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MAJOR ELEMENT GEOCHEMISTRY OF THE LATE PALAEOZOIC-EARLY MESOZOIC GRANITOIDS IN VIETNAM

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ABSTRACT

In this paper authors present the preliminary results of the geochemical-petrological study of the granitoid rocks (Dienbiemphu- and Queson-complex) in Vietnam. Several petrochemical diagrams and parameters have been used to recognize the nature and the tectonic affinity of these intrusive rock assemblages. Majority of them show calc-alkaline character, however, the evolved formations display higher alkaline-content. Both granitoids are characterized by a transitional affinity, they show both compressional and extensional features as well as S- and I-type nature. The plutonic rocks of these two complexes exhibit similar petrological and geochemical characters indicating that they were formed in the same tectonic position: in the inner part of the continental margin.

INTRODUCTION

In this paper we present the preliminary results of a detailed petrological and geochemical study on the granitoid rocks of Vietnam. Our conclusions are based on the major element geochemical compositions, therefore we note that the further investigations (rare-earth element chemistry, study of the main mineral phases, i.e. feldspars, biotite, opaques etc. in these rocks) will give more exact results and may slightly modify of these conclusions. Results of this major element geochemical study, which is the first one on the Vietnam granitoids using modern petrochemical tools, can be regarded as a working hypothesis for the following investigations.

The Late Palaeozoic-Early Mesozoic granitoids of Vietnam have been divided into two complexes: the Dienbiemphu (DBP)-complex and the Queson (QS)-complex (DOPJIKOP 1965; TRAN VAN TRI and NGUYEN XUAN TUNG 1977; HUYNH TRUNG 1980).

The DBP granitoids occur in the northwestern part of Vietnam, while the QS-granitoids can be found in the northern, western and southwestern margin of the Kontum area (Middle part of Vietnam; *Fig. 1*). Both magmatites were formed during the Late Permian-Early Triassic based on the following geological evidences:

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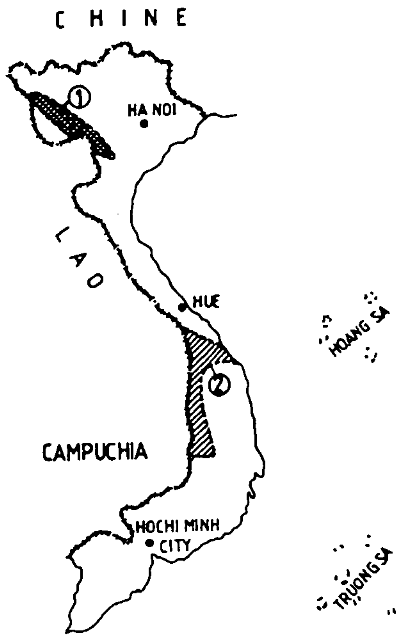

Fig. 1. Areal distribution of the granitoid rocks of the DBP- and QS-complexes.

a.) The granitoid rocks of the Nampo- and Nammung Massif belonging to the DBP-complex intruded into the Lower Permian sedimentary formations and they are overlain by Upper Triassic coal-bearing deposits (*Fig. 2*).

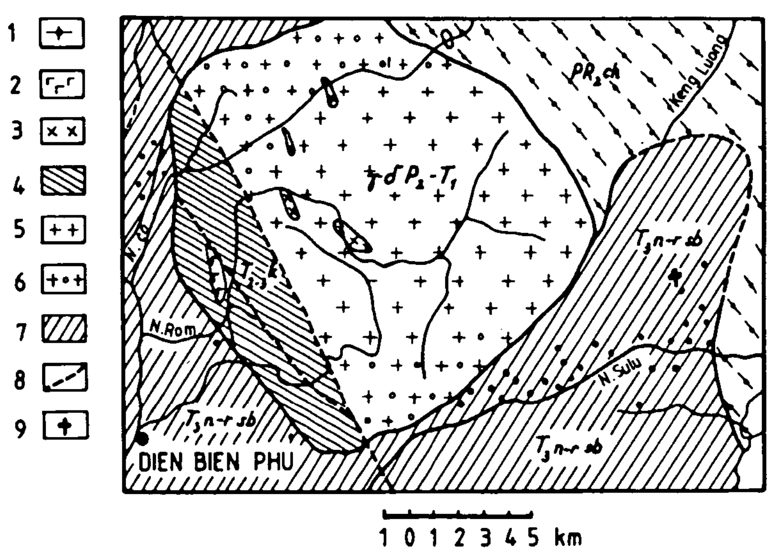

Fig. 2. Geological map of the NamRom massif (after DOPJIKOP *et al.*, 1965).
Legend: 1: Palaeozoic mica-schists, quartzite, amphibolite and marble (PZnc, PZch); 2: Late Permian gabbrodiorite; 3: Late Permian-Early Triassic diorite, quartzdiorite, granodiorite and granite; 4: Triassic Conglomerate, sandstone, argilite, rhyolite and basalt ($T_{2\text{-}3}$lc); 5: Triassic biotite-granite and two-micas granite; 6: Muscovite-granite; 7: Sandstone, aleurolite and conglomerate.

b.) The granitoids of Queson Massif intruded into the Ordovician-Lower Silurian volcano-sedimentary sequence resulted in a contact metamorphic zone characterized by epidote-amphibole hornfels. The intrusive formation is overlain also by the Upper Triassic coal-bearing deposits (*Fig. 3*).

c.) K/Ar radiometric data measured on separated biotite fractions show 235—266 Ma for the DBP granites (DOPJIKOV 1965; TRAUVANTRI 1977) and 234—302 Ma for the QS granites (HUYNH TRUNG 1980).

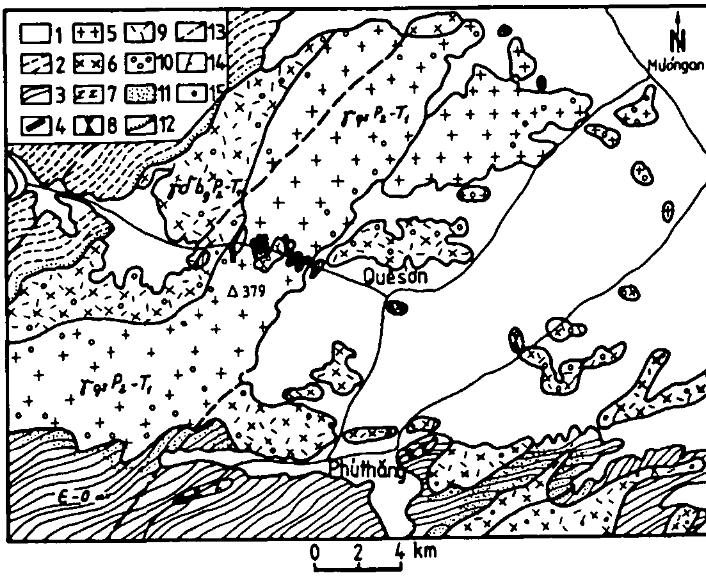

Fig. 3. Geological map of the Queson massif.
Legend: 1: Quaternary sediments; 2: Triassic coal-bearing conglomerate, sandstone and aleurolite; 3: Early Palaeozoic chlorite-quartz schists and greenschists; 4: Pegmatoids, aplite, graniteporpyre (III. phase); 5: Granite and granodiorite (II. phase); 6: Quartz-diorite, apodiorite and granodiorite (I. phase); 7: serpentinite and various ultramafics (Hiep Diu Complex); 8: diorite; 9: magmatic microclinitic rocks; 10: submagmatic microclinitic rocks; 11: Contact metamorphic rocks; 12: Geological boundary; 13: Faults; 14: Tectonic lines; 15: Locations of the samples collected for radiometric age-analyses.

PETROGRAPHY

The studied granitoid-complexes are considered to belong to a gabbrodiorite-quartzdiorite-granite-granosyenite differentiation sequence. The intrusive magmatism can be divided into three main phases resulted in the following formations:
/1/ *Gabbrodiorite and quartzdiorite (tonalite).* Mineral composition: plagioclase (50—60%), amphibole (10—15%), biotite (10—15%), clinopyroxene (3—5%), quartz (5—10%) and alkali feldspar (0—3%).
/2/ *Granite.* Mineral composition: plagioclase (30—35%), biotite (10—15%), amphibole (5—10%), alkali feldspar (25—30%), quartz (30—35%).
/3/ *Aplite, micrograniteandgraniteporphyre.* Mineral composition: alkali feldspar (35—40%), quartz (35—40%), plagioclase (20—25%), biotite (0—5%).

Accessory minerals of the formations are magnetite, ortite, sphene and ilmenite appearing with varying amount in the gabbrodiorite-granite assemblage.

Geological and petrological data indicate that the granitic magma resulted only in the large granodiorite and granite bodies (2. phase) and it did not differentiated further forming volatile-rich, granitophile rare-earth element-bearing phases. Aplites, microgranites and graniteporphyres may have been formed from an independent granitic magma (3. phase)

PETROCHEMISTRY

DBP Complex. Majority of data points of the DBP granites fall into the calc-alkaline field on the SiO_2 vs. alkali ratio diagram and only the late stage leucogranites show alkali nature (*Fig.4*). The petrochemical trend shows a continuous alkali-enrichment during the differentiation. The Na/K ratio in the DBP granites is predominantly larger than 1 (*Fig. 5*). The distribution of data points in the Na-K-Ca triangular diagram indicates that the first phase separated from the granitic magma was the Ca-rich plagioclase followed by the crystallization of alkali feldspar and Ab-rich plagioclase. The Na/K ratio decreases with the fractional crystallization, however, Na_2O always exceeds the potassium-content. This characteristics can be explained as the sodium-rich sequence derived from the partial melting of the oceanic slab subducted below the continental crust, then this acidic magma intruded into the upper levels and suffered crustal contamination resulted in a light potassium-enrichment.

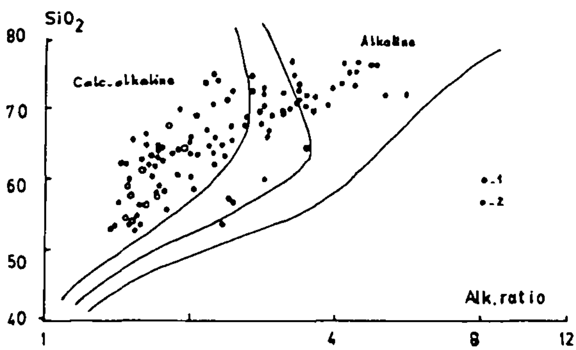

Fig. 4. Distribution of data-points of the DBP- and QS-granitoids on the WRIGHT-alkalinity ratio vs. SiO_2 plot.

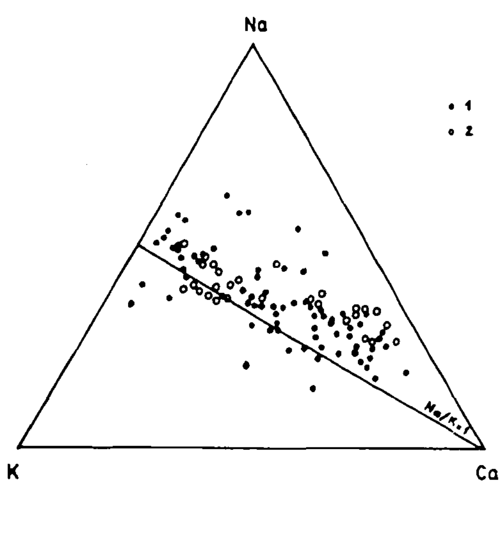

Fig. 5. Na-K-Ca triangular diagram for the DBP- and QS-granitoids.

The F/M ratio of the DBP granites is always larger than 1 *(Fig. 6)*, the MgO-content is moderate, while the total FeO is low as compared to the high alkali abundances. The petrochemical trend presented on the AFM diagram (*Fig. 6*) starts from the iron-rich composition and shows a continuous alkali-enrichment and a depletion in the mafic elements during the differentiation process. This evolution suggests that the Fe/Mg ratio remained more or less constant during the crystallization of the granitic magma.

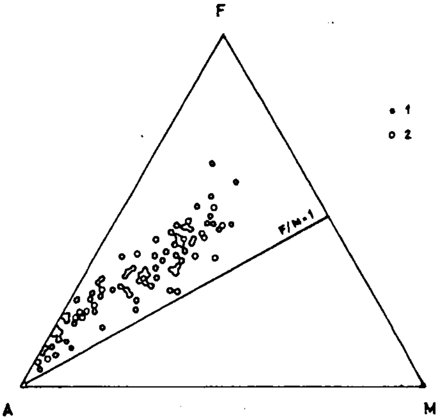

Fig. 6. AFM triangular diagram for the DBP- and QS-granitoids.

QS Complex. The data points of the QS granites fall also into the calc-alkaline field on the SiO_2 vs. alkali ratio diagram *(Fig. 4)* showing a continuous alkali-enrichment. The Na/K ratio and the F/M ratio always exceeds the unit which is similar to that of the DBP granites (*Fig. 5,6*), i.e. both granite complexes exhibit similar petrochemical evolutionary trend.

PETROGENESIS

Granitic rocks of the studied complexes show partly I-type and partly S-type affinity suggested by the ACF discrimination diagram (*Fig. 7*). The oxidation degree ($Fe_2O_3/(FeO+Fe_2O_3)$) of these rocks also indicates this two-fold character:

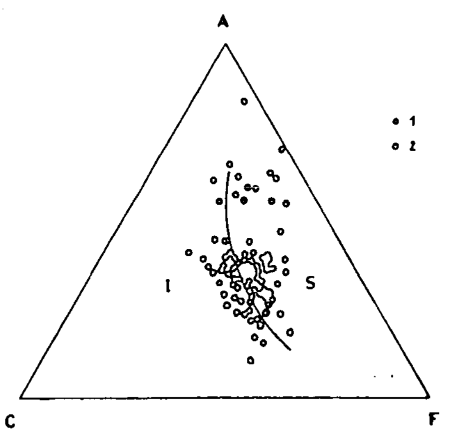

Fig. 7. ACF triangular diagram for the DBP- and QS-granitoids.

although, its values are varied strongly, the average of them is around 0.35 (*Fig. 8*) exhibiting both I-type and S-type feature. The Na/K ratio (1) and the high CaO-content indicate I-type nature, however, the peralumina index (Al/(Na+K+Ca/2)) is larger than 1.1 characterized the S-type granites (CHAPPEL and WHITE 1974). We can conclude from these data that both sedimentary and basic magmatic rocks had important roles in the ultrametamorphic granite petrogenesis.

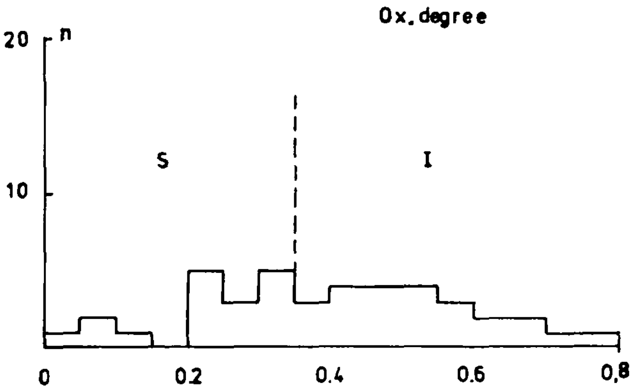

Fig. 8. Frequency distribution of the $Fe_2O_3/(Fe_2O_3+FeO)$ ratio in the studied granitoid series.

TECTONIC POSITION

The original tectonic position of the Late Palaeozoic-Early Mesozoic granitoid complexes in Vietnam was determined using the following parameters:

- *Differentiation Index* (DI, THORNTON and TUTTLE, 1960), the normative An-content, the shape and the mode of the distribution curve on the histogram of these values.
- The *F/M ratio* and the *differentiation trend* on the AFM triangular diagram.
- The *calc-alkaline index* ($CaO/(Na_2O+K_2O)$), the alumina saturation, the total alkali- and the CaO-content, the oxidation degree.

DBP granite complex. The average of the DI-values is 70±25 indicating a strongly differentiated nature for this intrusive assemblage (*Fig. 9*). The distribution curve of DI has two maxima at the values of 60—70% and 90—95% respectively. The distribution of the normative An-content proved to be similar to that of the DI. The average of An is 17±15 (note the high standard deviation!), the maxima of the curve are at 14—16% and 20—22% respectively (*Fig. 10*). It can be explained as the DBP granitoids contain two-generation plagioclases. These features as well as the F/M ratio and the evolutionary trend on the AFM diagram all show compressional-type granitoid character for the DBP intrusive rocks. The position of data points on the SiO_2 vs. $CaO/(Na_2O+K_2O)$ diagram (*Fig. 11*) also supports this conclusion. Nevertheless, the high Na/K ratio and the total alkali-content indicate extensional-type granitoid character. Based on this two-fold behaviour of the DBP intrusive rocks they can be regarded transitional type (PETRO *et al.* 1979) granitoids.

The normative q-or-pl triangular diagram clearly displays the calc-alkaline granodiorite sequence (*Fig. 12*) characterized by a moderate potassium-content. This intrusive formation has transitional nature between the trondhjemites and the

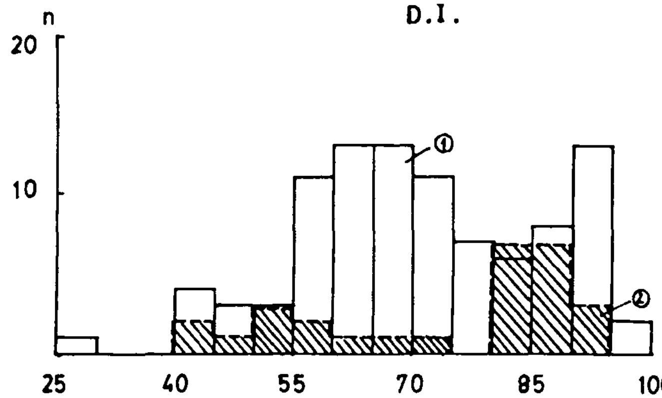

Fig. 9. Frequency distribution of the Differentiation Index in the studied granitoid series.

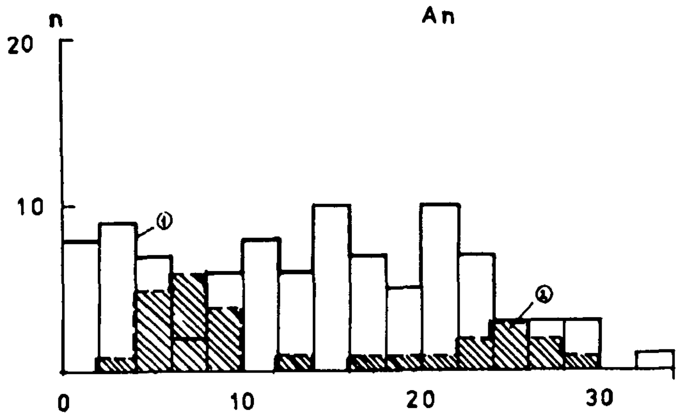

Fig. 10. Frequency distribution of the normative An-content in the studied granitoid series.

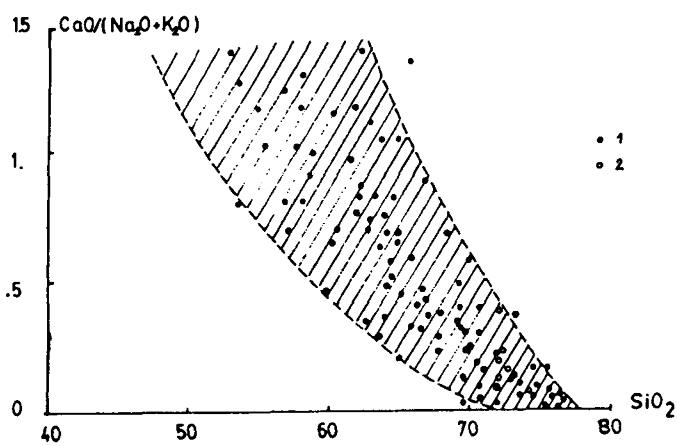

Fig. 11. The calc-alkaline index vs. SiO_2 plot for the DBP- and QS- granitoids.

monzonitic granites, i.e. they do not show direct relationship to the continental margin origin. They can be regarded as partly I-type and partly S-type (magnetite- or ilmenite-type; LAMEYRE *et al.* 1982) granitoids.

QS granite complex. It appears with a wide compositional variation (*Fig. 9*), the average of the DI-values is 70±25 indicating strongly differentiated behaviour. Two maxima can be observed on its frequency distribution curve at the values of 50—55% and 80—90% respectively. The normative An distribution is similar to that of the DI showing two maxima at the values of 6—8% and 24—26% respectively. The average of the An is 15±14 (note the high standard deviation!). These characters are typical to the extensional granitoids (PETRO *et al.* 1979), i.e. the QS granitoids differ from the DBS complex in this respect.

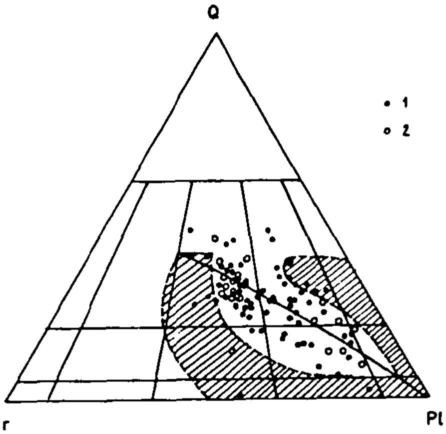

Fig. 12. Normative Q-Or-Pl triangular diagram for the DBP- and QS-granitoid series.

The F/M ratio (~1) on the AFM diagram (*Fig. 6*) is characteristic to the compressional plutonic rocks. The SiO_2 vs. $CaO/(Na_2O+K_2O)$ plot (*Fig. 11*), the peralumina ratio (1.1) as well as the calc-alkaline index also support the compressional nature of the QS granites like in the case of the DBP rocks.

On the normative q-or-pl plot (*Fig. 12*) data points of these rocks are situated along the line of the calc-alkaline granodiorite sequences. Summing up, the QS granitoids can be regarded as a transitional type plutonic assemblage showing both compressional and extensional feature.

CONCLUSIONS

Based on the major element chemistry the following characters have been recognized for the Late Palaezoic-Early Mesozoic Dienbienphu- and Queson granitoids (Vietnam):

— The Plutonic rocks of both complexes belong to a differentiation trend characterized by a petrochemical evolution from the calc-alkaline to the alkaline formations. Majority of these granitoids have calc-alkaline affinity, however, the evolved formations display higher alkaline-content. The Na/K ratio always exceeds the unit, the potassium-content increased slightly, whereas the sodium-content decreased during the fractional crystallization.

The first crystallization products were Fe-rich phases, the total iron content is higher than the MgO-content throughout the differentiation process.

- A part of the DBP- and QS-granitoids show S-type nature, while the others can be regarded as I-type granites. This means that not only sedimentary but magmatic rocks also had important roles in the ultrametamorphic process leading to the formation of the granitic magma.
- The DBS- and QS-granites are characterized by a transitional affinity, they show both compressional and extensional features. They belong to the calc-alkaline granodiorite sequences and they were formed in the inner part of the continental margin.
- The plutonic rocks of DBP- and QS-complexes exhibit similar petrological and geochemical characters indicating that they were formed in the same tectonic position. Therefore, despite the different spatial distribution and the slight differences in the K/Ar radiometric data of these complexes, they can be range into the same granitoid sequence formed during the Late Permian to the Early Triassic in the area of Vietnam.

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