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Textural and Geochemical Study of the Older Dykes from Perhentian Island, Peninsular Malaysia

Azman A. Ghani

Department of Geology
University of Malaya, 50603,
Kuala Lumpur, Malaysia

Abstract: Textures and relationships observed in the field suggest that the older dykes intruding the Perhentian Kecil Syenite, Perhentian Island, were coeval to their host. Lobate to crenulate contact and necking of the dykes suggest that the dyke magma was injected into mobile, semi solid syenitic magma. Geochemical analyses show that the older dykes have a wide range of SiO_2, between 48.87 – 56.87%..

INTRODUCTION

The study area is a group of islands situated about 15 km off the northeast coast of Terengganu (Fig. 1). They consist of six main islands: Perhentian Besar and Kecil, Rawa, Serenggeh and Susu Dara Besar and Kecil. Mac Donald (1967), Azman (1992) and Azman and Khoo (1998) have described in brief geology of this area. The igneous rocks of the Perhentian area lie to the north of the Kapal batholith and have been considered geographically as an extension of the batholith which has geological and geochemical affinities to the Eastern belt of Peninsular Malaysia. The island is made up of two types of igneous rock namely the Perhentian Kecil Syenite and Perhentian Granite.

The Perhentian granite occupies the whole of Perhentian Besar, Rawa, Tengku Burung islands and the northern and southern parts of Perhentian Kecil Island. The main mineral assemblages are K-feldspar, plagioclase, quartz, biotite, hornblende, allanite, zircon, epidote and opaque phase The Perhentian granite has been divided into two varieties, namely, hornblende-bearing and hornblende-free granite. The main body of Perhentian granite consists of medium- to coarse-grained biotite granite (hornblende-free granite) exposed along the coast of Perhentian Besar island, north and south parts of Perhentian Island and the whole Rawa Island (Fig. 1). Microgranite and granite porphyry are found at the contact with Perhentian Kecil Syenite at Pasir Patani, Pasir Karang and Tanjung Batu Nisan.

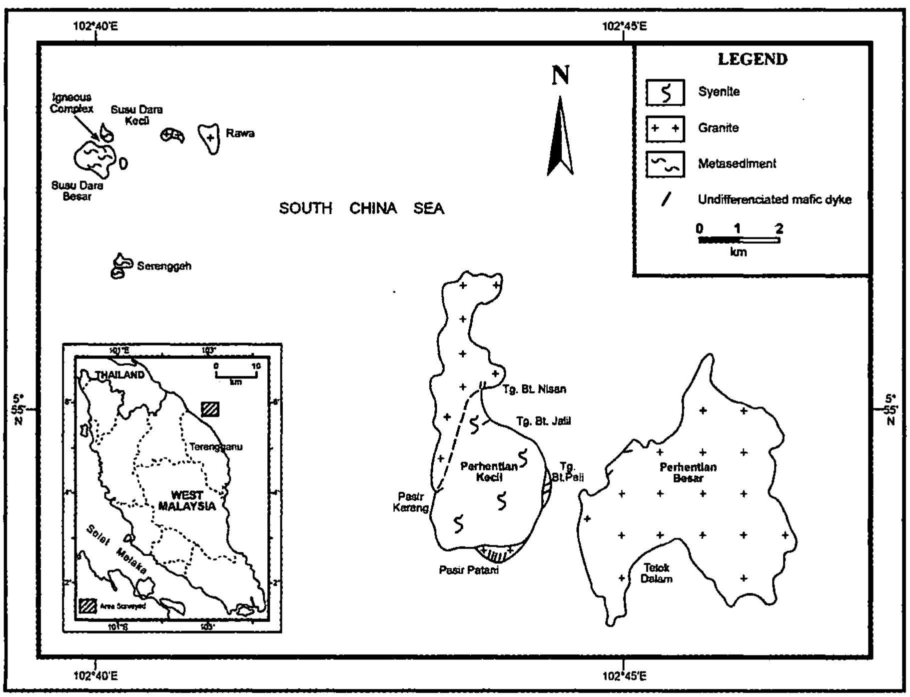

Figure 1: Map showing geology of the Perhentian Island and its surrounding area. Location of both dykes mention in the text also shown , Tanjung Batu Jalil and Tanjung Batu Peti

The Perhentian Kecil Syenite forms a circular outcrop at the central part of Perhentian Kecil Island. The pluton consists of a variety of igneous rocks ranging in composition from syenitic to monzonitic and even gabbroic. The essential minerals in the Perhentian Kecil syenite are K-feldspar, plagioclase, hornblende, pyroxene, quartz, biotite, sphene, epidote, apatite, zircon and magnetite. The monzonitic rocks can be found at Tanjung Batu Nisan about 10 m from the contact between Perhentian Kecil

Syenite and Perhentian Granite. In terms of areal distribution, the syenitic rock takes almost 90% of the pluton. Epidote nodules and veins (thickness from 2 to 5 cm) can be seen throughout the pluton. The gabbroic rocks are found as boulders mainly at eastern part of the pluton. Various types of enclaves can be found in the Perhentian Kecil Syenite such as synplutonic dykes, hornblende-rich enclaves and amphibolite blocks. They are invariably finer grained and darker coloured than their syenitic host. They usually show a sharp contact with their host.

SYNPLUTONIC DYKES FROM PERHENTIAN KECIL SYENITE

Both Perhentian Syenite and Perhentian Granite have been intruded by a series of mafic dykes. Azman (2002) divided the dykes from the Perhentian Island into older and younger dykes according to field occurrence and absolute age. The younger dykes, doleritic in composition, are commonly found intruding the Eastern Belt rocks of Peninsular Malaysia. The majority of the younger dykes strike between NE to E. The later have been study in some detail in term of their chemical composition, and K-Ar ages of the younger dykes from Kuantan area yield the age from 97 ± 2 Ma to 129 ± 2 Ma (Haile et al. 1983). They are found abundantly in several areas, such as Kuantan, Kenyir areas and island off the coast of Terengganu (Haile et al., 1983; Azman et al. 1998). The older dykes, which are far fewer in number, are mafic synplutonic dykes. Three synplutonic dykes are found in the Perhentian Kecil Syenite, on Perhentian Kecil island (Fig 1). The dykes are basaltic in composition. Azman et al. (1998) reported whole rock K-Ar ages for one dyke sample in the range of 219 ± 11 Ma.

The synplutonic dykes in Perhentian Island are found in two localities that are Tanjung Batu Peti and Tanjung Batu Sireh, both located at the eastern side of the Perhentian Kecil Island (Azman 1998). All dykes intruded the coarse grained sometimes megacrystic Perhentian Kecil Syenite. The thickness of the dykes varying from a few cm to 20 cm with lengths up to several meters and are marked by necking, disrupting or pinching and swelling along its length. Veinlets of syenitic material which may reach up to 1 cm wide penetrate into the dyke. Occasionally a K-feldspar pegmatite (2 to 3 cm across) or microsyenite can be seen bordering and sometimes veining into the dykes. Subhedral to anhedral syenitic inclusions with sizes ranging from several mm up to 2 cm across are scattered throughout the dykes. The inclusions are either monomineral (usually K-feldspar) or consist as clots of several minerals (K-feldspar, hornblende and plagioclase). The inclusion show 'drag' textures and accompanied by flow alignment of mafic phase in the dyke. The flow alignment seems to follow the shape of the margin of the syenitic inclusion and dying out away from the margin. Lobes of syenitic material occasionally penetrate into the dykes resulting in lobate and cuspate contacts between the dykes. Alignment of hornblende crystals (size up to 2 mm) can be seen in the middle of some dykes.

PETROGRAPHY

The dyke consists of plagioclase, biotite, hornblende, clinopyroxene and quartz. In thin section, the dykes usually show an amphibolitic texture (suggesting its basic origin) or sometimes hornfelsic texture. Detail examination of sawn slab of the sample from Tanjung Batu Sireh, show that the dyke is banded. It consists of alternating greenish amphibole rich band and reddish grey biotite (50%) bearing band. The contact between the bands is rather gradational with both amphibole and biotite shows some kind of mixing at the contact zone. Carefully examination of the contact indicate that the greenish band sometimes invade into the reddish band. The dyke consists of K-feldspar, hornblende, biotite and quartz as a main constituent. K-Feldspar, hornblende and occasionally biotite form a phenocrystic phase in the dyke. The K-feldspar phenocryst usually heavily sericitised K-feldspar surrounded by fine grained hornblende and biotite. The latter is usually aligned parallel to the inclusion margin forming a flow texture and dying out away from the inclusion. In the area of slow magmatic flow, quartz crystals developed along with other minerals.

A back veining of typical syenitic material up to 1 cm in thickness can be seen cutting the dyke from Tanjung Batu Peti. The back vein is made up of subhedral to anhedral K-feldspar set in relatively finer grained hornblende, biotite, opaque phase and sphene. Hornblende and sphene are the early formed phase, both occur as medium size crystal usually anhedral, closely associated with biotite and opaque in some part of the vein. The grain size of the mineral in the vein is up to 2.5 mm, compared to the dykes, usually less than 0.3 mm. Some K-feldspar is heavily sericitised and rarely contains inclusions of the matrix minerals. Flow texture produced by alignment of hornblende and sphene is well developed in the back vein. Evidence of plastic deformation shown by the sphene crystals may suggest that the veining occurred in a semi-solid condition. This implies that the syenitic magma has already crystallised when it came into contact with the dyke magma and sphene is among the first to crystallize in the syenitic magma. The flow alignment is commonly parallel to the vein margin. Strong flow alignment is also shown by the dyke minerals. Interestingly, the alignment of the minerals in the dykes curve following the crenulated outline of the vein (c.f Vernon 1991).

GEOCHEMISTRY

Two dyke samples each from Tanjung Batu Peti and Tanjung Batu Sireh were analysed for major and trace elements (Table 1). For comparison, the composition of major elements analyses of the younger dolerite dyke from Perhentian Island also given in the Table 1. The analyses show that the older dykes have a wide range of SiO_2 between 48.87 – 56.87%. The range of other elements are MgO (4.14 – 6.64), CaO (6.3 – 9.95), Na_2O (2.27 – 3.02) and K_2O (1.20 – 3.34). The range of trace elements are Rb (75-172 ppm), Sr (713 -989 ppm), Ba (118 – 228 ppm), Ce (42 – 100 ppm), Pb (2 – 5 ppm) and Zr (148 – 283 ppm). Compared to the amphibolite dyke elsewhere (e.g. Victoria Land, Antartica; Borsi et al.1995) the dyke from the study area has similar trace elements content except for Sr which is higher. Sr content of the study area dyke and Victoria Land Antartica ranging from 713 – 989 ppm and 114 – 538 ppm respectively.

DISCUSSION

Mafic dykes are a common expression of mantle magma generation related to the fracturing during extensional tectonics in both continental and oceanic environments (Hall & Fahrig 1987). The phenomenon of disruption of a mafic dyke within a felsic host is ubiquitous. It has been discussed in some detail by many authors (e.g. Roddick & Armstrong 1959; Moore & Hopson 1961; Kumar 1988; Pitcher 1991). Most of the older dykes from the study area can be matched to the examples described in this paper. The field features shown by the older dykes suggests that the dyke intrusion is coeval to its host. Lobate to crenulate contact and necking of the dykes suggest that the dyke magma were injected into the mobile semi solid syenitic magma. This is evident from the flow texture developed in both dykes and back vein. Plastic deformation shown by some of the mineral in the syenitic vein (e.g. sphene) suggests that the early crystallised mineral was dragged by the magmatic flow. Occurrence of syenitic inclusions in the dyke suggests that the quenched dykes' carapace were sometimes breached by syenitic vein material which broke up into globules on penetrating the more fluid interior of the dykes (Bussell 1991). Occurrence of fine grained or pegmatitic borders of syenitic composition suggests contraction of dyke magma after cooling. This give rise to syenitic liquid filling the marginal area. The amphibolitic or hornfelsic texture of the dykes suggests that they have undergone the metamorphism process. The texture may have been the result of metasomatic caused by differences in the concentration gradient of certain elements between the dyke and the host interface.

The dykes were metamorphosed under amphibolite facies condition. Borsi et al. (1995) showed that the dykes recrystallised under amphibolite facies metamorphism dyke from Victoria Land, Antartica reflected by increase in modal biotite and hornblende. Two analysed dyke samples show a wide range of major and trace elements.

Table 1: Geochemical analyses of the older dykes from Perhantian island

	Older Dyke samples		Average composition of younger dolerite dykes (Perhentian) n = 7
	Tanjung Batu Peti	Tanjung Batu Sireh	
SiO_2	56.28	48.87	48.26
TiO_2	1.41	1.62	1.28
Al_2O_3	16.07	17.11	16.67
FeO*	6.66	9.43	9.68
MnO	0.11	0.19	0.12
MgO	4.14	6.64	7.55
CaO	6.30	9.95	8.86
Na_2O	3.02	2.77	2.76
K_2O	3.34	1.20	1.55
P_2O_5	0.38	0.40	0.32
LOI	1.50	1.50	
Total	99.21	99.67	
Ni	7	34	
Cr	66	100	
Sc	24	36	
V	180	250	
Ba	918	228	
Rb	172	75	
Sr	989	713	
Zr	283	148	
Y	44	34	
Nb	14.2	7.2	
Ga	19	18	
Cu	6	25	
Zn	60	69	
Pb	5	2	
La	53	19	
Ce	100	42	
Th	10	3	
Nd	45	26	

REFERENCES

AZMAN A. GHANI. 1992. Petrologi dan geokimia kawasan Pulau Perhentian dan pulau-pulau sekitarnya. Unpubl. BSc. thesis, Univ of Malaya, 212pp

AZMAN A. GHANI. 1998. Occurrence of synplutonic dyke from the Perhentian Kecil island, Besut Terengganu. Warta geology 24 (1), 65 - 68

AZMAN A. GHANI. 2002. Mafic dykes from the Perhentian Island, Besut, Terengganu: Subdivision and preliminary textural and geochemical study. Jurnal Sains Malaysiana 31, pp 11 – 21

AZMAN A. GHANI AND KHOO, T.T. 1998, Field relation and petrology of igneous rocks in the Perhentian Island and its surrounding area, Besut Terengganu. Warta Geology, 24, 175-185

AZMAN A. GHANI., GRAPES, R AND KHOO, T.T. 1998. Geochemistry of dolerite dykes from the Perhentian and Redang islands, Besut Terengganu. ABSTRACT GEOSEA, K.LUMPUR.

BIGNELL, J.D. 1972. The geochronology of Malayan granites. Unpubl.D.phil thesis, Univ. of Oxford

BORSI, L., PETRINI, R., TALARICO, F. AND PALMERI, R. 1995. Geochemistry and Sr-Nd isotopes of amphibolite dykes of northern Victoria Land, Antartica. Lithos 35, 245 - 259

BUSSELL, M. A. 1991. Enclaves of the Mesozoic and Cenozoic granitoids of the Peruvian Coastal batholith. In J. Didier and B. Barbarin (Eds); Enclaves and granite petrology. Elsevier, 263 - 276.

COBBING, E. J., PITFIELD, P. E. J., DARBYSHIRE, D. P. F., AND MALLICK, D. I. J., 1992, The granites of the South-East Asian tin belt. Overseas Memoir 10, British Geological Survey

HAILE, N. S., BECKINSALE, R. D., CHAKRABORTY, K. R., HANIF HUSSEIN, A AND HARDJONO, T. 1983. Paleomagnetism, geochronology and petrology of the dolerite dykes and basaltic lavas from

Kuantan, West Malaysia. Geol. Soc. Malaysia Bull. 16, 71 - 85.
HALL, C.H. AND FAHRIG W.H. 1987. Mafic dyke swarms. GAC Spec. Paper 34, Publ. No. 120, Int. Lithosphere Programme
KUMAR, S.C. 1988. Microgranular enclaves in granitoids: agents of magma mixing. Jour. Southeast Asian Earth Sci., 2, 109 - 121.
MACDONALD, S. 1967. The geology and mineral resources of North Kelantan and North Terengganu. Geol. Surv. Mem. 10, 202 pp.
MOORE, J.G AND HOPSON, C.A. 1961. The independence dyke swarm in eastern California. Am.Jour.Sci. 259, 241 - 259.
PITCHER, W. S. 1991. Synplutonic dykes and mafic enclaves. In J. Didier and B. Barbarin (eds) ; Enclaves and granite petrology. Elsevier, 383 - 391
RODDICK, J. A. AND ARMSTRONG, J. E. 1959. Relict dykes in the Coast Mountains near Vancouver, B.C. Jour.Geol. 67, 603 - 613.
VERNON, R.H. 1991. Interpretation of microstructures of microgranitoid enclaves. In J. Didier and B. Barbarin (eds) ; Enclaves and granite petrology. Elsevier, 227 - 291.

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