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Formations of endogenous ore deposits and mineralization in Vietnam

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Abstract. Formations of endogenous ore deposits and mineralization are widely distributed in Vietnam. Detailed studies allow for distinguishing 30 ore formations representing 9 groups of mineral raw - materials: Cr, Ti, Fe, Sn - W, Mo, Pb - Zn, Au, Sb - Hg. Three of presented formations are of magmatic affiliation, one is pegmatitic, three others belong to skarn mineralization and the remaining ones are of hydrothermal - volcanic and controversial origin. Three metallogenic epochs can be distinguished: Proterozoic, Palaeozoic and Mesozoic - Cainozoic. Taking into consideration the recent structural data and economic importance along with the geochemical units can be distinguished in Vietnam: 1. Sialic - mafic Viet Bac; 2. Mafic Tay Bac; 3. Sialic Truong Son; 4. Mafic - metamorphic Kontum; 5. Sialic - alkaline Dalat - Nam Bo.

Keywords: Endogenous ore deposit; Mineralization.

Vietnam and other countries of SE Asia cover an outstanding area of the crossing of two structural and metallogenic belts: Pacific and Mediterranean. Simultaneously, this area is an active continental margin Abundant and variable ore mineralization is known with the famous W - Sn belt and deposits of Cr, Cu, Zn - Pb, Au, Sb - Hg, Bi, Mo and REE.

Geological history of the investigated area is influenced by the development of the two large adjacent structures: Southern China platform and Indo - China fold belt. Typical feature of Vietnam area is the Mesozoic and Cainozoic activization structures. Numerous intrusions ranging in age from Proterozoic to Cainozoic were formed in tectono - magmatic cycles operating within the fold belts and activated areas.

Detailed studies allow for distinguishing 30 ore formations representing 9 groups of mineral raw - materials: Cr, Ti, Fe (Fig. 1), Sn - W (Fig. 2), Mo, Zn - Pb, Au, Sb - Hg (Fig. 3). Three of presented formations are of magmatic affiliation, one is pegmatitic, three others belong to skarn mineralization and the remaining ones are of hydrothermal - volcanic and controversial origin.

Three metallogenic epochs can be distinguished: Proterozoic, Palaeozoic and Mesozoic - Cainozoic. Archean endogenous mineralization is poorely known but others contain numerous, genetically diversified magmatic and post - magmatic deposits.

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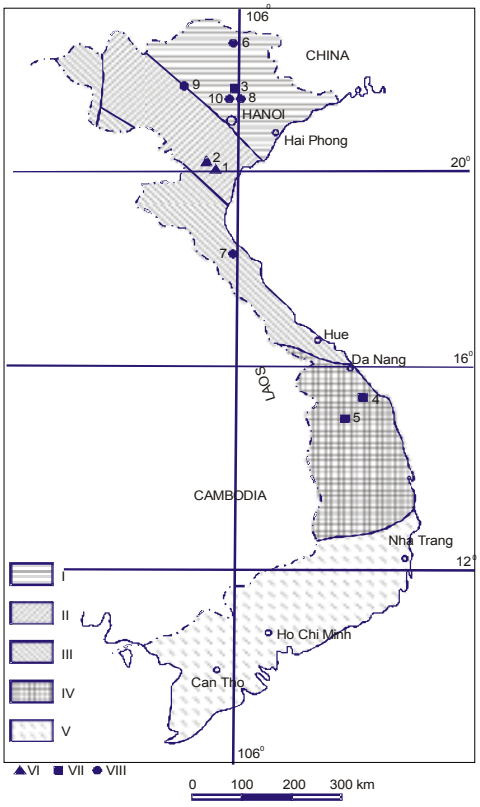

Fig. 1. Sheme of Cr, Ti, Fe ore formations in Vietnam

Metallogenic units: I. Viet Bac; II. Tay Bac; III. Truong Son; IV. Kon Tum; V. Da Lat - Nam Bo; VI. The Cr ore deposits (1. Nui Nua, 2. Hon Vang); VII. The Ti ore deposits (3. Nui Chua, 4. Tam ki, 5. Xa Hieu); VIII. The Fe ore deposits (6. Cao Bang, 7. Ha Tinh, 8. Trai Cau, 9. Lang Khuan, 10. Linh Nham).

During Proterozoic the area of Vietnam was a proto - geosynclinal - proto continental area marked by basaltoid - granitoid magmatism. In the initial geosynclinal stage sedimentary - volcanic pile of considerable thickness was deposited. Basic volcanic and meta - gabbros (ophiolite type) contain chalcopyrite - magnetite - ortite formation (s.c., Cu - pyrites) within metasomatic rocks of Proterozoic basement. Pyrite and polymetalic Cu - pyrite formations genetically connected with basic metavolcanics (greenschists) also belong to this stage.

Palaeozoic metallogenic epoch embraces several ore - formations. Few ultrabasic - basic intrusions contain Cu - Ni and Ti - magnetite mineralization. Pegmatites related to Late - Palaeozoic granite intrusions host cassiterite formation with accompanying Nb and Ta. Galena - sphalerite formation with Pb - Sb sulphosalts is connected with granite - grano - syenite intrusions and associated liparite - trachites.

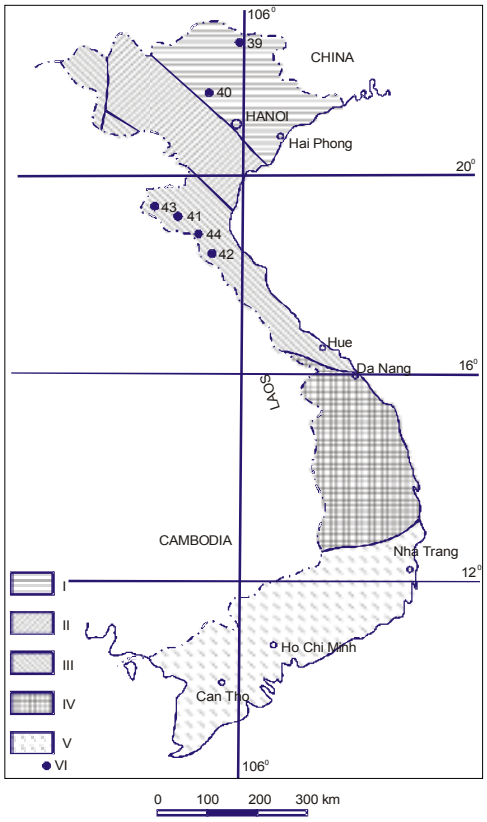

Fig. 2. Sheme of Sn - W ore formations in Vietnam.

Metallogenic units: I. Viet Bac; II. Tay Bac; III. Truong Son; IV. Kon Tum; V. Da Lat - Nam Bo; VI. The Sn - W ore deposits (39. Tinh Tuc, 40. Tam Dao, 41. Quy Hop, 42. Kim Cuong, 43. Ban Chieng, 44. Phu Loi).

Post - Permian rejuvenation of tectonic and magmatic activity in the whole area of Vietnam resulted in numerous valuable ore and other raw - material deposits. Two metallogenic epochs can be distinguished: Cimmerian and Alpine.

Cimmerian epoch includes deposits and mineralization of Fe, Cr, Cu, Ni, Pb - Zn, Mo, Sn, W, Sb - Hg, Au - Ag. In the Black River depression Permo - Triassic basic volcanics are common with the related formations of pyrites, Cu - pyrites, chalcopyrite - quartz and native copper. Magnetite - hematite hydrothermal - metasomatic formation can also be connected with this basic volcanism. Chromite formation occurs in Permo - Triassic apo - harzburgite intrusions located along the deep fault structure of Ma River. Ilmenite - Ti - magnetite mineralization is known from the widespread Upper Triassic basic intrusions, whereas Cu - Ni formation is hosted in Permo - Triassic serpentinized dunites. Granite - granodiorite complexes (Permo - Triassic) provide numerous other formations: sphalerite - galena in carbonate rocks, sphalerite - galena - pyrite - arsenopyrite, and galena - quartz in granites, magnetite in skarns and syderite. Granodiorite - mozonite intrusions (100 - 190 my) contain molybdenite - chalcopyrite formation. Sub - volcanic intrusions accompanied by acid - alkaline volcanics (Jurassic - Cretaceous) are connected with galena - sphalerite formation with Pb - Sb sulphosalts.

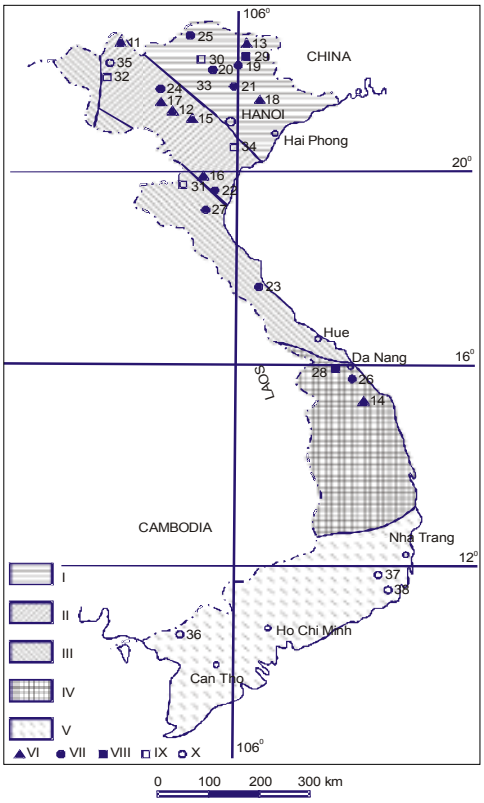

Fig. 3. Sheme of Cu, Pb - Zn, Au, Sb - Hg, Mo ore formations in Vietnam.

Metallogenic units: I. Viet Bac; II. Tay Bac; III. Truong Son; IV. Kon Tum; V. Da Lat - Nam Bo; VI. The Cu ore deposits (11. Sin Quyen, 12. Son La, 13. Cao Bang, 14. Tra Lam, 15. Van Sai, 16. Luong Son, 17. Nui Nua, 18. Bac Giang); VII. The Pb - Zn ore deposits (19. Ngan Son, 20. Cho Dien, 21. Lang Hit, 22. Quan Son, 23. Mi Duc, 24. Tu Le, 25. Na Son, 26. Duc Bo, 27. Phu Loi); VIII. The Au ore deposits (28. Bong Mieu, 29. Pac Lan); IX. The Sb - Hg ore deposits (30. Chiem Hoa, 31. Ba Thuoc, 32. Dien Bien, 33. Bac Thai, 34. Yen Ve); X. The Mo ore deposits (35. Sapa, 36. Nui Sam, 37. Krongfa, 38. Nui Dat).

Alpine metallogenic epoch is characterized by ore deposits of Sn, Mo, Zn - Pb, Ag - Au, Sb - Bi, U and REE with the leading deposits of Sn, W, Mo and REE. Sphalerite - galena - cassiterite formation rich in Ag along with Au - quartz - sulphide formation are connected with Upper - Cretaceous granites and leucogranites. Au - Sb formation is spatially related to the Sn and Zn - Pb - Ag ores. Tin deposits belonging to cassiterite - wolframite - quartz and cassiterite - silicate - sulphide formations are hosted in Upper Cretaceous two - mica granites. In Southern Vietnam quartz - molybdenite veins cut Cretareous leucocratic - biotitic granite massifs. Palaeogene granite - granosyenite intrusions provide Sn and Zn - Pb ores belonging to cassiterite - silicate - sulphide, cassiterite and galena - sphalerite formations in skarns, molybdenite - quartz formation and molybdenite - uraninite one.

Table 1. Metallogenic epochs in Vietnam

Epochs		Ore complex		Ore formation	Ore deposits
PR - PZ1		Relate to metasomatic rocks		- Chalcopyrite - magnetite - orthite (Cu - pyrite)	Sin Quyen
		Relate to green schist		- Pyrite - Polymetalic Cu - pyrite	Bo Xinh, Duc Phu, Duc Bo
PZ		Relate to ultramafic - mafic intrusions		- Pyrrhotite - pentlandite - chalcopyrite - Ilmenite Ti - magnetite	Tra Lam, Dac Sa Tam Ky, Xa Hieu
		Relate to granitoid		- Cassiterite in pegmatite	Kim Cuong
		Relate to alkaline acid extrusion		- Galena - sphalerite formation with Pb - Sb sulphosalts	Na Son
MZ - KZ	Cimmerian	Relate to basic extrusion		- Pyrite - Pyrite - Zn - Pb - Cu - Chalcopyrit - quartz - Native copper - Magnetite - hematite	Song Da Van Sai, Quy Huong Ban Mua Trai Cau
		Relate to apo - harzbugite		- Chromite	Co Dinh
		Relate to dunite, gabbro, peridotite		- Pyrrhotite - pentlandite - chalcopyrite	Ban Xang, Cao Bang
		Relate to gabbro		- Ilmenite Ti - magnetite	Cay Cham
		Relate to granite, grano diorit	- Dien Bien - Phiabioc	- Sphalerite - galena in carbonate rock - Sphalerite - galena - pyrite - arsenopyrite - Magnetite - hematite - Magnetite in skarns - Siderite	Dien Bien Cho Dien Thai Nguyen Ha Tinh, Na Rua Ban Phang
			- Van Canh - Phu Trai	- Galena - quartz in granite	Tien Thuan, An Khe
		Unknown relate to magma		- Bornite - chalcocite	Bac Giang, Mau Son
				- Antimonite - quartz	Quang Ninh
		Relate to granodiorite - mozonite		- Molybdenite - chalcopyrite - Galena - quartz in granite	Krongfa Gia Bac

Epochs		Ore complex		Ore formation	Ore deposits
		Relate to subpluton and alkaline acid extrusion		- Galena - sphalerite formation with Pb - Sb sulphosalts	Tu Le
		Relate to granite - granosyenite		- Cassiterite - wolframite - quartz	Mepu
				- Molybdenite - wolframite	Nui Dat
		Relate to basanite andesite		Pyrite with Au, Ag	Thu Duc
MZ - KZ	Alpine	Relate to granite - leucogranite	- Piaoak	- Sphalerite - galena - cassiterite formation rich in Ag	Ngan Son
				- Au - quartz - sulphide	Pac Lan
				- Cassiterite - wolframite - quartz	Tinh Tuc
				- Cassiterite - silicate - sulphide	Tam Dao
				- Au - antimonite	Chiem Hoa
			- Deo Ca	- Molybdenite - quartz	Nui Sam
		Relate to granite, granosyenite	Song Chu, Ban Chieng	- Cassiterite - wolframite - quartz	Bu Me
				- Cassiterite - silicate - sulphide	Quy Hop
				- Cassiterite in skarn	Phu Loi
			Yeyensun	- Galena - sphalerite in skarn	Ke Tang
				- Molybdenite - quartz	Sapa
				- Molybdenite - uraninite	Vi Kem
				- Chalcopyrite with U, REE	Sin Quyen

Taking into consideration recent structural data and economic importance along with the geochemical character of mineralizations, five large mineralogical units can be distinguished in Vietnam as follows:

1. Sialic - mafic Viet Bac;
2. Mafic Tay Bac;
3. Sialic Truong Son;
4. Mafic - metamorphic Kon Tum;
5. Sialic - alkaline Da Lat - Nam Bo.

The two first units belong to Vietnam - Chon fold belt whereas the remaining represents Indo - China fold belt. Apart from that, two separate zones were distinguished: Muong Te and Ha Tien which are the parts of Thailand - Malay geosynclinal - fold belt. Each unit reveal typical metalogenic features controlled by tectonic - structural development:

1. Viet Bac: Sn - W, Zn - Pb, Au, Sb - Hg;
2. Tay Bac: Cu, Cu - Ni, pyrites, Cr, Mo, REE, Zn - Pb;
3. Truong Son: Sn - W, Zn - Pb, Fe, Au, Sb - Hg;
4. Kontum: Au;
5. Dalat - Nam Bo: Mo, Bi.

Endogenous ore - forming processes are clearly confined to the magmatic and tectonic activity in the specific geological epochs. The first group embraces deposits of Cr, Ni, Co, Cu, Cu - Ni, Fe (contact - metasomatic), Ti and pyrites, all of them connected with basic/ultrabasic intrusions and located along the faults. The second group embraces polymetallic Zn - Pb, Ag, Sb, Hg, Au, Sn - W and rare - metal deposits genetically related to granites and/or granodiorites and occuring within the tectonic blocks or, commonly, at the contacts between two areas of different structural and facial characters. The crucial factor controlling the metallogeny of this territory was magmatic/tectonic activization cycle in Mesozoic and Cainozoic.

Endogenous mineralization in Vietnam bears the metallogenic features of the Pacific belt with typical Sn - W, Mo, Zn - Pb and Au deposits. Mediterranean belt features can be observed in Tay Bac unit with the typical Cu, Cu - Ni, pyrites, Cu - polymetallic pyrite deposits.

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