

Stratigraphic Order and Age of the Bang Ca Formation in Bang Ca Area, Ha Lang District, Cao Bang Province

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Abstract: Stratigraphic division also age of the sequence of cherty shale (the Bang Ca Formation) in Bang Ca Townlet, Ly Quoc Commune, Ha Lang District, Cao Bang Province, North Vietnam presently is still a subject for debate: Bourret R. 1922 (Late Devonian), Vasilevskaya A. D. 1965 (Eifelian-Givetian), Pham Dinh Long 1973 (Givetian), Duong Xuan Hao *et al.* 1973, 1980 (Frasnian); Pham Huy Thong, Nguyen The Dan 1984 (Famennian); Doan Nhat Truong, Ta Hoa Phuong 1999 (Middle-Upper Devonian); Doan Nhat Truong, Ta Hoa Phuong 1999 (Frasnian-Famennian); Tong Dzuy Thanh 2011 (Middle-Upper Devonian). Studying stratigraphic order of Devonian sequence exposed in the Ban Thung-Bang Ca-Lung Thoang section, also based on macro-fossils newly collected from the cherty shale, the Bang Ca Formation is recognized as a lithostratigraphic unit, overlying the Na Quan Formation (D₁₋₂ nq), and underlying the Toc Ta Formation (D₃-C₁ tt) with total thickness about 200 m. The Frasnian age of the Bang Ca Formation is based on macrofossil assemblages *Atrypa* (*Desquamatia*) cf. *zonataeformis*, *Spinatrypa* sp., *Monelasma* sp. (Brachiopoda); *Glyptohallicardia* cf. *ferruginea* (Bivalvia), *Manticoceras* sp. (Ammonoidea); *Homoctenus* sp., *Viriatellina* sp., *Striatostyliolina* sp., *Styliolina* sp. and conodont *Ozarkodina* sp.

Keywords: Na Quan, Bang Ca, Toc Tat Formations, Ly Quoc, Cao Bang, Vietnam

1. Introduction

Although the Bang Ca cherty shale exposed around the Bang Ca area, Ly Quoc Commune, Ha Lang District, Cao Bang Province (Figure 1) has been studied intensively, but presently the geological age also stratigraphic position of them always are controversial debate topics and questions for discussions. For example: it belongs a formation (the Bang Ca Formation) or only is a member of the Toc Tat Formation? One is the most important problem concerning paleontological data, whether there is Famennian conodonts in it? and its geological age: Eifelian-Givetian [4], Givetian [11], Frasnian [6, 7]; Early Famennian [13]; Middle -Upper Devonian [2, 19]; Frasnian-Famennian [3]. Based on the stratigraphic and paleontologic data were collected by author himself [5, 6, 7, 8, 16, 17] and paleontologic data newly collected by Nguyen Huu Hung, Doan Dinh Hung, Nguyen Ba Hung, Trinh Thai Ha at the end of 2018 year of the

Project BSTMV 29/15-18, Vietnam Academy of Science and Technology; first the Bang Ca cherty shale should be considered as a formation of lithostratigraphic unit (the Bang Ca Formation); its stratigraphic position overlying conformably the upper part of the Na Quan Formation (D₂gv), and underlying conformably the Toc Tat Formation (D₃-C₁ tt); the Frasnian age of the Bang Ca Formation based on cephalopod, brachiopod, bivalve, tentaculitid macrofauna.

2. Historic Study and Different Outlook of the Bang Ca Cherty Shale

Bourret R. [1] first described the presence of the Bang Ca cherty shale under the name “Les schistes en plaquettes de l’Est de Ban Cra” of Late Devonian in the Ha Lang geological sheet 1: 100.000 established by him. Vasilevskaya A. D. [4] stated that the cherty shale thin-bedded with total thickness 200-300 in the Ha Lang Zone belonging to the

Eifelian-Givetian stages for the succession of this cherty shale always sticking closely the underlying limestone and containing a rich coral, stromatoporoid fossils of Eifelian-Givetian age. Pham Dinh Long [11, 12] edited geological map of the Chinh Si-Long Tan sheet 1:200.000 establishing a new lithostratigraphic unit, described under the name “Bang Ca Suite”. According to this author, the Bang Ca Suite is composed of two subsuites: the lower subsuite consisting of bedded irregularly or massive limestone intercalated with thin siliceous layers or siliceous lens. The upper subsuite is composed mainly of thick-bedded or massive limestone, and at the places having synclinal structure, frequently appeared cherty shale. Fossils are very rich as *Stringocephalus burtini* (brachiopod), coral rugosa *Dendrostella* sp. of the Givetian age were collected from the upper subsuite, so “the Bang Ca suite” was assigned to the Middle Devonian. In fact, Pham Dinh Long’s description [11] of the “Bang Ca Suite” as mentioned above is not correct, because of the cherty shale in the Bang Ca area exposed largely with about 200 m thick always lying conformably upon the limestone containing brachiopod *Stringocephalus burtini*. This stratigraphic order not only seen in the Bang Ca area, but also can be seen in the section along the Quay Son River, from Da Nua Village to the Ly Van Border Gate, Ly Quoc Commune; and in the Toc Tat Manganese Mining, Tra Linh District.

“Les schistes en plaquettes de l’Est de Ban Cra” [1] has been assigned to the lower part of “Toc Tat Suite” by Duong Xuan Hao, Nguyen Thom, Nguyen Duc Khoa [6, 8]; Duong Xuan Hao [8], and cited the presence of the Frasnian fauna such as brachiopod *Atrypa* sp., tentaculitid *Homotenus* aff. *kiklensis* Ljash. Duong Xuan Hao *et al.* [8] used the name “Bang Ca Suite” for description of cherty shale beds exposed in Bang Ca area, in Trung Khanh and Dong Van areas; and with the reference of Frasnian fossils as *Atrypa* (*Desquamatia*) cf. *zonataeformis* Aleks., *Styliolina* sp. This description differs completely from those described by Pham Dinh Long before [11].

Pham Huy Thong, Nguyen The Dan [13] discovered Early Famennian conodonts including *Palmatolepis* cf. *triangularis*, *Pa. delicatula*, *Pa. superlobata* from a limestone outcrop in the Bang Ca-Frontier mark No 46 Section, so these authors suggested that “the Bang Ca siliceous Horizon” belonging Early Famennian. In fact, this limestone outcrop belonging to the bottom of the Toc Tat Formation.

In later publications of the Devonian system of Vietnam [16] (in Vietnamese), Devonian stratigraphy and Coelenterata [17] (in Russian) edited by Tong Dzuy Thanh; and in the legend of geological and mineral resources map 1:200.000 of the Chinh Si-Long Tan has been revised by Pham Dinh Long, Nguyen Van De [12]; the Bang Ca cherty shale only was accepted as a lower subsuite of the Toc Tat Suite (D₃-C₁ *tt*) or the Toc Tat Formation presently.

Doan Nhat Truong, Ta Hoa Phuong [2] stated that, the Bang Ca Formation exposed in Ha Lang area, Cao Bang Province and in Dong Van, Yen Minh areas, Ha Giang Province belonging to the Middle-Upper Devonian for containing the conodont *varcus*, *transitans* and *triangularis*

zones; but in 1999, these authors [3] concluded that the Bang Ca Formation belonging to the Frasnian-Famennian for limestone interbeds in cherty shale of the lower member of the formation exposed in the Binh Xa Tau-Bung O Section in the Toc Tat Manganese Mining area containing the conodonts *Palmatolepis* cf. *triangularis*, *P. subrecta* of Early Famennian.

The Frasnian-Famennian age of the Bang Ca Formation was cited by Tong Dzuy Thanh, Nguyen Duc Khoa [18] on the basis of Bang Ca-Lung Thoang Section, but with reference of fossils both from the Bang Ca Formation as *Desquamatia* cf. *zonstiformis*, *Homotenus* aff. *kiliensis*; and the Toc Tat Formation as *Palmatolepis* cf. *triangularis*, *P. subrecta*, *P. delictula*; *Camarotoechia* sp., *Praewaagenconcha* sp. ect.

The Bang Ca Formation in “Stratigraphic units of Vietnam” edited by Tong-Dzuy Thanh, Vu Khuc [19] are described on the basis of the Bang Ca-Lung Khoang (Lung Thoang?) Section with 4 members of terrigenous sediments have been divided, of 200-220 m thick. The Givetian-Frasnian age of the formation on the basis summing up paleontological data from the different sections, including brachiopod *Stringocephalus burtini*, a guide species for Upper Givetian only known from the upper part of the Na Quan Formation.

The Givetian-Frasnian age of the Bang Ca Formation cited by Ta Hoa Phuong [14] with reference of fossils both from the Na Quan Formation as *Stringocephalus burtini*, and from the Toc Tat Formation as *Camarotoechia* sp., *Praewaagenconcha* sp.

To clarify the age of the Bang Ca Formation also its stratigraphic relationship with lower and upper stratigraphic units, we select the section Ban Thung-Bang Ca-Trao Nhi-Lung Thoang for this study; simultaneously correlating with paleontological and stratigraphic data which were studied by the author himself [6-8]. Below our discussions of the presence of the Bang Ca Formation in Bang Ca area, Ly Quoc Commune, Ha Lang District, Cao Bang Province, North Vietnam.

3. Material and Methods

The materials of paleontology and stratigraphy concerning the Na Quan, Bang Ca, Toc Tat Formations have been collected by author himself [5-7] during 1973, 1974, 1984, 2003 together with colleagues from the Paleontologic and Stratigraphic Department of Institute of Geology and Mineral resources, Ministry of Natural resources and Environment.

150 fossils examples have been collected from the Bang Ca Formation at the end of 2018 housing at the Geological Museum of Institute of Geological Science, 84 Chua Lang Street, Hanoi City.

The biostratigraphic methods were applied for researching geological section in the Bang Ca area. All the paleontological specimens illustrated in this paper were photographed using a Leica Microscope Camera IC90E of the Laboratory of Geological Department, Vietnam National

Museum of Nature, Vietnam Academy of Science and Technology, 18 Hoang Quoc Viet Street, Hanoi City.

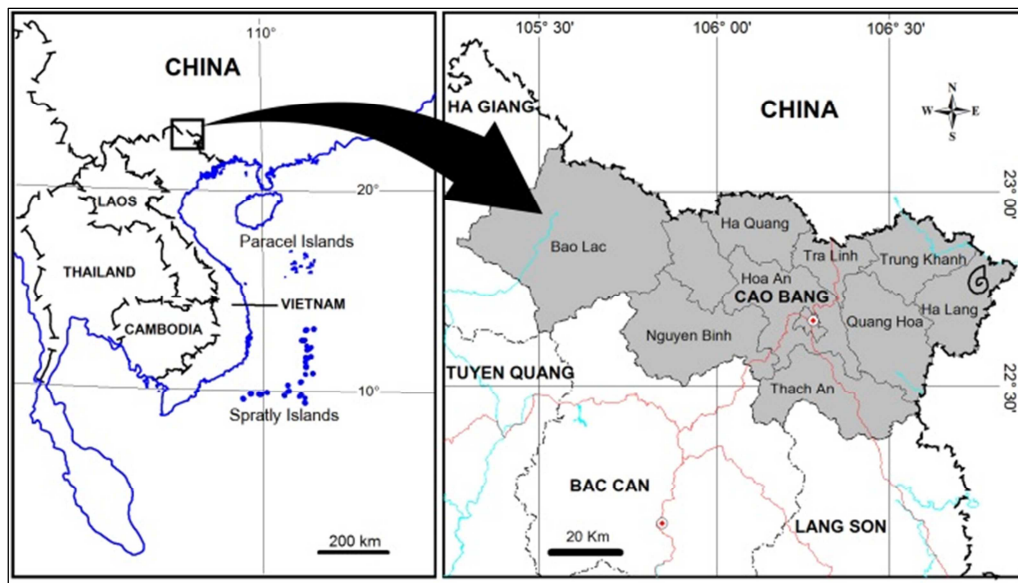


Figure 1. Map of Cao Bang Province showing position of the Ban Thung-Bang Ca-Trao Nhi-Lung Thoang Section at the Bang Ca area, Ly Quoc Commune, Ha Lang District, Cao Bang Province, North Vietnam.

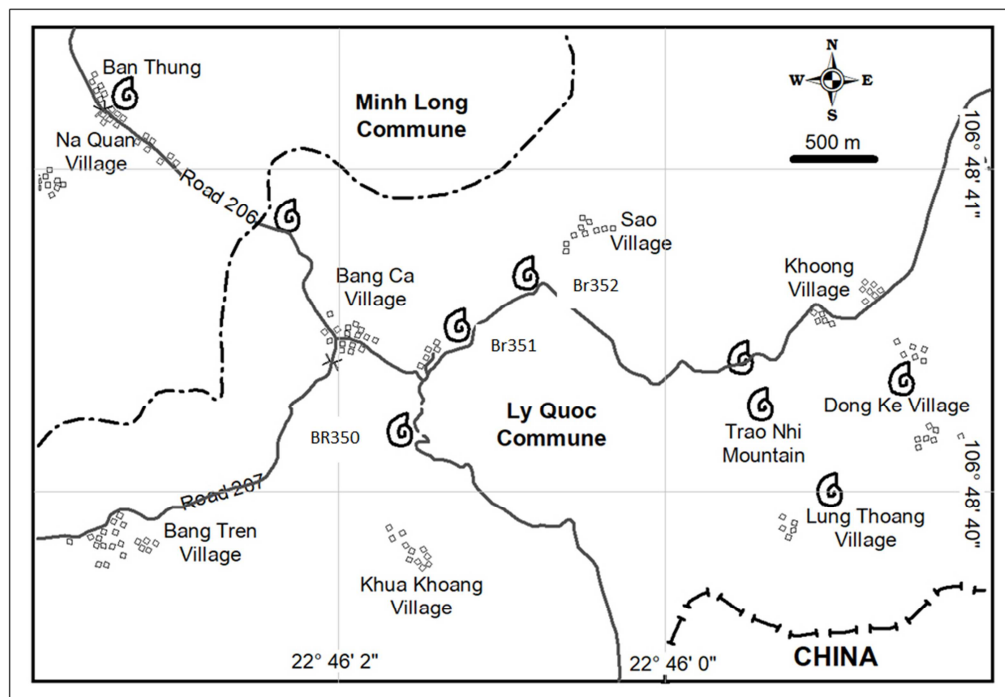


Figure 2. Index map showing position of fossils in the Ban Thung-Bang Ca-Trao Nhi Section.

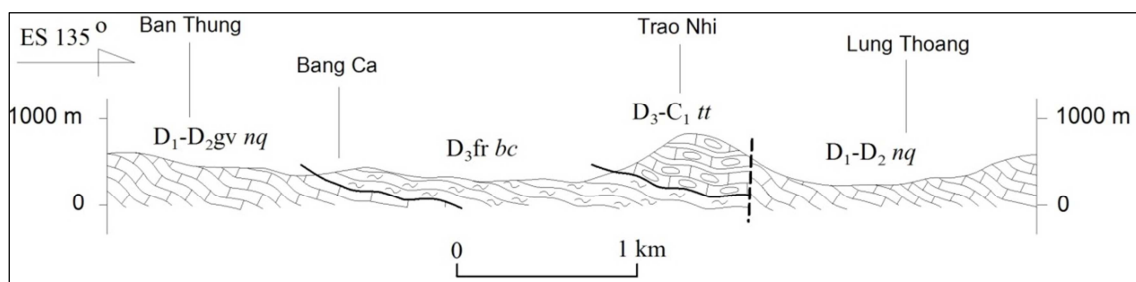


Figure 3. Geological section from Ban Thung across Bang Ca Townlet to Lung Thoang Valley.

4. The Ban Thung-Bang Ca-Trao Nhi-Lung Thoang Section

The section studied by us at the end of 2018 year, extends more 5 km, from Ban Thung Village across Bang Ca Townlet, the Trao Nhi Mountain to Lung Thoang Valley, Ly Quoc Commune (Figures 1, 2, 3). Most sedimentary beds in this section generally plunge monoclinally, southeastwards at about 135-140°, with a dip of 25-45°; excluding the cherty shale beds of the Bang Ca Formation, which in some place become folding.



Figure 4. *Stringocephalus grandis* (Grabau), ventral side of a complete conjoined shell, x 1; 3 km west of the Ly Van Border Gate, Ly Quoc Commune, Ha Lang District, Cao Bang Province (Photo: Nguyen Huu Hung, Col. CS355Br1 of the Project 28/15-18).

4.1. Upper Part of the Na Quan Formation (D₂gv)

At Ban Thung Village, herein exposed mainly grey medium-bedded limestone with interbeds or lenses of black chert, and light grey thick-bedded containing stromatoporoid *Amphipora ramosa*, rugose *Tabulophyllum* sp.; and light grey, thick-bedded limestone containing abundant stromatoporoid *Amphipora angusta*, *A. pinguis*, *Stachyodes insignis*, *S. radiata*, *S. caespitosa*, *Actinostroma clathratum*; rugoses *Dendrostella trigemme*, *Neostromaphyllum* sp.; tabulates *Caliopora battersbyi*, *Scoliopora denticulata*; and brachiopod shell of large dimension, may be shell of *Stringocephalus burtini* and *S. grandis*. This part of the section is about 250 m thick, was assigned to the Bang Ca Suite by Pham Dinh Long [11], or to upper part of the Na Quan Suite by Duong Xuan Hao [5, 8] and to the upper part of the Ban Pap Formation by Tong Dzuy Thanh [19]. This part of the Na Quan Formation also exposed along car road, from the Da Nua Village to the Ly Van Border Gate; where about 3 km west of the Ly Van Border Gate was collected a complete conjoined shell of *Stringocephalus grandis* 7,8 cm wide; 9,2 cm long (Figure 4).

4.2. Bang Ca Formation (D₃fr bc)

Around Bang Ca Townlet, Ly Quoc Frontier Post, and Khua Khoang Lake area, here exposed mainly terrigenous sediments; those can be divided into three members: The lower member, 60-70 m thick, consisting of yellowish-grey, brownish weathering, thin-bedded shale. Around the Khua Khoang Lake, and here in a outcrop under the dam shore of lake, one of us [6, 8] collected a brachiopod ventral exterior valve which was identified by Duong Xuan Hao as *Atrypa* sp. [7] and in the later time (1980) this fossil was reviewed and described by him as *Atrypa (Desquamatia) zonataeformis* Alekseeva [8]. There are many tentaculitids in this member, one of them was identified by Dang Tran Huyen as *Homoctenus* aff. *kikliensis* Ljash [7]. The middle member, 70-80 m thick, consists mainly of grey thin-bedded calcareous cherty shale intercalated with yellow laminated shale; occurred on a hill slope, left side to the Ly Quoc Frontier Post; yielding abundant *Maticoceras* sp., (Cephalopoda); *Homoctenus* sp., *Viraitellina* sp., *Striatostyliolina* sp., *Styliolina* sp. (Tentaculita); *Glyptohallicardia* cf. *ferruginea* (Bivalvia); *Ozarkodina* sp. (Conodonta). The upper member, 40-50 m thick, consists mainly of black-grey manganiferous cherty shale, well occurred on a hill, southeast 300 m of the Ly Quoc Frontier Post containing abundant tentaculitids *Homoctenus* sp., *Viraitellina* sp., *Striatostyliolina* sp., *Styliolina* sp.; brachiopods *Spiatrypa* sp., *Monelasma* sp.

Total thickness of the Bang Ca Formation about 200 m.

4.3. Toc Tat Formation (D₃-C₁ tt)

The Toc Tat Formation of Famennian-Early Tournaisian age has been founded by Pham Dinh Long [11], characterized by violet-red limestone containing manganese ore, largely distributed in Cao Bang Province. In the Ban Thung-Bang Ca -Trao Nhi -Lung Thoang Section, the Toc Tat Formation well occurred in Trao Nhi Mountain and left side of road to the Kenh Khoong Pass. Four members can be divided for the Toc Tat Formation in this section. The lower member consists of violet-red limestone and greenish-grey, brownish, banded limestone intercalated with cherty marl, 150 m thick; lies conformably upon the cherty shale of the Bang Ca Formation. The middle member consisting of grey, medium-bedded limestone, 30 m thick occurred in the northeastern slope of the Trao Nhi Mountain, near its top. Many Famennian bivalve fossils have been found in it: *Posidonia venusta* Münster, *P. cf. venusta* Münster identified by Vu khuc [6]; *Posidonia (Karadjalia) venusta* Münster, *P. (K.) nalivkini* Sadykov identified by Dang Tran Huyen [8]; brachiopods *Lingula* aff. *suparallela* Sand, *Schizophoria* cf. *striatula* Schl., *Productella* aff. *subacubata* Murchison, *Plathyris* cf. *sulcifera* Nalivkn? *Dielasma* sp. identified by Duong Xuan Hao [6]. The manganese ore seam of 0,6-1m thick lying conformably on this member. The uppermost member consists of light-grey, thick-bedded limestone,

weakly recrystallized, 50 m thick; overlying conformably the manganese ore seam. Total thickness of the formation about over 230 m.

Under the southeast slope of the Trao Nhi Mountain is Lung Thoang valley, at Dong Ke Village exposed grey, thick-bedded limestone containing abundant stromatoporoids *Amphipora ramosa* (Phillip.), *Stachyodes insignis* Yav. of Givetian age. We suggested that here there is a fault SW-NE orient along the Lung Thoang Valley, so in the final section, the Toc Tat Formation has tectonic contact with the upper part of the Na Quan Formation.

5. Discussions

As described above, the Ban Thung -Bang Ca-Trao Nhi Mountain Section exposed sedimentary beds plunging

monoclinally, southeastwards with a dip of 25-45°, including an ascending order: Na Quan, Bang Ca, Toc Tat formations (Figure 3).

5.1. Age of the Uppermost Part of the Na Quan Formation

Late Givetian of the uppermost beds of the Na Quan Formation is undoubtedly by the presence of faunal assemblages as *Amphipora angusta*, *A. pinguis*, *S. radiata*, *S. caespitosa*, *Actinostrom clathratum* (stromatoporoids); *Stringocephalus burtini*, *S. grandis* (brachiopods); *Caliopora battersbyi*, *Scoliopra denticulate* (tabulate corals); *Dendrostella trigemme*, *Tabulophyllum* sp (rugose corals), and brachiopod *Stringocephalus burtini*. All these faunal assemblages were described by Tong-Dzuy Thanh [15]; Tong Duy Thanh *et al.* [16, 17]; Duong Xuan Hao *et al.* [5, 8]; Nguyen Huu Hung [10].



Figure 5. Brachiopods, bivalves, ammonoids, and conodont in the Bang Ca Formation: a -*Atrypa* (*Desquamatia*) cf. *zonataeformis* Alekseeva, ventral valve, x 1 (described by Duong Xuan Hao 1980, p. 116, pl. 50, Figure 7); b, c, b.3 -*Spinatrypa* sp., internal ventral valve: b, x 1; b.3, x 3; Col. CS551Br1; c, x 1; Col. CS351Br2; d, e, d.3 -*Monelasmina* sp.: d -ventral valve, x 1; d.3 -ventral valve, x 3; Col. CS351Br3; e -dorsal valve, x1; Col. CS351Br4; f, g, h, i, k, f.4 -*Glyptohallicardia* cf. *palmata* (Goldfuss 1837): f -left valve, x 1; f.4 -left valve, x 4; Col. CS351Bi1; g -right valve, x 1; Col. CS351Bi2; h -left valve, x 1; Col. CS351Bi3; i -right valve, x 1; Col. CS351Bi4; k -left and right valves, x 1; Col. CS351Bi5; l, m, n, o -*Manticoceras* sp.: l -lateral view, x 1; Col. CS351Am1; m -imprint of inner whorls with the outer whorl, x 1; Col. CS351Am2; n -imprint of lateral side with sutures well conserved, x 3; Col. 351Am3; o -mold of lateral side, x 1; Col. CS351Am4; p -conodont *Ozarkodina* sp.; Col. 351Co1 (Photo: Nguyen Huu Hung 2021).

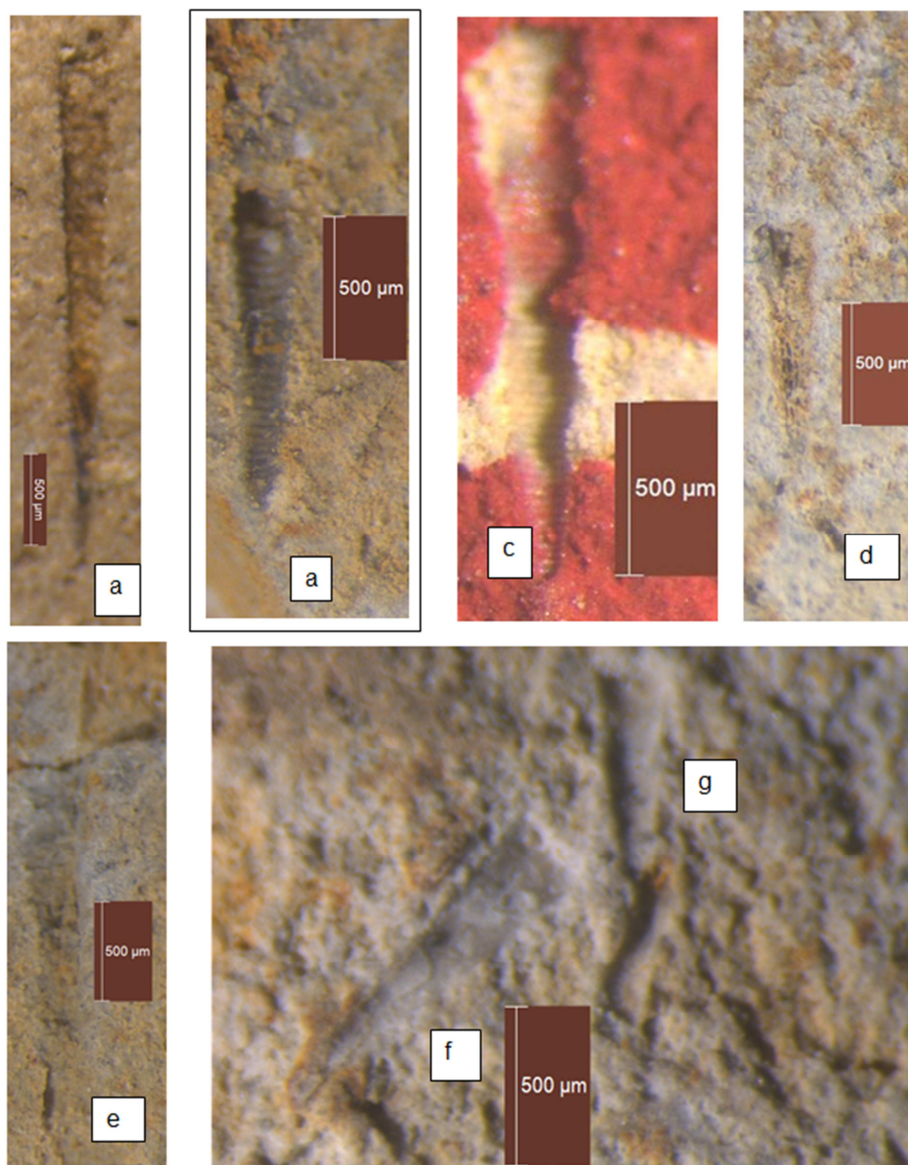


Figure 6. Tentaculitids in the upper part of the Bang Ca Formation: a, b, c -*Homoctenus* sp.; a -almost complete specimen, CS352Te1; b – a part specimen, CS352Te2; c -almost complete specimen, CS352Te4; d, e - *Viriatellina* sp., d – a part of specimen, CS352Te4; e – a part of specimen, CS352Te6a; f - *Striatostyliolina* sp., a part of specimen, CS352Te6a; g -*Styliolina* sp., a part of specimen, CS352Te6b (Photo: Nguyen Huu Hung 2021).

5.2. Age of the Bang Ca Formation

The benthic assemblages consist of *Atrypa* (*Desquamatia*) cf. *zonataeformis* Alekseeva from the lower member of the formation. In Russia, this species known from the Lower Frasnian strata; two other brachiopod representatives were collected from the upper member: *Spinatrypa* sp. appeared in the Upper Emsian Stage, abundant in the Frasnian stage, and disappeared completely at the end of this stage; *Monelasmina* sp., a orthid species distributed widely in the Upper Devonian strata in the world. *Glyptohallicardia* cf. *palmata* first discovered, rather rich with shell shape and ornamentation very similar to type *Glyptohallicardia palmata* (Goldfuss), a bivalve species widely distributed in the European Frasnian. The pelagic fossils represented by *Homoctenus* aff. *kikliensis* Ljash. collected from the lower

member, identified by Dang Tran Huyen [7, 8], known from Frasnian stage in Russia; four other tentaculitid representatives from the middle and upper members, consisting of *Homoctenus* sp. (predominant), *Viriatellina* sp. (dominant), *Striatostyliolina* sp. (dominant), and *Styliolina* sp. (dominant); their stratigraphic strata ranging from the Silurian to the Upper Devonian, but rather dominant in the Frasnian stage, and very rare in the Famennian stage of Devonian period. Faunal ammonoids were first discovered in very thin-bedded calcareous cherty shale of the middle member; they are very rich in individual development, belonging to genus *Manticoceras* which its representatives distributed widely in the Upper Devonian in the world. The conodont *Ozarkodina* sp. first has been found in this cherty shale, distributed widely in Paleozoic strata.

In summary, based on macrofauna, the Bang Ca Formation is assigned undoubtedly to certainly Frasnian stage.

5.3. Age of the Toc Tat Formation

When establishing the Toc Tat Suite, Pham Dinh Long [11] stated that most sediments of the Toc Tat Suite formed in the synclinal structures of Devonian formations, and underlying the chert and limestone beds yielding abundant *Stringocephalus burtini* of Givetian age of the Bang Ca Suite, so it was assigned to the Frasnian stage.

Recently, the Toc Tat Suite is considered to be equal to a formation in stratigraphic division of Stratigraphic International Code. On the other hand, many faunal assemblages both macrofauna and microfauna have been found. The lower part of the formation is characterized by *Palmatolepis gigas*, *Pa. triangularis* (Conodonta) showing the Frasnian-Early Famennian in age. The middle part consisting of *Posidonia (karadjalia) venusta* (Bivalvia); *Plicatifera* aff. *nigeriana* (Brachiopoda); *Palmatolepis minuta*, *Pa. glabra glabra* (Conodonta) giving out the Middle Famennian in age. The upper part consisting of *Siphonodella sinensis* (Conodonta), *Quasiendothyra kobeitusana*, *Septatournatella* aff. *rauserae*, *Planoendothyra* aff. *tschikmanica*, *Paleospiroplectammina tchernysiensis* (Foraminifera); *Overtonia* sp., *Donella* cf. *minima* (Brachiopoda) showing the Late Famennian-Early Tournaisian in age.

6. Conclusions

At present, evidence for stratigraphic order of Devonian-Carboniferous sediments in the Ban Thung-Bang Ca-Trao Nhi-Lung Thoang Section is defined clearly both on lithologic composition and paleontologic assemblages in ascending order: the upper part of the Na Quan Formation (Upper Givetian), the Bang Ca Formation (Frasnian), the Toc Tat Formation (Famennian-Lower Tournaisian). At Lung Thoang Valley, the Toc Tat Formation has tectonic contact with the Na Quan Formation.

The Bang Ca Formation contains the macrofaunal assemblages characterizing for Frasnian; in correlation, the Bang Ca Formation can be compared with the Liujiang Formation (D₃fr) of the interplatform trough facies in Guangxi Province and Eastern Yunnan of South China [21].

Acknowledgements

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