Metamorphic Belt and Slate belt, Kyaikhto Township of Mon State, Myanmar. It is consisting of meladiorite, diorite and granitic rocks intruded by a variety of lamprophyre dykes. Most of lamprophyres are fine-grained, porphyritic in nature, with phenocrysts of hornblende, feldspar and sometimes biotite. Occasionally, medium-grained textures of spessartite are observed and their strikes are trending NE direction. There are three types of lamprophyre encountered in the study area, which are camptonite, minette and spessartite. The whole rock chemical compositions are wide span range of SiO_2 (52.47-60.06), CaO (4.28-6.8), MgO (2.5-5.1) and Fe_2O_3 (5.6-9.6) consisting mainly of calc-alkaline to high-K calc-alkaline. Lamprophyres fall within the basaltic andesite-basaltic andesite, and trachy-andesite field. Enrichments in Cs, Rb, Ba and Th while depletion in Nb, and Ti were generated from the partial melting of the subducted related shallower mantle lithosphere. Trace element ratios, the pattern of the LREE to HREE show that the rocks were come from spinel lherzolite mantle (< 50 km depth) rather than garnet lherzolite mantle source. Calc-alkaline of lamprophyre related to the eastward late-subduction of Tethys II of the ancestral Indian Ocean.

Keywords: Lamprophyres; geochemistry; calc-alkaline; late-subduction; Myanmar

Introduction

The presence of interchangeable between tholeiite and calc-alkaline magma mixing related to three types of lamprophyres studies on a regional scale including the assigned area and its environs Stamp (1926), Chhibber (1926), Chhibber (1934), and Khin Zaw (1990). Tin Mar Win (2006, unpublished) studied the manual description of lamprophyres. Lamprophyres are very rare, alkaline, silica-undersaturated, small volume igneous rocks that commonly occur as dikes or small intrusions. They are melanocratic hypabyssal igneous rocks characterized by porphyritic with mafic phenocrysts (Rock, 1987). Lamprophyres are characteristically rich in porphyritic mafic minerals, typically biotite, amphibole and pyroxene, feldspar being confined to the groundmass (Le Maitre, 1989). Chemically, they are of intermediate to ultrabasic composition, they show rather high alkali contents for their silica, and in many varieties, they have high modal alkali feldspar for their color index (Rock, 1991). In the present work, we accounted for petrological and geochemical data of lamprophyres and related rock with laser ablation ICP-MS trace element microanalysis in order to recognize the genesis of lamprophyres and petrochemical evidence.

Regional Geology of the study area

The general regional geologic setting southern part of Mogok Metamorphic belt and within Slate belt (Fig.1). It consists of rhyolitic tuff, meta-sedimentary rocks, probably of Carboniferous age close to the Mesozoic granite of Chhibber (1926). The Western granite belt of South East Asia and this belt are associated with eastward subduction of the Oceanic Indian plate (Pitcher, 1962). The study area lies in the northern part of western Tin Belt of South East Asia Tin province (Mitchell, 1977 and Nyan Thin, 1984) and lies within part of the Mogok Belt (Searle and Haq, 1964). Maung Thein (1983), regarded the central granitoid belt of Burma were

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developed in the tectonic setting of subduction related magmatic arc. The area belongs to the central granitoid belts of Myanmar (Khin Zaw, 1990). The area is structurally bounded by two major faults which are the Papun Fault system in the north and the Three Pagoda Fault in the south. The Sagaing fault was 1000Km to south and lies west of Mogok Metamorphic belt.

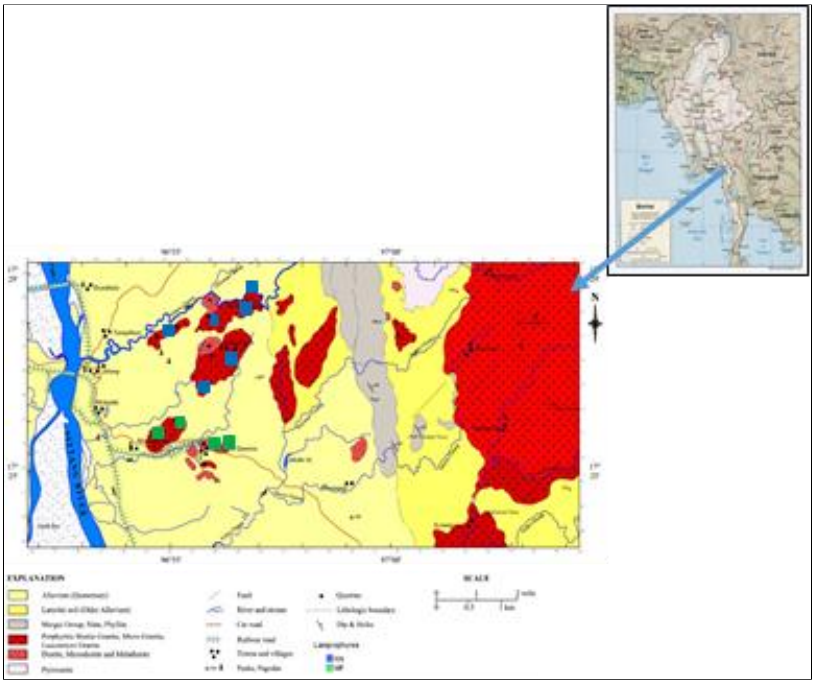

Figure 1 A geological map of the study area (modified after Zaw Naing Oo, 1998 unpublished).

Materials and Methods

Ten representative samples were sent to ALS laboratory of Geological Survey of Japan, AIST and the Acme analytical laboratories of Vancouver-Canada. In this study, most relevant methods available to determine contents of major, trace, and rare earth elements of the lamprophyres were applied for major and trace elements analysis were carried out using techniques of X-ray fluorescence spectrometry (XRF), inductively coupled plasma-mass spectrometry and inductively coupled plasma-atomic emission spectrometry.

Field study and Petrography of lamprophyres

Representative samples were collected from several locations throughout the Mokpalin and Kanni quarries. In the study area, twenty-five dikes of varying widths and orientations, exposed along the walls of the quarries. They strike is roughly trending N30˚E and dip vertically and nearly parallel and tabular-shaped nature. Most of lamprophyres are acting a sharp contact with host rocks.

Sometimes horizontal joints are remarked and also small amount of quartzofeld spathic veins are intruded in it. The exposed portions of the dikes are approximately 45 m long and are found intruded into diorites and granitic country rocks (Fig 2). The widths of the dikes vary from 0.15 to 8 m Lamprophyres are mostly fine grained, dark and grey in color. Some dikes exhibit chilled margins and sometimes observed granite xenoliths (Fig.3). The typical camptonite exhibits a beautiful grey color with shinning black elongated crystals of hornblende and occasionally with a few crystals of feldspar. It is found intruded into the dioritic rocks. Minette show sharp contact with granitic rocks at Mokpalin Quarry No.2 and Kanni Quarries. Spessartites are found that intruded into the dioritic and granitic rocks at Mokpalin Quarries and Kanni and Kyauk-Tan-Lay Quarries. Occasionally, they show irregular, pitch and swell possibly indicating limited mobility of the granite after dike intrusion. Camptonites are observed throughout the study area.

Lamprophyres are mesocatic to melanocratic igneous rocks, usually hypabyssal, with a panidiomorphic texture. Porphry of hornblende are euhedral to subhedral (0.1-1.9mm) and most are simple twined (Fig.5), sometimes occur sieve, hollow, and skeletal character. According to the model composition, most are camptonite, spessartite, and minette. Biotite of lamprophyre shows euhedral- subhedral showing strong pleochroism of greenish-brown to reddish brown colored (Fig.4 a) occurred in minette. Most of hornblendes showed simple contact twined (Fig.4 b). Feldspar phenocrysts and matrix show a larger range of compositions and albite to labradorite (An_{24-66}). Plagioclase feldspar is the dominant feldspar as megacryts or as matrix (Fig.5) and orthoclase is present in minor proportions.

Figure 2 Dike of lamprophyre intruded into granite at Kanni quarry area.

Figure 3 (a) Biotite granite xenolith in close-up view of camptonite lamprophyre (b) Showing strong pleochroism of subhedral biotite collected from Mokpalin and Kanni Quarries.

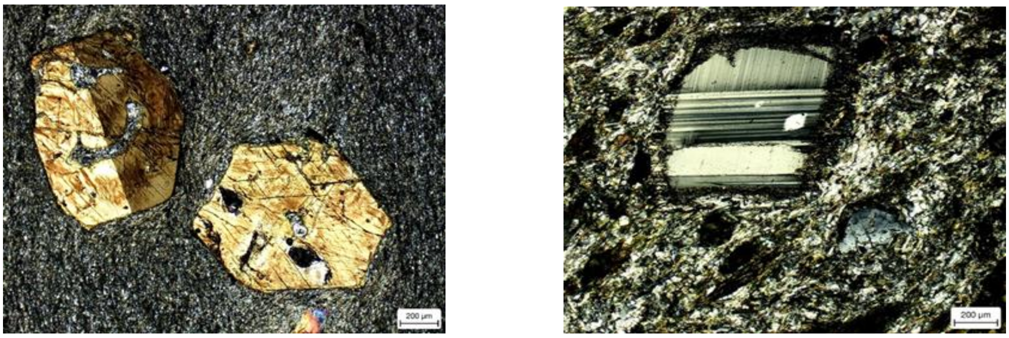

Figure 4 (a) Showing simple-contact twined of hornblende between X.N (b) Ragged megacryst of feldspars in lamprophyres.

Geochemistry of Lamprophyres

The SiO2 content of the ten representative samples are in the range of 52.47–60.06 wt. %. most probably derived from silica saturated magma. They have contents of alkalis, with K_2O ranging from 1.4-2.56 wt. % and Na_2O 4.04 -5.0 wt. %. All of lamprophyres are sodic and (K_2O/Na_2O <1) ratios (0.28-0.59). The high values of Na_2O (4.3 to 5.0) indicates the presence of a sodic phase in the source region (amphibole-bearing source) and so amphiboles are observed in phenocrysts and matrix. Aluminum contents are high in lamprophyres within the ranges of Al_2O_3 17.3–18.58 wt. %. Total FeO, 5.60–8.38 wt.%, and MnO, 0.0–0.1 wt.%, MgO, 2.55 –5.12 wt.%, TiO_2 0.5–1.3 wt.%, and P_2O_5 = 0.2–0.56 wt.% (Table 1) and notable that Al_2O_3 is higher than CaO, FeO_t and MgO. In Nb/Y-Zr/TiO_2 plot diagram (Winchester and Floyd 1977), all the lamprophyres included in the entire area fall andesite basaltic andesite and trachy-andesite group (Fig.6a). In FeO_t / MgO vs. SiO_2 diagram (Fig.5 b) notably two representative samples lie in the tholeiitic magma series and the rest in the calc-alkaline series (After Miyashiro, 1974). Fairly a flat and anomaly values are below <1 of HREEs and depletion of Nb, and Ti spikes in the N-MORB normalized multi-element diagrams are assume of arc magmatism and subduction related metasomatism (Fig.6 a). In chondrite-normalized diagram, negative slope of enrich REE relative to HREE values sign of moderate degree of partial melting (Fig.6 b). Slightly occur of negative Eu anomaly (Eu/Eu*= 0.87-1.03) may be few plagioclase fractionations the parent magmas. The sum of the REE data show arrange from (87.5 to 261.7) and suggesting a variable degree of REE fractionation. Most of the compatible elements (Ni, Sc, and Co) are no content and of Cr and V are low that seem to be depleted in the partial melting and highly fractionally from primary magma. The low mg# and low content of transition element show not from the primitive lamprophyres.

In Ba/Rb - Rb/Sr diagram (Furman & Graham, 1999), the values Ba/Rb show>20 and Rb/Sr vales < 0.1 and above are imply an amphibole bearing and a biotite or phlogopite bearing source (Fig.7 a). Plotted of lamprophyres in Nb - Nb/U diagram (after Ma et al., 2013) the amount of Nb/U between 0.22-20 observed that components the subducted sediments of upper crust and slab zone hydrous fluids (Fig.7 b). A quartz diorite dyke from one of the Mokpalin quarries gave a zircon U-Pb age of 90.8 ± 0.8 Ma and suggested that arc magmatism was related to the eastward subduction of Tethys II, the ancestral Indian Ocean (Mitchell et al., 2012). With references to the Th-Hf-Ta-Zr-Nb discrimination diagram (Fig 8), their tectonic setting indicates that all the representative samples of lamprophyres belong to the calc-alkaline basalt field.

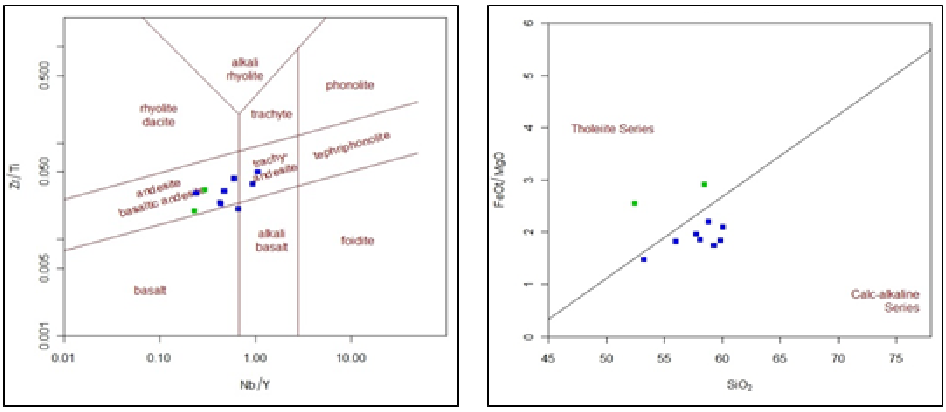

Figure 5 The chemical classification and nomenclature of lamprophyre rocks using (a) Nb/Y-Zr/TiO_2 plot (Winchester and Floyd 1977) and (b) Plot in SiO_2-FeO_t/MgO diagram subdividing the subalkaline magma series to Tholeiitic and Calc-alkaline series (After Miyashiro 1974).

Discussion and Conclusion

According to their modal composition, there are three types of lamprophyre encountered in the study area, which are camptonite, minette and spessartite. The chemical composition the matrix and megacryst plagioclase is albite to labradorite (An $_{24\text{-}66}$). Skeletal and vesicle nature of hornblende and oscillatory zoning of feldspar showing their crystallization is shallow depth and short time. These lamprophyres are characterized by calc-alkaline nature and partially tholeiite series are the derivatives of the partial melting of both crustal and shallower upper mantle lithosphere. The trace element supports that a variable degree of partial melting and enriched an amphibole bearing and a biotite or phlogopite bearing source. The shallower the angle of subduction, the greater the distance of volcanoes inland from the oceanic trench (Hyndman, 1985). Thus, they occur progressively farther from the trench near the subduction zone of apparently 200km distance. Eventually, on the surface, as a result of eastward subduction of the ancestral India Ocean or neo-Tethys II and extension (after Mitchell, et al., 2012) and magmas arrive close to the surface; they rapidly enter the fractures in the continental crust and crystallize at depth between 10-35 km and forming the lamprophyre dikes in all likelihood. Their tectonic setting belongs to calc-alkaline basalt field.

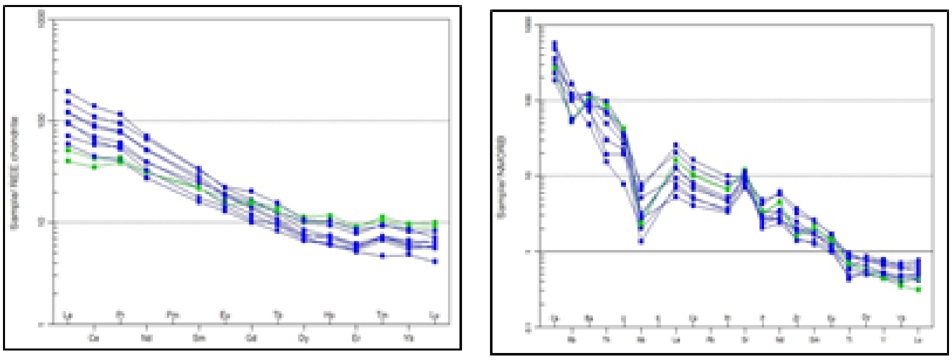

Figure 6 (a) Chondrite-normalized REE patterns (after Nakamura 1974) and (b) N-MORB normalized multi-element diagrams (after Sun and McDonough 1989).

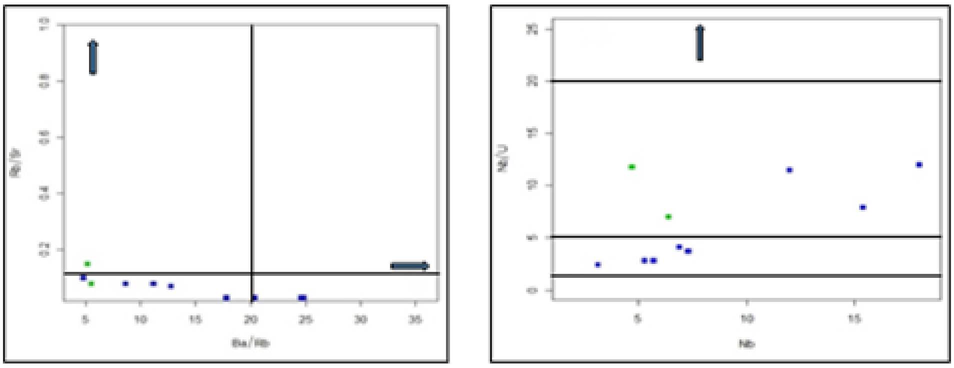

Figure 7 (a) Diagram plotted of lamprophyres Ba/Rb - Rb/Sr (Furman & Graham, 1999) and (b) Diagram plotted of lamprophyres Nb-Nb/U (redrawn after Ma et al., 2013).

Table 1 Representative selected whole-rock analysis for major and trace elements from lamprophyres

Rock type	**Calc-alkaline**				**Tholeiitic**		**Calc-alkaline**			
Sample	**TKN-2**	**MKN-L**	**L3**	**5Q**	**Q-L**	**CHO**	**L7**	**L8**	**L9**	**L10**
SiO_2	53.23	59.87	60.06	57.78	52.47	59.3	58.1	58.5	58.8	56
TiO_2	1.2	0.72	0.91	0.88	1.1	0.59	0.84	0.74	0.54	1.04
Al_2O_3	17.3	17.44	17.56	17.56	19.01	17.89	17.41	17.8	18.56	17.48
Fe_2O_3	8.38	5.77	5.69	6.85	9.67	5.61	6.5	8.26	6.27	7.07
MnO	0.19	0.09	0.07	0.09	0.15	0.09	0.09	0.15	0.13	0.12
MgO	5.12	2.81	2.45	3.15	3.41	2.89	3.16	2.55	2.57	3.5
CaO	6.81	5.27	4.57	5.41	6.79	5.3	5.44	4.28	5.2	5.08
Na_2O	4.04	4.66	4.72	5.01	4.13	4.65	5.01	4.59	4.57	4.32
K_2O	2.19	2.02	2.39	1.4	1.87	1.94	1.53	2.13	1.7	2.56
P_2O_5	0.39	0.3	0.49	0.38	0.31	0.24	0.36	0.34	0.27	0.56
LOI	0.71	0.52	0.56	0.41	0.44	0.58	0.97	0.86	1.31	2.16
Total	99.57	99.47	100.0	98.94	99.36	99.09	99.41	100.	101.2	99.89
K_2O/Na_2	0.54	0.4	0.51	0.28	0.45	0.42	0.31	0.46	0.37	0.59
Mg#	55.17	48.94	46.2	47.56	41.1	50.44	49.1	44.5	52.3	47.1
Eu	1.48	1.22	1.69	1.47	1.37	1	1.4	1.13	1.1	1.72
Cr	130	60	50	30	10	20	-	-	-	-
Zr	148	182	273	128	131	108	117	145	101	233
La/Yb	8.72	17.11	32.62	20.41	5.32	9.24	25.03	14.5	17.81	15.5
Eu/Eu*	0.97	0.98	0.93	0.94	1	1.02	0.96	0.78	1.04	0.87
Th/Ta	4	18	12	34	6	29	6	28	9	29
(Ta/Yb)	0.5	0.4	0.4	0.2	0.14	0.14	0.3	0.2	0.2	0.5
Rb/Sr	0.14	0.08	0.08	0.03	0.08	0.03	0.03	0.03	0.07	0.15
(La/Sm)	2.87	4.27	5.75	4.28	2.39	3.67	4.6	1.8	5.5	4.7
ΣREE	124.5	138.1	261.7	178.4	97.8	93.1	172	128.	221.3	87.5

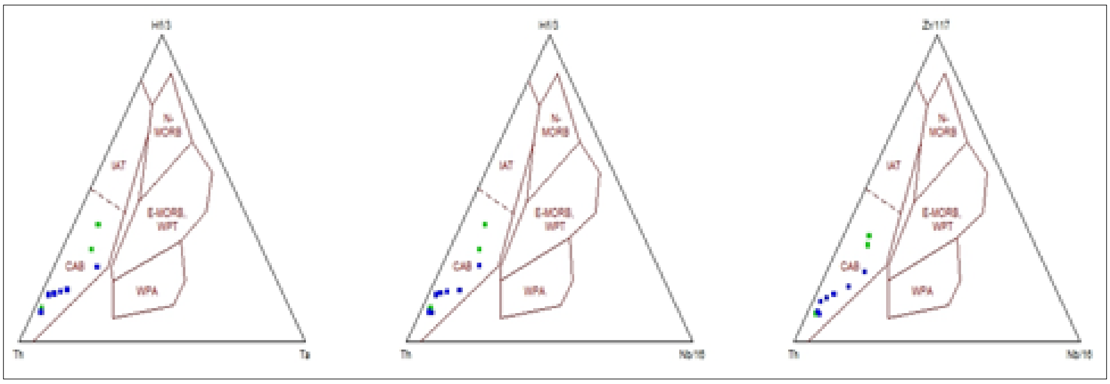

Figure 8 Triangular diagrams of the Th-Hf-Ta-Zr-Nb system showing lamprophyres fall in the field of calc- alkaline basalts, (After Wood 1980).

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