

TECTONICS AND MAGMATISM IN NORTHWEST VIETNAM

Tektonika i magmatyzm północno-wschodniego Wietnamu

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Treść: Na tle tektoniki płyt Azji południowo-wschodniej przedstawiono położenie północno-wschodniego Wietnamu i pięć grup skał magmowych genetycznie związanych z tą tektoniką. Najstarsza związana jest z powstawaniem Gondwany, druga obejmuje granitoidy związane z kolizjami i powstawaniem struktur kaledońsko-hercyńskich, trzecia zawiera ofiolity Paleotetydy, czwarta to anorogeniczne, jurajsko-kredowe granitoidy wewnątrzpłytkowe, piąta, kenozoiczna, reprezentowana jest przez granitoidy – efekt uskoków po kolizji Indii z Azją.

Słowa kluczowe: Wietnam, tektonika płyt, magmatyzm, paleozoik, mezozoik, kenozoik

Key words: Vietnam, plate tectonics, magmatism, Paleozoic, Mesozoic, Cenozoic

INTRODUCTION

Metcalf (1998, 2002) and Golonka *et al.* (2006) distinguished number of plates and terranes within Vietnam and adjacent areas (Fig. 1). The northwest Vietnam (NWN) belongs to Indochina block (ICB) and South China block (SCB). The SCB block includes southern part of China and northeastern fragment of Vietnam. It is separated from North China, by Quingling-Dabie suture, from Indochina by Song Ma suture, from Sibumasu plate by Ailaoshan suture, from Songpan-Ganzi accretionary complex by Longmenshan suture. Southeastern margin of South China is a passive margin connected to South China Sea by extended continental crust. To the East South China plate is bordered by Taiwan foldbelt and the Okinawa trough passive margin. The plate was finally formed during Precambrian times.

Indochina block (ICB) comprises the countries of Vietnam, Laos, Cambodia and western Thailand; perhaps also southeastern part of Malayan Peninsula, fragment of Sumatra and

westernmost fragment of Borneo belong to ICB. To the West it is separated from the Sibumasu plate (from south to north) by Raub-Bentong, Sra Kaeo and Nan-Uttaradit sutures; to the northeast it is separated from South China plate by Song Ma suture. Eastern margin of Indochina is a passive margin connected to South China Sea by extended continental crust. The tectonic structures in Northwest Vietnam could result of three major collisional events that took place during the Paleozoic, the Permo-Triassic and the Tertiary (Hung & Golonka 2008).

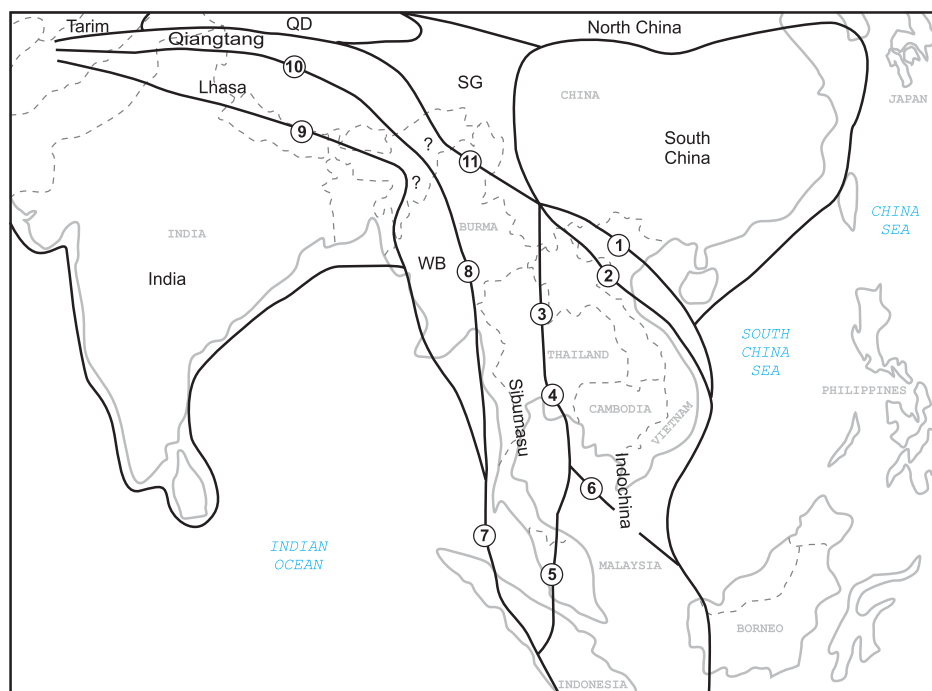


Fig. 1. Main plates and terranes of Southeast Asia (partially from Metcalfe 1998, Golonka *et al.* 2006)

Fig. 1. Główne płyty tektoniczne i terrany południowo-wschodniej Azji (częściowo z Metcalfe 1998, Golonka *et al.* 2006)

SEDIMENTARY SERIES

More than forty lithostratigraphic formations have been identified in the NWVN, divided according to 8 groups:

- 1) NeoProterozoic (NP) includes Xuan Dai group, Nam Su Lu and Nam Co formations, Boxinh group, Sapa group;
- 2) Cambria (C) group includes Camduong, Benkhe, and Hamrong formations;
- 3) Ordovician-Silurian (O-S) group contains Dongson, Sinhvinh and Bohieng formations;
- 4) Silurian-Devonian contains Banpap, Nampia, Taytrang, Namcuoi, NamPia, Bannguon, Namsap, and Bancai formations;
- 5) Carboniferous-Permian (C-P) includes Danieng, Bacson, Bandiet, Yenduyet formations;

- 6) Triassic (T) includes Tanlac, Hoangmai, Donggiao, Namtham, Muongtrai, Laichau, Nam-mu, Pacma, Suoibang formations;
- 7) Jurassic-Cretaceous includes Namthep, Nampo, Namma, Yenchau formations;
- 8) The last one includes Neogen-Quaternary sediments (Q).

TECTONIC SETTING

Northwestern Vietnam consists of four geological structural units (Fig. 2): from north to south, Songhong, Song Da, Song Ma and Samnua regions.

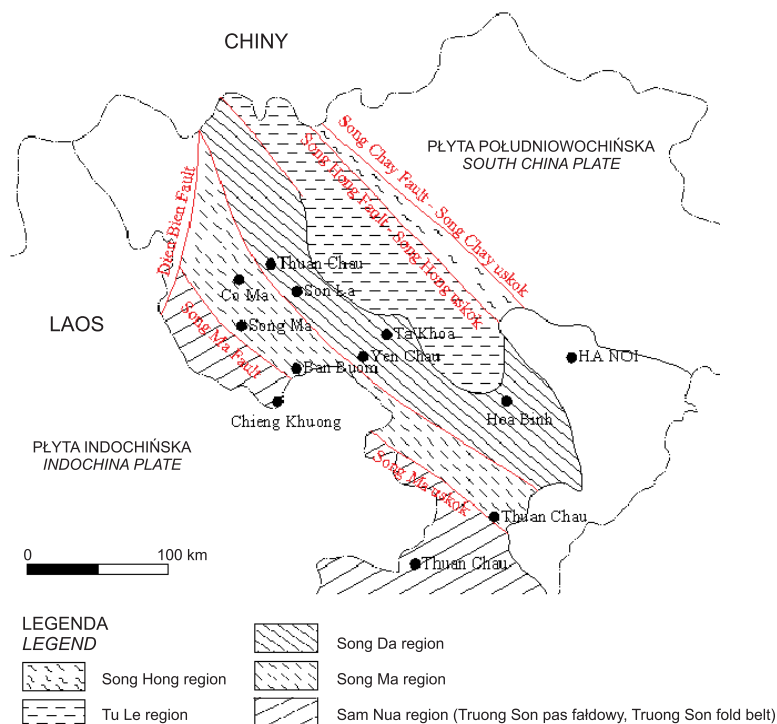


Fig. 2. Locality and geological region/terrané map of Northwest Vietnam (adapted from Fromaget 1941, Tran Van Tri 1979)

Fig. 2. Mapa lokalizacji i obszarów/terranów geologicznych północno-zachodniego Wietnamu (zaadoptowane za Fromaget 1941, Tran Van Tri 1979)

Songhong (Red River) region, which lies between the Songhong and Songchay faults and is dominated by a linear belt of highly strained high-grade schists assigned a Proterozoic age in Vietnamese geological maps. The northwestern part of this zone is occupied by Phan Si Pan massif where the geology is dominated by migmatitic and granitic complexes offset sinistrally by major fault. Slivers of Cambrian to Devonian sedimentary sequences also occur in this zone and trend more or less northwest.

The Song Da region is a part of SCB; it is bordered to the northeast by Songhong fault and to the southeast by Song Da fault. The Song Da terrane consists of Cambrian to Cretaceous sedimentary rocks ranging from marine carbonates to continental red beds, and includes a widespread series of Permian basalts and a Permo-Triassic sedimentary series. Besides, it is also comprise Tule region, which was referred to as the Tule rift depression in Tran Van Tri (1979). It is a region dominated by Jurassic to Cretaceous calc-alkaline volcanic units and continental sedimentary rocks.

The Song Ma region is located between the Truongson fold belt and the Song Da region. It is an arched northwest trending structure often referred as the Song Ma Anticlinorium (e.g. Tran Van Tri 1979). It is dominated by low to high-grade unfossiliferous schists intruded by Devonian and Triassic granitoids, metagreywackes, greenschists, amphibolites, and marbles. The southern part of the structure contains serpentinised ultramafic bodies referred by Vietnam geologists as ophiolites, and a gneissic plagiogranite called the Posen complex. The Song Ma region also contains non-schistose fossiliferous Middle Cambrian limestones at Dienlu and perhaps Permian Nuinua ultramafic massif west of Thanhhoa. The suture zone between IDB and SCB is located within the Song Ma region.

The Samnua region (Truongson fold belt) is a part of ICB within northwestern Vietnam; it is bordered to the northeast by Song Ma fault and limited westward by the border between Laos and Vietnam. This is a complex, faulted region with imbricated thrust folds and fault structures, dominated by Ordovician to Cretaceous sedimentary and subsidiary volcanic beds and contains possibly Cambrian but undated low to high-grade metamorphic rocks at Phuhoat (Tran Van Tri 1979, Phan Cu Tien 1989). The Triassic to Cretaceous units in northern part of the fold belt could be correlated with those in the Song Da zone (Tran Van Tri 1979, Phan Cu Tien 1989).

THE MAGMATIC UNITS

Five groups of magmatic rocks developed in different tectonic setting are recognized. The detailed magmatic units and their relationship to tectonics are presented in table 1. The first group represented by mafic and acid rocks is known as Baoha, Xongiau, and Posen complexes, respectively. They were formed in strong active continental margin of South China block during Proterozoic time. This event may be equivalent to a collisional event related to formation of Gondwana at 500 Ma (e.g. Metcalfe 2006). The second group comprises the Songchay granitoid and Phisilung granitoid complexes, which are related to continental collision. This magmatism was probably coeval with the “Caledonian” to “Hercynian” folding events (Tran Van Tri 1992).

The third group comprises the granitoid from Chiengkhuong, ultramafic Nuinua complexes, Boxinh gabbroid complex, Huoihao metabasalt effusive formation, respectively. They are represented an Ophiolite belt of remnant of Paleo-Tethys Oceanic lithosphere accreted into the northern edge of the Indochina block. The age of crystallization and accretion process of Boxinh (MOR), Nuinua ultramafic complexes or Honvang massif (NCMUM complex) in Samnua zone of Trung (2007) are still controversial. Probably, it could not be younger than Late Permian. The fourth group is Dien Bien Phu, Song Ma, Phiabioc granitoid complexes, respectively, which are related to collision tectonic setting.

Table (Tabela) 1

The magmatic rocks and related to tectonic setting of NWVN area
Skały magmowe i ich relacja do tektoniki północno-zachodniego Wietnamu

Era, <i>Era</i>	Period <i>Okres</i>	Lithological complexes <i>Kompleksy litologiczne</i>	Magmatic rocks <i>Skały magmowe</i>		Probable tectonic setting <i>Przypuszczalne reżimy tektoniczne</i>
			Intrusive	Effusive	
Cenozoic <i>kenozoik</i>	Paleogene <i>paleogen</i>	Putra		x	
		Cocpia	x		intraplate extension <i>rozsuwanie między płytowe</i>
		Pusamcap	x		intraplate extension <i>rozsuwanie między płytowe</i>
		Namxe-Tamduong	x		intracontinental extension <i>rozsuwanie interkontynentalne</i>
		West Yeyensun	x		intracontinental extension <i>rozsuwanie między płytowe</i>
Mesozoic <i>mezozoik</i>	Cretaceous <i>kreda</i>	East Yeyensun	x		intraplate magmatism <i>magmatyzm między płytowy</i>
		Phusaphin	x		intraplate magmatism <i>magmatyzm między płytowy</i>
		Muonghum	x		intraplate magmatism (?) <i>magmatyzm między płytowy (?)</i>
		Ngoithia		x	intraplate magmatism <i>magmatyzm między płytowy</i>
		Tule		x	intraplate magmatism <i>magmatyzm między płytowy</i>
		Namchien	x		continental margin type <i>granice kontynentalne</i>
		Suoibe		x	
	Permo-Triassic <i>permo-trias</i>	Phiabioc	x		convergent margin <i>granice konwergentne</i>
		Songma	x		postorogenic <i>postorogeniczne</i>
		Banxang		x	oceanic island basalt (OIB) <i>oceaniczne wyspy bazaltowe</i>
		Dienbienphu	x		process related to the subduction zone <i>procesy związane ze strefą subdukcji</i>
Paleozoic <i>paleozoik</i>		Viennam		x	Back-arc spreading (?) <i>spreding żałukowy (?)</i>
		Camthuy		x	Back-arc spreading (?) <i>spreding żałukowy (?)</i>
		Huoihao		x	pas ofiolitowy
		Chiengkhuong	x		pas ofiolitowy
		Boxinh	x		pas ofiolitowy
		Nuinua	x		ophiolite belt <i>pas ofiolitowy</i>
		Phusilung	x		
Proterozoic <i>proterozoik</i>		Songchay	x		continental collision granitoid <i>kontynentalna kolizja granitoidowa</i>
		Posen	x		the island arc or active continental margin <i>łuk wyspowy lub aktywny brzeg kontynentalny</i>
		Xomgiau	x		volcanic arc granite to syn-collision granite <i>granity łuku wulkanicznego do granitów synkolizyjnych</i>
		Baoha	x		convergent margins <i>granice konwergentne</i>

The Banxang ultramafic complex, Camthuy and Viennam volcanic formations, are perhaps related to back-arcs spreading (Lepvrier 1997, 2004, Golonka *et al.* 2006) or Song Da rift of Tran Van Tri (1979). This magmatism was probably formed by the convergent of the Sibumasu terrane from the southwest to the newly formed Indochina–South China block (Metcalf 2005, Golonka *et al.* 2006, Hung & Golonka 2008) during the Late Permian–Triassic times. The fifth group comprises the mafic effusive Suoibe formation, acidic volcanics from the Tule, Ngoithia complex and sienite, granosienite Phusaphin, Muonghum, East Yeyensun complexes, and Namchien gabrodiabase complex also stored, they were formed in Jurassic–Cretaceous within plate magmatism. Probably, this event was resulted from Yanshanian tectonic cycle activity, related to collision between west Pacific Ocean and South China blocks (Metcalf 1996). The last group comprises the alkaline granites and sienite, granosienite, potassium-high absarokite, lamprophyre from the West Yeyensun, Namxe–Tamduong, Pusamcap, Cocpia complexes, and trachyte volcanic Putra formation, respectively. They were resulted from the Paleogene intraplate extension related to the collision between India and Asia blocks (Leloup *et al.* 1995, Hoa *et al.* 2008a, b Golonka *et al.* 2006). Thus, the tectonic environment of the Northwest Vietnam changed from a subduction-related magmatism (orogenic) to matured continental (anorogenic) magmatism in the time span between the Paleozoic–Early Triassic and Cretaceous. Strike-slip faulting related to the Cenozoic collision of India with Eurasia lead to magmatic intraplate extension related along the Ailao Shan–Red River and Laocai–Dien Bien Phu fault zones.

REFERENCES

- Golonka J., Krobicki M., Pajak J., Nguyen Van Giang & Zuchiewicz W., 2006. *Global plate tectonics and paleogeography of Southeast Asia*. Faculty of Geology, Geophysics and Environmental Protection, AGH University of Science and Technology, Arkadia, 1–128.
- Hoa T.T., Anh T.T., Phuong N.T., Dung P.T., Anh T.V., Izokh A.E., Borisenko A.S., Lan C.Y., Chung S.L. & Lo C.H., 2008. Permo-Triassic intermediate-felsic magmatism of the Truong Son belt, eastern margin of Indochina. *Compte Rendu Geoscience*, 340, 112–126.
- Hoa T.T., Izokh A.E., Polyakov G.V., Borisenko A.S., Anh T.T., Balykin P.A., Phuong N.T., Rudnev S.N., Van V.V. & Nien A.N., 2008. Permo-Triassic magmatism and metallogeny of Northern Vietnam in relation to the Emeishan plume. *Russian Geology and Geophysics*, 49, 480–491.
- Khuong The Hung & Golonka J., 2008. Major plates and events shaping the complex tectonics of Northwestern Vietnam. In: Németh Z. & Plašienka D. (eds), *SlovTec 08, 6th Meeting of the Central European Tectonic Studies Group (CETeG) & 13th Meeting of the Czech Tectonic Studies Group (ČTS)*, 23–26 April 2008, Upohlav, Pieniny Klippen Belt, Slovakia. Proceedings and Excursion Guide, 60–61.
- Leloup P.H., Tapponnier P., Lacassin R., Searle M.P., Zhong Dailai, Liu Xiaoshan, Zhang Langshang, Ji Shaocheng & Trinh P.T., 1995. The Ailaoshan–Red River shear zone (Yunnan, China). Tertiary transform boundary of Indochina. *Tectonophysics*, 251, 3–84.

- Lepvrier C., Maluski H., Vuong N.V., Roques D., Axente V. & Rangin C., 1997. Indosinian NW-trending shear zones within the Truong Son belt (Vietnam): ^{40}Ar – ^{39}Ar Triassic ages and Cretaceous to Cenozoic overprints. *Tectonophysics*, 283, 105–127.
- Lepvrier C., Maluski H., Layreloup A., Vu Van Tich, Phan Truong Thi & Nguyen Van Vuong, 2004. The Early Triassic Indosinian orogeny in Vietnam (Truong Son Belt and Kontum Massif): implications for the geodynamic evolution of Indochina. *Tectonophysics*, 393, 87–118.
- Metcalf I., 1998. Paleozoic and Mesozoic geological evolution of the SE Asian region, multidisciplinary constraints and implications for biogeography. In: Hall R. & Holloway J.D. (eds), *Biogeography and Geological Evolution of SE Asia*. Backhuys Publishers, Amsterdam, 25–41.
- Metcalf I., 2002. Permian tectonic framework and paleogeography of SE Asia. *Journal Asian Earth Sciences*, 20, 551–566.
- Metcalf I., 2006. Paleozoic and Mesozoic tectonic evolution and palaeogeography of East Asian crustal fragments: The Korean Peninsula in context. *Gondwana Research*, 9, 24–46.
- Phan Cu Tien (Ed.), 1989. *Geology of Kampuchea, Laos and Vietnam. (Explanatory note to the geological map of Kampuchea, Laos and Vietnam at 1/1 000 000 scale)*, Institute for Information and Documentation of Mines and Geology, Hanoi, 149.
- Tran Van Tri (Editor in chief) *et al.*, 1979 (1977 in Vietnamese). *Geology of Vietnam, (the North part). Explanatory note to the geological map on 1 : 1 000 000 scales*. Hanoi, Science and Technology. Publish House, 354 (in Vietnamese), 78 (in English).