PETROLOGICAL CHARACTERISTICS OF POST-TECTONIC INTRUSIVE DOLERITES AND GABBROS IN THE VIJAYAN COMPLEX, SRI LANKA

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ABSTRACT

Few post-tectonic intrusives (three dolerite samples and two gabbro samples) collected from the Vijayan Complex, Sri Lanka were studied for their petrographical characteristics and mineral chemistry in order to evaluate their emplacement, spatial and temporal relationship with each other. Petrographical characteristics of the dolerites support for their post-peak emplacement at shallow levels of the crust. Granophyric texture resulting from rapid undercooling of the melt due to exhumation from the middle crust to shallower levels and/or crystallization under eutectic conditions was observed in these rocks. A garnet bearing gabbro sample indicates relatively early emplacement, at a relatively higher pressure than the dolerites. The garnet formation of this rock can be attributed to a possible isobaric cooling event of the host rocks following peak metamorphism. Preliminary geothermometry yielded 560-720 ^{o}C for this rock with very minor differences for assumed pressures of 7 kbar and 8 kbar. Absence of garnet in one of the gabbro samples which has characteristics of a slowly cooled rock at deeper level.

Keywords: *Dolerite dykes, Vijayan Complex, Sri Lanka, Post-tectonic, Petrography*

INTRODUCTION

High-grade metamorphic terrains throughout the world experience post-tectonic intrusions during their retrogression (Sengupta, 1993; Radhakrishna et. al., 1999; Riley et. al., 2005). Most of these intrusions are due to the formation of rheologically weak zones within the crust during processes such as crustal extension. Scrutinizing such post-tectonic intrusive rocks associated with high-grade terrains helps to give insight into final stages of the formation of such crustal blocks and in reconstructing the geological past relating spatial and temporal evolution of super- continents. Apart from numerous quartz-feldspar pegmatites, there are only a limited number of post-tectonic intrusive rocks in Sri Lankan Precambrian basement and petrological studies on these intrusives are also very limited (Cooray, 1984; Ellis and Abeysinghe, 1987; Yoshida, 1989; Takigami, 1999; Pitawala et al., 2003, Pitawala et al., 2008, Pitawala and Lottermoser, 2012). Though their occurrences are limited, scientific study of them is vital for the understanding of Gondwana breakup and the relationship of Sri Lanka to other Gondwana fragments.

Of all the post-tectonic intrusives, dolerite dykes in the Vijayan Complex of Sri Lanka bear a high significance in understanding Sri Lanka – Gondwana relationship. Although some geochronological (Yoshida, 1989; Takigami, 1999), geochemical (Ellis and Abeysinghe, 1987) and geophysical investigations (Samaranayake et al., 2015) have been carried out on these rocks, proper petrological investigations are scarce. Here we report, petrological characteristics of such post-tectonic intrusives such as dolerite and gabbro in the Vijayan Complex.

GENERAL GEOLOGY OF THE VIJAYAN COMPLEX

Mainly based on Nd-model ages the Sri Lankan basement has been subdivided into four lithotectonic units (Milisenda et al., 1988, 1994; Liew et al., 1991, Cooray, 1994) namely, the Wanni Complex (WC), the Kadugannawa Complex (KC), the Highland Complex (HC) and the Vijayan Complex (VC) (Figure 1). The HC rocks which have been metamorphosed under granulite facies conditions have yielded Nd model ages from 3000-2000 Ma while the upper amphibolites to granulite facies WC and KC rocks have yielded Nd model ages from 2000 – 1000 Ma (see Santosh et al., 2014 and Dharmapriya et al., 2016).

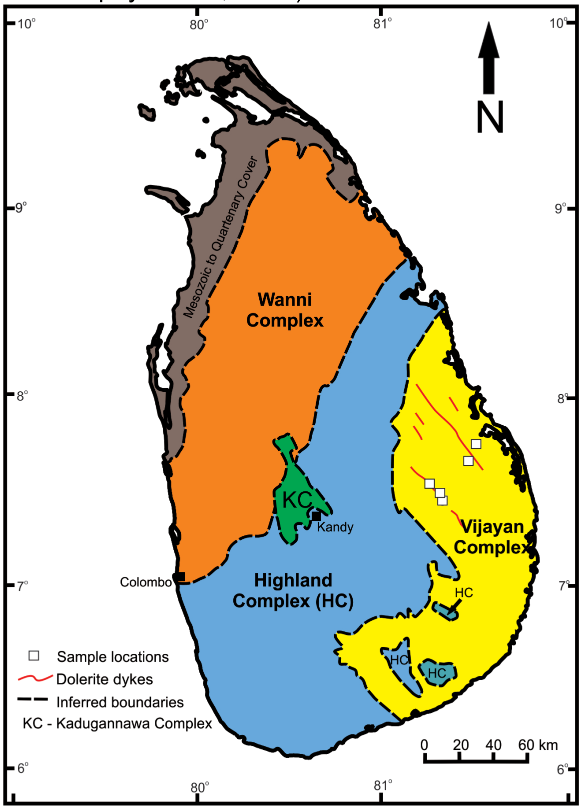

Fig. 1. Generalized litho-tectonic subdivision of Sri Lanka (modified after Cooray, 1994) indicating sample locations.

The dominantly upper amphibolite facies VC mainly consists of microcline-bearing granitic gneisses, augen-gneisses, migmatites and hornblende-biotite gneisses (Cooray, 1984; Kehelpannala, 1997; Kröner et al., 2013). Most metagranitoids, are present as hornblende ± biotite-bearing gneisses, ranging in composition between diorite and leucogranite with the dominant compositions being granodiorite and granite (Kröner et al., 1991; Kleinschrodt, 1994; Milisenda et al., 1994; Kröner et al., 2013; He et al., 2016). These granitoids were interpreted to be products of subduction-related magmatism (Milisenda, 1991; Pohl and Emmermann, 1991). Metasediments such as quartzite, calc-silicate rocks and marble have also been reported (Dahanayake, 1982; Dahanayake and Jayasena, 1983). Charnokitic rocks have been reported in the area around Pottuvil (Cooray, 1984; De Maesschalck et al., 1990; Kröner et al., 2013) while localized granulite facies transitions were also reported (e.g. Kröner et al., 2013). The limited number of petrological studies carried out on the VC revealed that the peak metamorphic temperature conditions are around 750-850°C (Kleinschrodt and Voll, 1991; Kleinschrodt, 1994). Reliable paleo-pressure estimates are not available for the VC.

The Nd-model ages of the VC are in the range of 1800-1100 Ma (Milisenda et al., 1988; 1994) and the HF crust formation ages are mainly in the range of 1600-1000 Ma. The Hf isotopic data confirm a generally juvenile origin for most Vijayan gneisses with the possible mixing of minor amounts of older continental material in their genesis (Kröner et al., 2013).

The emplacement age of the protolith of the VC is considered to be 1100–920 and 820 - 620 Ma (Kröner et al., 2003 and 2013; He et al., 2016). Zircon U–Pb ages of ca. 590–456 Ma (Hölzl et al., 1991 and 1994) have been interpreted as the age of metamorphism. Kröner et al. (2013) and He et al. 2016) reported that the age of metamorphism in the VC was Pan-African (ca. 610–520 Ma).

FIELD FEATURES OF MAFIC DYKES

There are a few mafic dykes extending in NW-SE direction mapped as dolerite dykes. Some of them appear to extend of the Geological Survey) for distances over 50 km (Geological Map of Sri Lanka, 1982; 1:100,000 Geological Maps). All of them occur as discordant dykes crosscutting the typical Vijayan gneisses. The widths of these dykes are generally 5-10 m but in some instances they are observed with even 40 m width (Samaranayake et al., 2015)

Samples of dolerite

Three samples were collected (Figure 1) from westernmost dolerite dyke close to Wahawa (samples DOL/1, DOL/2) and Gallodai (sample DOL/3). These are dark coloured massive rocks with fine to medium grained plagioclase and clinopyroxene.

Samples of gabbro

Two gabboic samples were collected (Figure 1) from isolated outcrops, occurring as 2-5m diameter lenticular or circular bodies, near Rukam (samples GAB/1, GAB/2). Unlike the dolerite dykes, the lateral extensions of these rocks are not very clear. Both rocks are dark coloured, massive, medium to coarse grained plagioclase and clinopyroxene bearing bodies and are discordant with their host rock. Interestingly sample GAB/1 contained fine grained garnet.

PETROGRAPHY

Dolerite

All the dolerite samples (DOL/1, DOL/2, DOL/3) show very similar petrographic features (Figure 2a). Samples contain plagioclase (45-50%), clinopyroxene (30-35%) and biotite (10-12%) as major mineral phases while minor amounts of quartz (1-2%), hornblende (1-2%) and alkali feldspar (1-2%). Ilmenite and pyrite occur as accessory phases. Locally some minerals are pseudomorphically replaced by sericite and chlorite. There is no preferred orientation of above minerals.

Plagioclase grains are fine to medium (0.5mm-2.0mm) tabular crystals, mostly subhedral, with diffused grain boundaries. Plagioclase arranged irregularly/randomly occupies most parts of the matrix. When associated with pyroxene, they exhibit ophitic texture. Most of the plagioclase seems to be partially broken-down into sericite. At some locations, angular intergrowths of quartz and alkali feldspar can be observed, showing granophyric texture (Figure 2b).

Clinopyroxene occur as fine to medium (0.5mm-1.0mm) grains. They are mostly subhedral but few euhedral and anhedral grains can also be seen. In large grains compositional zoning can be observed (Figure 2c). Simple twinning is also evident in some grains.

Biotite grains are relatively fine grained (0.1-0.5mm). These subhedral to anhedral biotite grains are disseminated throughout the rock. Quartz also occur seldom throughout the rock as anhedral fine grains (0.1-0.3mm) and angular intergrowths in granophyric texture. Hornblende grains rare and they are usually highly altered. They are medium grained (1.0-2.0mm). Ilmenite and pyrite occur as accessory phases and are mostly associated with pyroxenes. They occur as small clusters usually showing sharp crystal outline. Sericite and chlorite occur as secondary minerals replacing plagioclase, pyroxene and hornblende.

Gabbro

Sample GAB/1

This sample comprises of Plagioclase (40-45%), garnet (15-20%), clinopyroxene (10-12%), biotite (8-10%), and hornblende (8-10%) as major minerals. Quartz (1-2%) and othopyroxene (less than 1%) occur as minor minerals with ilmenite and pyrite as accessory phases.

Plagioclase occurs as subhedral or anhedral, fine to medium grains (0.5-1.0mm). Plagioclase is randomly oriented throughout the matrix. Compositional zoning towards the rim is also observed in some grains.

Garnet is present as fine to medium (0.5-1.0mm) anhedral grains. Finest grains are sugary and form clusters (Figure 2d). Some of these are seen as “atolls” along pyroxene and plagioclase interface (Figure 2f). Larger grains contain inclusions of biotite and ilmenite. Around some garnets plagioclase moats are observed (Figure 2e).

Clinopyroxene occurs as fine (0.1-0.5mm) anhedral grains and form small clusters. Fine grained (0.1-0.5mm) biotite can be observed throughout the rock. These are either euhedral or subhedral and do not show any preferred orientation. Hornblende occur in small isolated clusters consisting of fine grains (0.1-0.5mm). At few places hornblende form coronas around pyroxene clusters.

Orthopyroxene and quartz occur as isolated anhedral fine grains (less than 0.5mm) in very minor amounts in the matrix. Accessory phase ilmenite is observed with mafic minerals as fine (less than 0.5mm) anhedral grains.

Sample GAB/2

This sample contains plagioclase (45-50%) and clinopyroxene (35-40%) as major minerals (Figure 2g,h). Orthopyroxene (3-5%), hornblende (1-2%), biotite (1-2%) and quartz

(<1%) occur in minor quantities with ilmenite and pyrite as accessory phases.

Plagioclase grains are coarse to medium grained (0.5-3.0mm) and are euhedral or subhedral in shape. These randomly arranged plagioclase without any preferred orientation form the most parts of the matrix (Figure 2g,h). Some plagioclase laths surround pyroxene forming ophitic texture (Figure 2g). Clinopyroxene is coarse to medium grained (1.0-3.0mm) and most of the grains are being subhedral. Some grains show simple twinning.

Few coarse and medium sized (1.0mm to 3.0mm) grains of orthopyroxene occur dispersed in the matrix. Fine grained (less than 0.5mm) anhedral hornblende, biotite and quartz occur in very minor amounts. Fine to medium grained (0.5-1.0mm) ilmenite occur in association with pyroxene, and are subhedral to anhedral in shape.

MINERAL CHEMISTRY

Mineral compositions were analyzed by Energy-dispersive X-ray spectroscopy (EDS) with an Oxford Instruments – X-act® $10mm^2$ SDD detector mounted on a Carl Zeiss EVO LS 15® scanning electron microscope at the Department of Geology, University of Peradeniya. A voltage of 20 kV was used during the analysis.

Pyroxene

Clinopyroxene in dolerite (samples DOL/1, DOL/2 and DOL/3) are high in Mg (X_{Mg} = Mg/(Fe + Mg) = ~0.60 – 0.70), and are identified as augite. Some of these are compositionally zoned with decreasing X_{Mg} values from core to rim. The Al_2O_3 content varies from core (~2.00 wt.% Al_2O_3) to mantle (~2.50 wt.% Al_2O_3) to rim (1.7 wt.% Al_2O_3). Garnet bearing gabbro (sample GAB/1) shows the highest X_{Mg} value out of all the rock is Ca-deficient and is identified as possible pigeonite. In these the Ca component is high along the rim (Fs35-36, En51-49, Wo13-11) than in the core (Fs24- (sample26, En68-70, Wo6-7). However they are more Mg-rich in the core (XMg = 0.74-0.72) than in the rim (XMg = 0.58-0.56) and are poor in Al content (1.1 -1.5 wt.% Al2O3). GAB/2). Augite Orthopyroxene in dolerite are poor in Mg (XMg = 0.30 -0.32) and indicate a Fe-rich hypersthene composition (Fs66-62, En29-31, Wo0-2). In the garnet bearing gabbro (GAB/1) hypersthene (Fs44-46, En52-54, Wo0-1) is identified with moderate Mg content (XMg = 0.53 -0.55). the samples (X_{Mg} = 0.74 –0.78). In these, the core is Al enriched (2.1 -2.5 wt.% Al_2O_3) than the rim (0.8 -1.1 wt.% Al_2O_3). Two types of clinopyroxene occur in the other gabbro (type 1), which is the more common clinopyroxene in this rock, has an XMg value of 0.66 -0.68 and are Al-enriched (2.0 -2.9 wt.% Al2O3). The other clinopyroxene (type 2), seldom encountered in

Plagioclase

Plagioclase in dolerite (samples DOL/1, DOL/2 and DOL/3) generally have intermediate albite–anorthite composition (An_{44-51}), except rarely in some grains the composition become more sodic (An_{32-34}) with even some grains becoming entirely albite rich (An_{0-5}). Alkali feldspar which are in association with quartz forming granophyric texture are orthoclase (Or_{68-66}). Considering plagioclase in garnet bearing gabbro (sample GAB/1) a clear difference in plagioclase formed around garnet as a rim and plagioclase in the matrix can be identified. Matrix plagioclase are more anorthitic (An_{64-70}) than the plagioclase formed around garnet (An_{45-50}). Plagioclase in garnet absent gabbro (sample GAB/2) also has an intermediate albite – anorthite composition (An_{45-52}).

Garnet

Garnet is only found in a gabbro (sample GAB/1) and are generally almandine in composition with minor components of pyrope and grossular. These do not show a strong compositional zonation but the core (Alm_{60-62}, Pyr_{20-22}, Grs_{18-19}) is slightly almandine rich than in the rim (Alm_{55-57}, Pyr_{21-23}, Grs_{17-19}). These are low in Mg (X_{Mg} = 0.25 -0.27).

GEOTHERMOMETRY

Preliminary temperature conditions of the garnet bearing gabbro (sample GAB/1) were measured using conventional thermometric calculations. A conventional geothermobarometric strategy is more reasonable to apply temperature conditions since, minerals assemblages of these rocks equilibrated during the post-tectonic (retrograde) setting. As a result re-equilibration of minerals is minimum compare to mineral assemblage/s that were equilibrated during prograde or peak metamorphic conditions. Temperature conditions were calculated using garnet–ilmenite thermometer by Pownceby et al. (1991) and garnet–

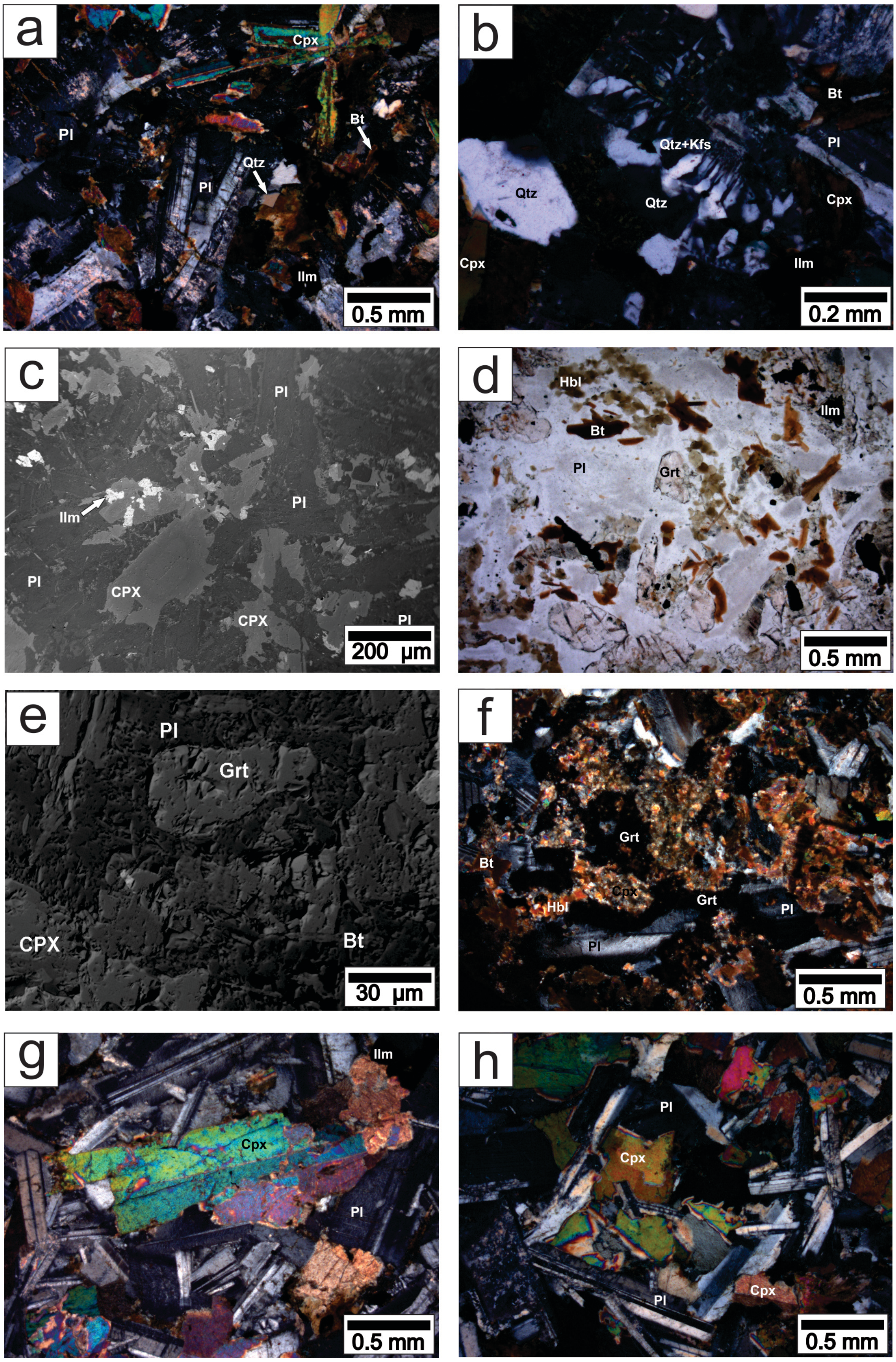

Fig.2. (a) CPL image of a cluster of Cpx with Pl laths in the matrix with minor amounts of Bt, Qtz and Ilm in dolerite (Sample DOL/2). (b) Granophiric texture showing intergrowth of Qtz-Kfs in CPL in dolerite (Sample DOL/3). (c) BSE image showing a compositionally zoned Cpx in Pl matrix of dolerite (Sample DOL/1). (d) PPL image of fine grained Grt in the matrix with Pl, Bt and Hbl in gabbro (Sample GAB/1). (e) BSE image of Pl rim around Grt in gabbro (Sample GAB/1). (f) CPL image of "Atoll" garnets formed along Cpx-Pl margin in gabbro (Sample GAB/1) some Cpx replaced by Hbl. (g), (h) CPL image of coarse Pl and Cpx showing ophitic texture in gabbro (Sample GAB/2). (Cpx: Clinopyroxene, Bt: Biotite, Qtz: quartz, Ilm: Ilmenite, Hbl: Hornblende, Grt: Garnet, CPL: Crossed polarized light, PPL: Plane polarized light, BSE: Back-scattered Electron)

Table 1. Representative mineral chemistry of gabbro samples analyzed by Energy-dispersive X ray spectroscopy (EDS).

	Garnet		Clinopyroxene[1]			Clinopyroxene[2]		Orthopyroxene	Plagioclase			Ilmenite			
Sample	GAB/1		GAB/1		GAB/2	GAB/2		GAB/1	GAB/1		GAB/2	GAB/1		GAB/2	
	Core	Rim	Core	Rim	Core	Core	Rim	Core	Around garnet	Matrix	Matrix	Core	Rim	Core	Rim
SiO2	38.61	38.59	53.81	52.93	51.61	53.92	50.73	52.03	56.32	51.24	54.89	0.12	0.17	1.02	0.05
TiO2	nd	nd	0.14	0.07	0.66	0.33	0.44	nd	0.08	nd	nd	53.39	53.46	21.1	20.01
Al2O3	20.17	20.83	0.82	1.62	2.05	1.53	1.16	0.84	26.79	31.65	27.25	0.14	nd	1.73	2.21
Cr2O3	0.21	0.25	0.09	0.03	0.22	0.22	0.13	nd	0.12	0.04	0.08	0.12	0.24	nd	nd
FeO	27.63	26.93	7.59	8.28	13.2	15.48	22.74	27.48	0.46	0.05	0.92	45.13	44.73	73.4	75.27
MnO	0.21	1.35	0.22	0.05	0.32	0.26	0.57	0.27	nd	nd	0.02	0.35	0.36	0.49	0.64
MgO	5.28	5.55	14.95	13.38	14.7	24.98	17.82	18.83	0.04	0	0.21	0.74	0.75	0.06	nd
CaO	6.79	6.56	22.05	23.03	16.95	3.16	6.27	0.5	9.67	13.6	10.89	nd	0.12	0.62	0.23
Na2O	0.14	nd	0.36	0.55	0.32	nd	0.05	0.12	6.19	3.45	5.25	0.01	0.18	0.2	nd
K2O	0.04	0.02	nd	0.06	nd	0.1	0.01	0.09	0.36	0.07	0.42	0	0.03	nd	0
Total	99.08	100.08	100.03	100	100.03	100.11	99.92	100.16	100.03	100.1	99.93	100	100.04	98.62	98.41
O	12	12	6	6	6	6	6	6	8	8	8	3	3	3	3
Si	3.054	3.021	1.991	1.972	1.938	1.939	1.937	1.982	2.541	2.323	2.492	0.003	0.004	0.031	0.002
Ti	0	0	0.004	0.002	0.019	0.02	0.013	0	0.003	0	0	1.003	1.004	0.478	0.461
Al	1.88	1.922	0.036	0.071	0.091	0.086	0.052	0.038	1.425	1.691	1.458	0.004	0	0.061	0.08
Cr	0.013	0.015	0.003	0.001	0.007	0.002	0.004	0	0.004	0.001	0.003	0.002	0.005	0	0
Fe	1.828	1.763	0.235	0.258	0.415	0.369	0.726	0.875	0.017	0.002	0.035	0.943	0.934	1.849	1.93
Mn	0.014	0.09	0.007	0.002	0.01	0.01	0.018	0.009	0	0	0.001	0.007	0.008	0.013	0.017
Mg	0.622	0.648	0.824	0.743	0.823	0.846	1.014	1.069	0.003	0	0.014	0.028	0.028	0.003	0
Ca	0.575	0.55	0.874	0.92	0.682	0.716	0.256	0.02	0.468	0.661	0.53	0	0.003	0.02	0.008
Na	0.021	0	0.026	0.04	0.023	0.015	0.004	0.009	0.542	0.303	0.462	0	0.009	0.012	0
K	0.004	0.002	0	0.003	0	0	0	0.004	0.021	0.004	0.024	0	0.001	0	0
Tot. cation	8.012	8.011	3.999	4.011	4.006	4.005	4.025	4.006	5.023	4.985	5.02	1.991	1.995	2.466	2.497
Fe^{3+}	0.012	0.011	0	0.033	0.019	0.014	0.024	0.006							
Fe^{2+}	1.815	1.752	0.235	0.225	0.395	0.356	0.702	0.869							
Alm	0.6	0.576													
Spe	0.005	0.029													
Pyr	0.206	0.213													
Grs	0.184	0.175													
Adr	0.006	0.006													
XMg	0.254	0.269	0.778	0.742	0.665	0.696	0.583	0.55							

Fe–Mn partitioning for garnet–ilmenite yielded a temperature of 680-720^oC for 7 kbar pressure and 685-730^oC for 8 kbar pressure. Garnet–clinopyroxene thermometer in Saxena (1979) indicates temperatures 645-670^oC at 7 kbar pressure and 650-675^oC at 8 kbar pressure. According to Powell (1985) and Berman et al. (1995) the estimated temperatures are relatively low as 560-620^oC at 7 kbar pressure and 565-625^oC at 8 kbar pressure. For the pressure values of 7 kbar and 8 kbar from Ganguly et al. (1996) temperatures resulted are 650-710^oC and 655-720^oC respectively. A pressure of 7-8 kbar was assumed in the calculations regarding the results of pressure independent thermometer (Pownceby et al., 1991) and comparison of those data with the others. Regardless of the increment of pressure the resulting temperature increments were insignificant.

DISCUSSION

Geochronological studies on dolerite using K-Ar and Ar-Ar methods (Yoshida, 1989; Takigami, 1999) in the VC indicated that the intrusion of these dykes has taken place ca. 130 Ma -170 Ma. In terrains derived from Gondwana it is clear that their emplacement is linked with the breakup of Gondwana. Most of these dolerites are emplaced associated with the fracturing and rifting of middle to upper crust resulting from the extension during the breakup around the same time period. Brittle deformation of the crystalline basement of Sri Lanka is also attributed to the breakup of Gondwana around 130 Ma (Kehelpannala, 1997, 2003) and almost all the dolerite dykes in the VC more or less follow the fracture lineaments resulted from this brittle deformation, especially in NE-SW, NW-SE, NNE-SSW and NNW-SSE directions (Ellis and Abeysinghe, 1987; Yoshida, 1989; Takigami, 1999; Samaranayake et al., 2015). Geochronological data obtained from Yoshida (1989) and Takigami (1999) indicates ages around 140 Ma to 170 Ma for the dolerites which are coeval with the time period of East Gondwana breakup around 130 Ma to 180 Ma (Storey, 1995; Encarnacion et al., 1996). So it is reasonable to speculate the intrusion of dolerites in the Vijayan Complex took place along the weak regions formed with crustal extension under brittle conditions during Gondwana breakup. Further the petrography of dolerites support the occurrence and cooling of the mafic magma under shallow crustal conditions. Fine to medium grained ophitic texture without any preferred orientation of minerals indicate that these intrusives did not suffer penetrative deformation that strongly affected the

Table 2. Representative mineral chemistry of dolerite samples analyzed by Energy-dispersive X-ray spectroscopy (EDS).

	Clinopyroxene		Orthopyroxene	Plagioclase[1]	Plagioclase[2]	K-feldspar	Magnetite
	Core	Rim					
SiO2	51.92	52.1	37.04	59.14	68.63	74.05	1.3
TiO2	0.7	0.56	nd	0.07	0.03	nd	12.97
Al2O3	1.95	1.68	16.92	24.54	18.42	13.83	0.86
Cr2O3	0.08	0.04	nd	0.03	0.03	nd	0.17
FeO	11.82	14.62	35.46	0.6	0.4	0.09	82.28
MnO	0.33	0.48	0.28	0.04	0.04	nd	0.61
MgO	15.2	14.87	8.7	0.04	nd	nd	0.08
CaO	17.9	15.34	0.95	7.47	1.07	0.2	1.27
Na2O	0.21	0.39	0.5	7.56	10.84	2.66	0.17
K2O	nd	nd	0.28	0.53	0.56	9.34	nd
Total	100.11	100.08	100.13	100.02	100.02	100.17	99.71
O	6	6	6	8	8	8	4
Si	1.939	1.958	1.496	2.657	3.012	3.266	0.055
Ti	0.02	0.016	0	0.002	0.001	0	0.412
Al	0.086	0.074	0.806	1.299	0.953	0.719	0.043
Cr	0.002	0.001	0	0.001	0.001	0	0.006
Fe	0.369	0.459	1.198	0.023	0.015	0.003	2.903
Mn	0.01	0.015	0.01	0.002	0.001	0	0.022
Mg	0.846	0.833	0.524	0.003	0	0	0.005
Ca	0.716	0.618	0.041	0.36	0.05	0.009	0.057
Na	0.015	0.028	0.039	0.659	0.922	0.227	0.014
K	0	0	0.014	0.03	0.031	0.526	0
Total cation	4.005	4.003	4.128	5.035	4.987	4.751	3.516
Fe^{3+}	0.014	0.008	0.124				
Fe^{2+}	0.356	0.451	1.074				
XMg	0.696	0.644	0.304				

metamorphic basement. This observation strongly supports post-tectonic emplacement in shallow to medium crustal conditions. Granophyric texture, a texture with angular grains of quartz grown with alkali feldspar observed in these rocks indicates a crystallization of very local and small felsic potions from the mafic magma. Such kind of crystallization is possible under eutectic conditions or by undercooling of the melt (e.g. Lowenstern et al., 1997). Formation of a felsic melt may have resulted from the fractional crystallization of the mafic melt, where near the final stage it is left out with a minute felsic potion. Undercooling of this final, minute felsic potion due to rapid exhumation or reaching eutectic conditions in the shallow crust must have given rise to the texture. The lack of garnet, even though the core mineral chemistry of clinopyroxene and plagioclase are very much similar to those of the garnet bearing mafic dyke (GAB/1), indicates the formation of these dolerites outside garnet stability field. This is most probably due to the lack of necessary pressure in the crustal level of its emplacement and also may have been influenced by the minute differences in bulk chemistry.

Gabbroic sample GAB/1 indicated its emplacement under higher pressure than the dolerites. The presence of garnet implies that it has crystalized in the garnet stability field. Inclusions of biotite in garnet and, growth of garnet as atolls along clinopyroxene-plagioclase interface indicates its formation consuming plagioclase with biotite and/or clinopyroxene. The lack of a planer fabrics indicates post-peak intrusion under retrogressing conditions of the host rock, and the garnet formation can be attributed to a later isobaric cooling event. Careful observation of some plagioclase formed around garnet show different chemistry than the matrix grains, indicating further garnet breakdown forming a new generation of plagioclase. This may have occurred during a period of decompression with the exhumation of the intruded rocks. Mineral habit and texture of matrix biotite in this sample imply them to have formed during further cooling associated with the retrogression of the host rock.

The gabbro sample GAB/2 indicates relatively deeper emplacement and slow cooling than the dolerites since the grain size is coarse. The grains are randomly oriented and do not possess a planer fabric indicating a post-tectonic emplacement. Comparing with the garnet bearing gabbro (sample GAB/1), the lack of garnet in this rock can be attributed possibly to the contrasting bulk chemistry of the two rocks. This different bulk chemistry is even reflected in minerals such as plagioclase and clinopyroxene, which usually form the garnet.

It is seen that these kind of dolerites and similar kind of post tectonic mafic intrusions are almost entirely confined to the VC. This may be due to the fact that the VC was in contact with the upper mantle for a longer period than the rest of the crystalline basement, allowing the emplacement of these bodies. With further geochemical analysis of these rocks, it would be possible to speculate their source and can be used to understand VC relationship with the upper mantle.

CONCLUSION

Petrographic evidence confirm that studied dolerite and gabbroic dykes totally escaped the penetrative deformation affected the host Vijayan basement. Thus, Petrographic observations are in conformity with younger intrusive ages and field relations. Petrographical characteristics and geothermobarometry of the studied samples supports the emplacement of dolerite dykes following peak metamorphism of the host rock under hypabyssal conditions

Our preliminary findings may speculate that post tectonic intrusive mafic rocks such as dolerite and grabroic dykes in the VC which are possibly of mantle origin resided in the upper mantle for much longer period than the host VC. Further geochemical and isotopic investigations are necessary for conformation of this tentative conclusion.

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