Petology of Late Cenozoic Basalts in Vietnam

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ABSTRACT

Basalt magmatism occurred over large parts of east and Southeast Asia following the early Tertialy Indo-Eurasian collision. In Indochina (Vietnam, Cambodia and Laos) and Thailand the basalt occupy over 30,000 km^2 and produced numerous basalt plateaus several hundreds of meters thick, stratigraphically recorded in many cases by hydrologic drill sections. In Vietnam the basalt occurred abouth 23,000 km^2 and comprises numerous of eruptive centers (Fif.1). The basalt first appeared ca. 16 – 17 ma BP with the bulk of eruptions occurring in the last 5 ma, the most recent being in 1923 in the offshore 'Ile de Cendres' complex (Tab.1)

Tab.1. Some characteristics of basaltic centers

Centers	Area (km^2)	Thickness (m)	Age (ma)	Centers	Area (km^2)	Thickness (m)	Age
Lung Po Ho	1	100	?	BuonMaThuot	3,800	260	8.9-1.63
DienBienPhu	2	?	5.8	Pleiku	>4,000	>440	7.4-1.59
Phu Quy	6	?	5.9	Quang Ngai	5		1.8-1.68
Quang Tri	>12		7.8-0.4	Xuan Loc	2,400	>130	11.58-0.44
Dalat	2,500	300	17.6-0.37	Ile de Cendres			2.5-(1923)
Phuoc Long	>6,000	250	9.1-4.6				

In Vietnam the basalts penetrate at least four lithospheric sectors marking the successive amalgamation of Precambrian and younger crustal blocks that from the Indochina Plate. The northern sector comprises accretionary complexes of Precambrian and Paleozoic age in northern Vietnam, through which isolated basalt eruption occurred at (e.g.) Kon Plong, Dien Bien Phu, Phu Quy, Quang Tri, and Con Co island. The central sector is defined by the Kontum massif, a quasi-cratonic mass of unknown thickness with an Archean core and concentric sutures reflecting Proterozoic, Cambrian, and Permian-Triassic tectonic episodes. It includes basalt complexes at Song Cau (erupted through Archean), Buon Ma Thuot, Pleiku, and Kong Plong (erupted through Proterozoic), smaller centers at Quang Ngai and Re Island, and further offshore eruptives north of 15^0N (all erupted through Cambrian). The southwestern sector includes the eastern part of the Khorat Plateau, represented by a Precambrian core (in Thailand), encloses accretionary belts of Paleozoic and Mesozoic ages (in southeastern Vietnam). It contains the

largest single basalt complex, Phuoc Long. The southeastern sector consists of undifferentiated Precambrian over lain by Paleozoic and Mesozoic accretionary belts. This sector includes basalts of both oldest and youngest onshore complexes, Dalat and Xuan Loc respectively, and the active offshore Ile des Cendres.

Late Cenozoic basalts from Vietnam consist of two main groups related to two eruptive episodes, in many cases separated from one another by 0.5 – 5 m-thick paleosol horizons. The early phase comprises large-volume quartz and olivine tholeiite flows, erupted from extensional fissures, and the late phase comprises central eruption of olivine tholeiite, alkali basalt and basanite. This two-phase pattern is repeated at Dalat, Pleiku, Buon Ma Thuot and Xuan Loc centers, although the less well-documented centers at Phuoc Long and Ile de Cendres appear to be represented, respectively, by early and late phases only. Quartz tholeiites are generally aphyric to moderately phyric (<10% phenocrysts) with plagioclase (An_{83-72}), olivine (Fo_{78-84}) and augite ($Wo_{47-49}En_{40-36}Fs_{13-14}$). Quartz tholeiites from Phuoc Long, Dalat and Dien Bien Phu centers may contain small, uncreacted phenocrysts of orthopyroxene (~En_{82-78}). Olivine tholeiites are aphyric to sparsely phyric. Phenocrysts rarely exceed 10-15% by volume and are mostly olivine (Fo_{82-78}) and augite ($Wo_{44-43}En_{42-40}Fs_{16-19}$). Alkali basalts are moderately phyric with 7 – 15% olivine phenocrysts (Fo_{89-70}) of several generations together with lesser amount of augite phenocrysts. The alkali basalts often host mantle xenoliths of garnet and spinel lherzolite, and harzburgite, a rang of cumulus fractionation products including wehrlite, websterite and pyroxenite, eclogite of unknown provenance, and megacrysts of olivine, augite, anorthoclase, phlogopite, corundum (sapphire) and zircon. The early-phase basalts were characterized by high SiO_2 and low FeO*, TiO_2 and P_2O_5, in contrast, the later-phase basalts were characterized by low SiO_2, and higher FeO*, TiO_2, and P_2O_5 (Fig.2). The features of petrography and major element compositions of basalts, on one hand, reflected the magmatic source and on the other hand, were the results of different melt conditions. Early series were generated under large melt fractions with a low pressure, less differentiated, and later series were generated under high pressure, in small melt fractions, strongly affected by fluids, characterized by differential crystallization in intermediate chambers.

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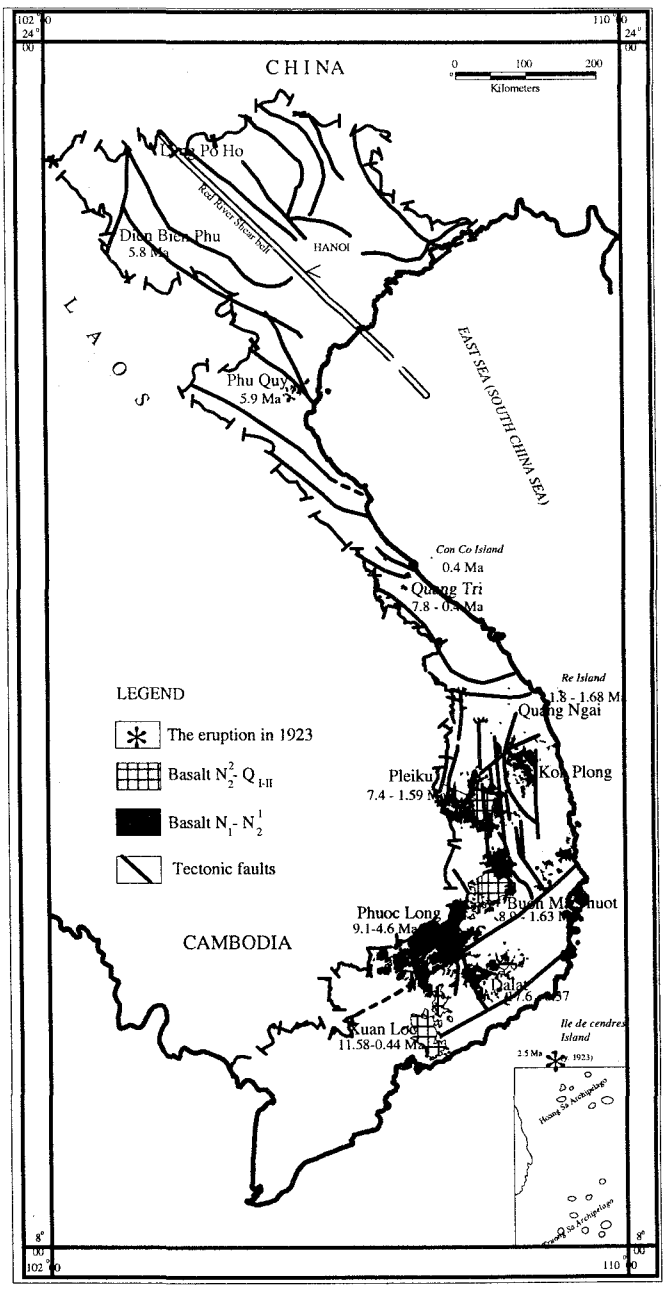
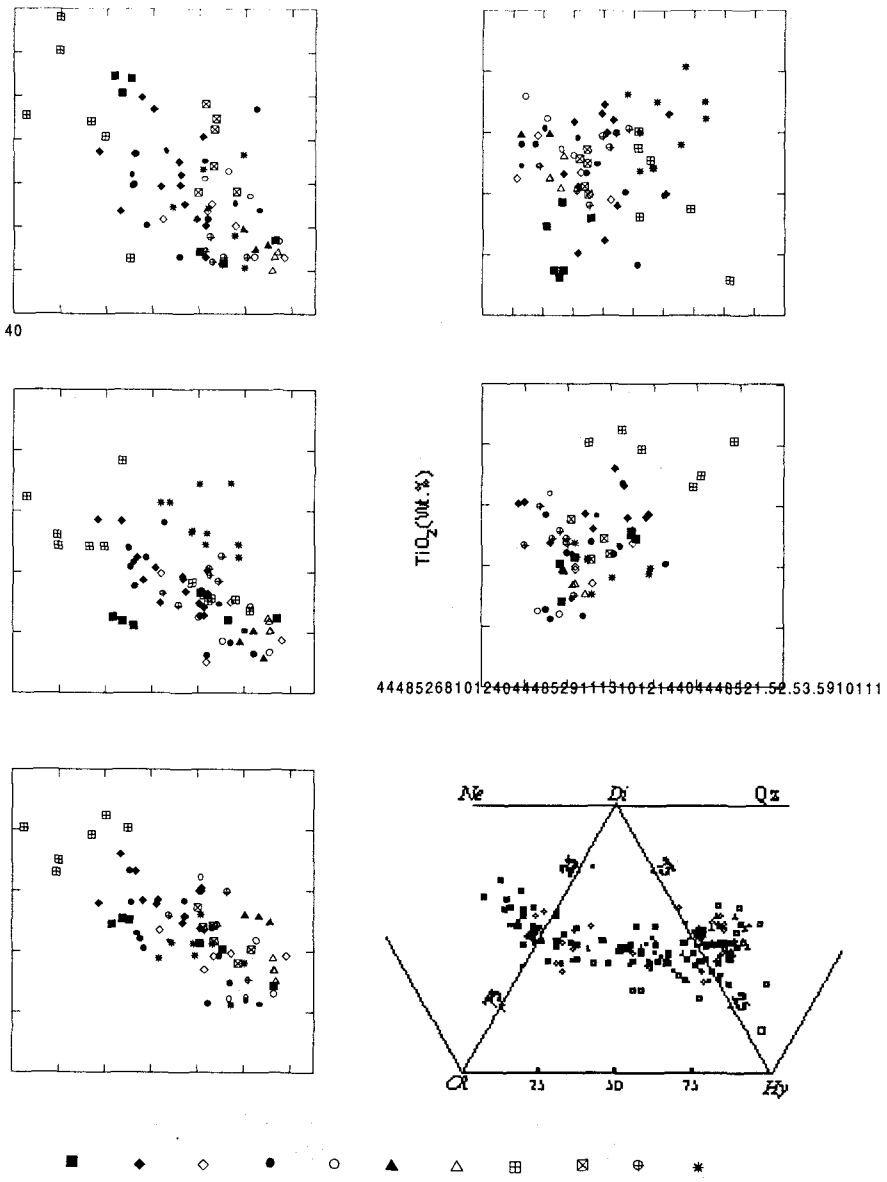


Fig.1. Map of distribution of Cenozoic basalt in Vietnam (shaded), showing fault system (shaded lines), and age of volcanic rocks (numbers)



1. Quang Ngai – Re Island; 2. Pleiku (upper series); 3. Pleiku (lower series); 4. Buon Ma Thuot (upper series); 5. Buon Ma Thuot (lower series); 6. Dalat (upper series); 7. Dalat (lower series); 8. Xuan Loc (upper series); 9. Xuan Loc (lower series); 10. Phuoc Long; 11. Ile de Cendres.

Fig. 2. Plot of wt.% major oxides vs. SiO_2 (a,b,c), FeO* vs. Na_2O (d), and CaO/Al_2O_3 vs. TiO_2 (e).

Fig.2f shows CIPW normative variation for representative Vietnamese basalts.

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